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Front cover : *Example of a large displacement field measured by interferometry. The two ERS-1 images were acquired on April 24, 1992 and June 18, 1993 and combine nicely in an interferogram despite the 14 months elapsed, which did not alter the surface in this desert environment. Each fringe corresponds to a displacement of 28 mm toward the satellite. The contribution of the topography has been removed using the digital elevation model elimination method and a USGS digital elevation model. The large scale deformation field has been caused by the (Mw=7.3) Landers earthquake, on June 28, 1992. The small concentric fringes have been caused by a (Mw=5.4) replica on December 4, 1992. The discontinuity in the fringe pattern which can be observed across the image has been caused by a slip, probably coseismic, on the Lenwood fault. The slip is half a fringe, or 14 mm, in range. The image illustrates the ambiguous nature of SAR interferometry results. Fringes must be counted to reach the final value of the displacement. (More on pp. 23-31).*

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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.

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Editorial

Dear URSI Correspondent,

In this issue, along with other contributions, we are happy to publish four papers presented at the URSI 75th anniversary symposium "Space and Radio Science", held in April 1995. Mobility is one of the key issues in the development of modern telecommunication systems. Dr. Kato's paper provides an excellent overview of planned and existing satellite and terrestrial cellular radio systems designed to reach this goal, and of the relevant technological problems. With the papers of Dr. Massonnet and Prof. Kalmykov we learn much about the extremely high accuracy as well as on the practical usefulness of embarked remote sensing radars. These and many other applications of radio science would not be possible without the existence of very precise and stable clocks. Prof. Salomon's paper introduces you to the most advanced time control techniques, a problem which has always been of major concern to radio science.

In view of the forthcoming General Assembly, this issue also contains the latest version of the URSI Statutes. As you may know, French and English are the official languages of the Union. This is why the Statutes are published in both languages, the French version being authoritative.

On the inside of the back cover page, you will - for the first time - find detailed instructions to authors of contributions to the Radio Science Bulletin. This offers a good opportunity to recall that the Bulletin is yours, dear Correspondent.

P. Delogne, Editor.

URSI on the Web

The URSI Homepage can be found at URL :

http://intec.rug.ac.be:8080/www/u/ursi/

We thank the Commissions who sent in contributions, and we cordially invite the remaining Commissions to do the same. Please send your remarks and contributions to :

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UTC Time Step

On n'introduira pas de seconde intercalaire à la fin de juin 1996.

La différence entre UTC et le Temps Atomique International TAI est: de 1996 janvier 1, 0h UTC, jusqu'à nouvel avis : UTC-TAI = -30 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.

Martine FEISSEL
Directeur, Bureau Central de l'IERS
Service International de la Rotation Terrestre

No positive leap second will be introduced at the end of June 1996.

The difference between UTC and the International Atomic Time TAI is: from 1996 January 1, 0h UTC, until further notice : UTC-TAI = -30 s.

Leap seconds can be introduced in UTC at the end of the months of December or 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 will be no time step at the next possible date.

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75th ANNIVERSARY

URSI - 75 Years Space and Radio Science Symposium

PERSONAL COMMUNICATION SYSTEMS AND LOW EARTH ORBIT SATELLITES

Shuzo Kato

Abstract

To realize the ultimate goal of communications, communications with everyone at anywhere and anytime, a number of efforts have been made in various fields. The key issues are frequency utilization efficiency to accommodate as many customers as possible in the limited frequency bands and cost effective realization of nation-wide or world-wide coverage. These lead to the research and development of advanced system concepts, multiple access, modulation/demodulation, forward error correction, voice coding/decoding, channel assignment schemes and so on in addition to hardware implementation technologies which directly affect portability characteristics such as size, weight, talk time, mobility, service coverage and menus available. Cellular and satellite personal communications systems employ macro cells, from half a km to several km cell size for terrestrial cellular and at least several hundred km cell size for satellite personal communications, to realize high mobility. Since system capacity is proportional to $1/R^2$ (R: cell diameter), these systems employ low bit rate codecs to achieve high system capacity. On the other hand, personal communications systems based on digital cordless systems employ micro cells, a couple of hundreds meter in diameter and most of them have been employing a 32 kbit/s ADPCM codec. This is because micro cell systems can achieve larger system capacity and cordless phone systems must realize toll quality voice transmission for use at home or offices. Since personal communication systems are supposed to be used in a wide variety of situations and environments, a compromise must be reached between high quality voice transmission (a must for home use) and mobility (a must for mobile passengers), and integration must be carried out between terrestrial and satellite personal communications to offer cost effective mobile communication services, nation-widely and/or world-widely. Communications with everyone at anywhere and anytime by one common hand set will be seen in the third generation mobile communication era.

I. Introduction

There have been a number of studies and field tests on personal communication systems ranging from radio access technologies to network technologies. These have resulted in a number of different system proposals with different multiple access schemes, bit rates, modulation schemes, codecs, transmission power and so on since there is no absolute definition of personal communications systems. Among the various definitions on personal communications, the following concept is widely accepted [1].

Personal communications systems provide the capability to communicate with everyone, anywhere and anytime by featuring personal identification instead of terminal identification, person-based communications instead of location based communication, and personalized services to serve different customers' different requests.

This concept, communications with everyone, at anywhere and anytime is the ultimate goal of communications and translates to portability of services. If all services are portable, we can communicate with everyone at anywhere and anytime.

To realize this ultimate goal of communications, a number of efforts have been made in various fields. These are classified into network technologies and radio access

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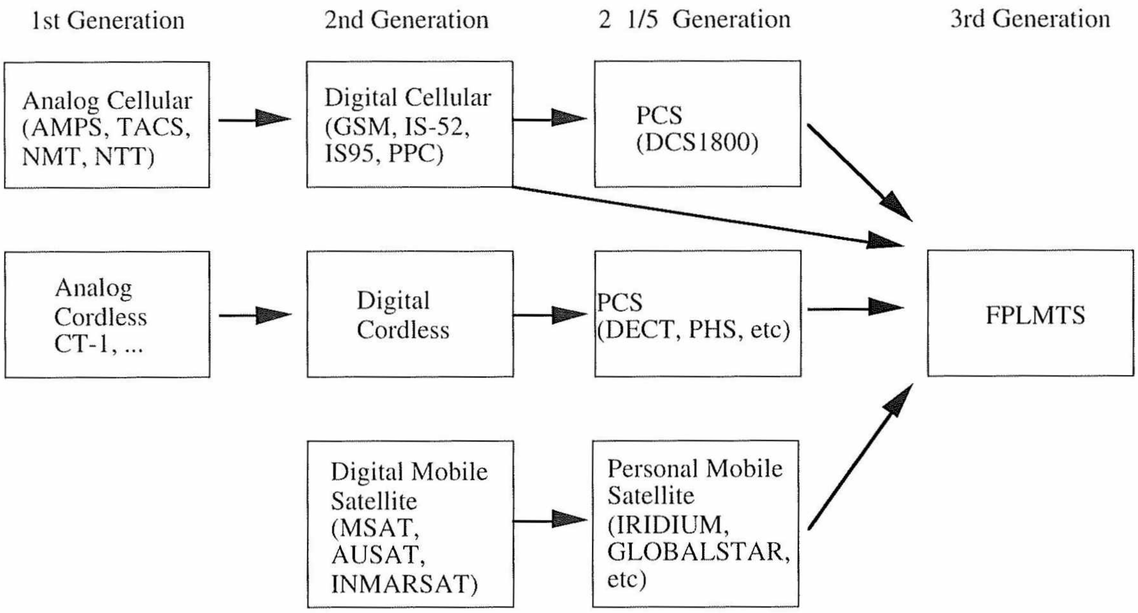

Fig. 1 - Mobile communication evolution

		JDC	ADC	GSM	NTT (Analog)	AMPS	NAMPS	CDMA (Qualcomm)
Frequency band (MHz)		800 & 1500 (New)	800	800 (New)	800	800		800
Carrier spacing (kHz)		25 Interleaving	30 Interleaving	200 Interleaving	25 / 12.5	30	15	1,250
Modulation		π/4 QPSK		GMSK	FM / N-FM	FM	N-FM	Forward : QPSK-SS Reverse : OQPSK-SS
Multiple access (Half rate codec		3(6)ch TDMA		8(16)ch TDMA	FDMA	FDMA		CDMA
Carrier bit rate (kbps) [CODEC]		42 [VSELP 11.2 kbps]	48.6 [VSELP 13 kbps]	270 [RPE-LTP 22.8 kbps]	——	——		Forward: 19.2k (r=1/2FEC) Reverse: 28.8k (r=1/3FEC) [QCELP : 9.6kbps]
Equalizer		Option	Mandatory	Mandatory	Not required	Not required		Forward : 3finger RAKE Reverse : 4finger RAKE
Diversity		Option	Option	?				Spatial diversity : 2RX-4RX @base station Time diversity 20msec
Frequency hoppin		——	——	Option	No	No		No
Spacial frequency utilization efficiency	Carrier spacing (kHz)	25	30	200	25	30		1,250 (60-64ch)
	kHz/ch (Full codec)	*2 33.5	*2 40	*3 100				*1 21 (with Voice activation)

Table. 1 - Major features of digital and analog cellular communication systems
**1 : 1/10 of AMPS *2 : Frequency reuse factor Analog FDMA/TDMA/CDMA : (1/7)/(1/4)/1*
**3 : as same as *2 (under estimation)*

technologies. The former is well represented by the intelligent network which provides the infrastructure needed to perform location registration, roaming, and routing to track down the called party anywhere, authentication and so on. The latter provides wireless access methods to provide last 100 m portability to customers. This comprises infrastructure, base stations and consumer products, the handset. Therefore, the key issues are frequency utilization efficiency to accommodate as many customers as possible in the limited frequency bands which lead to the research and development of advanced multiple access, modulation/ demodulation, forward error correction, voice coding/ decoding, channel assignment schemes and so on in addition to hardware implementation technologies which directly affect portability characteristics such as size, weight, talk time, mobility, service coverage and so on.

The important thing to remember is that when there is only one system providing communication capability, customers have no choice but to use it. However, this will not be valid in the personal communications era and only the best system will be chosen in terms of price, quality, talk time/ standby time, size and weight of handset. In such circumstances, consumer products aspects rather than radio engineering aspects will dominate the success or failure of the system.

In the following chapters, the most important and often overlooked condition: customer requirements will be discussed by comparing the cordless phone and cellular phone approaches toward personal communications systems (PCS). A perspective of customer's requirements through PHS field tests in Japan will be given with survey data on acceptable tariff and what customers really want. Examples of advanced technologies will be described to meet these customers' requirements: high quality voice transmission, longer talk time, small and light weight handset.

2. Mobile communications evolution [1-5]

The evolution of mobile communications is shown in Fig. 1. Mobile communications started with analog cellular systems and analog cordless phone systems. The most important issue in analog cordless systems has been how to achieve high frequency utilization efficiency to meet traffic demands with limited frequency resources, and various analog systems have been developed in this direction as shown in Table 1. Examples include AMPS (Advanced Mobile Phone Systems) in north America, NMT (Nordic

		PHS (Japan)	DECT (Europe)	DCS1800 (Europe)	CT-2 (England)	WACS (USA)
Frequency band (MHz)		1895-1918.1	1880-1900	1710-1785 1805-1880 (UK)	864.1-868.1	1850-2200
Access Scheme		TDMA-TDD	TDMA-TDD	TDMA-FDD	FDMA-TDD	TDMA-FDD
Channels/Carrier		4ch	12ch	8ch	1ch	8ch
Carrier spacing (kHz)		300	1728	200	100	300
Channel Bit Rate (kbps)		384	1152	270.833	72	400
Speech Codec		ADPCM (32kbps)	ADPCM (32kbps)	PRE-LTP (13kbps)	ADPCM (32kbps)	ADPCM (32kbps)
Modulation		π/4 QPSK	GMSK	GMSK	FSK	π/4 QPSK
Portable Transmit Power, Max/Ave		80mW/10mW	250mW/10mW	1W/125mW	10mW/5mW	200mW/20mW
Channel Control		Dedicated CC	Associated CC	?	Associated CC	Dedicated CC
Function	Termination Call	O	O	O	X	O
	Hand Over	O	O	O	X	O
	Access Network	Digital/Analog	Digital	Digital/Analog	Analog	Digital
Availability		1994	1992	1993	1989	1995?
Remarks		• Medium scale • Diversity at base station	• Too many channels for home use • Equalizer for outdoor use	• GSM air-interface	• Originating call only	• Two frequency band required • Switched antenna diversity in portable set

Table. 2 - Personal communication systems

	Iridium	Globalstar	Odyssey	Inmarsat P
Orbit inclination	90°	52°	56°	45°
Number of orbital planes	6	8	3	2
Altitude (km)	765	1,389	10,354	10,355
Number of satellites/plane	11	6	4	5+(1)
Number of satellites	66	48	12	10+(2)
Number of beams/satellite	48	6	37	121
(Total active beams)	(2,150)	(288)	(444)	(1,210)
Weight (in orbit) (kg)	700	232	1,180	1,200
Transponder	Regenerative	Non-regenerative	Non-regenerative	Non-regenerative
Life time (yrs)	5	7.5	10 - 15	10
Frequency bands				
User link (up) (MHz)	1610-1626.5	1610-1626.5	1610-1626.5	*1980-2010*
User link (down) (MHz)	1610-1626.5	2483.5-2500	2483.5-2500	*2170-2200*
Feeder link (up)	27.5-30GHz	6484-6841.5MHz	29.5-30GHz	*5100-5250MHz*
Feeder link (down)	18.8-20.2GHz	5158.5-5216MHz	19.7-20GHz	*6925-7075MHz*
Intersatellite link (GHz)	22.55-23.55	——	——	——
System capacity (voice (4.8kb/s) channels)	3,840/Sat	134,400/48 Sat	3,000/Sat	4,000-5,000/Sat
Multiple access technique	TDMA/FDMA	CDMA	CDMA	*TDMA*
Planned service				
Digital voice (kb/s)	4.8	2.4, 4.8, 9.6	4.8	*TBD*
Data (kb/s)	2.4	9.0	9.0	*TBD*
Radio determination	Yes	Yes	Yes	*TBD*
Compatibilty with cellular system	Yes (Dual mode terminal)	Yes (Dual mode terminal)	Yes (Dual mode terminal)	Yes (Dual mode terminal)
Handset outou power (mW)	390	250	250	TBD
Tariff (/minute)	$3	$0.23	<$1	$1-4
Planned operation	1998 -	1998 -	1997 -	1999 -

Table 3 - Low earth orbit satellite systems

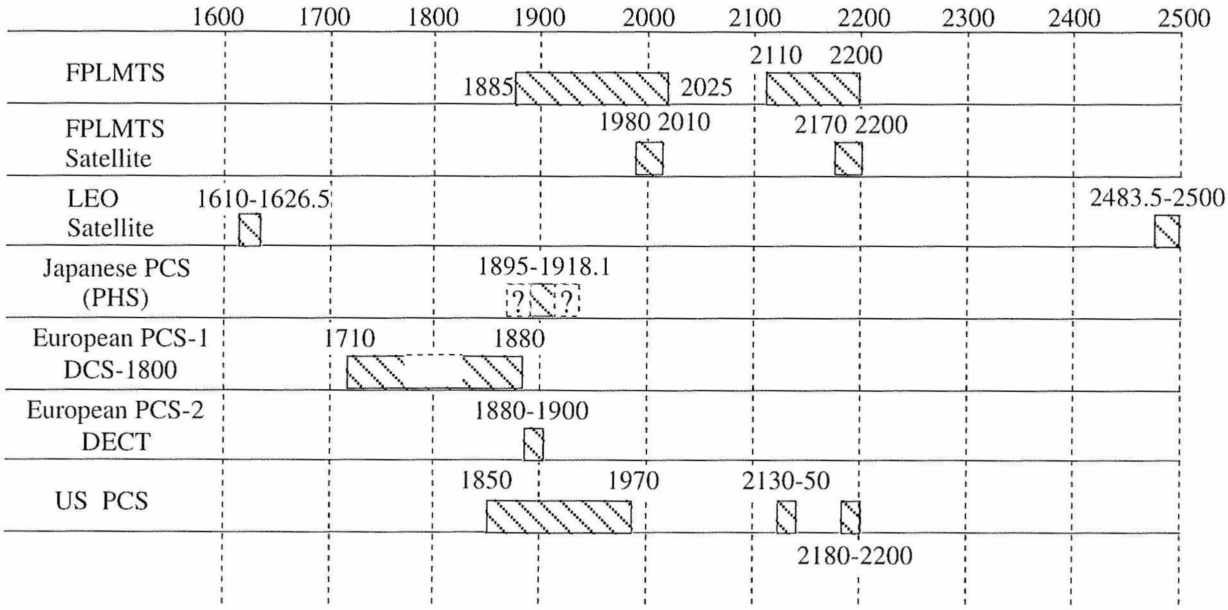

Table 4 - Frequency allocation in the 1400 - 2200 MHz band

Mobile Telephone) in Europe and the NTT (Nippon Telegraph and Telephone) system in Japan. To meet higher traffic demands and advanced services, digital cellular systems were developed and have been used. Major digital cellular systems developed so far are GSM (Global Mobile Systems, developed in Europe), IS-52, IS-95 (both developed in the USA) and PDC (Personal Digital Communications, developed in Japan). Similarly, analog cordless phone systems were also digitalized and are being used. Moreover, digital mobile satellite communication systems have been developed to complement mobile communications where terrestrial mobile communications are not cost effective.

Currently, the next (2.5) generation systems in the above mentioned three categories are being investigated, developed and tested. These are personal communication systems such as DCS 1800 based on GSM, DECT and PHS based on cordless phone systems and satellite personal communication systems such as IRIDIUM, GLOBALSTAR, Odyssey, Inmarsat P and so on as shown in Table 2 and 3. Current frequency allocations for terrestrial and satellite personal communications are listed in Table 4. As shown in this Table, the frequency bands for terrestrial and satellite personal communication systems are not much different except the 1.6 and 2. 5 GHz frequency bands for low earth orbit (LEO) satellite communication systems.

3. Terrestrial versus satellite personal communications

As shown in Table 5, cellular communications systems employ macro cells, from half a km to several km in diameter to realize high mobility for mobile passengers. Since system capacity is proportion to $1/R^2$ (R: cell diameter), these systems employ low bit rate codecs to achieve high system capacity. On the other hand, digital cordless systems employ micro cells, a couple of hundreds meter in diameter and most of them have been employing a 32 kbit/s ADPCM codec. This is because micro cell systems can achieve larger system capacity and cordless phone systems must realize toll quality voice transmission for use at home or in offices.

One disadvantage of smaller cell size is the limited mobility management for mobile passengers. The other disadvantage is the huge number of base stations required for covering service areas. This will not cause any severe problem in urban and populated areas but may cause a big problem in rural and un-populated areas in that full coverage is not economically possible with only terrestrial personal communication systems. Thus, terrestrial personal communication systems can achieve high system capacity and give a cost effective coverage in populated areas but not in un-populated areas. Also the high capacity characteristics of personal communication systems allow us to employ higher bit rate voice codecs to offer toll quality voice transmission capability at home and offices.

On the other hand, satellite personal communication systems can provide global coverage but offer a very small capacity which can not meet all traffic demands. Although the voice codec bit rates for satellite personal communication systems are lower than current digital cellular communications as shown in Table 5, the total system capacity is very low due to the limited bandwidth and frequency reuse is very low compared with those of personal or cellular communication systems. Although the voice codec bit rates might not be high enough for home or office use, they will be good enough for outdoor, especially rural area communications where no other mobile communications can provide communications capability.

Since personal communication systems are supposed to be used in a wide variety of situations and environments, a compromise must be reached between high quality voice transmission (a must for home use), mobility (a must for mobile passengers) and better geographical coverage. Otherwise, the developed systems will be used by a few people and will not be used as it should be.

4. Two approaches to PCS [1]

Although the objective of communications is to offer the best services at the best price, customers consider the price, tariff, utilities and functions available but do not worry about system capacity, or frequency utilization efficiency which are often the most important research targets of

	Cell size	System capacity	Voice codec	Home use / Office	Unpopulated areas
Terrestrical PCS	Micro (100-500m in diameter)	Large	32kb/s ADPCM	◎	△
Cellular	Macro (-2km)	Medium	11-22 kb/s	○	△
Satellite PCS	Extra macro (-500km)	Small	4.8 kb/s	△	◎

Table 5 - Major features of PCS and mobile communications

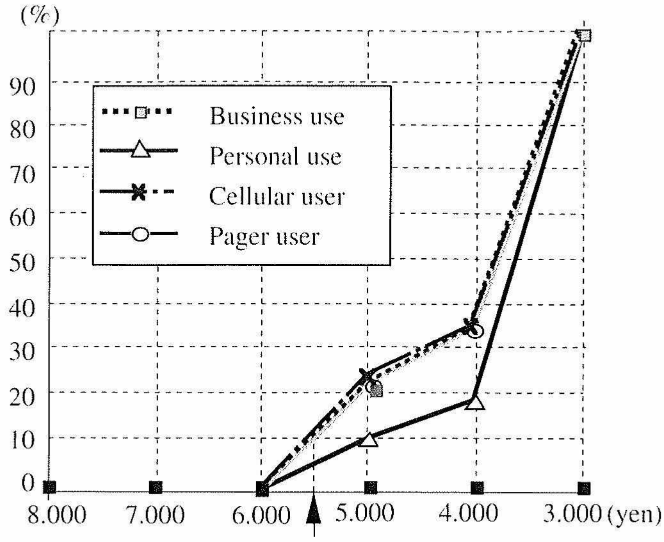

Fig. 2 - Number of people to subscribe vs. monthly charge

researchers and engineers. If there is no alternative to use like life-line communication, whatever system available will be used. However, in the competitive environments which most personal communication systems will face, it is the customers' choice that determines system suitability.

Based on this basic and important fact, two approaches to PCS, cordless phone approach and cellular phone approach are compared. The condition which both systems must satisfy is to provide communication through an open-air-interface in the home, at the office and outdoors.

The cordless phone approach will be easier to deploy since a huge market can be seen for this approach by replacing currently popular analog cordless phones by digital cordless phones provided voice transmission quality is as high as toll quality and handset price is comparable to that of the analog one. Extended usage outside the house or office will give more incentives to people to buy the digital cordless phones. The drawback of this approach is limited mobility, up to walking speed for use.

The cellular phone approach provides high mobility as is well understood: however, there is a lower limit in cell size to offer this high mobility. This lower limit in cell size limits the system capacity since the traffic which can be handled is proportional to $1/R^2$. To improve system capacity, usually low bit rate voice codecs are used and unfortunately, this leads to lower than toll quality voice signal transmission. The point of this approach might be whether this voice transmission quality is acceptable in the home or office.

5. Perspective view of PCS through PHS field tests [1, 6]

To see what customers really want from PCS, field tests (Phase 1) on Japanese PCS, named as PHS (Personal Handy Phone Systems) were carried out in the northern part of Japan from 1 October 1993 to March 1994 and Phase 2 PHS field tests lasted in Tokyo from last April to the end of last September. PHS employs the time division multiple access - time division duplex (TDMA-TDD), π/4 QPSK schemes and transmits up to 4 channels per carrier at a bit rate of 384 kbit/s over a 300 kHz channel. As the voice codec, a 32 kbit/s ADPCM codec is employed to realize toll quality voice transmission.

About 800 monitors tested PHS in Phase 1. Among them, the number of cellular phone users was 120 and that of pager users was 163. Major results obtained on charges are as follows:

- Acceptable monthly charge: about $30 (100 % want to subscribe) (Fig. 2)
- Acceptable per-call charge: about $25 (80-100 % want to subscribe)

As seen from Figure 3, survey results show that customers want higher quality, longer talk time, smaller size and lighter weight handsets.

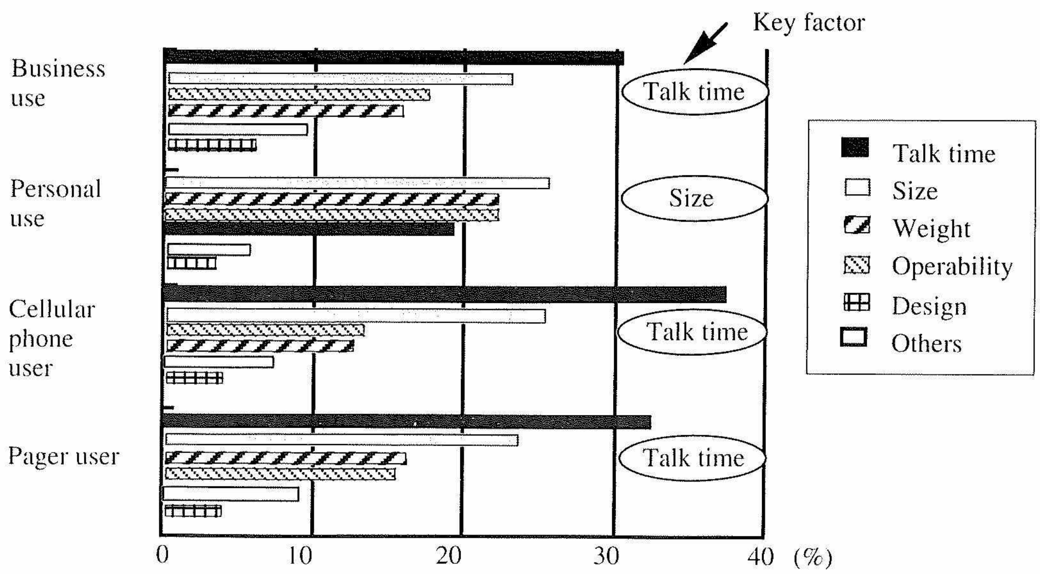

Fig. 3 - Important factors to design portable set

6. Requirements for PCS - High performance handset

For network operators, frequency utilization efficiency is a very important factor to develop personal or mobile communication systems to accommodate as many customers as possible. However, in competitive environments in the personal communications era, more important factors might be customers' satisfaction as summarized below:

(i) High-quality voice transmission

(ii) Better portability (longer talk/standby time, smaller in size and weight)

(iii)Wider coverage for seamless communications

(iv)Lower charge

To meet these requirements, a lot of effort has been taken. The following are two examples developed from this direction [7-9]. These are (1) coherent demodulation using a reverse modulation type carrier recovery scheme and (2) an error concealment technique. The proposed coherent demodulation scheme improves the frame error rate (FER) by about 3dB in terms of Eb/No — ratio of energy per bit to noise power spectral density — (Fig. 4) and the proposed error concealment technique improves voice transmission quality by 0.5 in mean opinion score (MOS) or equivalently 3 dB in terms of Eb/No. Thus, these schemes improve the receiver sensitivity by 6 dB to meet the customers requirement. To meet the other requirements, 1-chip CMOS LSIC implementation has been carried out. The developed LSIC operates at 2 volts and has the quite low power consumption of 70 mw. Moreover, a Lithium ion battery has been developed with an excellent performance of 72 Wh/kg. The handset developed by using these techniques can achieve a 10-hour talk time, and 150 hour standby time at a weight of only 120 g and a size of less than 120 cc.

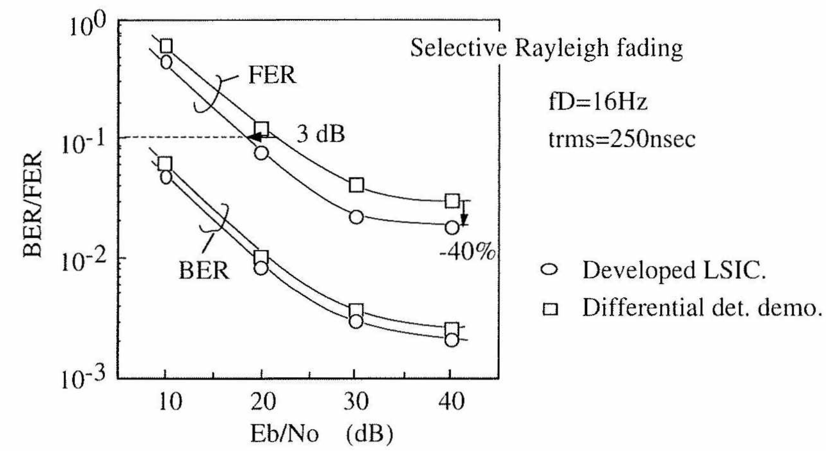

Fig. 4 - BER and FER (Rayleigh fading)

7. Technologies for Integration

- Commonalty -

A number of key technologies for terrestrial and satellite personal communications have some commonalty.

Linear modulation schemes such as quadrature phase shift keying (QPSK) and π/4 QPSK are popular for both systems to satisfy narrow band spectrum in nonlinear channels. Demodulation schemes for such systems were once considered to be differential detection to cope with the Rice or Rayleigh fading which characterize mobile satellite and personal communication channels, respectively. However, recent research results show coherent demodulation is possible in both Rice or Rayleigh fading environments resulting in significantly improved bit error rate performance [7], [10]. It is noteworthy that coherent demodulation was thought as complicated and power consuming but by employing advanced hardware and LSIC processing technologies, the penalty of better bit error rate performance is no longer conceivable as seen from the examples in the previous section. For data transmission, forward error correction (FEC) is popular for both systems, but FEC for voice signal transmission is not so popular due to slow fading and longer error bursts which degrade FEC performance quite a lot or need prohibitive interleaving length to obtain the full advantage of FEC [11].

CMOS LSI technology is promising for baseband signal processing for its high capacity and low power characteristics. The capacity of CMOS LSICs has been nearly doubled every second years and the operation voltage (V) has decreased to 3 - 2 volts. Current CMOS LSICs can accommodate up to 400 to 500k gate digital circuits or equivalent digital and analog circuits and CMOS LSICs with a quite low operation voltage of 2 volts are becoming commercially available. Since the power consumption of CMOS LSICs is proportional to V^2, digitalization of analog circuits and one-chip implementation of the baseband signal processing circuits with a low operation voltage CMOS LSIC is the obvious way to realize advanced portability of services for both systems.

RF components such as power amplifiers, synthesizers and mixers have been implemented in monolithic microwave (MM) ICs for both systems resulting in reducing size to about 1/5 every 5 to 7 year. This is very effective especially for low power applications such as PHS or DECT. MMIC implementation is also effective to reduce power consumption. GaAs MMIC s have been studied and developed for high power amplifiers and front end amplifiers for their high performances. We must accept high price and multiple supply voltages. Silicon MMICs have also been used for price sensitive but less performance-sensitive terminals. Currently, RF IC operation voltage is 3 volts for practical applications with reasonably high power-added-efficiency for power amplifiers.

- Difference -

As seen from the previous discussion, the voice codec rate is a key parameter for personal communication systems since the voice codec must provide toll quality at home and office use. On the other hand for the outside service, toll quality voice transmission is not necessary since there will be less competition and it can be considered as a kind of life-line communication.

8. Integration of terrestrial and satellite PCS

Integration of terrestrial and satellite personal communication systems is preferable for everybody: customers, operators and manufacturers. Integration of both systems is good for customers because we can provide seamless services nation-widely or globally. Since terrestrial personal communication systems are good for urban and densely populated area but not for rural areas and satellite personal communication systems can not supply high capacity to meet traffic demand in urban areas, both systems compliment each other and provide roaming capability across both systems. From the operators point of view, this integration expands service coverage cost effectively. Current cellular systems cover about 90 % of the population but their geagraphical coverage is only about 50 %. The coverage by personal communication systems is expected to be about the same (In some countries, population coverage realization of about 90 % in a fixed term is a condition for spectrum auction). Therefore, the integration of terrestrial and satellite personal communications systems is good for operators too.

- Common terminals -

There will be a number of different integration levels starting with two discrete terminals combined in one unit (lowest level) to just one set for both systems with roaming capability (highest level). As seen from the previous discussion, there is a lot of commonalty but some differences can not be resolved. A medium level integration of the terminals which employ the same RF components (satellite FPLMTS frequency bands are quite similar to that of terrestrial personal communications), the same CPU and man machine interface (MMI) components, which allow different modulation, multiple access, bit rates, bursts formats, is a good choice with upcoming technologies described in the previous section. The last components (baseband signal processing components except cpu and MMI components will consume only about 1/5 of the total power of the handset with advanced LSIC technologies, and having two baseband signal processing components increases the power consumption by a maximum of only 20 % (practically about 10 % by using common processors). This will allow customers to have high voice transmission quality at home or offices and still allow communication everywhere in the world with reasonably good voice transmission quality.

- Traffic sharing -

Since the capacity of satellite personal communications is limited and this system cannot be a major traffic carrier, satellite application areas must be carefully designed. Against this disadvantage, satellite personal communications can provide world-wide/global coverage very easily, which can not be met by terrestrial personal communications. Combining these two complementary characteristics of terrestrial and satellite personal communications systems, large system capacity and local coverage suitability, low capacity but wide coverage suitability, the idea of traffic sharing can be applied [12-13]. The integration of terrestrial and satellite communication networks in traffic sharing has been in commercial use in Japan since 1988 [12-13]. The traffic is shared in this system, as heavy traffic is carried by terrestrial digital networks and sparse and geographically distributed traffic is carried very efficiently by demand assignment time division multiple access (TDMA) satellite communication systems. The system takes the advantage of global coverage and on demand basis channel assignment capability of TDMA satellite communication systems to complement inflexible channel assignment of terrestrial digital networks which can achieve high efficiency in carrying heavy and steady traffic. By carrying the overflow peak traffic of terrestrial digital networks intentionally caused by reducing the number of channels required for the terrestrial network to reduce installation cost, satellite channels can be used very efficiently while the total installation cost is reduced but retaining the same blocking rate for the customers.

The same idea can be applied to terrestrial and satellite personal communication systems: they complement each other except for the difference in voice codec bit rates in both systems. In traffic sharing, heavy traffic in urban areas will be carried by terrestrial personal communication systems while sparse traffic will be carried by satellite personal communication systems. The voice codec bit rate difference will not be a problem as far as both systems are supported by digital networks operating on 64 kbit/s PCM voice codecs since there must be codec translators between personal communications network and supporting digital networks such as ISDN. On the other hand, the combined system can maximize the advantages of both systems: good voice quality at homes and high capacity in populated areas, and cost effective communication ways in un-populated areas.

System integration will benefit customers by providing seamless communications at reasonable price. Moreover, network operators will benefit by not having to install terrestrial networks to meet excessive coverage requirements. Furthermore, manufacturers will benefit from this approach by producing a larger number of "common use" handsets, which will lead to lower costs. For satellite operators and handset manufacturers, the integration might be vital since the market for satellite personal communications handsets will be smaller than that of terrestrial personal communications.

Conclusion

This paper has reviewed current terrestrial and satellite personal communication systems and discussed the ideal integration of both systems. One of the important issues is what customers want and it is shown that high quality voice transmission is the first priority in PCS in its nature and also confirmed by field tests carried out on PHS in Japan. These are summarized as (i) High-quality voice transmission, (ii) Better portability (longer talk/standby time, reduced size and weight), (iii) Wider coverage for seamless communications, (iv) Lower charge. From the technological view point, the advanced technologies such as coherent demodulation can be applied to both systems to improve performances, and there will not be not much more components required for a handest (less than 10 - 20 % difference). That is to say, dual mode terminals for both terrestrial and satellite PCSs can be easily developed. The integration of both systems by traffic sharing way has been discussed to offer high voice transmission quality at home or office, and offers cost effective wide coverage for customers by complementing each other. This integration of both systems with one portable unit will be essential for both systems to glow and for customers and manufacturers.

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75th ANNIVERSARY

URSI - 75 Years Space and Radio Science Symposium

REAL-APERTURE RADAR (RAR) IMAGING FROM SPACE

A.I. Kalmykov

Introduction

The 75th URSI anniversary symposium is a brilliant testimony of a unified research community in the world and it is also a showcase of its potentialities that are not affected by the frontiers dividing the present world. And it would be worth to say that these frontiers seem to be far less tangible especially when the Earth is observed by radar right from space. I have the feeling that the very fact that we are together at this symposium makes us realise that we have gained one of the primary URSI objectives: we all enjoy the breakthroughs of individual researchers and groups of experts and we are actually proud to have them readily available to most of the countries.

In my report I will inform you about one of the developments which are actually based on the results of long-standing research work that had been previously carried out by scientists of different countries. This development concerns the side-looking radar (SLR) which had been originally tested on the Cosmos-1500 satellite and later paved the way to the elaboration of techniques for observing oceans, seas, ices and glaciers from space-borne carriers.

Now let me dwell on some background facts concerning the SLR development.

1. Historical background

As far back as in the 2nd World War, when the radar observations of targets on sea helped to locate their reflections, "sea clutters" were identified. Any attempts to synthesise and interpret this phenomenon [1] over many years ended in a failure. One of the first steps to yield certain results in gaining a deeper insight into the "clutter" mechanism was the detection of selective decametric radiowave band scattering by the sea surface [2, 3]; the decametric waves were found to be scattered by the sea waves $\Lambda=\lambda/2$. And while the computations involving the use of the small perturbation method [4, 5] helped in principle to interpret the features of the decametric band scattering by the sea surface, adequate models for the microwave band did not exist for many years. In the phenomenological models [1, 6, 7] which were used to make in attempts to interpret individual scattering characteristics, the emphasis was put on energy characteristics. However, with these particular models it was impossible to describe spectral, polarization and other characteristics.

In late 50s and early 60s many countries were actively engaged in the studies on the process of microwave scattering by the sea surface. The primary aim of the investigations that were carried out at the Institute of Radiophysics and Electronics of the NAS of Ukraine (Kharkov) was based on the following attemption. Inasmuch as all the elements of the surface are in a state of motion, the sea-scattered signal should have a Doppler shift ΔF whose magnitude will make it possible to determine the velocity of the scatterers V_s . In terms of the dispersion law $V_s(\Lambda)$ the nature of scatterers can be specified. To ensure that this concept could become a reality the Institute of Radiophysical and Electronics developed in 1960-61 a multifrequency coherent radar for 8 mm, 3 cm, 50 cm, 1.5 m and 4 m waves [8] and as early as in 1962 the selective scattering of microwaves [9] was identified.

In the 60s efforts were intensified to work up the procedure for computing the characteristics of the SHF radiowave scattering by the sea surface. For the case of microwave scattering a complex computational method [10] evolved into a two-scale model [11]. The basic experimental dependencies were interpreted, namely the changes in scattering cross-section s with an incidence angle $\sigma(\theta)$ and the relationship between the spectral

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characteristics of signals and roughness parameters. It is precisely during this period that a series of investigations aimed at updating the model was carried out in the USA [12-16]. As a result of all those studies the basic properties of scattering were found to be described in the two-scale model. The basic scatterer is the ripple $\chi_o = 2k \sin\theta$ ($\chi_o = 2\pi/Q_o$..., $k = 2\pi/\Lambda$, θ = the incidence angle) where as the large waves give rise to a modulation of ripple-scattered signals; ripples manifest themselves in the spatial-frequency structure of scattered signals.

It is precisely this phenomenon that provided the basis for early papers on oceanography, namely,those devoted to the determination of sea roughness parameters (spectra, length, distributions, periods, heights of waves) from the characteristics of scattered signals. The oceanologists were very interested in the studies of the ripple. They found that the ripple spectral density is dependent upon the wind velocity [16-18] and that σ increases with wind [19]. At any rate, this gave a stimulus to make the first attempts at conducting radar observations from space.

2. The space radar era and the first"Cosmos-1500" satellites

The main source of information on the state and structure of the seasurface in the microwave observations is the gravitational-capillar ripple.The principal characteristics of the scattering cross-section are relatedto the spectral density of the scattering ripple χ_o

$$\sigma_o \sim \alpha(\chi_o)$$

In its turn, the ripple spectral density is related to the speed of the near-sea surface wind *W* and depends on currents, surface-active films, etc. It is precisely these points that have led to the well-substantiated design of many space-borne radar systems. (Table 1).

The late 70s saw the emergence of initial space programs which envisaged the use of radar systems as the prime source to draw on necessary information. The first attempt was to develop a radar-radiometer for the"Skylab" space station.

The first practical results were obtained following the launch of the "Seasat" oceanographic satellite [21]. The SAR and a scatterometer that were originally tested in space made it possible to derive unique information which was subsequently processed and extensively used by researchers. I would not like dwell on all the peculiar features of the "Seasat" system. Their merits have received general acceptance.

When a space-borne radar was being designed in the Soviet period we allowed for the "Seasat" experience and adopted a different approach. Following the evaluated model of selective scattering, we decided on the radar parameters keeping in mind the peculiarities of radiowave scattering by the sea surface and sea ice. Initially the selection of the band λ= 3 cm resulted from the capability of observing the seasurface wind and inhomogeneities of the sea surface; it is also influenced by factors such as high sensitivity to variations in age gradation of ice, etc. A 1-3 km spatial resolution was achieved over this band using an antenna with a diameter of about 10 m. A crucial point was the use of a 50 km swath for the observations of basic mesoscale processes occurring on the ocean surface and the sea ice.

Since the processes to be studied are highly dynamic, the usefulness of data is directly dependent on how they are efficiently derived and employed. Real-time, operational observations of the Earth covers are,above all, related to all weather facilities; the band $\lambda \geq 3$ cm is particularly appropriate for this purpose. Another essential consideration in effectively gathering information by users is real-time, on-board data processing and transmission of results in a form virtually suitable for a wide network of users. This objective was achieved by forming radar data via APT (which was widely used in theoptical data transmission) and transmitting formed images in the 137 MHz wave band. The reception points for this band were more than 500.

Now let us consider some technical aspects. A side-looking radar (the radarbeam is oriented orthogonally to the satellite velocity vector) provides for sensing in a sector of incidence angles $\theta = 20° ... 52°$. The signal range selection is ensured by the pulse operating mode; the pulse duration was 3 µs. The transmitter used a magnetron with a radiated power (in a pulse mode) of 100 kW. The receiver was equipped with a temporal automatic gain control that equalizes the average signal level over an entire band, which is so essential for image users.

We had some serious problems with the development of the antenna system. The length of the antenna had to be approximately larger than 12 m and the antenna had to be installed on the wing of the satellite, which was 3 m in size. In other words, the antenna should consist of 4 collapsible sections. The problems of radiation and losses on joints proved to be less significant as compared to the provision of conditions for antenna operations in outer space where the temperature drop exceeds 200°. In order to keep the antenna parameters invariable (primarily its gain), it was necessary to maintain the deviation from the plane of the 12 m long antenna within 2 mm (!). The solution to this problem turned out to be quite straightforward: the "bow" principle was employed. The antenna appears to be like a bow-string with a spring-loaded draw mechanism— the bow. This version of the antenna system has been tested on the"Cosmos-1500"/"Okean" satellites and proved to be highly reliable.

In regard to the on-board data processing it should be pointed out that, due to the integrated-data store, a high contrast-background sensitivity was achieved (nearly 1 dB). This made it possible for users to take advantage of the data thus available with no additional processing. The system is capable of forming returned signals into an image. The sweep for the range coordinate, which is orthogonal to the flight direction, is provided through the change in signal delay (line scan); the sweep for the other coordinate is produced by the satellite passage (frame scan); the scales for both coordinates were selected as being equal.

Space Radar Systems

Radar Type	Program Sattellite	Date Operation life	Wavelength (cm) Polarization	Swath (km)	Spatial resolution	Data processing
Scattero-	SEASAT	1978/3m	2.1 / VV, HH	500	50 km	onground
meter	ERS-1	1991/	6 / VV	500	50 km	onground
	SEASAT	1978/3m	23 / HH	100	25 m	onground
Synthetic	SIR-A SHUTTLE	1981/5d	23 / HH	54.6	37 m	onground
Aperture	SIR-B SHUTTLE	1984/7d	23 / HH	50	35 m	onground
Radar	COSMOS-1870	1987/24m	10 / VV	20	25 m	onground
(SAR)	ALMAZ	1991/	10 / VV	20	20 m	onground
	ERS-1	1992/	6 / VV	100	30 m	onground
	JERS-1	1992/	23 / HH	75	18 m	onground
	SHUTTLE	1994	3 / VV			onground
	SIR-C / X-SAR	1994	24 / VV, HH			onground
	COSMOS-1500	1983/33m	3.1 / VV	475	0.8 x 2.5 km	onborne
Real	COSMOS-1602	1984				
Aperture	COSMOS-1766	1986				
Radar	COSMOS-1869	1987				
	OKEAN-1	1988				
	OKEAN-2	1990				
	OKEAN-3	1991				
	OKEAN-4	1994				
	OKEAN-5	1995				

Perspective Maps - Multipurpose radar rystem (spaceborn variant)

Synthetic Aperture Radar with Active Phazed Array		23 / VV, HH	3 x 100	5-15 m / / 50 m	onground / / onborne
Real Aperture Radar		3 / VV	2 x 700	0.5 x 1.5 km	onborne
Scatteromete		3 / VV	600	(5..25) km	onground

Maps - Multipurpose radar system on the aircraft-laboratory IL-18D

Real Aperture Radar		3 / VV	2 x 45	20..50 m	onborne
Synthetic Aperture Radar with Active Phazed Array		23 / VV, HH	30 (120).	2.5..25 m / / 25..50 m	onground / / onborne
Real Aperture Radar		0.8 / VV, HH	15	25..50 m	onborne
Synthetic Aperture Radar with Phazed Array		180 / VV, HH	45	25 m / / 50..100 m	onground / / onborne

Table 1

A wide spectrum of practical problems had to be tackled for analyzing the image patterns being obtained. Several applications require absolute ESA (effective scattering area) measurements. For this purpose the SLR is provided with an automatic potential calibration which is implemented by feeding a fraction of the radiated signal to the input of the receiving channel. This calibration signal is delayed as a radiated pulse and is level-variable for calibration of the dynamic range of the whole channel.The calibration signal is subject to all those transformations the returned signal has to undergo. As a result, it becomes possible to perform the s measurements on the basis of relative measurements of a returned and calibrated signal.

The SLR polarization was chosen to be vertical so as to allow better observations of the sea surface; the selection of polarization indeed has no appreciable effect on the observations of sea ice and glaciers. With regard to ice there is a certain advantage offered by cross polarization mesurements. However, these could only be achieved by using the margin in excess of 10 dB; this accounted for some trouble at the critical stage of the SLR development.

The sector of incidence angles $\theta \geq 20°$ was chosen in such a way as to afford uniqueness of observations of sea surface and sea ice inhomogeneities against thebackground reflections by the sea. With $\theta < 20°$ one can indeed clearly see quasi-mirrors reflections whose nature is essentially due to non-diffuse scattering.

And finally, when we were actively engaged in the design of the SLR, we proceeded from the assumption that in the early 80s most of the users would not have any experience in the interpretation and utilization of radar images. Therefore, the transmitted SLR imagery was combined in different variants with optical (scanner MSU-M) and radiometric images (8 mm band scanning radiometer). The testing of the first SLR was run on the "Cosmos-1500" series of satellites. The operations of these systems over the first 3 years [22] strongly suggested that they were highly efficient and this fact sounded quite convincing to the whole of the research community. This stimulated the development of the SLR-based space operational system "Okean", which permitted the launch of 8 satellites (Table 1)

3. Experience gained with the "Cosmos 1500"/"Okean" SLR's

Now let us consider the basic capabilities of the "Cosmos 1500"/"Okean" SLR. Although this system was designed to observe the Ocean's surface, its parameters were selected so as to enable the sea ices and glaciers to be efficiently observed and, what is more, to tackle some terrain problems.

Figure 1 presents particular observation aspects in conjunction with a number of objectives that can be achieved through the use of SLR systems. A good deal of experience has been gained in utilizing the SLR sea ices imagery [23, 24]. It will be recalled that within less than a month of the satellite launching the "Cosmos-1500" SLR got involved in the rescue of 22 cargo ships which were to deliver wintering supplies to the north-eastern area of the Arctic region. This convoy found itself trapped in pack ice during the polar night in the Long strait. Two nuclear-powered ice-breakers were unable to force their way to the distressed fleet and set about the rescue operations. The conventional methods of ice surveying had failed.The "Cosmos-1500" SLR succeeded in locating the polynya near the Wrangel Island and the channels leading to it (Figure 2). This gave an excellent chance to carry out adequate rescueoperations. Only one ship was lost. A heavy material damage estimated at 70 x 10^9 \$ was thus avoided, whereas the cost incurred in the SLR development amounted to 10^9 \$. Meanwhile, the most impressive was the social effect.

Two years later the research ship "Mikhail Somov" found itself in the same distress situation. It drifted for nearly 4 months in the sea ice throughout the polar night. The diesel ice-breaker "Vladivostok" was unable to make its way through the huge thickness of the sea ice to rescue

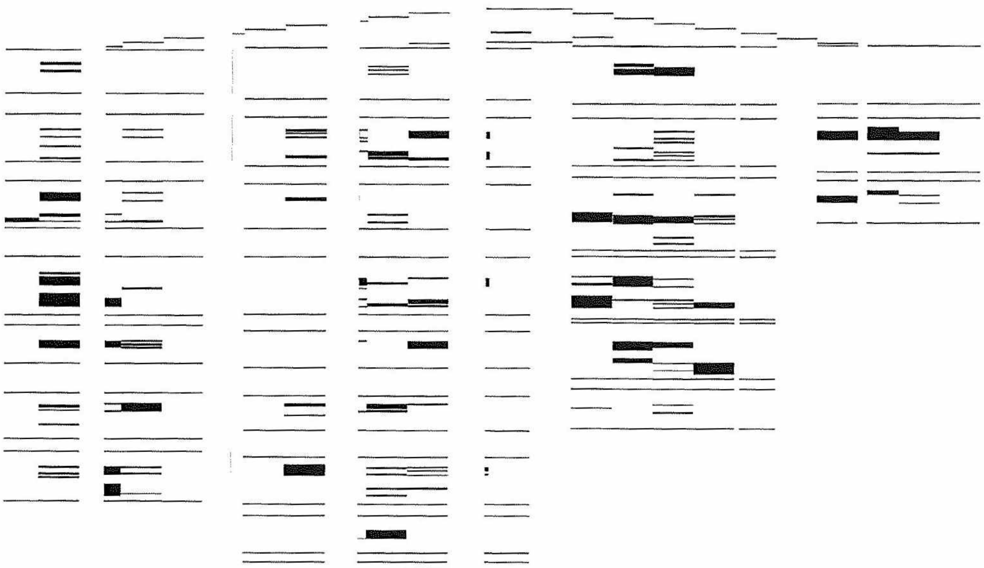


Fig. 1 - Spotting of critical changes in natural environment and warning of natural catastrophes.

Fig. 2 - "Cosmos-1500" Radar image of the Long Strait with dark channels.

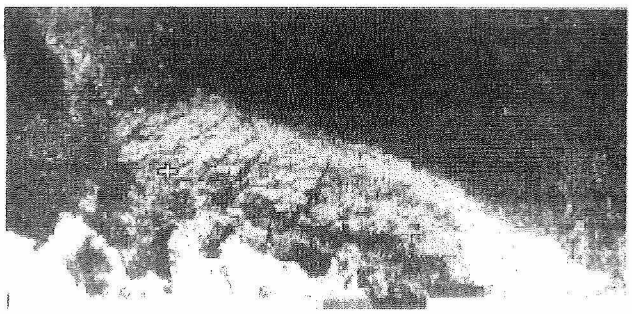


Fig. 3 - Rescue of the vessel "Mikhail Somov" in the Antartic

that ship, which was actually in distress. The "Cosmos-1500" SLR discovered a channel in the ice mass (Figure 3), through which the ship led by the ice-breaker could travel at a speed of up 8-10 knots (as in icefree water). The whole rescue operation only lasted for more than 2 days.

An extensive use of the SLR is currently being made in Russia to provide observation data on the sea ices in the Arctic and Okhotsk seas [24]; some Scandinavian countries also benefit from the SLR data both for scientific research and a varieties of practical applications (Figure 1).

In regard with the study of oceans the SLR opens up vast fields in practical use. In this respect the most successful combination is a SLR equipped with an optical scanner. This combined system was found to be able to study numerous interaction processes in the ocean-atmosphere system, because the optical scanner is capable of monitoring the atmospheric structure under cloud cover conditions, whereas the radar is destined for observing the sea surface.

As a consequence of numerous observations of various interaction processes we have determined [23, 26] a high correlation of optical and radar images, that is to say, all the processes in the ocean-air system are "imprinted " on the surface and observed by the SLR.The level of radar echoes is related to the sea-surface wind speed; this enabled them to be determined by a wind velocity module (10-20% accuracy); the wind direction (accuracy of 20-50%) depends on the radar measurements (Figure 4).

As can be seen, the radar is capable of determining near-hurricane winds in the range from units to tens of meters per second. While the well-developed cyclones are featured by relatively contrasted optical and radar images [23, 26] (as is clearly evident in (Figure 5 a, b)) the "young" (incipient) cyclones cannot be optically identified, especially during the polar night, although, to a large extent, they are seen to be controlling weather factors. The SLR discovers this type of cyclones at an initial stage of their generation (Figure 5 c). The SLR is also efficient in reliably detecting the storm and particularly hazardous squalls zones where in the wind is changing from the calm to a forceful hurricane (Figure 6).

During the regatta Tallinn-Riga the squall moving from west to east came upon quite abruptly; several yachts sank and many people lost their lives.

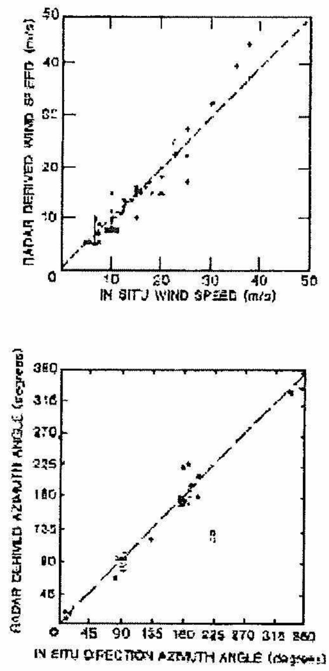
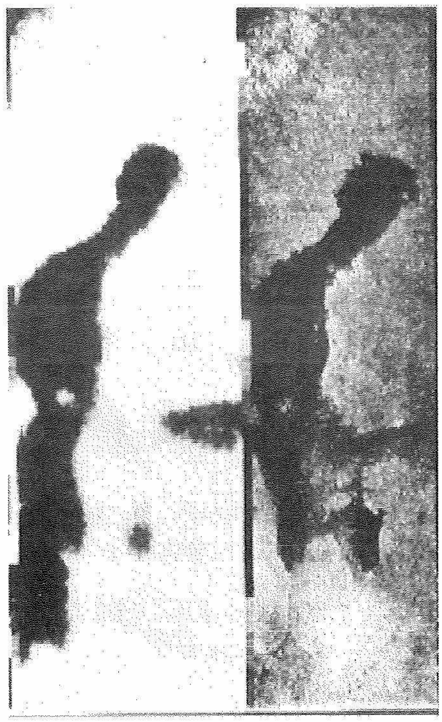
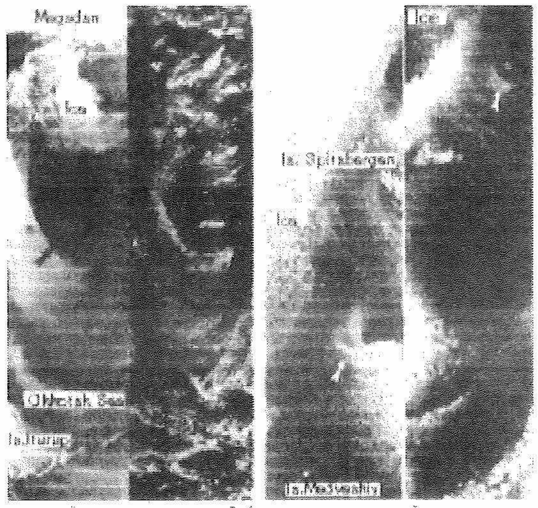


Fig. 4 - Comparison between the sea surface wind speed (a) and the sea surface wind direction (b) measured with the "Cosmos-1500" SLR and in-situ sea surface measurements. Different symbols refer to different experiments.



(a) (b)



(a) (b) (c) (d)

Fig. 5 (on the left) - Radiometric (a) and radar (b) "Cosmos-1500" images of the squalls in Riga Gulf

Fig. 6 (above) - Radar (a, c) and optical (b. d) "Cosmos-1500" images of cyclones in the Polar zone,(a, b) - strong cyclone, (c, d) - "diying" cyclone

Using this sort of information in due time serves to avoid catastrophes during the navigation period in the areas affected by squalls and storms. One of the remarkable results obtained using the SLR are the "footprints"(or "imprints") of convective cells observed on the ocean surface [23, 26]. In remote sensing practice the convective cells had been observed in cloud patterns before. It was found that manifestations ("imprints") of convective cells on the surface could be spotted by the SLR as being more contrasting than it could be occasionally seen in the cloud structures. The convective cells were observed to have a size ranging from 1-3 km (as compared to the SLR resolution) to 150-200 km (Figure 7). A good deal of attention that was drawn to the studies of the convective cells is accounted for the fact that these phenomena are of specific importance.

Thus, the navigation at high latitudes under conditions of warm ocean-atmosphere brings about heavy icing of ships, which may subsequently result in catastrophes. According to manuals of navigation it is stated that while staying at polar latitudes it is necessary to abandon the hazardous area immediately. It is just for this reason that information derived from the SLR allows that zone to bedetected and an optimum route to be properly selected.

Another selected hazardous situation results from the merging (collapse) of convective cells into a large structure,

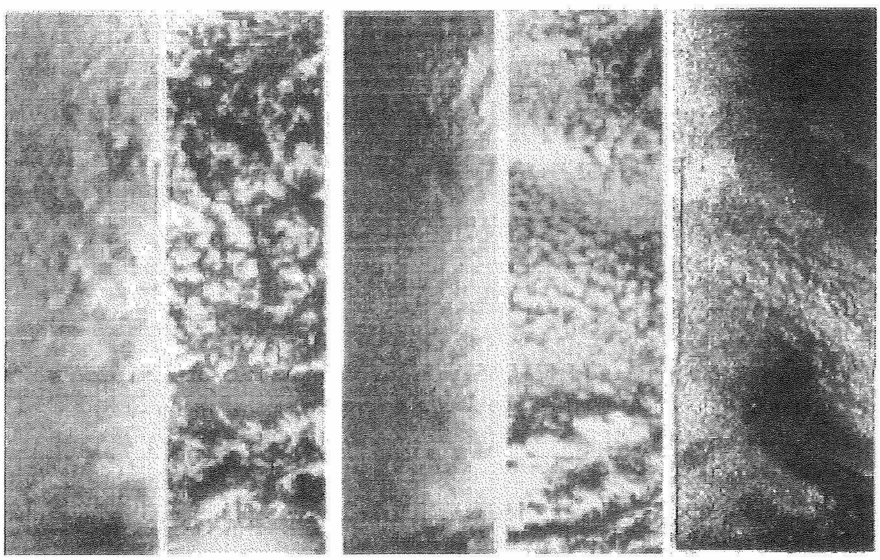


Fig. 7 - Optical (b, d) and radar (a, c, e) "Cosmos-1500" images of convective cells in different scales

(a) (b) (c) (d) (e)

although the energy of each cellis small; their number may be greater (Figure 7) and eventually they are likely to become a source of incipient tropical cyclones. Then a question arise: will we succeed in getting a clue to the ways of controlling the hurricane generation ?

The "Cosmos-1500"/"Okean" series SLR has proved to be an effective tool for observing tropical cyclones (Figure 8). On the one hand, the SLR parameters are conductive to this: a wide swath turns out to be useful in locating and observing the whole structure of a hurricane and this can be achieved by implementing 1-3 km resolution.On the other hand, the 3 cm band provides for a high sensitivity to the wind speed which can be measured over wide ranges (Figure 4).

As a result, the data obtained from the radar measurements of the cross-section of the wind velocity field made it possible to evaluate the power of tropical cyclones [29]; thus, the power of one of the very hazardous cyclones "Diana-84" was 1.2 10^8 MW. The SLR is capable of monitoring the pattern and dynamics of hurricanes. Specifically, we were able to identify this hurricane within two weeks before it encountered land [23]; the most dangerous cases are the eye-shaped hurricane and the zone of torrential rains; they are clearly evident in the radar imagery (Figure 8).

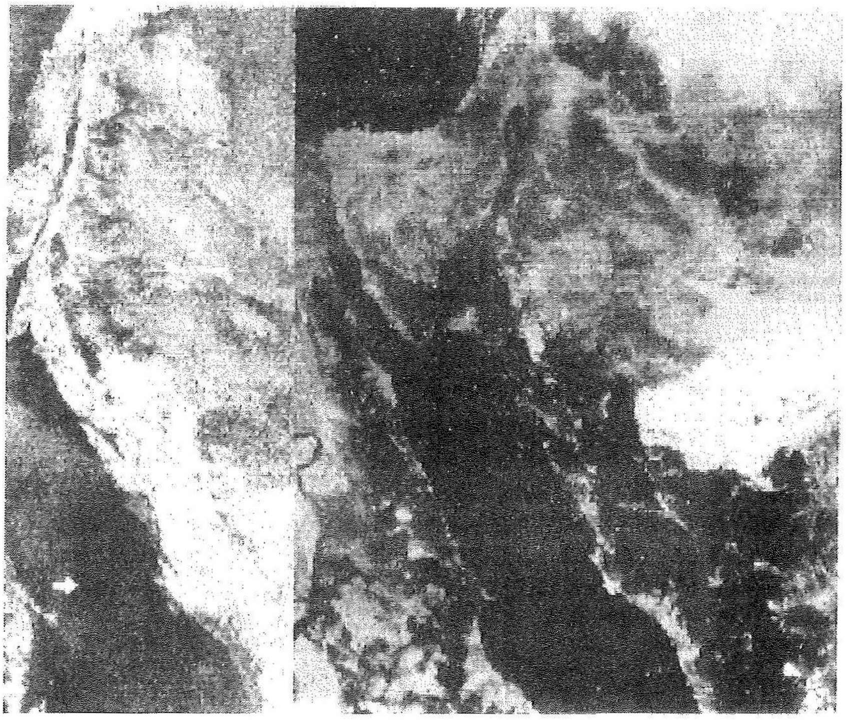
The SLR is capable of resolving the frontal zone, the upwelling regions, and to ensures that ships move along right in the wake of a hurricane. It can help ships in discovering the areas that hold much promise for fishing. The experiments we have done yield the results that substantiate these capabilities.

The X-band SLR can be used to locate sea surface roughness variations due to simple dampening (slicks)

Fig. 8 - Optical (a) and radar (b) "Cosmos-1500" images of the hurricane "Diana-84"

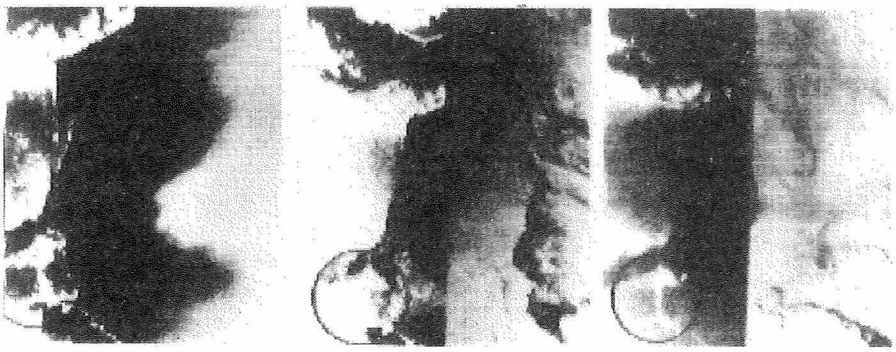
[30]. The most hazardous of them are oil pollutions (Figure 9). We have used the SLR to perform the ecological monitoring of the maritime economic zone of the Black and Aral seas. The SLR can detect the oil slicks spread over an area ≥ 0.1 m^3 since its sensitivity makes it easy for the radar to spot the films with a thickness of more than 0.1 μm.

The sensing of glaciers is based on the SLR capability to observe not only the surface, but also its internal structure [23, 31]. This permits mapping of the glaciers, monitoring of the dynamics of offshore glaciers, their split and iceberg formation, iceberg tracking, etc. Of special interest is geological surveying of internal glacier structure. All these features are exemplified by the fate of the Antarctic station Druzhnaya-1 (the coast of the Weddell sea) (Figure 10).



(a) (b)

Fig. 9 - Radar (a) and optical (b) "Cosmos-1500" images of the Red Sea with oil pollutions



(a) (b) (c) (d) (e)

Fig. 10 - Radar (a, c, e) and optical (b, d, f) "Cosmos-1500" images of the Filchner's glacier break away. (a, b) "Cosmos-1500", 1984; (c, d) "Cosmos-1500", february 1986; (e, f) "Cosmos-1766", august 1986

4. Use of the SLR for natural disasters reduction

One of the fields in which the SLR imagery is utilised, is the detection of critical situations and the avoidance of natural catastrophes [32]. The solution of these problems can be found through the use of SLR's capable of detecting environmental changes.Most of the issues that were taken up in connection with the SLR being applied and properly considered in the previous section of the paper clearly show that the SLR may well be utilized to the best advantage. For instance, information inferred from the SLR was, in some cases, useful in preventing huge material damages involving losses of human lives, for that matter (Figure 2-3).

Yet another example of preventing a catastrophe was the monitoring of snowmelting in Ukraine (Figure 11). The heavy snowfalls in 1988 resulted in an imminent danger of floods because of the snow melting in an area where the Chernobyl disaster had taken place two years before. The fear was that the waters drained off in the Dnieper cascade of reservoirs could cause a heavy loss of natural resources. A team of experts were involved in supervising the rate of snow melting (according to the SLR data) and the water level in the reservoirs.

We regret to say that SLR information was not always properly used even though there did exist a good chance to do so. For instance, the squalls (Figure 6) were located by the SLR and the data obtained were not taken into account. The same is true for the disastrous situation that emerged at the Druzhnaya-1 station (Figure10). As a result, it caused great material damage and led to heavy death toll, which could have been avoided. Therefore, in this regard, the early warning is of considerable value to the countries that could be worst hit by tropical cyclones, especially by those involving death and destruction. For example, in a powerful cyclone that swept over Bangladesh in 1970, 900'000 people died and 1.3 million people were left homeless. According to the conclusive reports by the UNESCO the timely warning of a devastating tropical cyclone reduces the number of victims by more than 20 times. In the context of the UNESCO appeal to declare the last decade of the 20th century as an International Decade for Natural Disaster Reduction (IDNDR) we believe that the potentialities of all space-borne radar systems can be successfully utilized for this noble mission.

5. Joint use of SLR and SAR

While the space-borne radar systems were initially aimed at environmental studies, recently developped radars are more and more frequently designed to deal with the problems of locating and preventing natural disasters. In this case these systems are called upon to provide observations both of land, oceans, ice and glaciers. For such applications, however, no comparison can be made between the SLR and the SAR just like it is impossible to compare and oppose a car and a truck. Nowadays efforts are being made in Ukraine to develop the space-borne radar system "Sitch" incorporating the SLR and SAR facilities. This combined system is dictated by the need to ensure that the Earth is simultaneously observed in a wide swath and with a high resolution. The wide swath is provided by the SLR whereas high resolution is achieved though the use of the SAR.

The basic parameters of the radar system"Sitch" are summarized in Table 2.

This SLR version is of the coherent type and its resolving capacity will be subsequently brought up to hundreds of meters. The SAR version is made with an active phased array antenna, which is electrically controlled

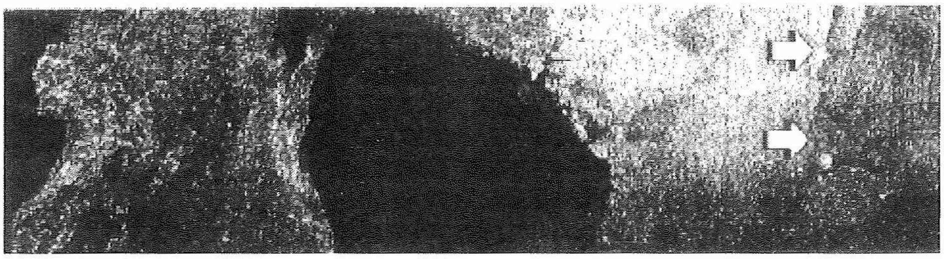


Fig. 11 - Radar "Cosmos-1500" image of the southern region of the Ukraine, during the snow melting process monitoring

Radar Type	Wavelength (cm)	Polarization	Swath (km)	Resolution	Information processing
SLR	3.1	VV	2 x 750	0.5..1.5 km	onboard
SAR	23	VV HH	300	50 m	onboard
		VV HH	310	5..15 m	onground

Table 2

in two planes. The scanning in the azimuth plane ensures that the synthesizing process is not influenced by the SAR carrier orientation. This enables the data processing to be done onboard the radar system. Additionally, this factor also makes the requirements for carrier stabilization less stringent. Scanning at elevation angle allows the SLR and SAR images to be combined in definite zones. The SAR capabilities are clearly demonstrated in the system that had been previously tested (Table 1). The combined SLR and SAR systems open up new fields in remote sensing. For instance, the X-band SLR is efficient at measuring the sea-surface wind fields whereas the L-band SAR is only slightly sensitive to wind. However it is capable of discerning the sea roughness structure [34] (Figure 12).

A new practice of controlling oil pollution is based on the joint use of both SLR and SAR systems. The X-band SLR's are able to detect the thinnest films of oil spills whereas the L-band SAR can pick up the localised areas of films having greater thicknesses [33].

In remote sensing of sea ice the X-band is efficient in winter; in summer,the most reliable data are inferred over the L-band. Fresh studies into the Antarctic glaciers can be made by using the X-band and L-bands of the SLR and SAR respectively. Specifically the SAR could also be employed to monitor the radioactive contamination zones and earthquake precursors. Monitoring of incipient earth-quakes is based on the sensitivity of the L-band SAR to moisture, which was seen to be particularly contrasting in arid (zones).

Conclusions

The radar observation system which iscurrently being developed in Ukraine will serve the purpose of solving national problems and promoting international collaboration and cooperation. In order to achieve this objective one of the operating modes is set in such a manner that onboard processed SLR and SAR data are transmitted to a wide network of users in the 1.7 GHz band.

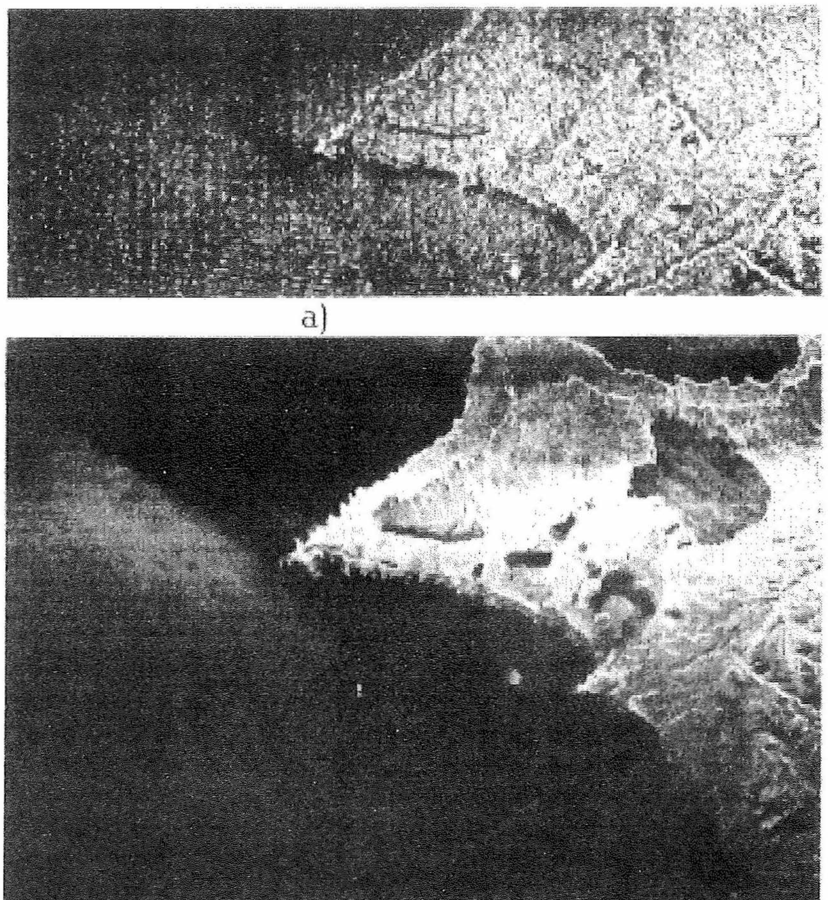


Fig. 12 - L-band SLR (a) and X-band SAR (b) image of the Pacific Ocean surface from an airplane

We hope that the 75th URSI jubelee symposium will be a useful contribution to concerted efforts by researchers in their endeavor to seek for wider fields in which space-borne systems will be extensively employed.

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SAR INTERFEROMETRY AND THE MONITORING OF THE EARTH SURFACE AT CENTIMETER LEVEL

Didier Massonnet

1. Introduction

Proposed some twenty years ago for the assessment of the topography, Synthetic Aperture Radar interferometry demonstrated its huge potential only recently, when a large amount of high quality data was provided by ERS1, and, later on, by J-ERS1.

Its topographic capabilities were confirmed by these data, sometimes with an unprecedented accuracy. However, an interferometric image, obtained from two radar images taken at different times, reveals the sub-centimetre displacements between the acquisition times once the topographic contribution has been subtracted. This capability was spectacularly demonstrated by the determination of the coseismic displacements of the Landers earthquake. The technique has also been applied to other earthquakes, as well as volcanoes, landslides, artificial or natural subsidence, tectonic fault slip or expansion. Troposphere and ionosphere propagation delays were also characterised by this mean.

Being an advanced measurement tool, SAR interferometry is likely to discover previously unknown phenomena. Surface phase changes have been obtained with Seasat data and repeatedly with ERS1 data, in relation with moisture and surface occupation, indicating more potential applications in environment monitoring.

2. Synthetic aperture radar signal special features

Synthetic aperture radar (SAR) is often described as an observation tool for which all weather capability is obtained at the cost of unusual radiometric features. SAR is indeed an all weather tool; it is its own source of light and can therefore operate by night and the wavelengths used in the remote sensing field (3 to 25 cm) are not significantly attenuated by a cloudy atmosphere. The quality of the images, often quoted as poor, must not be judged through the criteria of optical images. The wavelength of a radar being somewhat 100000 times larger than the one of visible light, there is no wonder a radar image looks different than a conventional image. Concerning the aesthetic aspect, one could say that a radar image looks poor when compared to an optical image (except in total cloud cover !). Why not say it looks better than an X-ray scanning ?

The real question deals with the information content. Radar is more sensitive to the physical and geometric properties of the ground, such as electrical conductivity, where optical systems reflects its chemical properties. The difference between the two systems is actually deeper than this, and concerns technology as well as physics. The aperture of a radar system may reach 10 meters at most, which is only one hundred wavelengths. The natural resolution of a radar system is therefore poor when compared to the one of an optical system. As an example, the natural along track resolution of the radar instrument of ERS-1 is about 6 km. The poor angular resolution of a radar antenna is not a problem in range, where the resolution is obtained by sorting the samples in range using their travel time. This is why imaging radar's are side looking, thus avoiding ambiguous echoes coming from each side at the same range. The situation differs in azimuth (the direction parallel to the satellite track) where the 6 km wide antenna pattern is the complex summation of, typically, 1000 end pixels if we assume that the final resolution goal is 6 metre. To achieve this goal, the radar must send pulses at a sufficient rate to ensure a ground sampling better or equal to 6 metre. It is the task of the ground processing to sort out the contribution of an individual pixel by analysing the somewhat 1000 pulses to which it participated, where it

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was mixed with its neighbours. This is done by taking advantage of the delay phase law experienced by a target as it closes, and then recedes, from the radar. The phase law is quadratic and characterised by a Dirac-like autocorrelation function. The final resolution is therefore obtained by complex correlation with a replica of the azimuth phase law.

The processing does not change the complex nature of the signal, which ends up as high resolution pixels made of complex numbers.

3. Signification of the phase in a radar image; interferometry

Each pixel in the image can be considered as a collection of individual targets. Each target is characterised by its amplitude and phase. The amplitude is typical of the gain of the target with respect to the direction of the radar. The phase reflects the conductivity or the internal geometric organisation of the target. The complex number which represents the pixel is the sum of the complex contributions of the individual targets. However, in this sum, each target is multiplied by a phase term which reflects the position of the target within the pixel. This phase term comes from the round trip delay experienced by the wave in reaching the target, compared to a reference delay (for instance the pixel centre). Each contribution is also modified by the combined impulse response of the instrument and the processing. This impulse response modifies the contribution of each target in amplitude and, possibly, phase depending on its position within the pixel. It is clear that a global displacement of the pixel would create the same phase delay for all the individual targets and would be observed at pixel level. We will therefore break down the phase of a radar image into three types of information :

- a macroscopic phase delay, which contains the geometric delay common to all the elementary targets of a pixel. We will consider it to be the fractional number of phase cycles obtained from the round trip delay due to the range of the centre of the pixel with respect to the instrument.
- a physical phase shift representing the electrical conductivity of the targets, assuming it varies collectively, for instance due to a global change in moisture.
- an organisation phase term, which combines the influence of the relative positions of the elementary targets within the pixel and the amplitude and phase laws applied by the instrument and the processing (i.e. the modulation transfer function).

In a radar image, exchanging the positions of two elementary targets within a pixel has much more consequences than doing the same in an optical image. This explains the fact that a same collection of targets (i.e. an homogenous landscape) may exhibit a large variation of the amplitude (the speckle noise). The third term of phase is clearly out of reach since, by definition, we have only one piece of complex information per pixel. This third term also explains why the phase of a radar image is uniformly distributed between 0° and 360° in general. This uniformity is even considered as a criterion of good image quality and is part of the standard radar image quality tests. Yet the phase is half the information provided by a radar and is it very tempting to use it. This is the purpose of radar interferometry, the principle of which is to eliminate the contribution of the third term between two radar images in order to exhibit a possible variation of the two first terms. Radar interferometry has been proposed and demonstrated 20 years ago with the data of an airborne imaging radar [1] and more recently [2] using space borne data.

To apply this idea, we simply have to subtract the phases of two radar images covering the same area in order to eliminate the third term. The challenge is only to keep the third term constant. In a simultaneous acquisition, such as the one in [1], where two antennae are mounted on a plane, the organisation of the pixel in each image can change if the processing applies a different complex weighting to each image. This point is avoided by proper image processing techniques such as a very precise registration of the complex radar images, processed with the same impulse response function. Another reason for the third term to change is a different incidence of observation in the two images. The range between two targets included in the same pixel will change according to the incidence angle of the wave. If the range differs in the two images by more than a fraction of the radar wavelength, the third phase term will build differently in the two images and the subtraction trick will not work. This places a limit on the variation of the angle of incidence which may, alternatively, be expressed by a limit on the geometric dilatation or contraction from one image to the other.

Working with radar images acquired at different times, such as in [2], also requires the third phase term to be stable in time. This implies that the elementary targets must stay at the same place, at least relative to each other, and be the same. For instance, water surface will never give the same third phase term at different times, deciduous trees will not be the same targets if observed six months apart, a snow covered landscape will not be the same as before the snow fall, etc. However, in principle, one cannot exclude major changes in the targets which would keep the third term constant, or equivalently, to change it by the same phase in all the pixels of an image. If a field of plants blossoms and the main radar target becomes the flowers in the second image rather than the leaves in the first image, the third term could remain stable or show a constant change within the image if the geometry of the plants is such that there is always the same distance between the flower and the leaf. This phenomenon has never been evidenced but would explain some strange properties we observed, such as large variations of the amplitude between the two radar images to be compared which do not prevent the interferometric effect.

4. The geometric content of the phase and its applications

Assuming that the conditions for proper interferometric combinations have been observed and that there is no contribution from the second phase term, which is to say that the physical properties of the elementary targets did not change, the difference of phase between images contains a geometric information. The image formed by the difference of the phases of two radar images of the same area, once they have been registered, is called an interferogram. The main feature in a raw interferogram is a family of phase cycles, or fringes, parallel to the satellite track. They denote the change of range caused by the different angle of incidence in the two images, taken from slightly different points of view (in practice less than one kilometre apart for space borne images). The "condition of interferometry" of the previous paragraph can be expressed as a condition on the fringe density, which must be kept well below one fringe per pixel. These fringes (figure 1) are easily modelled and subtracted from the interferogram. If the two tracks are not exactly parallel, if they are closing for instance, the resulting phase delay reduction can be observed. A proper modelling of the orbits allows the elimination of this geometric contribution. The determination of the relative position of the two tracks with a centimetre accuracy is a by-product of SAR interferometry. A second order effect is caused by the topography, which creates a stereoscopic effect when observed from two slightly different points. This stereoscopic effect is tiny, given the proximity of the tracks demanded by interferometry. It is however observed because the accuracy is on the order of a fraction of the phase, or a few millimetres. Radar interferometry has been essentially introduced as a mean to compute topography [1,2]. Another, much more spectacular, application of SAR interferometry is the direct measurement of a displacement, provided it occurred in between the acquisition of the radar images. In this case, unlike the above "stereoscopic" effect, the displacement is directly recorded as a phase shift, with the typical accuracy of a few millimetres generally allowed by the available signal to noise ratio. This technique cannot be applied with simultaneous interferometry (i.e. not with [1]) and must, therefore, cope with the surface change possibly experienced by the ground during the time elapsed between the data take, which we may call the temporal loss of coherence of the surface. Another feature of this technique is its being unique in the sense that there are other means for precise orbit computing or digital elevation model derivation, but no other technique, so far, can map displacements with a precision of a few millimetres with such a dense spatial sampling as the one allowed by radar imaging. All these reasons made CNES undertake a research program in this field in 1985, after a paper study indicated its possibility [3]. From the beginning, it was decided that we would not mix the topographic aspect of interferometry and its displacement aspect. This is why we worked along the idea of digital elevation model elimination, where topographic fringes are simulated from the best available elevation model and the orbital estimations. Simulated fringes are then subtracted from the interferogram, which reveals displacements. This method is in contrast with the three pass method developed by JPL [4], which does not require a model of the topography, but three images meeting the conditions for interferometry.

The technique was applied to a variety of phenomena where moderate displacements are expected, such as coseismic displacements fields [5, 8, 9], deformation of volcanoes [10], ice plate motion [6] or artificial subsidence due to mining or underground nuclear blasts (Figure 2, 3, 4 and 5). More studies are underway concerning more subtle displacements such as continental drift is rifting areas. The advantages of the technique are clearly its dense spatial sampling and its accuracy, in the sub-centimetre range. The limitations are both physical - the surfaces do not always present the required level of stability - and geometric - only the line of sight displacement is measured. This point has to be compensated by *a priori* knowledge of the three dimensional aspect of the displacement or by multiple observations along different angles.

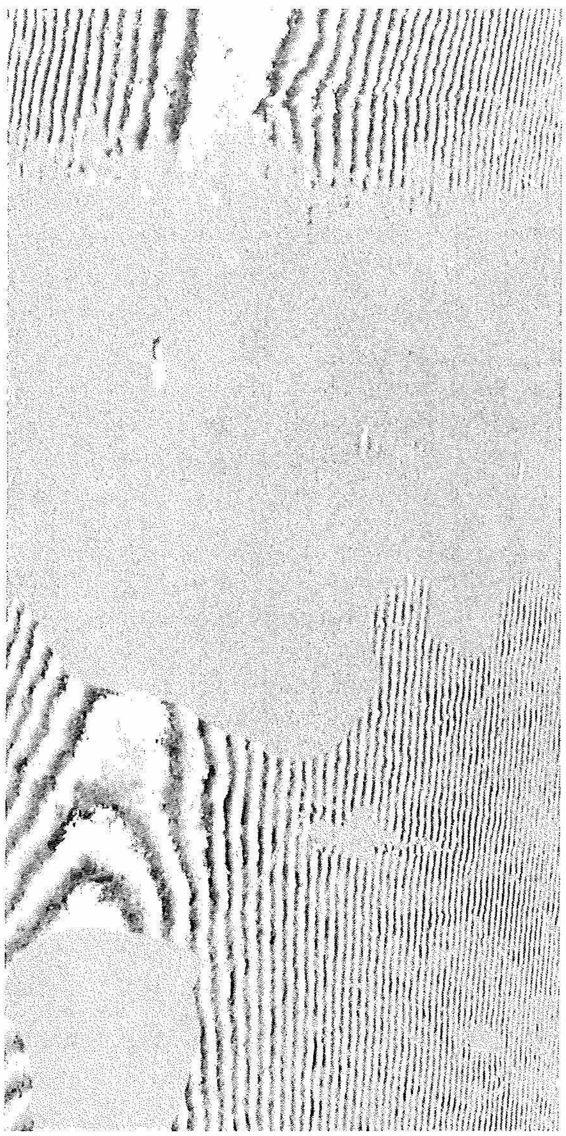
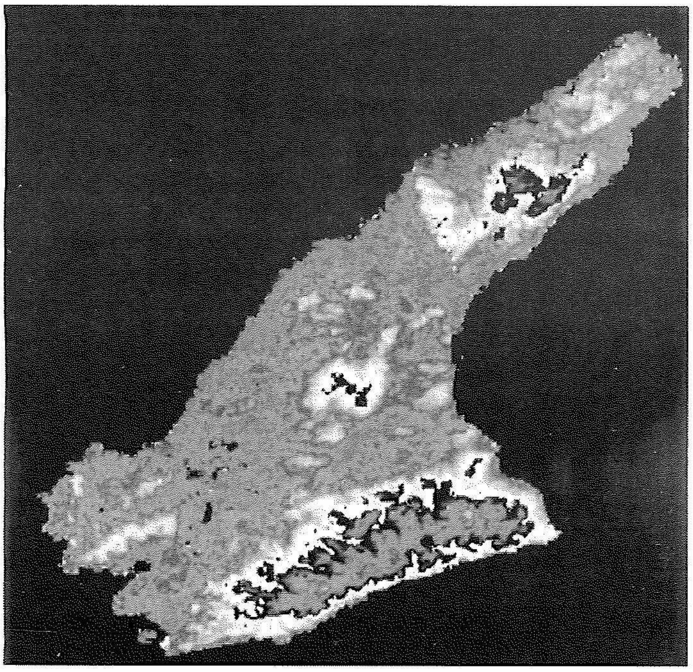


Fig. 1 - Example of "orbital fringes", typical of the satellite trajectories during the two data takes. The satellites travelled from bottom to top on the left side of the image. The bulk of the orbital contribution consists in a very dense fringe pattern across the image. The contribution of the one meter or so closing of the two satellite tracks along the 100 km long image is represented by fringes disappearing on the sides of the image. Each fringe corresponds to a closing of half a radar wavelength, or 28 mm. The two radar images have been acquired near Saint Petersburg on September 25 and October 1, 1991 by the European satellite ERS1. They have been processed at CNES. The places where the fringes are not clear did not show the necessary stability. This is the case for the lakes.



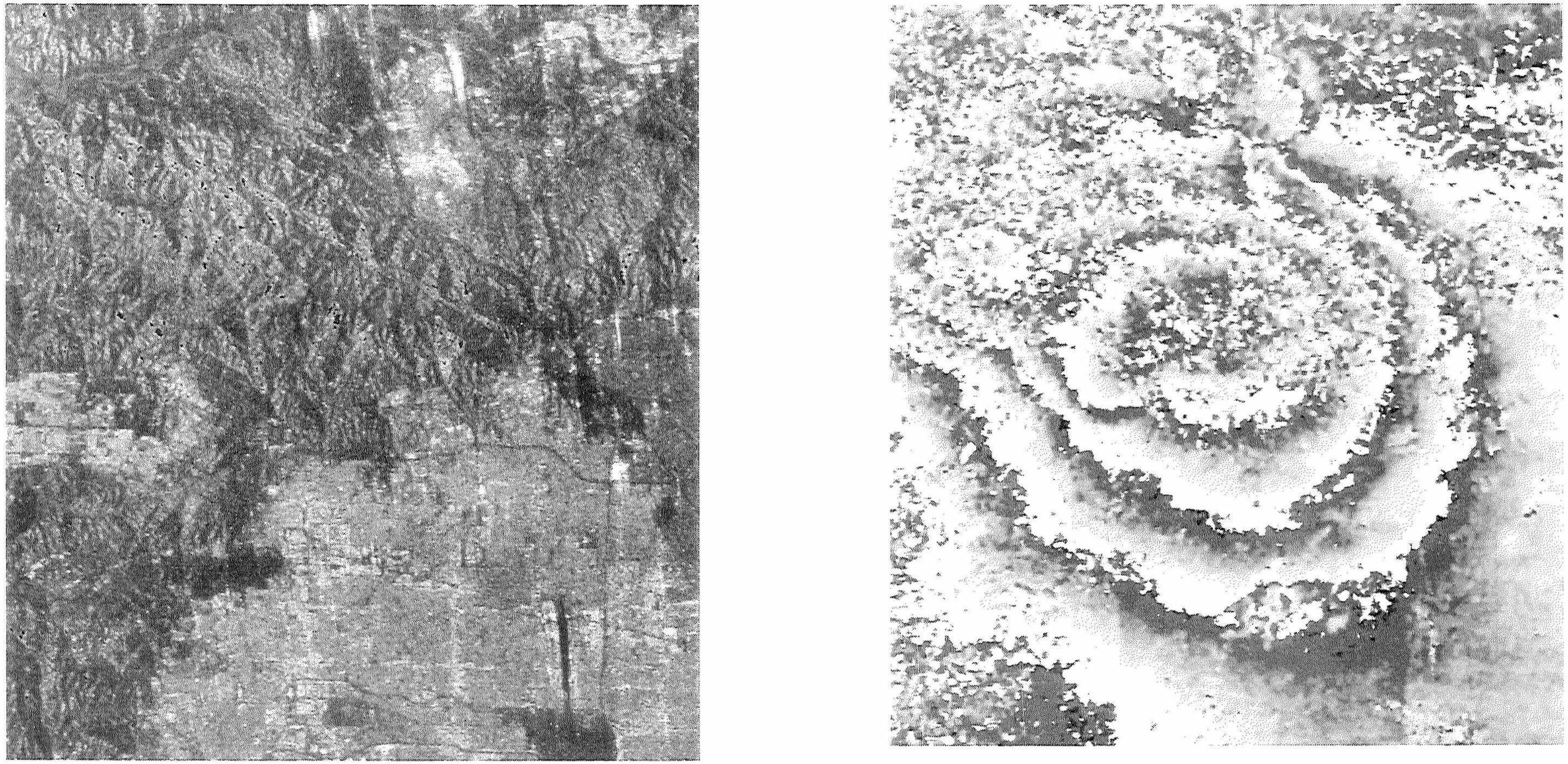
Above :

Fig. 2 - Example of topo-graphy revealed by SAR interferometry. The image shows the interferogram obtained on Awaji island [7], in Japan, using two radar images of the Japanese J-ERS radar satellite. The images have been acquired on May 31 and July 14, 1993 and were part of the investigation program proposed by CNES to NASDA (the Japanese Space Agency). Given the orbital geometry, a full cycle corresponds to a 300 m change in altitude. This site was the epicentre of the disastrous earthquake which damaged Kobe in January 1995. However, no displa-cement can be recorded here since the images were both acquired before this event. The island is 50 km long

Below :

Fig. 3 - Example of a large displacement field measured by interferometry [8]. The two ERS-1 images were acquired on April 24, 1992 and June 18, 1993 and combine nicely in an interferogram despite the 14 months elapsed, which did not alter the surface in this desert environment. Each fringe corresponds to a displacement of 28 mm toward the satellite. The contribution of the topography has been removed using the digital elevation model elimination method and a USGS digital elevation model. The large scale deformation field has been caused by the (Mw=7.3) Landers earthquake, on June 28, 1992. The small concentric fringes have been caused by a (Mw=5.4) replica on December 4, 1992. The discontinuity in the fringe pattern which can be observed across the image has been caused by a slip, probably coseismic, on the Lenwood fault. The slip is half a fringe, or 14 mm, in range. The image illustrates the ambiguous nature of SAR interferometry results. Fringes must be counted to reach the final value of the displacement.

Northridge Earthquake by JERS-1



SAR Image *(NASDA data, CNES processing)* *Displacement field*

Fig. 4 - Another example of coseismic displacement, this time caught by J-ERS. The earthquake took place in Northridge, North of the city of Los Angeles, on January 17, 1994. We used two radar images provided by NASDA and combined them with an accurate 30 m grid USGS digital elevation model. The radar images were acquired on April 30, 1993 and July 14, 1994. The observed four fringes on the interferogram correspond to quite a large displacement since half the wavelength of the L-band J-ERS is 115 mm. This event has been reported in [9] using the same data. On the left, we have the radar amplitude on Northridge.

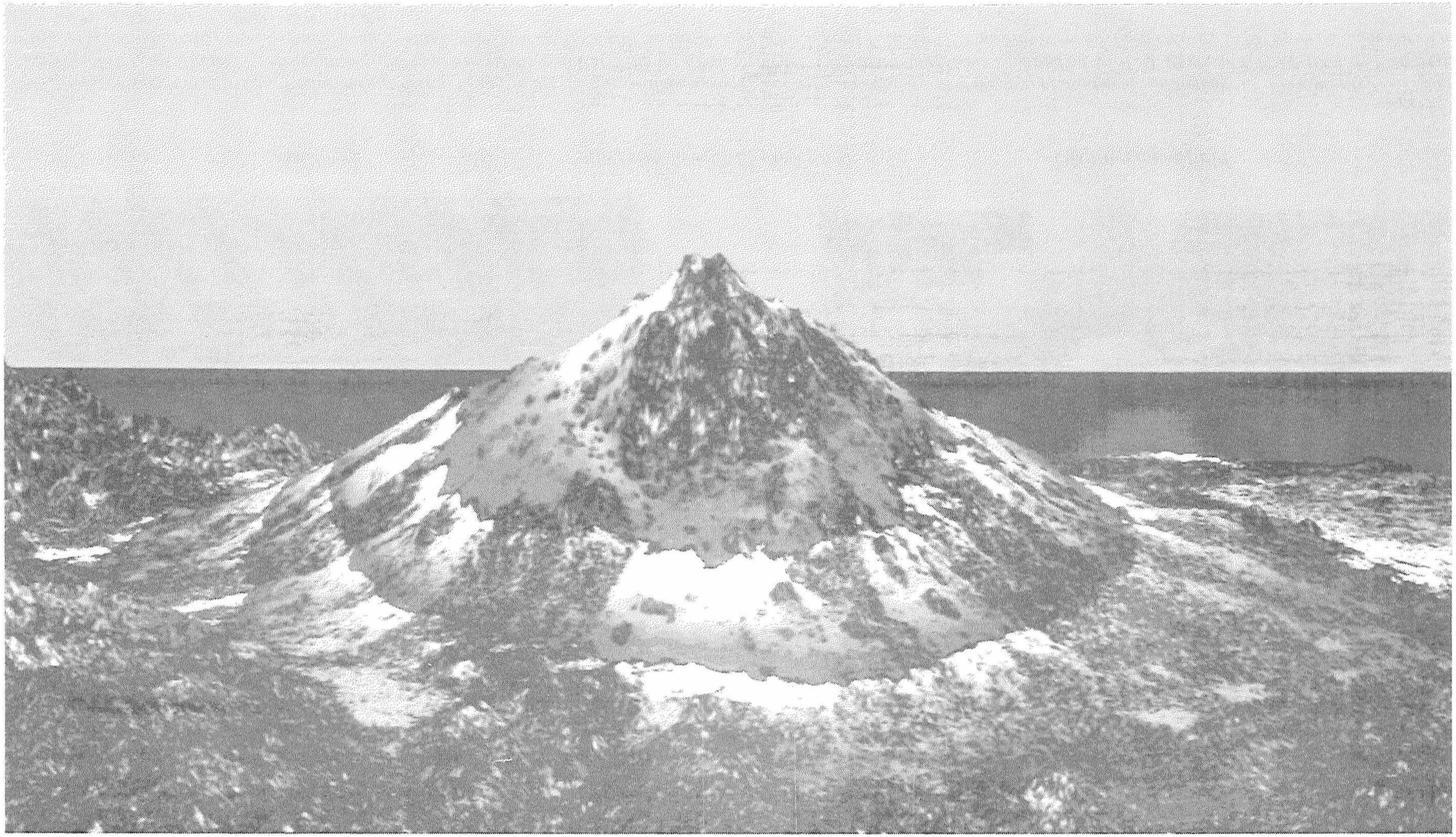


Fig. 5 - Perspective view of Mount Etna, built from a topographic model and a radar image acquired by ERS-1. Fringes obtained by an interferometric survey of the volcano have been added. They were formed using two ERS-1 images acquired one year apart [10]. The displacement ranges from zero to four fringes as we close to the top of the volcano and reaches two fringes on the volcanic edifice alone. These fringes indicate a deflation of Mount Etna during the year of observation, due to the draining of the deep magmatic chamber at the end of the eruption.

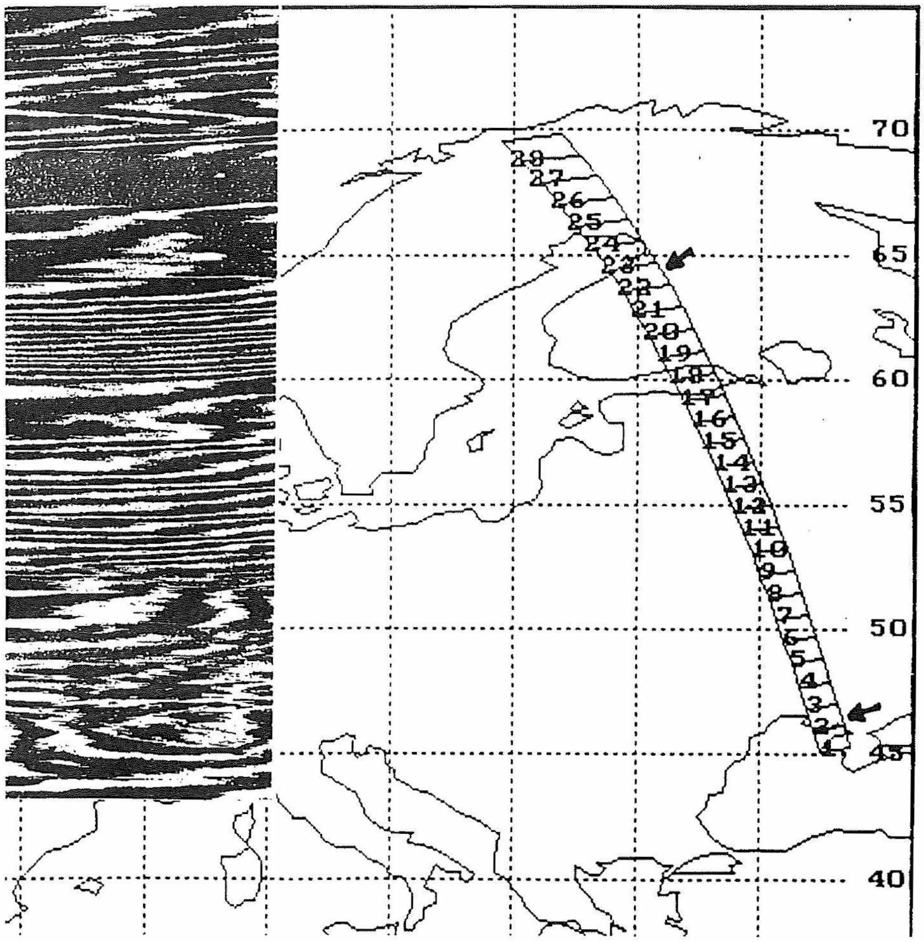


Fig. 6 - Typical interferometric artefact caused by a drift in the radar clocks [11]. SAR oscillators have been designed for keeping coherence on the typical one second of data required for image reconstruction. Radar interferometry demands a much longer stability. On this 2000 km long data segment, bracketed by arrows on the map and deformed on the left side for the sake of representation, we observe groups of fringes perpendicular to the track. These fringes cannot by attributed to topography on this very flat landscape observed by ERS-1 from two very close tracks. The 10 or 15 fringes of each group cannot be attributed to any atmospheric propagation problem due to the magnitude it would involve. Perpendicular fringes are a typical signature of perturbations associated with the spacebus or the radar itself. With only two images, It is impossible to say which image was affected by the drift or if both contributed to it.

Another limitation is the ambiguous nature of the fringes, which must be counted to restore the displacement field in full. In some cases, this is not only a lack of comfort : a field of fringes must be continuous to be "unwrapped". It happened that the deformation of an off-shore island could not be related to the deformation of the nearby mainland because the number of fringes obscured by the straight (water is not coherent) could not be observed nor guessed safely.

5. Atmospheric artefacts and new potential uses

Any change in the propagation conditions of the atmosphere will contribute to the change of range observed in SAR interferometry. The image where the problem occurred is identified because all the interferometric pairs to which it participated are affected by the artefact with a constant level. Once the faulty image has been identified, one can check, knowing the exact time of the data take, the meteorological conditions at that time and prove the case. In figure 7, the 5 to 10 km wide irregular, circular pattern, amounting to three fringes, has been linked to troposphere turbulence, caused by the formation of thunderstorm clouds. In this case, the wave is delayed. We attributed other examples of propagation artefacts to local neutralisation of the ionosphere because the wave was found to travel faster in some places than in the surrounding. We called artefacts these phenomena quite improperly, because they reflect a real physical situation. They are artefacts with regard to the measurement of ground geophysical phenomena. We detected real instrumental artefact by analysing large portion of radar data where groups of fringes cannot possibly be related to atmospheric propagation problems nor topographic or displacement contribution. These fringes are perpendicular to the track of the satellite which indicated that the observed phase changes are almost constant within a pulse. The only explanation proposed [11] is a slow drift of the carrier frequency of the radar. This drift is well within the engineering specification of the satellite which has never been designed for interferometry. We have other examples showing that this new technique, which has been developed in a quite opportunistic manner, will now generate its own specifications. The example of figure 6 suggests building radar satellites with a much more stable internal clock. The use of several frequencies may also be proposed to cope with ionosphere shortening.

The phase surface changes first observed in [4] using Seasat data and illustrated in figure 8, where we processed ERS-1 data, are not an artefact. We consider them as a very promising application which may allow SAR interferometry to become an investigation tool in crop monitoring. It is too early to assess the potential of SAR interferometry in this field, but the technique may end up by finding applications in most of the remote sensing domain.

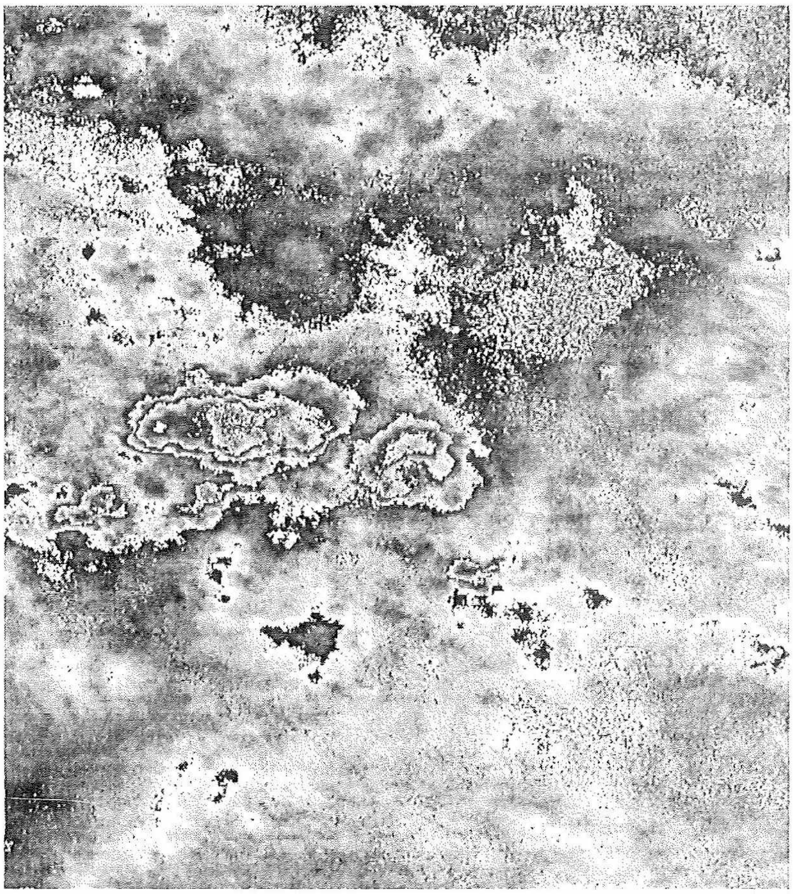


Fig. 7 - Atmospheric depth heterogeneity observed by SAR interferometry [12]. These propagation problems are linked to one particular image and appear in each interferometric combination in which it is involved. They appear with a constant magnitude regardless of the orbital configuration (as for topography) and of the time elapsed between the acquisitions (as for displacements). This particular phenomenon was caused by thunderstorm clouds forming in August 1993 over the Mojave desert (California). In this case, the turbulent atmosphere lengthened the wave path. We observed other examples where the travel was shortened with respect to surrounding areas. This shortening is attributed to a local neutralisation of ionosphere.

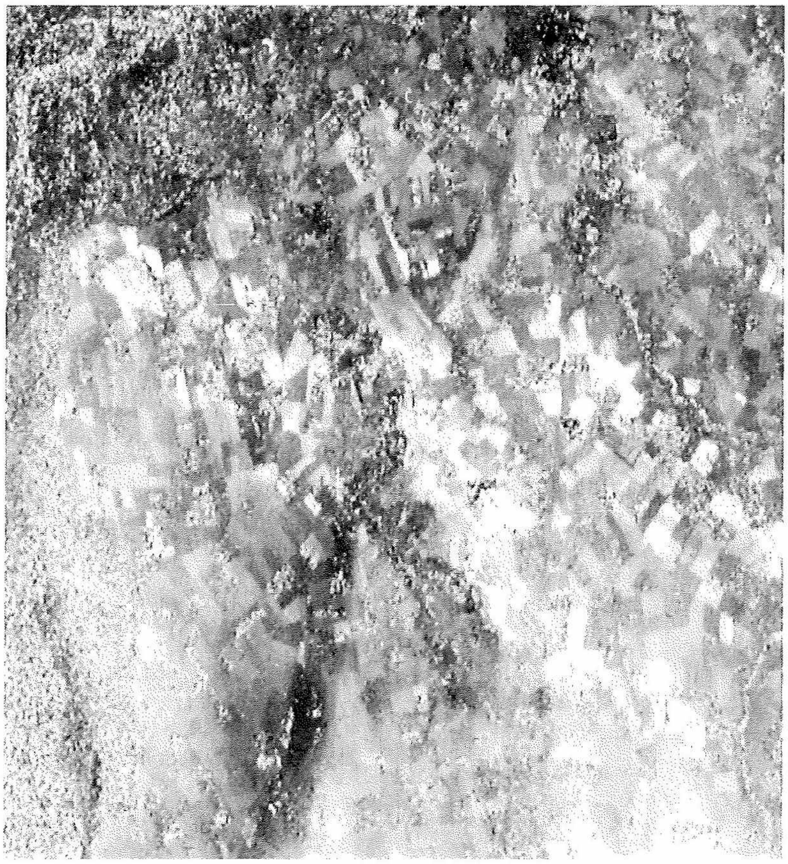


Fig. 8 - Surface phase changes associated with moisture on agricultural fields. This image was obtained from ERS-1 data, but the effect has been first observed with L-band Seasat data [4]. In the Seasat data case, the moisture was caused by irrigation. Here, it is likely to have been caused by rain. A brightness difference can be observed in the amplitudes of the images which form the interferogram over the area where surface phase change is sizeable. It is not clear whether the change is geometric (due to soil swelling under the action of moisture) or radio-electrical (due to moisture induced conductivity change).

6. Conclusion

SAR interferometry was first developed to compute topography, but evolved to other fields where it is really unique. The first radar satellites were not designed for this technique. They provided data in a quantity and quality which not only permitted many opportunistic and spectacular demonstrations, but allowed us to contour the specifications of a dedicated satellite system. Such a system would strengthen some points of design, such as clock accuracy, and relax others, such as radiometric precision and calibration. Making SAR interferometry enter the operational field is well within current technologies. It would allow a new dimension in Earth monitoring and create the "meteorology" of solid surface phenomena.

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ULTRACOLD ATOMS AND MICRO-GRAVITY CLOCKS

Christophe Salomon et al.

Abstract

Recent progress in laser cooling and trapping of neutral atoms is paving the way for the development of more accurate caesium atomic clocks. Producing micro-Kelvin atoms having an r.m.s. velocity of 1 cm/s requires no more than two diode lasers and a small glass cell.

This paper surveys the progress of ground-based fountain clocks, reporting the most recent results obtained with the prototype clock operating at LPTF. Satellite-based clocks, by taking advantage of a reduced-gravity environment, should enable the full potential of laser cooling to be realized, opening the fascinating possibility to achieve performances superior to those of their ground-based counterparts.

The expected relative stability of fountain and satellite clocks is about 3 10^{-14} at one second or ~10^{-16} per day with an accuracy in the 10^{-16} range. The intercomparison of clocks with these performances raises interesting challenges in the time and frequency transfer domain and should also allow a new generation of tests of general relativity.

1. Introduction

Today, the most stable clocks are atomic clocks, the Hydrogen Maser, trapped ion clocks and the caesium clock. The unit of time, the second, is defined using a hyperfine transition in atomic caesium. Caesium clocks have the best long term stability (~10^{-14} from 1000 s to several years) and accuracy while H masers present the best short term stability (~10^{-15} from 100 to 1000 s). These clocks are currently used on Earth in a variety of science areas ranging from fundamental tests of physics laws to Very Large Baseline Interferometry (VLBI), the timing of millisecond pulsars and the positioning of mobiles on Earth (GPS) or in deep space. A Hydrogen maser has flown in space for two hours in 1976 in the NASA Gravity Probe experiment (GPA) [18]. Several tens of caesium clocks (as well as less precise Rubidium clocks) are now in continuous operation in GPS satellites orbiting at 20'000 km above the Earth.

Recent progress in the field of cooling and trapping of neutral atoms or ions is having considerable impact on time and frequency standards. Ions can be trapped with magnetic or radio frequency electric fields for days and weeks leading to very long coherent interrogation times (500 seconds) [2]. Commercial systems with stability approaching that of H masers exist and space versions are being actively developed. The field of laser cooling of neutral atoms is less than ten year old and the application to the realization of better time and frequency standards is actively pursued since 1989 [3, 4].

2. The benefits of cooling

Commercial caesium clocks use a 400 Kelvin atomic beam of caesium atoms. By contrast, caesium clocks using laser cooled atoms operate with atoms at temperatures in the 1 μK range allowing a 100-fold improvement in the observation time. Nowadays, one can very easily produce a dense gas of cold caesium atoms at a temperature of 2.5 μK corresponding to atoms with an r.m.s velocity of 12 mm/s [5]. These small velocities allow interaction times between atoms and electromagnetic fields approaching one second on Earth when using an atomic fountain geometry. As the atomic resonance linewidth in caesium clocks is inversely proportional to this interaction time, an improvement of two orders of magnitude in the clock performances over conventional devices running at a temperature of 400 K is expected. It is predicted that

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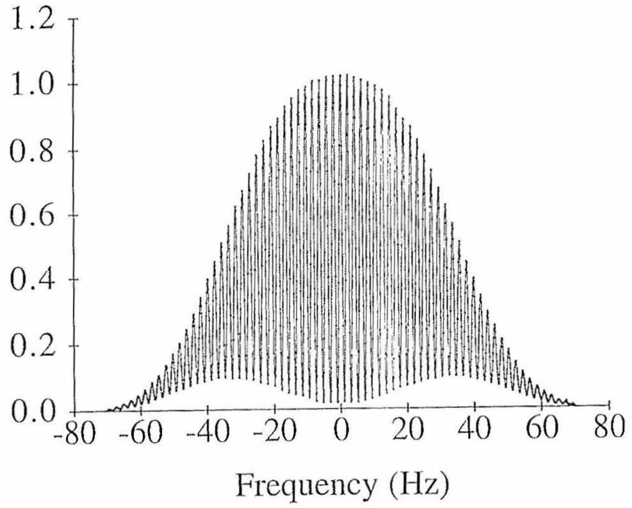

Fig. 1 - Ramsey fringes of the LPTF fountain clock for a 0.5 second flight time of the atoms above the microwave cavity [15]. The fringes are 1 Hz wide and signal to noise is 300 per point. The frequency detuning is scanned around the cesium hyperfine transition frequency at 9 192 631 770 Hz.

microgravity conditions should enable a further factor of ten improvement in the interaction time with a simple and compact device [6].

Furthermore, new laser cooling techniques enabling to reach temperatures below the temperature set by the single photon recoil are presently being developed in several laboratories [7, 8, 9, 10, 11, 12]. Atoms have been cooled in one and two dimensions to much less than the recoil velocity, down to the nano Kelvin range.

2.1. Atomic Fountain

On Earth, the gravity limits the available interaction time and it was Zacharias' idea in 1953 to use an atomic fountain to obtain interrogation time in the one second range when using Ramsey's method of separated oscillatory fields. Efforts to build such an atomic fountain in that period were unsuccessful because of collisions near the oven exit. Laser cooling and the very slow velocities in optical molasses have enabled this idea to be brought-up to date [3, 4]. Fountain clock prototypes are being built in more than a dozen laboratories around the world and two of them (at Stanford [14] and LPTF [15]) are running as frequency standards. In the LPTF fountain, Ramsey fringes as narrow as 0.7 Hz have been obtained with a signal to noise ratio of 300 at one second integration time (Figure 1). The short term frequency stability, measured against an H-maser is $3\ 10^{-13}\ t^{-1/2}$ (Figure 2). While this stability is three times better than in any conventional caesium device, it is still limited by the local oscillator frequency noise (ultra-stable BVA quartz crystal) and not by the caesium fountain noise. The long term relative stability (Allan variance) as compared to a Hydrogen maser reaches $2\ 10^{-15}$ at 10'000 seconds, a value which is most probably limited by the H maser itself.

2.2. Microgravity clock

Gravity imposes an obvious limit on the resolution which can be obtained in a fountain clock: the resolution increases only as the square root of the fountain height. Going much beyond a 1 s fountain time would require an expensive and bulky apparatus and would probably be to the detriment of the accuracy. A promising alternative is to build a clock in a reduced gravity environment. Measurement time of several seconds can be envisaged using a smaller and simpler apparatus, leading to a factor of 10 improvement in resolution and accuracy. First experiments on laser cooling of atoms in microgravity were recently performed by our group in Paris using jet plane parabolic flights and very simple experimental techniques [6]. Efforts now concentrate on building a clock prototype designed for microgravity conditions. Such a system is an extension of the work developed for fountain clocks on Earth described in detail in [14, 4, 15, 16, 17]. A prototype of a micro-gravity clock is schematically described in [17] and is under study at CNES (PHARAO project). It includes a laser diode system and optics for atom manipulation and cooling, a high stability 9.2 GHz microwave source and a vacuum tank containing a cooling region, a microwave interrogation region and a detection zone. The clock is operated fully automatically using a micro-computer.

3. Expected performances of a Space Clock

A first scientific objective of a clock experiment in space could be the demonstration of a clock running with laser cooled atoms in micro-gravity conditions and the determination of its performances. These performances are expected to be better than $10^{-13}\ t^{-1/2}$ where t is the integration time in seconds. For one day of operation, the stability will be 10^{-16}, corresponding to an absolute time fluctuation of 30 picoseconds. This stability would be two orders of magnitude better than present Cs clocks. Such a demonstration would

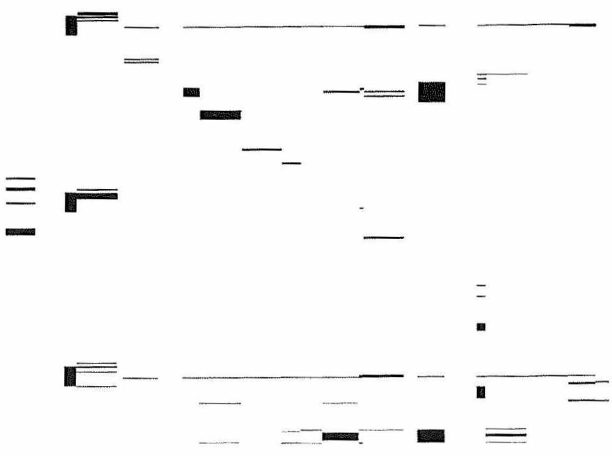

Fig. 2 - Frequency stability of the fountain clock measured against a Hydrogen Maser: Allan variance versus the number of fountain cycles [15]. Each cycle lasts 1.1 second. The stability reaches that of the H maser at about 10^4 seconds and is probably limited by the maser stability for longer measurement times.

open a new era of space missions using ultra-stable clocks as space VLBI, high precision measurement of the sun gravitational potential to second order and of the Shapiro delay as proposed in the SORT mission (Solar Orbit Relativity Test) [13].

Since no other clock is known to give yet such performance for a one day measurement time, it will be necessary either to fly two identical systems in order to make frequency comparisons on board the spacecraft or to use high performance two-way time and frequency transfer systems with Earth-based clocks of similar performances. These frequency links could be in the microwave or optical domains using either X or K-band microwave signals or pulsed lasers as in the lunar ranging experiment. The required timing precision is on the order of a few ps at 10^3 s or, as said above, 30 ps at one day.

If microgravity cold atom clocks become eventually more stable than their Earth-based counterparts, two or more similar clocks on board the spacecraft are required in order to assess their performances using frequency intercomparison techniques.

4. Possible Applications

With clocks having a stability of 10^{-16} in one day, it should be possible to measure with a potential 100-fold improvement over the 1976 GPA experiment the gravitational red-shift (Einstein effect). This general relativity effect was determined at the 10^{-4} level using H masers having a stability slightly better than 10^{-15} over the 2 hour mission duration [1]. The precision on such a measurement depends directly upon the eccentricity of the orbit. A satellite with a large eccentricity (e=0.6, major axis 20'000 km and a 12 hour period) would be an ideal choice.

A second application belongs to the field of time and frequency dissemination. A geostationnary satellite is an ideal tool for dissemination toward the Earth of ultra-stable timing signals and for frequency comparisons between various Earth stations. The very low drift of the space clock might also allow frequency comparisons between Earth-based clocks without the constraint of common view of the satellite. Positioning of mobiles on the surface of the Earth as in the GPS system could also benefit from satellite clocks with improved stability.

More ambitious space applications deal with measuring the relativistic Shapiro delay in the Sun gravitational potential with four orders of magnitude improvement in precision over current values [13]. A measurement of the second order Sun gravitational potential is also possible using these highly stable clocks.

Time and Frequency Transfer

When a stable clock is orbiting around the Earth, a crucial factor appears to be the quality of the frequency comparison between the satellite clock and one or several clocks on Earth. The picosecond time stability over a few minutes required for assessing properly the stability of the satellite clock demands that the frequency comparison be at least two-way. Since the GPA experiment, the Harvard group has performed detailed studies of several possibilities for achieving frequency comparisons below the 10^{-15} range [18]. Today, two major directions emerge, a microwave two-way link and an optical link using picosecond laser pulses [13]. By contrast to the optical link, the microwave link has the advantage of being independent of weather conditions. It is clear that both methods are very different in their approach of the time transfer. A comparison of the performances of the two methods is highly desirable and would certainly be an important issue. The synchronized two-way frequency transfers (Earth-spacecraft-Earth) and (spacecraft-Earth-spacecraft) allow complete cancellation of isolated tropospheric or ionospheric noise as well as of the first order Doppler effect [18]. Measurements of the relativistic effects (second order Doppler and redshift) requires a good knowledge of the satellite orbit and velocity.

5. Summary

The possibility to install high stability clocks in space is very attractive from the viewpoint of testing new concepts of clocks using cold atoms and for potential applications. The development of time and frequency transfer with picosecond accuracy is required in order to read these ultra-stable clocks in orbit. This would open the way for more ambitious physics missions such as space VLBI or tests of general relativity in solar orbit with unprecedented precision.

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Lateral Waves and the Pioneering Research by the late Kenneth A. Norton, 1907-1992

James R. Wait

In recent years, there has been a strong inclination to introduce lateral waves into the lexicon of radiowave engineering. The monumental treatise by King, Owens and Wu (1992) is an expression of this trend. But it may not be realized that the early pioneering research by Norton (1937, 1941) contained the vital essence of lateral waves in the context of radio. In this brief essay, I would like to dwell on this issue. My motivation is partly personal because I was greatly encouraged by Norton in my embryonic attempts to extend his analyses to other geometries and configurations. Here I will deal with a restricted aspect of the subject which is relevant to the prediction of low-angle radiation end propagation, at VHF, over an idealized imperfectly conducting plane earth. My time factor is $\exp(j\omega t)$.

Let me summarize the relevant factors here. For a vertical electric dipole located at a height h_1 over a flat earth with a surface impedance 377 Δ ohms, the vertical electric field E_v at height h_2 at a horizontal range r is well approximated by

$$E_v \cong 2E_0 W \quad (E_0 \text{ is the free-space field}) \qquad (1)$$

where

$$W = -(1/2p)(1+q_1)(1+q_2) \qquad (2)$$

is the "Sommerfeld attenuation function" and the other quantities are defined as follows : $p = -jkr\Delta^2/2$ is the "numerical distance" $(k = 2\pi/\lambda)$, $q_1 = jk\Delta h_1$ and $q_2 = jk\Delta h_2$ are dimensionless height parameters. The approximations, in the asymptotic sense, are equivalent to those made by Gilbert et al (1994). Here I say that $|p| >> 1$, and $|q_1|$ and $|q_2| << |p|$. An explicit derivation of (2) is given by Norton (1941).

The factors $(1+q_1)$ and $(1+q_2)$ are height gain functions applicable to the source and observer heights, respectively. The $-1/(2p)$ factor is the far-zone (large distance) attenuation function for vanishing terminal heights h_1 and h_2 . For a spherical earth model (i.e. not the naive flat earth case !), the $-1/(2p)$ is replaced by a more complicated form (e.g. see Hill and Wait, 1980) but I will not dwell further on this point here, except to say the height-gain functions are also applicable in a limited sense.

By employing explicit notation, I can write (2) as follows :

$$W = -(2jkh_1h_2/r)[1 - j(h_1+h_2)/(\Delta h_1 h_2) - 1/(k^2\Delta^2 h_1 h_2)] \qquad (3)$$

When the normalized surface impedance Δ is approximated by $1/n$, where n is the complex refractive index (such as for sea water), (3) is the same as the result given by Gilbert et al (1994) as their eqn. (30 for vertical polarization. A more refined result is obtained by using the result for Δ corresponding to a vertically polarized wave at grazing incidence [In this case, we would simply set $\Delta = n^{-1}(1-n^{-2})^{1/2}$]. Two particularly relevant papers are by Barrick (1971a and 1971b) who has contributed so much to our understanding of H.F. transmission and scattering for ocean-like surfaces.

A related question stimulated by Norton (1937) is : "Does the Zenneck surface wave get excited ?". In two papers (Hill and Wait, 1978 and 1979), we showed how the Zenneck wave could be excited over the surface of the earth if a large enough aperture was constructed. Certainly the Zenneck wave alone would not dominate the far field for a realistic source. But other interesting things happen when the effective surface impedance has an (inductive) phase angle exceeding 45°. The resulting enhancements of the ground wave field, such as occur over ice covered oceans, was pointed out many years ago (e.g., see Wait 1968, and Hill and Wait 1980). The height gain functions do not have the simple form as described above. In fact the fields decay more rapidly with height and the distance dependence is more like $1/r^{1/2}$ than $1/r^2$ in the so-called lateral wave case. Indeed we now have a "trapped surface wave" as opposed to the Norton surface wave.

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Inertia from Electromagnetic Waves?

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Electromagnetism has been honoured from a direction that few might have expected. We have always been familiar with it as one aspect of the forces we encounter in Nature. Electromagnetism is the second force in our scale of forces leading from the gravitational, through the electromagnetic, the weak and the strong, with the gravitational force being the very long-range force dominating large-scale events in the universe. The electromagnetic force essentially governs atomic physics, the weak force beta decay, and the strong force governs the processes taking place inside the nucleus among the elementary particles or more precisely among the quarks which constitute them. This picture has been the traditional and satisfactory viewpoint. Each of the forces is related to charges: the strong one to the colour charges of the quarks, the electromagnetic to the electric charge of the electron, the weak force, as we now know from the electroweak unification, to this one also, and the gravitational force to the heavy mass which, by the equivalence principle, is equal to the inertial mass. But between the charges of all other forces and the charge of gravitation there are two differences. First, the charges of the other forces have well defined values (for instance the electronic charge has the renormalized value of 1.6×10^{-19}C), while mass has a rather broad spectrum of values. Secondly, while all other charges may have two signs - positive or negative (or charged or anti-charged), the gravitational charge, mass, has only one sign: it is positive, indicating it is inert and not anti-inert. Why is this so?

Bernard Haisch and co-workers (Phys. Rev. D, 1994) have recently claimed to have found the answer in the existence of the electromagnetic field. Their claim is that the electromagnetic field causes some drag on any charged particle which moves in it so that the motion of the particle appears retarded. This retardation manifests itself in inertia and therefore in the existence of mass which must be attributed to every charged particle . Mass is, in their picture, nothing else but a global retardation effect on the motion of a charge.

According to this claim the electromagnetic field becomes the most important global or macroscopic field in the Universe, while the gravitational field and hence all cosmology turns out to be nothing else but a secondary effect of the existence of electromagnetism and electromagnetic waves.

It should be acknowledged that this idea, even if not formulated with this strength, is not entirely new. It had been proposed in 1968 by the Russian Nobel prizewinner and dissident Andrei Sakharov who was responsible for a number of unconventional ideas, such as, for instance, the finite life-time of the proton - a concept which still awaits confirmation. Sakharov proposed that charges moving across the electromagnetic zero-point vacuum fluctuations in the Universe should experience some drag and that this drag should appear to us as an electromagnetic mass.

It is exactly this idea which Haisch and co-workers elaborate on. They take the electromagnetic vacuum fluctuation level which can be easily calculated using quantum electrodynamics and which is well known to exist. Proofs of its reality are manifold; one proof is given by the Lamb shift which can be explained only on the basis of the vacuum fluctuation field, another is the Casimir force effect where the vacuum fluctuation field exerts a real macroscopic force on two metallic plates between which (as known from wave guide and quantum electrodynamic theory) only a certain number of modes can exist; hence the energy content outside the plates is larger than that between them, leading to the net Casimir force. With the knowledge of these zero-point vacuum fluctuations and their spectrum, they calculate the interaction between a moving electron and the total electromagnetic field including the zero-point spectrum. This interaction in classical terms must lead to a Loretz-force. The interesting point is that this Lorentz-force turns out to be directly proportional to the acceleration (deceleration) of the electron with a proportionality factor depending only on the vacuum fluctuations, a characteristic frequency, and on the electromagnetic damping increment of the electrons which is entirely expressible through electromagnetic wave properties.

Their trick is to interpret this force in the spirit of Sakharov as a Newtonian force, a procedure which immediately leads to an expression for the inertial mass of the electron which contains only its charge. In this way it seems as if the mass of the electron is actually generated by its retardation in the zero-point electromagnetic vacuum fluctuations. Remarkably, if this were true, gravitation would be degraded to a side-effect of electromagnetism. Hard to believe!

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But so far the theory has been developed non-relativistically and only in the classical electromagnetic limit where quantum effects are taken into account only through the zero point energy. Clearly, if the theory is covariant, which the authors have not demonstrated as yet, the mass determined must necessarily depend on the particle velocity in the usual way as prescribed by the special relativity formula $E=mc^2$, where m is the relativistic mass which is nothing but the product of the rest mass (determined already in the non-relativistic limit by the authors) and the gamma factor.

Hence a naive generalization of mass to special relativity would be straight forward. What effect QED would have on the result cannot easily be predicted. It must in the first place, explain why the electron, after achieving a rest mass or inertia from the vacuum fluctuations, does not come to rest with its motion being entirely braked. This, however, might be a result of the finite value of the vacuum energy - the lowest value of energy the electron may assume in equipartition. Hence straight uniform motion would also be a consequence of the zero-point energy of the vacuum. On the other hand, general relativity and all its consequences would be spurious in itself and would not exist without the electromagnetic field and its vacuum energy level. The whole idea sounds a little esoteric. There are some serious objections from the point of view of field theory, especially concerning the validity of the kind of mixed classical/quantum calculation we discuss above. A strong QED theory could clarify these points. However, gauge field theory does not, in principle, provide any serious difficulty to generating masses by symmetry breaking. In this way masses are assigned to elementary particles, while the masses also have well defined values. One therefore asks oneself why it is beneficial to explain the masses in an alternative way. The authors' reason that their theory provides insight into the nature of inertia. We have to wait for more consequences to be derived from the theory and for the predictions of these for testing. One problem concerns neutral particles such as the photon, the neutron and the neutrino. In its current form the theory does not give an answer to the question of why the photon has no mass while interacting with the zero-point fluctuations. The neutron, being a composit particle, requires extending the theory to the chromodynamic strong force regime - there is still a long way to go here. The neutrino requires an extension to the electroweak interaction domain. Why in these latter regimes does the photon suddenly becomes so heavy when it splits into W and Z bosons? In gauge theory this seems obvious.

Nevertheless, Haisch and colleagues are optimistic. They believe that their discovery of a similarity between mass and the interaction force on a charge in the zero-point fluctuation of the vacuum has something that tells us about the deeper structure of nature. It is interesting that electrodynamics in their theory becomes the fundament of everything. One must explore the consequences the idea has on many fields in physics, in the first place on gravitation and cosmology. As the referee of their papers wrote: "If it would be true, they would have discovered something very fundamental. But it possibly cannot be true."

Lille General Assembly 1996

CURRENT STATUS OF THE SCIENTIFIC PROGRAMME

This is the second progress report on the Scientific Programme for Lille General Assembly. We issued the first progress report on this matter in the September issue of Radio Science Bulletin (No.274, 1995), presenting the outline the Scientific Programme. It contained the address/ FAX/e-mail information of the Local Committee in Lille with an announcement of one Guest Lecture and three General Lectures. Also presented were the list of sessions with the list of names of convener(s) in each Commission and those in the category of Joint-Sessions.

In this report, therefore, I would like to describe the on-going procedure towards the finalization of the Scientific Programme.

The deadline for the submission of one-page abstracts of all types (Invited, Contributed and Poster) of papers was Jan. 8, 1996. As of February 1st, 1996, the Lille LOC received 1520 one-page abstracts for 108 sessions(including 1 Giant Poster Session for all Commissions).

The procedure which we will adopt for Programme finalization is :

Feb. 15 : Lille LOC will send Copies of Abstracts to Coordinators, to Commission Chairs and to Conveners,

March 1 : Convener(s) and Chairs, after discussion if necessary, will send acceptance letters to Authors. In parallel to this, conveners will inform the Lille LOC of Titles, Addresses, and Phone and FAX numbers of the Authors of the accepted papers.

March 15 : All conveners send final lists of all papers to Chairs of relevant Commissions (or Leading Commissions if Jointly held). Then Commission Chairs will send sorted list of all papers of all relevant sessions to the Coordinator of Scientific Programme. Upon receipt of information from Commission Chairs, the Coordinator will then send the final list of all papers with the final session time tables (time slot assignment for individual sessions) to Lille LOC and URSI HQ in parallel. This procedure will last until the end of March.

April 23-25 : The Coordinator will report the Status of the Scientific Programme for the Lille GA to URSI Board in Brussels.

April 30 : The Lille LOC will send out the Second Announcement of the General Assembly with a full Scientific Programme to Coordinator, Commission Chairs, Conveners and Authors.

The distribution of the submitted papers to each Session with classification into Invited, Contributed, Oral and Poster papers, is tabulated below.

The following is the list of received abstract information provided from Lille LOC to me as of Feb. 1st. The number of papers in each category may be subject to change, correction or modification partly because of the time delay in the communication among Conveners, Commission Chairs, Lille LOC and Coordinator(myself), and partly because of delayed submission and time taken to assign some papers to the appropriate session.

NUMBER OF ABSTRACTS RECEIVED BY COMMISSION, as of FEBRUARY 1, 1996

		invited	contributed	poster	unknown	total
Commission A						
Session	A1	9	0	0	0	9
	A2	9	2	0	3	14
	A3	9	3	4	3	19
	A4	6	0	0	1	7
Total Commission A						49
Commission B						
Session	B1	3	12	0	1	16
	B2	5	11	2	1	19
	B3	0	18	1	6	25
	B4	2	2	8	2	14
	B5	2	13	0	5	20
	B6	4	40	2	8	54
	B7	2	20	0	3	25
	B8	4	1	9	2	16
	B9	6	37	3	2	48
	BP	-	-	24	-	24
Total Commission B						261
Commission C						
Session	C1	1	1	0	0	2
	C2	2	3	1	6	12
	C3	2	15	1	2	20
	C4	6	4	0	2	12
	C5	0	0	0	0	0
	C6	8	2	1	1	12
	C7	0	1	0	1	2
	C8	1	1	0	0	2
	C9	0	5	0	1	6
Total Commission C						68
Commission D						
Session	D1	0	0	0	0	0
	D2	0	1	4	5	10
	D3	2	2	0	1	5
	D4	6	1	0	1	8
	D5	5	3	3	0	11
	D6	3	2	1	1	7
	D7	5	8	1	1	15
	D8	5	1	0	0	6
	D9	2	2	0	1	5
Total Commission D						67

Commission E

Session	invited	contributed	poster	unknown	total
E1.1	8	0	1	1	10
E1.2	7	0	3	0	10
E2.1	6	14	5	0	25
E2.2	3	5	0	1	9
E3	9	0	1	0	10
E4	8	0	1	1	10
E5	6	0	2	0	8
E6	4	2	0	0	6
E7	3	0	5	3	11
E8	3	0	1	2	6
Total Commission E					105

Commission F

Session	invited	contributed	poster	unknown	total
F1	8	10	0	0	18
F2	6	2	0	3	11
F3	6	6	1	2	15
F4	4	7	0	0	7
F6	2	2	0	2	6
F7	5	0	0	0	5
F8	8	1	11	4	24
F9	3	4	0	2	9
F10	6	15	3	2	26
Total Commission F					133

Commission G

Session	invited	contributed	poster	unknown	total
G1	6	14	4	0	24
G2	8	17	2	2	29
G3	1	6	1	1	9
G4	6	8	7	4	25
G5	1	16	8	3	28
G6	4	5	3	1	13
G7	1	22	10	4	37
G8	8	4	9	1	22
Total Commission G					187

Commission H

Session	invited	contributed	poster	unknown	total
H1	2	14	3	1	20
H2	2	10	5	0	17
H3	5	8	4	0	17
H4	11	0	32	0	43
H5	0	22	9	1	32
Total Commission H					129

Commission J

Session	invited	contributed	poster	unknown	total
J1	2	0	0	2	4
J2	9	1	1	3	14
J3	0	1	2	4	7
J4	0	2	2	1	5
J5	4	1	2	2	9
J6	3	3	2	2	10
J7	0	2	2	1	5
J8	0	3	2	2	7
Total Commission J					61

Commission K

Session	invited	contributed	poster	unknown	total
K1	5	10	4	4	23
K2	5	1	2	3	11
K3	2	6	1	0	9
K4	3	11	5	1	20
Total Commission K					63

Joint Sessions

Session	invited	contributed	poster	unknown	total
AB1	5	2	0	0	7
AB2	5	1	7	1	14
AD	7	0	5	0	12
AE	4	2	3	2	11
AF	6	0	0	0	6
CD	7	2	0	1	10
CE	0	6	0	0	6
DA1	3	5	2	1	11
DA2	3	2	0	0	5
DB1	3	3	0	2	8
DB2	8	0	1	0	9
DC	6	3	0	1	10
EA	4	0	2	0	6
EB	5	1	2	2	10
EF	2	0	2	1	5
EK	1	0	0	3	4
HCJ	0	22	9	1	32
HEG	1	17	5	2	25
HG1	6	0	11	0	17
HG2	4	14	7	1	26
HG3	10	20	3	2	35
HGCJ	3	1	2	1	7
HJ	0	11	3	1	15
JB1	3	1	1	2	7
JB2	4	5	1	2	12
JCE	7	3	4	1	15
KA	2	2	2	2	8
KB	7	8	2	1	18
D-ICO	3	1	0	1	5
D-IWGP	20	0	0	2	

Total Joint Commission 358

Abstracts submitted without indication of session : 39

Total Abstracts received February 1st, 1996 : 1520

Hiroshi Matsumoto
Coordinator, Scientific Programme

Conferences

CONFERENCE REPORTS

Biophysical Aspects of Coherence

Prague, Czech Republic, 11 - 15 September, 1995

A preliminary report on this conference was printed in the December 1995 issue of this Bulletin. The President of the Joint Committee of the Czech and the Slovak Committee was so kind to send us this more detailed and comprehensive report for your information.

Workshop "Biophysical Aspects of Coherence" was organised by the Faculty of Mathematics and Physics, Charles University, Institute of Radio Engineering and Electronics, Academy of Sciences of the Czech Republic, Faculty of Electrical Engineering, Czech Technical University, National Institute of Public Health, Faculty of Technical Sciences, Novi Sad, Union of Czech Mathematicians and Physicists, Czech Society for Gynaecological Cytology, and under sponsorship of the Joint URSI Committee for the Czech and the Slovak Republic and of the Commission K of the International Union of Radio Science. The Workshop was organised in the framework of the Czech participation in the project COST 244 too.

The Workshop was devoted to coherence phenomena in living matter especially to the Fröhlich mechanism of coherence. Oscillations (i.e. longitudinal, torsional, bending etc. vibrations) in macromolecules and/or in cellular structures (e.g. in the micro tubules) carrying charge generate an electromagnetic field mediating linear and non-linear interactions inside the system and with the surroundings (i.e. with a hear bath). Energy supplied to a non-linear system is subjected to spectral transformation; energy is not thermalized but distributed in a special way. Fröhlich assumed a non-linear mechanism of interaction between two modes with different frequencies and with a heat bath resulting in energy and energy condensation in the lowest frequency mode. (Nevertheless, energy may condense in some high frequency modes too.) If the energy is high enough the amplitude and phase of the oscillators are not random but coherent? The system is far from thermodynamic equilibrium. The electromagnetic field generated by the coherent vibrations has very likely an important role in organization and self-organization of biological systems.

Papers on the theory of biophysical mechanisms of coherence, non-linear mechanisms, and charge transfer were presented by Professor T.-M. Wu, Professor F. Kaiser, Professor R.E. Mills, Professor E.G. Petrov, and Professor G.L. Sewell. The role of micro tubules in coherence was included in papers by Professor J.A. Tuszynski, Professor H. Bolterauer, Professor M. Costato and Professor M. Milani. Professor S. Hameroff related the micro tubule coherent states to brain activity. Coherence and brain activity was discussed by Professor G. Vitiello and modelling of action potential in axons was presented by Professor M. Sataric. Paper on Bioenergetics was presented by Professor M.-W. Ho. Dr. V. Krsmanovic reported on inhibition of differentiation of erythroid cells. Malignant transformation of cells and biophysical mechanisms of coherence was discussed by Professor J. Ladik. Mechanisms of protein phosphorylation as a fundamental mechanism of regulation in biological systems was in the paper by Dr. Z. Tuhackova and a possible role of protein phosphorylation in coherence quenching and cancer transformation was presented by Dr. J. Pokorny. Hyperthermic cancer treatment was presented by Professor J. Vrba.

Effects of electromagnetic field on biological systems was presented by Dr. W. Grundler (growth of yeast cells) and by Professor J.C. Lin (effects of microwaves on neurons). Results of measurements of endogeneous cell field was presented by Dr. R. Hölzel.

A large amount of theoretical papers on Fröhlich coherence was published up to now. Nevertheless, research in this interdisciplinary field among biology, biochemistry, physical chemistry, biophysics, and engineering is still in the initial phase. Regardless of the plausibility the Fröhlich theory of coherence has to be verified experimentally. Experimental findings are inadequate. The main effort in the future bas to be focused on finding convenient experimental methods in the future has to be focused on finding convenient experimental methods and measurements of coherent systems, especially of the endogeneous electromagnetic field.

The idea of coherence in biological systems emanated from the distinguished Professor H. Fröhlich, F.R.S. The great scientific work of Professor H. Fröhlich was highly appreciated by Dr. G.J. Hyland who presented the Fröhlich memorial lecture in the Bethlehem Chapel followed by a concert.

The Joint URSI Committee of
the Czech and the Slovak Republic

ISSSE '95

San Francisco, CA, USA, 25-27 October , 1995

The International Symposium on Signals, Systems and Electronics 1995 (ISSSE '95) was held at Parc Fifty Five Hotel in San Francisco on October 25-27, 1995. This meeting was organized jointly by Commissions C and D of URSI. This is the third of the ISSSE series originated in Erlangen, Germany in 1989 while the second was held in Paris in 1992. The 1995 meeting was the first ISSSE ever held outside Europe.

The meeting was financially supported by URSI and Commissions C and D. In addition, it attracted an impressive array of financial co-sponsorships. The IEEE Microwave Theory and Techniques Society provided co-sponsorship for 10% financial interest while United States Army Research Office and United States Office of Naval Research provided substantial financial grants. In addition, the following IEEE Societies provided cooperative sponsorships: Electron Devices Society (ED), Lasers and Electro Optics (LEOS), Circuits and Systems (C&S) and Communication (COM).

The meeting started with the opening session when Dr. J. Mink of North Carolina State University, General Chairman of the Steering Committee presented a short greeting that was followed by a congratulatory note by Dr. David Chang, President of Polytechnic University and Chairman of US National Committee of URSI. The first Keynote Session followed with Dr. Charles Rush of Compass Rose International on the topic "Global Information Infrastructures: Challenges and Realities. He described many issues and challenges related to the so-called information superhighway. The second and third days have also started a keynote session. On the second day, the keynote address was given by Dr. Andrew Viterbi of Qualcomm on "Universal Wireless Communication: Convergence of Technology and Market Forces." On Friday, October 27, the keynote was presented by Professor Alwyn Seeds of University College London on "Mining the Optical Fiber Bandwidth Goldmine." All keynote sessions were extremely well attended.

After the keynote sessions, four parallel sessions were run in the late morning, early afternoon and late afternoon for each of the three days. These sessions were roughly divided equally to Commission C subjects and Commission D subjects, although the Commission boundaries were less clear in a number of sessions. In addition, there was a poster session on Thursday evening in a relaxed atmosphere during the wine reception. The meeting was attended by 175. This number includes 8 Young Scientists who were provided a partial financial support.

The Steering Committee consists of: General Chairman, J. W. Mink, North Carolina State University; Vice Chairmen, T. Itoh, UCLA (Commission D) and P. H.Wittke, Queen's University, Canada (Commission C); Technical Program, A. N. Willson, Jr., UCLA (Commission C), M. Shur, University of Virginia (Commission D); Local Arrangement, A. P. Khanna and R. Soohoo, HP Avantek; Finance, H. J. Kuno, Quinstar; Publicity, J. Harvey and R. Trew, Army Research Office; Publication, W. Sander, Army Research Office; Executive Secretary, M. C. Wu, UCLA. Under the Technical Program Co-Chairmen, there was International Scientific Program Committee consisting of 22 scientists from US, Europe, Canada and Japan.

T. Itoh

Satellite Studies of Ionospheric and Magnetocpheric Processes

Moscow, Russia, 11 - 13 December, 1995

The International Symposium Satellite Studies of Ionospheric and Magnetospheric Processes was devoted to the 25th Anniversary of wave experiments in the frames of the "Intercosmos" space programme.

The Symposium was held at the Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences (IZMIRAN) during December 11 - 13, 1995, under the sponsorship of the Russian Foundation of Fundamental Research and was sponsored by the International Union of Radio Science (Commission H).

The Symposium was attended by 72 scientists from Russia, Ukraine, and Poland. Many active participants of "Intercosmos" could not arrive because of the delay of financial support. The scientific programme included 82 presentations divided into 6 sessions. Besides the mentioned countries, some papers were submitted by the authors from the Czech republic and France. Before the opening of the Symposium, all participants received a book of abstracts of the accepted papers.

The main topics of the Symposium were as follows :

1. Active experiments in space
2. Wave/particle interactions in the Earth plasma environment
3. Magnetospheric/ionosphere coupling
4. Low-frequency electromagnetic radiation relevant to seismogenic and technogenic activity.

The idea of the Symposium was that of Professor Ya. I. Likhter, who unfortunately did not live long enough to participate. The Opening Session began with a lecture devoted to the life and scientific heritage of Professor Ya. I. Likhter, one of the pioneers of the satellite wave studies.

The programme was tight enough and covered the topics mentioned above. The Closing Session outlined the prospects of research in the fields under discussion. The following tasks of fundamental research were recognized most important :

- the study of spatial and time characteristics of the near-Earth wave and plasma environment (especially during artificial injections) by using a series of satellite measurements.
- The study of energy exchange in space, the effect of solar wind streams on high-energy particles in the magnetosphere and their precipitation to the ionosphere and atmosphere.
- The study of electromagnetic field modification and distribution of plasma components over the regions of high seismic activity.
- To develop comprehensive models of geomagnetic storms.

The participants highly appreciated the Symposium and suggested that similar conferences on the topics of Commissions E, G, H and J be held on the regular basis under the auspices of URSI.

The Organising Committee

High Sensitivity Radio Astronomy

Jodrell Bank, United Kingdom, 22 - 26 January 1996

The meeting was attended by 115 participants from 12 countries. There were 18 invited talks, 42 contributed talks and 35 poster presentations.

Current high sensitivity radio observations were reviewed in the areas of weak radio spectral lines, radio continuum emission from galaxies, cosmology, pulsars and stars. In most of these presentations it was clear that further progress in these areas required significantly higher sensitivity than could be achieved with existing instruments. Proposed enhancements to a number of existing large instruments (including VLBI) were described together with a description of two new large instruments (the Giant Metre Wave Telescope and the Greenbank Telescope) which are currently under construction.

The status of proposals for European and US mm arrays were also reviewed. The final day was devoted to a discussion of progress towards a large decimete instrument with approximity 1 square km of collecting area. This is an instrument being considered by the URSI/IAU large telescope working group.

A number of technical developments were reported, as well as discussions concerning radio frequency interference.

R.D. Davies

CONFERENCE ANNOUNCEMENTS

1996 International Conference on Plasma Physics (ICPP 96)

Nagoya, Japan, 9 - 13 September, 1996

General Information

The 1996 International Conference on Plasma Physics will be held from 9 to 13 September 1996 at the Nagoya Congress Center in Nagoya, Japan. The conference will be co-organized by the Japan Society of Plasma Science and Nuclear Fusion Research and the National Institute for Fusion Science. The series of conferences, which was initiated in 1980 at Nagoya as a joint conference of the Kiev International Conference on Plasma Theory and the International Conference on Waves and Instabilities in Plasmas, brings together plasma physics from a variety of research fields including nuclear fusion, space and astrophysical plasmas, and industrial applications to discuss common subjects in plasmas that provide the basis of the various research fields.

Plasma physics emerged during the late fifties, when many branches of physics and engineering combined to form a new stream. During the subsequent two decades, this tiny stream evolved to a well-identified research field of physics. Controlled fusion research and space and astrophysical plasma research have been developed as two research fields of science. Recently, another new stream emerged in plasma physics with innovative tools of research such as large scale computer simulations. Furthermore, there have been other developments of plasma physics and technologies concerning advanced plasma applications.

The conference will be organized to discuss a wide variety of prospects of these plasma physics.

Topics

The conference consists of general sessions and plenary sessions. The general sessions are devoted to contributed papers and invited talks. The topical fields covered by the General Sessions include:

1. General Plasma Physics
   Waves and Instabilities, Nonlinear Phenomena, Transport Phenomena, Heating and Current Drive, Particle Accelerations and Beam Production, Radiation Sources and Processes, Magnetic Reconnection, Plasma Production and Confinement, Plasma-Edge Phenomena, Plasma-Material Interaction, Elementary Processes, Diagnostics, Thermodynamics of Plasma, Others
2. New Trends in Plasmas
   Self-Organizing Plasmas, Non-Neutral Plasmas, Strongly Coupled Plasmas, Non-Ideal Plasmas, Laser Plasmas and Short-Pulse Phenomena, Dust and Fine-Particle Plasmas, Reactive Plasmas for Material Processing, New Approaches, Others

In addition to the General Sessions, the reviews and frontier topics covering the following fields are scheduled in the Plenary Sessions:

* Plasma Science : P. Pines (Univ. Illinois), I. Prigogine (Brussels Univ.)
* Fusion Research : B. Kadomtsev (Kurchatov), M. Key (Rutherford), F. Wagner (Max-Planck-Inst. Plasmaphysik)
* Space and Astrophysical Plasma : K. Makishima (Univ. Tokyo), H. Matsumoto (Kyoto Univ.), E. Parker (Chicago Univ.)
* Advanced Plasma Applications : N. Watanabe (Kyushu Univ.), T. O'Neil (UCSD)

Contact

ICPP 96 Nagoya Conference Secretariat:
c/o Prof. Hiromu Momota
National Institute for Fusion Science
Nagoya 464-01, Japan, Tel. : +81-52-789-4260
Fax : +81-52-789-1037, e-mail : icpp96@nifs.ac.jp

OTHER MEETINGS BROUGHT TO OUR ATTENTION

European Conference on Multimedia Applications, Services and Techniques (ECMAST)

Louvain-la-Neuve - Belgium, 28-30 May, 1996

The European Conference on Multimedia Applications, Services and Techniques is sponsored by: EC (ACTS and COST 237), EBU and EUREL

The information and communication technology landscape has changed fundamentally during the last few years. Considerable progress has been made in the digital signal representation and coding of data, sound and images. Wideband digital network technologies have been developed for broadcasting and telecommunication networks. The speed and power of processors is steadily increasing. Multimedia technologies needed to build the information society are thereby near at hand, although it is fair to say that, in many cases, they will be continuously evolving over the next decade.

The objective of ECMAST is to provide an open forum to monitor and anticipate the development of technologies that make multimedia applications possible. ECMAST'96 is the first issue of a recurrent event launched by a group of major European industrialists together with the European programs RACE and ACTS on Image Communication and Multi Media and COST-237. People inside and outside Europe are invited to submit contributions and to share the discussion.

Topics include but are not limited to:

1. Production, creation
   Image analysis and synthesis tools (hard- and software). Multimedia tools for application creation in a workstation/ PC environment. Information sensing and presentation devices, virtual reality, 3D vision, telepresence. Image quality assessment.
2. Coded representation of images, sound and data
   Object/content/knowledge based representation of natural and synthetic images and computer graphics. Advanced compression techniques. Advanced signal processing architectures.
3. Multimedia delivery on broadcast networks
   Digitisation of analogue delivery systems: DAB, DTTB, satellite, CATV/MATV, microwaves. Interactivity, return channels and associated multiple access architectures.
4. Multimedia on telecom and professional networks
   Core and access networks architectures requirements for MM services. Multimedia enhanced transport services, synchronisation issues. Multipeer/Multicast transport services. Multimedia in distributed systems platforms. WAN multimedia collaboration tools and services. QoS semantics for service users/providers, end-to-end QoS provision. Impact of multimedia on OSI and TCP/IP.

5. Servers, terminals and storage
   Multimedia servers and data bases. Terminal equipment architecture. User ergonomics. Service information multiplexing and browsing.
6. Services
   Multimedia contents and related requirements. Conditional access and copyright protection. Interoperability of multimedia services on telecom and broadcast networks, standardised interfaces. Mobility issues. Service management and maintenance.

Topical Sessions: Very Low Bit Rate Image Coding, Networks for Multimedia, Copyright Protection, Security for Multimedia, Langages Command, Digital Television. Invited speakers: L. Chiarliglione (DAVIC), A. Danthine (COST 237), M. Kunt (EPFL, Berkeley)

Important dates

Deadline for submission of papers : 9 January 1996
Acceptance/rejection notification : 1 March 1996
Final version of paper due : 1 April 1996

Contact

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E-mail: Rouyer@tele. ucl.ac.be
web site http://www.ecmast.tele.ucl.ac.be.

PIERS 1997

Progress In Electromagnetics Research Symposium

Kowloon, Hong Kong, January 6 - 9, 1997

The Progress In Electromagnetics Research Symposium (PIERS 1997) will be organized by the Telecommunication Research Centre at the City University of Hong Kong on January 6 - 9, 1997 on the campus of the City University of Hong Kong in Kowloon, Hong Kong.

PIERS provides an international forum for reporting progress and recent advances in the modern development of electromagnetic theory and its new exciting applications. Suggested topics are listed below, but consideration will be given to papers on others subjects.

Symposium Organization Chairman: J.A.Kong

Suggested Topics

1. Mobile antennas
2. Antenna theory and measurements
3. Measured Equation of Invariance
4. Microstrip and printed antennas
5. Dielectric resonator antenna and array
6. FDTD methods and applications
7. Electromagnetic Compatibility
8. Computational techniques
9. Photonics, nonlinear optics and devices
10. RF & microwave circuits
11. Time-domain electromagnetics
12. Superconducting electronics
13. Neural network techniques in electromagnetics
14. Ferrite devices and measurements
15. Wavelets in Electromagnetics
16. Waves in composite and complex media
17. Rough surface scattering
18. Medical applications and biological effects
19. Millimeter, submillimeter and lightwaves
20. Scattering and diffraction
21. Remote sensing
22. Reflector antennas
23. Random media, nonlinear media and turbulent media
24. Polarimetric radar scattering
25. Static fields
26. Low frequency applications
27. Interconnects

Important dates

Abstract deadline : 1 May , 1996
Acceptance notification will be mailed by 1 July , 1996.
Advance Program : 15 September, 1996.

Contact

For participants from United States and Canada :

Prof. K.F.Lee, PIERS 1997
Department of Electrical Engineering
University of Missouri-Columbia
349 Engineering Bldg, West Columbia, Missouri 65211
Tel: (314)882-6387, Fax: (314)882-0397
E-mail: lee@ece.missouri.edu

For participants from other countries :

Dr. K.M.Luk, PIERS 1997
Department of Electronic Engineering
City University of Hong Kong
83 Tat Chee Avenue, Kowloon Hong Kong
Tel: (852)27887352 Fax: (852)27887791
E-mail: eekmluk@cityu.edu.hk

URSI cannot be held responsible for any errors contained in this list of meetings.

March 1996

EUSAR'96
Konigswinter, Germany, 26-28 March 1996
Contact : Dr. R. Klemm, FGAN-FFM, Neuenahrer Str. 20, D-53343 Wachtberg, Germany, Tel. +49-228-852-377, Fax +49-228-348-953, E-mail: r.klemm@elserv.ffm.fgan.de

May 1996

IGARSS'96
Burnham Yates Conference Center, Cornhusker Hotel, Lincoln, Nebraska, USA, 27-31 May 1996
Contact: Ms. Tammy Stein, IEEE Geoscience and Remote Sensing Society, 2610 Lakeway Drive, Seabrook, Texas 77586-1587, USA, Tel. +1-713 291 9222, Fax +1-713 291 9224, E-mail : stein@harc.edu

June 1996

10th Int. Conf. on Atmospheric Electricity
Osaka, Japan, 10-14 June 1996
Contact : Prof. M. Hayakawa, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu Tokyo 182, Japan, Fax +81-424-80-3801, E-mail: hayakawa@aurora.ee.uec.ac.jp

Conference Precision Electromagnetic Measurements (CPEM'96)
Braunschweig, Germany, 17-20 June 1996
Contact: Mrs. Sabine Rost, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany, Tel. +49-531-592-2129, Fax +49-531-592-2105, E-mail: erich.braun@ptb.de

13th International Wroclaw Symposium and Exhibition on Electromagnetic Compatibilty
Wroclaw, Poland, 25-28 June 1996
Contact : Mr. W. Moron, EMC Symposium 1996, Box 2141, 51-645 Wroclaw, Poland, Tel. +48-71-728812, Fax +48-71-728878

July 1996

Fifth International Symposium on Bio-Astronomy
Capri, Italy, 1-5 July 1996
Contact : Prof Stuart Bowyer, Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450, USA, Fax +1-510 643-8303, E-mail: bowyer@ssl.berkeley.edu

COSPAR Scientific Assembly
Birmingham, United Kingdom, 14-21 July 1996
Contact : Prof. S. Grzedzielski, 51, bd de Montmorency, F-75016 Paris, France, Tel. +33-1-4525 0679, Fax +33-1-4050 9827, E-mail: cospar@paris7.jussieu.fr

August 1996

XXVth URSI General Assembly
Lille, France, 28 August -5 September 1996
Contact : Dr. M. Lienard, Université de Lille, Dept. Electronique, Bat. P3, F-59655 Villeneuve d'Ascq Cedex, France, Tel: +33 20-337206, Fax: +33 20-337207, E-mail: agursi@univ-lille1.fr

September 1996

8° Colloque internationale et exposition sur la Compatibilité électromagnétique
Lille, France, 3-5 September 1996 (co-located with the URSI General Assembly)
Contact : Prof. P. Degauque, Université des Sciences et Techniques de Lille 1, UFR/IEEA, Bâtiment P3, F-59655 Villeneuve d'Ascq Cedex, France, Tel. +33 20-434849, Fax +33 20-436523

International Conference on Plasma Physics (ICPP'96)
Nagoya, Japan, 9-13 September 1996
Contact : Prof. H. Momota, National Institute for Fusion Science, Nagoya 464-01, Japan, Tel. +81 52-789-4260, Fax : +81 52-789-1037, E-mail : icpp96@nifs.ac.jp

Sixth International Conference for Mathematical Methods in Electromagnetic Theory (MMET'96)
Lviv, Ukraine, 10-13 September 1996
Contact : Prof. Z. Nazarchuk, Karpenko Physico-Mechanical Institute, 5 Naukova St., Lviv 290601, Ukraine, Tel. +380-322-637038, Fax +380-322-649427

22nd European Conference on Optical Communication ECOC'96
Oslo, Norway, 15-19 September 1996
Contact : ECOC'96 Secretariat, Norwegian Telecom Research, P.O. Box 83, N-2007 Kjeller, Norway, Tel. +47 - 63 - 80 93 41, Fax+ 47- 63 - 81 98 10, E-mail: krosby@tf.tele.no

IEEE ISSSTA'96
Mainz, Germany, 22-25 September 1996
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23rd International Conference on Lightning Protection (ICLP)
Firenze, Italy, 23-27 September 1996
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Int. Symp. on Antennas and Propagation
Chiba, Japan, 24-27 September 1996
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Book Review

Radiation and Scattering of Waves

by L. B. Felsen and N. Marcuvitz
IEEE Press Series on Electromagnetic Waves, 1994
888 pages, ISBN 0-7803-1088-8
Hardcover, $69.95

My first encounter with *Radiation and Scattering of Waves* dates back to the mid-80s to my theses on mathematical techniques for electromagnetic wave propagation and radiation in anisotropic media. As my main interest concerned gyrotropic media (cold magnetoplasmas), I had encountered the seminal work of Arbel and Felsen of some 20 years earlier. Their studies on guided-wave representation of fields in gyrotropic media (which later became Section 8.3 of *Radiation and Scattering of Waves*) were inspirational and encouraged me to delve into a book which, at not much below 1000 pages, looked slightly daunting.

Of course, in those days, *Radiation and Scattering of Waves* was already out of print, and the 10 years since have been a constant struggle against the other users who were as keen as I was to get their hands on the single copy which my respective University libraries were holding. That is now a thing of the past and I, for one, am certainly delighted by the reissue of Felsen and Marcuvitz's book by the IEEE Press. And indeed the book is a natural choice for *IEEE Press Series on Electromagnetic Waves* because this is certainly a true classic in the field of electromagnetics which deserves its place on the shelves next to the Strattons, the Jacksons and Van Bladels.

The contents of the book is as follows:

1. Space- and time-dependent linear fields.
2. Network formalism for time-harmonic electromagnetic fields in uniform and spherical waveguide regions.
3. Mode functions in closed and open waveguides.
4. Asymptotic evaluation of integrals.
5. Fields in plane-stratified regions.
6. Fields in cylindrical and spherical regions.
7. Fields in uniaxially anisotropic regions.
8. Fields in anisotropic regions.

Rather than provide a detailed listing of the contents of the individual chapters with their vast scope, I will embark on a brief tour of my personal highlights of *Radiation and Scattering of Waves.* Such a selection will of course contain a strong personal flavour but that's the reviewer's privilege!

With the main emphasis on source-excited fields, let me commence with the basic material of field representations. The major tool are Green functions — in scalar, dyadic or general matrix flavour — and they are brightly illuminated in a didactically attractive manner in Chapter 1 by focussing on acoustic, electromagnetic, plasma and general linear field problems. The derivation of closed-form solutions for infinite-medium Green functions is captivating and the subsequent alternative solution representations lead to a natural first encounter with ray-optical methods.

The subsequent derivation of modal representations develops the interesting connection of vector electromagnetic differential equations to transmission-line equations — a parallel less exploited nowadays. This line of approach culminates in the final chapter where the fields from arbitrary sources in anisotropic media are obtained from the solution of two simple first-order transmission line equations.

As the authors write in their *Perspectives on the Reissue,* Chapter 4 (on asymptotic evaluation of integrals) has been most frequently cited over the years. I would argue that the main use of asymptotic techniques (such as saddle-point methods) now should be seen in a symbiosis with numerical methods, i.e., in their ability to extract singular and badly-convergent terms from the integral representations. That ability, to transform a given problem in a manner suitable to numerical analysis is today as important as it ever was, despite the supercomputers of the 1990s.

In the 23 years since the first publication of *Radiation and Scattering of Waves,* electromagnetics has seen a vast expansion. Not surprisingly, numerical methods have become the main tool of investigation in many a research area and it needs no prophet to predict that this trend will continue as increasingly powerful computing facilities become available. Yet, in all of this, Felsen and Marcuvitz's book has retained its appeal in two ways: First, in providing the basic mathematical tools to explore wave propagation and radiation problems; second, through the detailed and exhaustive presentation of evaluation techniques (such as asymptotic methods).

The reissue of *Radiation and Scattering of Waves* will provide a new generation of electromagneticists with the opportunity to benefit from the wealth and depth of presented material. For me and many others who were unable to purchase the original, it also means we don't have to fight for the single library copy anymore.

Reviewed by Dr Werner S. Weiglhofer
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News from the URSI Community

PROFILE OF URSI MEMBER COMMITTEES

PERU

The Instituto Geofisico del Peru, a government agency dedicated to geophysical research and applications, has been very active in radio science and related topics since the early thirties. A number of important discoveries (equatorial electrojet, Forbush effect, etc.), alternative theories (incoherent scatter, Spread-F occurrence, etc.), techniques (two pulse correlation method, magnetic field inclination, etc.), and instruments (MST radar, etc.) has been made, presented, devised, and built, respectively, by Peruvian and foreign scientists at the Instituto's observatories in Huancayo, Ancon and Jicamarca.

As a matter of fact, the radio scientific and technical staff of the Institute were naturally the core of the Peruvian National Committee. Funds were allocated by the Peruvian government to cover the Committee's expenses and, at a high point, the Peruvian National Committee hosted URSI's 1975 General Assembly in Lima.

Later on, due to repeated financial crises and a protracted period of social turmoil, the government reduced its economic support to the Institute below the bare essentials. The Jicamarca Radar Observatory continued its operation largely due to the generous backing of the National Science Foundation of the U.S.A., through the University of Cornell. Under these difficult circumstances the Committee had to forgo its full membership in the Union.

Presently, the Committee has obtained financial sponsorship from Ciencia Internacional - a nonprofit organization for the promotion of science in Peru - subject to two conditions: presentation of its bylaws and extension of its membership. The first condition has been fulfilled and the second one is in the process of being met shortly.

At this point, the Peruvian National Committee would like to express its gratitude to the Secretary General and the Board of Directors of URSI for helping it regain full membership in URSI and its most cordial greetings to its fellow Committees.

Dr. Carlos Calderon-Chamochumbi
Secretary Peruvian National Committee

NEWS FROM URSI MEMBER COMMITTEES

THE UNITED KINGDOM

22nd Queen Mary and Westfield College Antenna Symposium

The 22nd QMW Antenna Symposium will be held on 16 - 17 April 1996 at Queen Mary & Westfield College.

The symposium provides an informal occasion for the presentation of contributions dealing with recent developments in the theory and practice of antennas and related electromagnetic theory. Contributions on all aspects of antenna research, design, development, modelling and measurement are welcome.

Titles of proposed contributions should be sent not later than 1 March - by e-mal if possible - to Dr. Clive Parini, QMW College, Department of Electronic Engineering, Mile End Road, London E1 4NS, United Kingdom, Tel. +44 171-975 5339, Fax +44 181 981-0259, E-mail : C.G.Parini@qmw.ac.uk

The Programme will be announced and registration forms despatched in early March 1996.

There will be no formal printed proceedings, but authors will be asked to provide a one-page summary of their contributons which will be disctributed to participants at the symposium.

For any additional information, please contact either Clive Parini or Tony Monk (+44 171-975-5340, a.d.monk@qmw.ac.uk).

URSI Publications

Status Report on the "Review of Radio Science"

Editor : Dr. W. Ross Stone

The *Review of Radio Science, 1993-1995* ("the *RRS*") is a major contribution to radio science, made by URSI each triennium. The purpose of this note is to give the readers of this publication a status report on the writing, editing, and production of this book.

In the previous triennium, the *Review of Radio Science, 1990-1992* was published by Oxford University Press (OUP) as an 814-page book, consisting of 40 peer-reviewed, fully-edited papers, each a chapter of the book. Each chapter provided a review of advances and research in a segment of the field of interest of one of the Commissions, which the Commission believed was of significant importance for the previous three years. These reviews were intended to be objective-what some refer to as "critical reviews"-in their reporting and analysis. This format and content, and the fact that each chapter was peer-reviewed by at least three other experts in the field, resulted in a publication which was a significant departure from the *Review of Radio Science* books which had been published by URSI in previous years. The publication and marketing of the *RRS* by the OUP also significantly expanded the potential audience for the book.

The current *RRS* follows this same format, and the same guidelines for content and the peer-review process. It will have between 36 and 39 chapters.

The *RRS* for the previous triennium included a disk of references ("the *Disk*"), also submitted by the Commissions, which took up about 6.6 MB of disk space when decompressed into ASCII text. These files were the references which each Commission believed to be the most significant in its area of radio science for the past triennium. This produced more than an electronically-searchable database of references which could be installed on a worker's PC. It included annotation or, at a minimum, key words, and was of particular value because of the selection process used in its production.

For the current triennium, most Commissions are again contributing to the *Disk*. However, at the Kyoto General Assembly, some Commissions felt that the on-line databases available in their fields made the *Disk* of less importance, and they chose not to participate in production of the *Disk* for the current triennium. The production of the *Disk* to be included in the current RRS is basically on schedule, with final contributions coming in from the various Commissions as this is written.

The production of the current *RRS* began at the Kyoto General Assembly. Since then, the Commission Editors have, in general, done an excellent job of carrying out a very formidable and time-consuming set of tasks: identifying topics and authors; keeping the authors on schedule to produce the preliminary manuscripts; identifying reviewers, and coordinating the reviews (in many cases, this involved several iterations between the reviewers and the authors of a given paper); and delivering the final manuscripts, figures, and an electronically readable version of each manuscript to me. I am now in the process of editing each paper; having the authors give a final proof reading to their chapters; and producing the camera-ready pages which OUP will combine with the figures to produce the plates to print the book. The book is on schedule, and will be given to attendees when they register for the Lille General Assembly.

The following list of the chapters in the *Review of Radio Science, 1993-1995*, reflects the status of each Commission's contributions. With very few exceptions, the final manuscripts for each of these chapters have been received, and the editing process is underway. In those few cases where final manuscripts have not yet been received but are expected in time to be included, the notation "*Expected*" has been added after the author's name. Where a chapter was begun, but has not been received and its current status could not be verified, the notation "*Questionable*" has been added.

The Editors for each Commission, for both the *RRS* and the *Disk*, have been identified under each Commission in the list below. These people have done a tremendous amount of work, as have the authors. When you see the result in Lille, let them know how much you appreciate it.

Review of Radio Science, 1993-1995

Planned Table of Contents

Commission A

Dr. Motohisa Kanda is the Editor for the *RRS*. Dr. Luc Erard is the Editor for the *Disk*.

1. "Conventional Microwave Frequency Standards: Cs-, H-, and Rb-Clocks"
   K. Dorenwendt and B. Fischer
2. "Primary Atomic Frequency Standards: New Developments"
   R. E. Drullinger, S. L. Rolston and W. M. Itano
3. "Optical-Frequency Standards"
   J. Helmeke
4. "Methods for Distributed Time and Frequency: Review"
   J. Levine
5. "Optical Power and Fiber Optics Metrology"
   Douglas Franzen, D. H. Nettleton
6. "Developments of Automatic Network Analyzer Calibration Methods"
   Burkhard Schiek
7. "EM Metrology for Guided Waves"
   Richard F. Clark

Commission B

Prof. Ralph Kleinman is Editor of the *RRS* for Commission B, and Prof. Anton Tijhuis is Editor of the *Disk*.

8. "Advanced Sampling Techniques in Electromagnetics" O. M. Bucci and G. D'Elia
9. "Approximate Boundary Conditions in Electromagnetics" Thomas B. A. Senior and John L. Volakis
10. "Wavefield Inversion of Objects in Stratified Environments: From Back-Propagation Schemes to Full Solutions"
    Dominique Lesselier and Bernard Duchene

Commission C

Prof. Barry Evans is Editor of the *RRS* for Commission C. Commission C voted not to participate in the *Disk* at the Kyoto General Assembly. No additional information nor submissions regarding Commission C's chapters for the *RRS* has been received.

Commission D

Prof. Roberto Sorrentino is Editor of the *RRS* for Commission D. Commission D voted not to participate in the *Disk* at the Kyoto General Assembly.

11. "Nanometric Structurization Towards Future Quantum Electronics"
    Hans L. Hartnagel
12. "Active Integrated Antennas"
    C. Pobanz and T. Itoh
13. "Optical Transmission of Microwaves"
    Alwyn Seeds
14. "Noise Analysis of Linear Microwave Circuits with General Topology"
    Peter Russer

Commission E

Prof. Masashi Hayakawa is the *RRS* Editor for Commission E. Dr. Robert L. Gardner is the Commission E *Disk* Editor.

15. "Terrestrial and Planetary EM Noise and Its Effects"
    H. Kikuchi, Z. Kawasaki, and M. Hayakawa
16. "Radio Spectrum Management for Spectrum Efficiency"
    R. D. Parlow and A. D. Spaulding
17. "Analytic Solution of Uniform and Non-Uniform Multiconductor Transmission Lines with Sources"
    C. E. Baum, and R. J. Sturm
18. "Effects of Electromagnetic Interference and Transient Disturbances on Electronic Devices and Equipment"
    P. Degauque and V. Scuka

Commission F

Mr. Martin P. M. Hall is the Commission F *RRS* Editor. Prof. Yoshio Hosoya is the Commission F *Disk* Editor.

19. "Remote Sensing of Clouds and Precipitation"
    K. Okamoto, T. Kosu, H. Kumgai and T. Iguchi
20. "SAR Polarimetry and Interferometry"
    J van Zyl and H. Zebker
    Questionable
21. "Gaseous Absorption at 10-2000 GHz and Remote Sensing of Water Vapor"
    A. J. Gasiewski and H. J. Liebe
    Questionable
22. "Climatic Parameters in Radiowave Propagation Prediction"
    M. P. M. Hall and J. P. V. Poiares Baptista
    Questionable
23. "Remote Sensing for Ecology"
    M. Hallikainen
24. "Depolarization Due to Hydrometeors"
    A. Paraboni
25. "Mobile and Personal Communications"
    J. Bach Andersen
    Expected

Commission G

Dr. Phil Wilkinson is the Editor for both the *Disk* and the *RRS* for Commission G.

26. "Advanced Visualization Tools: Applications to Data Handling and Model Validation in Space Science"
    Ed Szuszczewicz
    Expected
27. "Ionospheric Investigations Using Imaging Riometers"
    Peter Stauning
28. "Critical Review of Ionospheric Patches and Blobs"
    Geoffrey Crowley

Commission H

The Commission H *RRS* Editor is Dr. Vladimir Fiala.
Prof. Wynne Calvert is the Commission H *Disk* Editor.

29. "Active Plasma Experiments: Steps Toward a Space Laboratory Facility"
    W. J. Raitt
30. "Computer Simulation of Multiple-Scale Processes in Space Plasmas"
    J. L. Horwitz and S. T. Zalesak
31. "Lightning, Trimpis, and Sprites"
    H. J. Strangeways
32. "Analysis Techniques for Resolving Nonlinear Processes in Plasma Turbulence"
    Thierry Dudok de Wit
33. "Electromagnetic Precursors of Earthquakes: Review of Recent Activities"
    M. Hayakawa
34. "Observations and Interpretations of Interplanetary Radio Emissions"
    J. L. Bougeret

Commission J

Dr. Tasso Tzioumis is the Commission J *RRS* Editor. Commission J voted not to participate in the *Disk* at the Kyoto General Assembly.

35. "Millimeter and Submillimeter Techniques"
    John Carlstrom and Jonas Zomuidzinas
36. "Imaging Algorithms"
    R. J. Sault and T. A. Oosleroo
37. "Recent Advances in Solar Radio Astronomy"
    M. R. Kundu

Commission K

Prof. James C. Lin is Commission K *RRS* Editor.

38. "Biological Effects of Electromagnetic Fields"
    R. de Seze and Bernard Veyret
39. "Medical Applications of Electromagnetic Fields"
    C. K. Chou and W. W. Wang

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Les Statuts de l'URSI

BUTS

ART. 1. - L'Union Radio-Scientifique Internationale a pour but de stimuler et de coordonner, à l'échelle internationale, les études dans les domaines des sciences de la radioélectricité, des télécommunications et de l'éléctronique et, plus particulièrement :

a) de promouvoir et d'organiser les recherches exigeant une coopération internationale, ainsi que la discussion et la diffusion des résultats de ces recherches;
b) d'encourager l'adoption de méthodes de mesure communes, ainsi que la comparaison et l'étalonnage des instruments de mesure utilisés dans les travaux scientifiques;
c) de stimuler et de coordonner les études portant sur
   - les aspects scientifiques des télécommunications utilisant les ondes électromagnétiques guidées et non guidées,
   - la production et la détection de ces ondes, ainsi que le traitement des signaux dont elles sont porteuses.

MEMBRES

ART.2 - Les Membres de l'Union sont les Comités dont les demandes d'admission ont été acceptées au cours d'une Assemblée générale ordinaire.

ART. 3 - Un Comité Membre est créé dans un territoire donné, par l'Académie des Sciences ou le Conseil de la Recherche, ou bien par une institution ou association d'institutions analogues.

ART. 4 - L'Union peut admettre comme membre tout Comité qui, dans un territoire donné, développe une activité dans le domaine de la radioélectricité scientifique.

ART. 5 - Dans leurs territoires respectifs, les Comités Membres ont les mêmes buts que l'Union; entière liberté leur est laissée quant à leur organisation interne.

ART. 6 - Chaque Comité Membre désigne un Représentant au Conseil (voir Art. 21) et un Membre officiel au sein de chacune des Commissions (voir Art. 30). Un même Membre officiel peut représenter son Comité au sein de deux ou plusieurs Commissions. Les membres du Bureau ne peuvent pas représenter un Comité Membre au Conseil.

ART. 7 - Lors de leur adhésion à l'Union, les Comités Membres choisissent la Catégorie dans laquelle ils se proposent d'être classés. Le nombre des unités de contribution annuelle dues à l'Union ainsi que le nombre de voix qui leur est attribué au sein du Conseil sont déterminés par la Catégorie choisie et sont spécifiés ci-dessous :

Catégorie :						
1	2	3	4	5	5A	6
Nombre de voix :						
2	4	6	8	10	11	12
Nombre d'unités de contribution :						
1	2	4	8	16	24	32

Le montant de l'unité de contribution est fixé par le Conseil.

ART. 8 - Les Comités Membres peuvent passer à une Catégorie supérieure au début de l'année financière. Ils peuvent passer à une Catégorie inférieure soit au cours d'une Assemblée générale ordinaire, soit dans la période de trois mois qui suit la fin de l'Assemblée. Tout transfert d'une catégorie à une autre entre en vigueur au début de l'année financière suivante.

ART. 9 - A moins d'une décision contraire du Conseil, tout Comité Membre qui n'aura pas versé sa contribution annuelle à deux reprises est considéré comme cessant de faire partie de l'Union. Ce Comité pourra néanmoins demander à être admis dans la catégorie des Membres associés.

ART. 10 - Les Comités Membres peuvent quitter l'Union en signifiant leur intention par écrit au Secrétaire général. En cas de démission, ils sont tenus de payer leur contribution annuelle pour l'année en cours.

ART. 11 - Les Comités Membres qui quittent l'Union, ou qui sont considérés comme ayant cessé d'en faire partie en vertu de l'Art. 9, perdent tous droits à l'actif de l'Union.

ART. 12 - En cas de dissolution de l'Union, le Conseil dispose des avoirs de l'Union; ceux-ci ne seront pas répartis entre les Membres.

MEMBRES ASSOCIES

ART. 13 - La catégorie des Membres associés est réservée, à titre d'option, a) aux Comités qui sont créés en vertu des Arts 3, 4, et 5, mais qui ne réunissent pas encore toutes les conditions pour solliciter leur adhésion en tant que Membres, et b) aux Comités Membres de l'Union qui, pour des raisons d'ordre financier, souhaitent passer temporairement à la catégorie de Membres associés. Le statut de chacun des Membres associés sera réexaminé lors de chaque Assemblée générale.

ART. 14 - Les Membres associés de l'Union sont les Comités dont les demandes d'admission dans cette catégorie ont été acceptées au cours d'une Assemblée générale ordinaire.

ART. 15 - Les Comités Membres associés ne versent pas de contribution annuelle à l'Union. Ils n'ont pas droit de vote au Conseil et dans les Commissions, et n'ont aucun droit à l'actif de l'Union.

ART. 16 - Chaque Comité Membre associé désigne un observateur au Conseil et un observateur au sein de chacune des Commissions. Un même observateur peut représenter son Comité au sein du Conseil et de plusieurs Commissions.

ADMINISTRATION ET ORGANISATION

Le Bureau

ART. 17 - La direction des affaires de l'Union et l'organisation de ses activités sont confiées au Bureau qui agit en conformité avec les résolutions et les lignes de conduite générale formulées par le Conseil.

ART. 18 - Le Bureau est composé du Président, du Président sortant, de quatre Vice-Présidents et du Secrétaire général. Le Président peut inviter les Présidents d'honneur à assister aux séances du Bureau à titre consultatif.

ART. 19 - Le Bureau se réunit au cours et dans l'intervalle des Assemblées générales, à l'initiative du Président ou de deux de ses membres.

ART. 20 - Dans l'intervalle des Assemblées générales, le Bureau, agissant au nom de l'Union, est autorisé à prendre des décisions sur les affaires urgentes à condition que les décisions ne soient pas en contradiction avec les résolutions et les lignes de conduite générale formulées par le Conseil. Les décisions ainsi prises sont reconsidérées lors de l'Assemblée générale ordinaire suivante.

Le Conseil

ART. 21 - Le Conseil est composé du Président de l'Union et des Représentants des Comités Membres. Chaque Comité Membre ayant rempli ses obligations statutaires désigne un Représentant au Conseil de l'Union.

ART. 22 - Le Conseil se réunit pendant les Assemblées générales de l'Union pour examiner les points figurant à l'ordre du jour cité à l'Art. 65 ou 72.

ART. 23 - Dans le cas où le Représentant d'un Comité Membre serait empêché d'assister à une séance du Conseil, le Comité qu'il représente, ou la Délégation de ce Comité, peut désigner un suppléant pour cette séance. Cette désignation doit être signifiée au Président ou au Secrétaire général avant le début de la séance.

ART. 24 - Dans le cas où un Comité Membre ne pourrait envoyer aucun délégué à l'Assemblée générale, il peut adresser son vote par écrit au Président sur toutes questions figurant à l'ordre du jour, qui est diffusé conformément à l'Art. 65. Pour être valable, ce vote doit être reçu avant le dépouillement du scrutin.

ART. 25 - Le Président invite les membres du Bureau et, lorsque les délibérations portent sur des questions scientifiques, les Présidents des Commissions intéressées à assister aux séances du Conseil à titre consultatif. Il peut inviter les Présidents d'honneur au même titre.

Les Commissions Scientifiques

ART. 26 - La réalisation des buts de l'Union dans les différents domaines de la radioélectricité scientifique incombe aux Commissions scientifiques, qui sont établies par le Conseil. Les Comités scientifiques sont établis par le Conseil pour étudier les questions présentant un intérêt commun à plusieurs Commissions.

ART. 27 - Les Commissions ont pour fonctions :

(a) de se tenir au courant des progrès réalisés dans la mise en œvre des buts définis à l'Art. 1;

(b) d'assurer la présentation et la discussion d'exposés relatant ces progrès au cours des Assemblées générales ordinaires;

(c) de préparer les programmes de travail, résolutions et recommandations à soumettre au Conseil en conformité avec l'Art. 29;

(d) de former des Groupes de travail pour l'étude de sujets scientifiques déterminés;

(e) d'organiser, dans l'intervalle des Assemblées générales, les colloques scientifiques ainsi que les réunions des Groupes de travail qui ont reçu l'approbation du Bureau.

ART. 28 - Les Commissions se réunissent pendant les Assemblées générales ordinaires. Dans des circonstances particulières et avec l'approbation du Bureau, les Présidents des Commissions peuvent convoquer des réunions de leur Commission en tout autre moment.

ART. 29 :

a) Pour toutes questions se rapportant à l'administration de l'Union ou ayant des implications financières, les Commissions présentent leurs vues et opinions sous forme de recommandations.

b) Pour toutes questions ressortissant à leurs mandats respectifs, et ne tombant pas sous a) ci-dessus, les Commissions peuvent adopter les résolutions. Celles-ci sont présentées au Conseil pour information.

ART. 30 - Chaque Commission est composée d'un Président, d'un Vice-Président et des Membres officiels désignés par les Comités Membres, à raison d'un Membre officiel par Comité Membre.

ART. 31 - Dans le cas où un Membre officiel serait empêché d'assister à une séance de sa Commission, il peut soit désigner un suppléant parmi les membres de sa délégation, soit adresser son vote par écrit au Président de la Commission, sur toute question à l'ordre du jour. Dans la deuxième éventualité, ce vote, pour être valable, doit être reçu avant le dépouillement du scrutin.

ART. 32 - La mise en œvre des programmes recommandés par les Commissions ou les Comités scientifiques incombe aux Comités Membres qui acceptent d'y prendre part.

ART. 33 - Chaque Groupe de travail formé en vertu de l'Art. 27 d) est dissous à la fin de l'Assemblée générale ordinaire qui suit celle de sa création. Le Groupe de travail dont la tâche n'est pas terminée au moment de l'Assemblée générale peut être reconstitué par la Commission-mère.

ART. 34 - Les Présidents et les membres des Groupes de travail sont désignés par le Président de la Commission-mère après consultation des Membres officiels, si besoin par correspondance.

ART. 35 - Chaque Groupe de travail prépare un rapport d'activité comprenant ses conclusions et recommandations; la data de présentation de ce rapport est fixée par le Président de la Commission-mère.

Le Comité de Coordination

ART. 36 - Le Comité de Coordination est composé des Présidents des Commissions et des Comités scientifiques, et des membres du Bureau. Dans le cas où le Président d'une Commission serait empêché s'assister à une réunion du Comité de Coordination, il peut se faire représenter par le Vice-Président de sa Commission.

ART. 37 - Le Comité de Coordination a pour tâche :

a) de coordonner les activités scientifiques des Commissions, particulièrement dans les domaines où l'action conjointe de deux ou plusieurs Commissions paraît souhaitable,
b) de préparer le programme scientifique des Assemblées générales.

ART. 38 - Le Comité de Coordination se réunit au moins un an avant chaque Assemblée générale ordinaire pour en établir le programme scientifique. Le Président convoque des réunions du Comité de Coordination pendant l'Assemblée générale.

Divers

ART. 39 - Le Président de l'Union préside les séances du Bureau, du Conseil et du Comité de Coordination. En cas d'absence ou d'empêchement, il est remplacé par le Président sortant.

ART. 40 - Le Bureau désigne l'un des Vice-Présidents comme Trésorier de l'Union. Le Trésorier gère les fonds de l'Union en conformité avec les directives du Conseil. Il est tenu de déléguer au Secrétaire général les pouvoirs nécessaires à la conduite des affaires financières courantes.

ART. 41

a) Le Secrétaire général assure la gestion des affaires de l'Union et l'organisation de ses activités en conformité avec les directives du Bureau. Il est chargé, en particulier, de la mise en œvre des résolutions adoptées au cours des Assemblées générales, du maintien des rélations avec les Comités Membres, les Comités Membres associés, les Commissions et autres organes de l'Union, ainsi que des publications de l'Union.
b) Le Bureau a pouvoir de désigner, sur proposition du Secrétaire général, un Secrétaire général adjoint qui restera en fonction de la date de sa nomination jusqu'à la fin de l'Assemblée générale ordinaire suivante. Le Secrétaire général peut déléguer certaines des tâches qui lui incombent au Secrétaire général adjoint.

ART. 42 - Tous les actes qui engagent l'Union et ont été approuvés par le Bureau sont signés par deux membres du Bureau dont l'un doit être soit le Président soit le Secrétaire général.

ART. 43 - Le Bureau peut donner pouvoir à l'un de ses membres pour ester en justice.

ELECTIONS

ART. 44 - L'admission officielle de nouveaux Comités Membres par le Conseil ne peut s'effectuer qu'au cours d'une Assemblée générale ordinaire. L'admission provisoire de ces Comités, sans droit de vote, peut être autorisée par le Bureau à partir de la date de paiement de la première contribution annuelle à l'Union.

ART. 45 - L'admission officielle de nouveaux Comités Membres associés par le Conseil ne peut s'effectuer qu'au cours d'une Assemblée générale ordinaire. L'admission provisoire de Membres associés peut être autorisée par le Bureau.

ART. 46 - Les membres du Bureau sont élus par le Conseil au cours de l'Assemblée générale ordinaire. Leur mandat entre en vigueur à l'issue de l'Assemblée qui a prononcé leur élection et prend fin à l'issue de l'Assemblée générale ordinaire.suivante.

ART. 47 - Les candidats aux fonctions de membre du Bureau sont présentés par les Comités Membres. Les candidats ne sont éligibles que moyennant les conditions suivantes :

a) soit leur candidature est présentée par au moins deux Comités, soit elle est présentée par un seul Comité et appuyée ultérieurement par au moins un autre Comité;
b) ils doivent confirmer au Secrétaire général qu'ils acceptent de prendre part aux élections.

ART. 48 - La liste définitive des candidats éligibles est établie selon la procédure suivante :

a) Au plus tard six mois avant l'ouverture de l'Assemblée générale ordinaire, le Secrétaire général invite tous les Comités Membres à présenter leurs candidats, à raison d'un candidat à chacun des postes suivants : Président, quatre Vice-Présidents, Secrétaire général.
b) Sur la base de ces propositions, qui doivent lui parvenir au plus tard cinq mois avant l'Assemblée, le Secrétaire général diffuse aux Comités Membres deux listes provisoires indiquant les noms des candidats et les Comités proposants :
   Liste A : candidats présentés par au moins deux Comités,
   Liste B : candidats présentés par un seul Comité.
c) Tout Comité peut appuyer les candidatures figurant dans la liste B, à raison d'une candidature pour chacun des postes cités en a). Notification en est donnée au Secrétaire général au plus tard trois mois avant l'Assemblée.
d) La liste définitive des candidats éligibles est diffusée aux Comités Membres au plus tard deux mois avant l'Assemblée.

ART. 49 - Dans le cas où le Secrétaire général ne serait pas réélu, le Bureau veille à prendre toutes les dispositions utiles pour que les responsabilités soient transférées au nouveau Secrétaire général au plus tard six mois après la fin de l'Assemblée générale.

ART. 50 - Le Président n'est pas rééligible. Les Vice-Présidents peuvent être réélus une fois.

ART. 51 - Après consultation des membres du Bureau et des Comités Membres, le Président peut pourvoir aux vacances intervenant au sein du Bureau. Tout membre ainsi nommé assume ses fonctions jusqu'à la fin de l'Assemblée générale ordinaire suivante ; il peut être élu pour le terme suivant même dans le cas où le membre du Bureau qu'il a été appelé à remplacer n'est pas rééligible.

ART. 52 - Le Conseil peut conférer le titre de Président d'honneur à un ancien membre du Bureau ou à un ancien Président de Commission qui a apporté une contribution particulière à la réalisation des buts de l'Union ; le nombre des Présidents d'honneur n'excédera pas cinq.

ART. 53 - Les Présidents et les Vice-Présidents des Commissions sont élus par le Conseil sur recommandation des Commissions respectives. Les Présidents entrent en fonction à la fin de l'Assemblée qui a prononcé leur élection et leur mandat expire à la fin de l'Assemblée générale ordinaire suivante. Sauf circonstances exceptionnelles ou abolition de la Commission, les Vice-Présidents succèdent automatiquement aux Présidents.

ART. 54 - Les Présidents de Commission qui sont en même temps Membres officiels au sein de leur propre Commission sont tenus de désigner un autre membre de leur délégation comme Membre officiel pour la durée de l'Assemblée générale.

ART. 55 - Chaque Commission peut élire un secrétaire de langue française et un secrétaire de langue anglaise parmi les délégués présents à l'Assemblée générale.

ART. 56 - Les Présidents des Comités scientifiques sont élus par le Conseil sur recommandation du Bureau.

ART. 57 - Les représentants de l'Union auprès d'autres organisations internationales sont élus par le Conseil sur recommandation du Bureau.

L'ASSEMBLEE GENERALE ORDINAIRE

ART. 58 - L'Union se réunit normalement tous les trois ans en Assemblée générale ordinaire. Au cours de l'Assemblée ont lieu :

a) des séances du Conseil, du Comité de Coordination et du Bureau,
b) des séances administratives des Commissions,
c) des séances plénières réunissant tous les délégués désignés par les Comités Membres et les observateurs,
d) des séances scientifiques des Commissions et des colloques,
e) des séances des groupes de travail établis par les Commissions.

ART. 59 - A l'assemblée générale ordinaire assistent :

a) les membres du Bureau,
b) les Présidents et Vice-présidents des Commissions,
c) les Présidents des Comités scientifiques,
d) les délégations des Comités Membres comprenant chacune le représentant au Conseil, les Membres officiels des Commissions et des délégués ordinaires,
e) les délégations des Comités Membres associés comprenant chacune l'observateur au Conseil, les observateurs au sein des Commissions et des délégués ordinaires,
f) les Présidents d'honneur et anciens Présidents de l'Union,
g) les représentants invités en vertu de l'Art. 61.

ART. 60 - Les séances scientifiques des Commissions et les colloques sont ouverts à tous les scientifiques (y compris les étudiants) inscrits comme participants au début de l'Assemblée générale. Le nombre total des participants pourrait être limité par le Comité Membre qui organise l'Assemblée générale en fonction des possibilités locales.

ART. 61 - Le Président de l'Union peut inviter les représentants désignés par des organisations internationales à assister à l'Assemblée générale en qualité d'observateurs.

ART. 62 - La date et le lieu de l'Assemblée générale sont communiqués par le Secrétaire général aux Comités Membres et aux Comités Membres associés au moins six mois avant l'ouverture de l'Assemblée.

ART. 63 - L'ordre du jour des séances du Conseil est établi sur la base des propositions présentées par les Comités Membres, le Bureau, le Comité de Coordination, les Commissions et les Comités scientifiques de l'Union.

ART. 64 - Les questions à inclure à l'ordre du jour du Conseil doivent parvenir au Secrétaire général au moins quatre mois avant l'ouverture de l'Assemblée générale. Toute question présentée ultérieurement n'est prise en considération qu'avec l'assentiment préalable d'au moins la moitié des voix émises par les membres présents à la séance.

ART. 65 - L'ordre du jour des séances du Conseil est préparé par le Secrétaire général et communiqué aux Comités Membres et aux Comités Membres associés au moins trois mois avant l'ouverture de l'Assemblée.

ART. 66 - Pour chaque Assemblée générale ordinaire, le Secrétaire général prépare :

a) à l'intention du Conseil, un rapport circonstancié sur les affaires de l'Union, y compris un état des recettes et des dépenses, depuis la dernière Assemblée générale ordinaire ainsi qu'un projet de prévisions budgétaires pour le triennat suivant,
b) à l'intention de tous les délégués, un rapport général sur les activités de l'Union depuis la dernière Assemblée générale ordinaire.

ART. 67 - Le Conseil a pleins pouvoirs pour décider de toutes les activités découlant pour l'Union des buts définis à l'Art. 1.
Il a pour attributions particulières :

a) d'examiner les mesures prises par le Bureau depuis l'Assemblée générale ordinaire précédente relativement aux affaires de l'Union;
b) d'élire :
   (i) les membres du Bureau,
   (ii) les Présidents et Vice-Présidents des Commissions,
   (iii) les Présidents des Comités scientifiques,
   (iv) les représentants de l'Union auprès d'autres organisations internationales;
c) de créer et d'abolir les Commissions et les Comités scientifiques et d'en déterminer les titres et mandats;
d) d'examiner et, si jugé opportun, d'approuver les programmes de travail, résolutions et recommandations présentés par les Commissions et les Comités scientifiques de l'Union;
e) sur proposition du Bureau, d'examiner les demandes d'admission à l'Union et, si jugé opportun, d'accepter ces demandes;
f) sur proposition du Bureau, d'examiner les demandes d'admission à l'Union dans la catégorie des Membres associés et, si jugé opportun, d'accepter ces demandes;
g) de fixer l'année et le lieu de l'Assemblée générale ordinaire suivante;
h) de désigner un Comité des finances permanent chargé:
   (i) de préparer un rapport sur les comptes de l'Union depuis la dernière Assemblée générale ordinaire et sur les prévisions budgétaires pour la période allant jusqu'à l'Assemblée générale ordinaire suivante,
   (ii) de présenter ses recommandations concernant les finances de l'Union,
   (iii) d'aider le Trésorier, à sa demande, à faire le point sur les affaires financières de l'Union pendant la période allant jusqu'à l'Assemblée générale ordinaire suivante.
i) sur proposition du Comité des finances, d'approuver les comptes et les prévisions budgétaires et de considérer les recommandations formulées par ce Comité;
j) de déterminer le montant de l'unité de contribution définie à L'Art. 7;
k) sur proposition du Bureau, d'approuver les amendements aux Statuts;
l) de prende des décisions sur toutes autres questions touchant les activités de l'Union.

ART. 68 - Les résolutions adoptées par le Conseil et les Commissions au cours de l'Assemblée générale sont présentées pour information à la séance plénière de clôture de l'Assemblée à laquelle assistent tous les délégués et observateurs.

ART. 69 - A défaut de prescriptions pertinentes dans les Statuts, ou bien dans des circonstances exceptionnelles, le Conseil est autorisé :
a) à prendre des décisions sur toutes les questions relatives aux activités de l'Union,
b) à établir des règles pour la conduite des travaux de l'Assemblée générale.

Ces décisions et règles ne peuvent contenir de prescriptions qui seraient en contradiction avec les termes des Statuts.

L'ASSEMBLEE GENERALE EXTRAORDINAIRE

ART. 70 - Dans des circonstances particulières et avec approbation de la majorité des voix des Comités Membres, le Président peut convoquer une Assemblée générale extraordinaire. Il est tenu de le faire lorsqu'il en est requis par un tiers au moins des voix de tous les Comités Membres.

ART. 71 - Le Conseil, tel que défini à l'Art. 21, siège au cours de l'Assemblée générale extraordinaire. Le Président peut inviter les membres du Bureau, les Présidents d'honneur et les Présidents des Commissions à assister aux séances à titre consultatif.

ART. 72 - L'ordre du jour, la date et le lieu de l'Assemblée générale extraordinaire sont communiqués aux Comités Membres par le Secrétaire général au moins trois mois avant l'ouverture de l'Assemblée.

Procedure de vote

ART. 73 -
a) Au sein du Conseil, seuls les Représentants des Comités Membres ont droit de vote. Le nombre des voix attribuées à chacun des Représentants est déterminé par la Catégorie de son Comité, suivant le barème figurant à l'Art. 7. Toutes les résolutions du Conseil sont adoptées à la majorité simple des voix, exception faite de celles portant modification des Statuts, pour lesquelles la majorité des deux tiers est requise.
b) Au sein des Commissions, chaque Membre officiel présent, ou votant en vertu de l'Art. 31, ou bien son suppléant, a une voix.
c) Au sein du Bureau, du Comité de Coordination et des Comités, chaque membre présent a une voix. Un membre du Bureau qui est rémunéré pour ses services à l'Union n'a pas droit de vote.
d) Au sein du Bureau, du Conseil, du Comité de Coordination, des Commissions et des Comités, les décisions sont prises en tenant compte du nombre des votes positifs et des votes négatifs émis par les membres présents et prenant part au scrutin. En cas d'égalité des voix, la décision appartient au Président. Les votes adressés par écrit en vertu des Arts 24 et 31 ne sont admis que dans les séances du Conseil et des Commissions.

Quorum

ART. 74 - Dans les séances du Bureau et du Conseil, le quorum est atteint par la moitié du nombre des membres. Dans les séances du Comité de Coordination, il est constitué par la moitié du nombre des membres du Bureau et les représentants de la moitié du nombre des Commissions.

ART. 75 - Dans le cas où le quorum ne serait pas atteint par le nombre des membres présents au Conseil, le Président peut convoquer une séance extraordinaire ; celle-ci n'aura pas lieu avant expiration d'un délai de 24 heures. Dans ces conditions, si le nombre des membres présents n'est pas inférieur à douze, le quorum sera atteint nonobstant l'Art. 74.

Finances

ART. 76 - Les recettes de l'Union proviennent

a) des contribution annuelles payées par les Comités Membres en vertu de l'Art. 7,
b) de donations et de subsides des Comités Membres,
c) de donations et de subsides provenant d'autres sources et acceptés avec l'assentiment du Conseil.

ART. 77 - Les fonds provenant de donations et de subsides sont utilisés selon les désirs exprimés par les donateurs. Tous les autres fonds sont consacrés à couvrir les dépenses faites par l'Union en vue de la réalisation de ses buts.

ART. 78 - Les dépenses ordinaires de l'Union comprennent:

a) les frais de voyage des membres du Bureau, des Présidents et Vice-Présidents des Commissions et des membres du Secrétariat se déplaçant pour les besoins de l'Union,
b) les frais de rédaction et d'impression des publications de l'Union,
c) les frais d'administration,
d) toutes autres dépenses autorisées par le Conseil.

ART. 79 - Au cours de l'année financière, le Trésorier peut autoriser des dépenses supplémentaires ne dépassant pas le tiers du solde du Fonds pour Cas Speciaux à la fin de la dernière Assemblée générale ordinaire. Toutes les dépenses excédant ce montant doivent être autorisées par le Bureau.

ART. 80 - L'année financière de l'Union commence le 1er janvier et prend fin le 31 décembre.

Divers

ART. 81 - Les langues officielles de l'Union sont le français et l'anglais. Tous les documents administratifs sont publiés dans les deux langues.

ART. 82 - En cas de contestation, le texte français des Statuts fait foi.

The URSI Statutes

OBJECTS

ART. 1. - The object of the International Union of Radio Science (Union Radio-Scientifique Internationale) is to stimulate and to coordinate, on an international basis, studies in the field of radio, telecommunication and electronic sciences and, within these fields:

a) to promote and organize research requiring international cooperation, and the discussion and dissemination of the results of this research ;
b) to encourage the adoption of common methods of measurement, and the intercomparison and standardisation of the measuring instruments used in scientific work ;
c) to stimulate and coordinate studies of :
   - the scientific aspects of telecommunications using electromagnetic waves, guided and unguided.
   - the generation and detection of these waves, and the processing of the signals embedded in them.

MEMBERS

ART. 2 - The Members of the Union are the Committees whose applications for membership have been adopted at an Ordinary General Assembly.

ART. 3 - A Member Committee is established in a territory by the Academy of Sciences or the Research Council, or by a similar institution or association of institutions.

ART. 4 - The Union can admit to membership a Committee in any territory in which there is an interest in radio science.

ART. 5 - Member Committees, within their respective territories, have the same objects as the Union; they have complete freedom in matters relating to their internal organization.

ART. 6 - Each Member Committee appoints a Representative to the Council (See Art. 21) and one Official Member to each Commission (See Art. 30). The same Official Member can represent his Committee on more than one Commission. A Member of the URSI Board of Officers cannot be appointed as Representative to the Council.

ART. 7 - Each Member Committee is free to choose the Category in which it will adhere to the Union. The number of units of contribution payable annually to the Union by a Member Committee and the number of votes allocated to it in meetings of the Council are determined by the Category chosen and are as follows :

Category						
1	2	3	4	5	5A	6
Number of votes						
2	4	6	8	10	11	12
Number of units of contribution						
1	2	4	8	16	24	32

The value of the unit of contribution is fixed by the Council.

ART. 8 - A Member Committee can transfer to a higher Category at the beginning of any financial year. A transfer to a lower Category can be made during an Ordinary

General Assembly or during the three-month period after the end of an Assembly. The transfer takes effect from the beginning of the next financial year.

ART. 9 - Unless the Council decides otherwise, a Member Committee which has not paid its annual contribution for two years is considered to have resigned from the Union. The Committee may, however, apply for Associate Membership.

ART. 10 - A Member Committee can resign from the Union by giving notice in writing to the Secretary General. In the event of resignation, the Member Committee is liable to pay its annual contribution for the current year.

ART. 11 - A Member Committee which resigns from the Union, or which is considered as having resigned in accordance with Art. 9, loses all rights to the assets of the Union.

ART. 12 - In the event of the dissolution of the Union, the Council decides on the disposal of the assets of the Union. The assets may not be distributed among the Members.

ASSOCIATE MEMBERSHIP

ART. 13 - Associate Membership is reserved, as an option, for a) Committees which are established in accordance with Art. 3, 4 and 5, but are not yet ready for full membership ; and b) Committees which, being already Members of the Union, wish to transfer temporarily to Associate Membership for financial reasons. Every Associate Membership will be reviewed at each General Assembly.

ART. 14 - Associate Member Committees are admitted to the Union at an Ordinary General Assembly.

ART. 15 - Associate Member Committees are not required to pay an annual contribution to the Union. They have no voting rights in the Council and in the Commissions, and have no rights to the assets of the Union.

ART. 16 - Each Associate Member Committee appoints one observer to the Council, and one observer to each Commission. The same observer can represent his Committee on the Council and no more than one Commission.

ADMINISTRATION AND ORGANIZATION

Board of Officers

ART. 17 - The direction of the affairs of the Union and the organization of its work are the responsibilities of the Board of Officers which acts in accordance with the resolutions and general guidance of the Council.

ART. 18 - The Board of Officers comprises the President, the Immediate Past President, four Vice-Presidents and the Secretary General. The President can invite Honorary Presidents to attend meetings of the Board in an advisory capacity.

ART. 19 - The Board of Officers meets during and between General Assemblies at the request of the President or of two of its members.

ART. 20 - During the interval between General Assemblies, the Board of Officers, acting in the name of the Union, can make decisions relating to urgent matters provided that these decisions do not conflict with the resolutions and general guidance of the Council. Decisions made in this way are subject to review at the next Ordinary General Assembly.

Council

ART. 21 - The Council comprises the President of the Union and Representatives of Member Committees. Each Member Committee which has complied with its statutory obligations appoints one Representative to the Council of the Union.

ART. 22 - The Council meets during General Assemblies of the Union to consider the agenda referred to in Art. 65 or 72. Resolutions of the Council are adopted in the name of the Union.

ART. 23 - If the Representative of a Member Committee is unable to be present at a meeting of the Council, the Committee that he represents or the Delegation of this Committee can appoint a substitute for that meeting. Notice of such a substitution must be given to the President or the Secretary General before the beginning of the meeting.

ART. 24 - If a Member Committee is unable to send any delegate to a General Assembly, the Committee can submit its vote in writing to the President on any item which appears in the agenda circulated in accordance with Art. 65. Such a vote is valid only if it is received before the counting of the votes.

ART. 25 - The President invites the members of the Board of Officers and, when scientific matters are discussed, the appropriate Chairmen of Commissions to attend meetings of the Council in an advisory capacity. He can invite Honorary Presidents in the same capacity.

Scientific Commissions

ART. 26 - The achievement of the objects of the Union within particular parts of the fields of radio science is the responsibility of the scientific Commissions which are established by the Council. Scientific Committees of the Union are established by the Council to deal with matters which are of interest to several Commissions.

ART. 27 - The functions of a Commission are :

(a) to keep under review the progress made in the achievement of the objects referred to in Art. 1;

(b) to arrange for the presentation and discussion of surveys of progress during Ordinary General Assemblies;

(c) to prepare programmes of work, resolutions and recommendations for submission to the Council in accordance with Art. 29;

(d) to form Working Groups for the study of particular scientific subjects;

(e) to organize, between General Assemblies, scientific symposia and meetings of Working Groups that have been approved by the Board of Officers.

ART. 28 - The Commissions meet during Ordinary General Assemblies. In special circumstances and with the approval of the Board of Officers, the Chairman of a Commission can convene a meeting of his Commission at any time.

ART. 29 :

(a) The opinion of a Commission on any matter which relates to the administration of the Union or which has financial implications is submitted to the Council in the form of a recommendation.

(b) A Commission can adopt resolutions on matters within its terms of reference other than those specified in (a). Such resolutions are submitted to the Council for information.

ART. 30 - Each Commission comprises a Chairman, a Vice-Chairman and the Official Members ; one official Member is appointed by each of the Member Committees.

ART. 31 - If an Official Member of a Commission is unable to be present at a meeting of the Commission, he may nominate a member of his delegation to represent him, or he may submit his vote on any item in writing to the Chairman of the Commission. In the latter case his vote will be valid only if it is received before the counting of the votes.

ART. 32 - The execution of programmes recommended by the Commissions or the scientific Committees is the responsibility of the Member Committees which agree to participate in them.

ART. 33 - Each Working Group formed in accordance with Art. 27 (d) is dissolved at the end of the General Assembly following that of its creation. A Working Group which has not completed his task by the date of the General Assembly can be reconstituted by the parent Commission.

ART. 34 - The Chairman and the members of a Working Group are chosen by the Chairman of the parent Commission after consultation with the Official Members, if necessary by correspondence.

ART. 35 - Each Working Group prepares a report on its work including conclusions and recommendations ; the date for the submission of this report is fixed by the Chairman of the parent Commission.

Coordinating Committee

ART. 36 - The Coordinating Committee comprises the Chairmen of the Commissions and of the scientific Committees and the members of the Board of Officers. If a Chairman is unable to be present at a meeting of the Coordinating Committee, he can authorize the Vice-Chairman of his Commission to represent him.

ART. 37 - The Coordinating Committee is responsible for:

(a) the coordination of the scientific activities of the Commissions, especially where joint action by or more Commissions is desirable ;

(b) the planning of the scientific programme of General Assemblies.

ART. 38 - The Coordinating Committee meets at least one year before each Ordinary General Assembly to define the scientific programme for the Assembly. The President convenes meetings of the Coordinating Committee during a General Assembly.

Miscellaneous

ART. 39 - The President of the Union presides at meetings of the Board of Officers, the Council and the Coordinating Committee. If he is absent or unable to preside the Immediate Past President presides.

ART. 40 - The Board of Officers nominates one of the Vice-Presidents as Treasurer of the Union. The Treasurer manages the finances of the Union in accordance with the directives issued by the Council. The Treasurer must delegate to the Secretary General the powers necessary to enable him deal with day-to-day financial matters.

ART. 41 -

(a) The Secretary General is responsible for the management of the affairs of the Union and for the organization of its work under the direction of the Board of Officers. In particular he is responsible for the implementation of Resolutions adopted during General Assemblies, for maintaining contact with the Member Committees, the Associate Member Committees, the Commissions and other organs of the Union, and for the publications of the Union.

(b) The Board is empowered to appoint, on nomination by the Secretary General, an Assistant Secretary General, who will serve from the date of his appointment until the end of the next Ordinary General Assembly. The Secretary General may delegate some of his duties to the Assistant Secretary General.

ART. 42 - All documents that are formally binding on the Union and that have been approved by the Board of Officers are signed by two members of the Board, one of whom must be the President or the Secretary General.

ART. 43 - The Board of Officers can nominate one of its members to act for the Union in legal proceedings.

Elections

ART. 44 - The formal admission of new Member Committees by the Council takes place only at an Ordinary General Assembly. Provisional membership, without voting rights, can be authorized by the Board of Officers from the date of payment of the first annual contribution to the Union.

ART. 45 - The formal admission of new Associate Member Committees by the Council takes place at an Ordinary General Assembly. Provisional admission to Associate Membership can be authorized by the Board.

ART. 46 - The Members of the Board of Officers are elected by the Council during an Ordinary General Assembly. Each member holds office from the end of the Assembly at which he is elected until the end of the next Ordinary General Assembly.

ART. 47 - Candidates for membership of the Board of Officers are nominated by Member Committees. A candidate is not eligible for election unless :

(a) either he has been nominated by two or more Committees, or he has been nominated by one Committee and has later been supported by at least one other Committee.
(b) he has confirmed to the Secretary General that he is willing to stand for election.

ART. 48 - The final list of eligible candidates is prepared in accordance with the following procedure :

(a) Not later than six months before the beginning of an Ordinary General Assembly, the Secretary General invites every Member Committee to nominate one candidate for each of the following offices : President, four Vice-Presidents, Secretary General.
(b) On the basis of the nominations he receives not later than five months before the Assembly, the Secretary General sends to the Member Committees two provisional lists showing the names of the candidates and the Committees which nominated them:
List A, candidates nominated by two or more Committees;
List B, candidates nominated by one Committee only.
(c) Any Committee can support one of the candidates in List B for each of the offices mentioned in (a) by notifying the Secretary General not later than three months before the Assembly.
(d) The final list of eligible candidates is sent to Member Committees not later than two months before the Assembly.

ART. 49 - If the Secretary General is not re-elected, the Board of Officers is responsible for making all the necessary arrangements for the transfer of responsibilities from the outgoing to the incoming Secretary General within a period not exceeding six months after the end of the General Assembly.

ART. 50 - The President can not be elected for a second term, but the Vice-Presidents can be re-elected for a second term.

ART. 51 - A vacancy which occurs in the Board of Officers can be filled by the President after consultation with the Board of Officers and the Member Committees. An Officer appointed in this way holds office until the end of the next Ordinary General Assembly ; he can then be elected to the Board even if the Officer whom he replaced was not eligible for re-election.

ART. 52 - The Council can confer the title of Honorary President on not more than five former members of the Board of Officers or former Chairmen of Commissions who have made notable contributions to the achievement of the objects of the Union.

ART. 53 - The Chairmen and Vice-Chairmen of Commissions are elected by the Council on the recommendation of the respective Commissions. Each Chairman assumes his responsibilities at the end of the Assembly at which he is elected and serves until the end of the next Ordinary General Assembly. Except in unusual circumstances, the Vice-Chairman succeeds automatically as Chairman unless his Commission has been abolished.

ART. 54 - A Chairman of Commission who is also an Official Member for the same Commission must nominate another member of his Delegation to act as official Member during a General Assembly.

ART. 55 - Each Commission may elect one French-speaking and one English-speaking Secretary from the delegates present at a General Assembly.

ART. 56 - The Chairmen of the Scientific Committees are elected by the Council on the recommendation of the Board of Officers.

ART. 57 - The representatives of the Union on other international bodies are elected by the Council on the recommendation of the Board of Officers.

ORDINARY GENERAL ASSEMBLY

ART. 58 - The Union holds an Ordinary General Assembly normally at intervals of three years. At each Ordinary Assembly there are :

(a) Meetings of the Council, the Coordinating Committee and the Board of Officers;
(b) Business Meetings of the Commissions;
(c) Plenary Meetings attended by all Delegates appointed by Member Committees and Observers;
(d) Scientific Meetings of the Commissions, and Symposia;
(e) Meetings of Working Groups established by the Commissions.

ART. 59 - The Ordinary General Assembly is attended by:

(a) Members of the Board of Officers,
(b) Chairmen and Vice-Chairmen of Commissions,
(c) Chairmen of Scientific Committees,
(d) Delegations of Member Committees, each of which comprises the Council Representative, Official Members of Commissions, and ordinary delegates,
(e) Delegations of Associate Member Committees, each of which comprises the Observer to the Council, Observers to the Commissions, and ordinary delegates
(f) Honorary and Past Presidents of the Union,
(g) Representatives invited in accordance with Art. 61.

ART. 60 - Scientific Meetings of Commissions, and Symposia, are open to all scientists (including students) who have registered as participants at the beginning of the General Assembly. The total number of registrants may be restricted by the host Committee so that the meeting can be accommodated within the facilities available.

ART. 61 - The president of the Union can invite representatives nominated by international organizations to attend the General Assembly as observers.

ART. 62 - The date and place of the General Assembly are communicated by the Secretary General to Member Committees and Associate Member Committees not less that six months before the beginning of the Assembly.

ART. 63 - The agenda for the meetings of the Council are based on the proposals submitted by the Member Committees, the Board of Officers, the Coordinating Committee, the scientific Commissions and Committees of the Union.

ART. 64 - Items for inclusion in the agenda for the meetings of the Council must be received by the Secretary General not later than four months before the beginning of the General Assembly. Items received after this date can be added to the agenda only if approval is given by at least half of the votes of those present at the meeting.

ART. 65 - The Secretary General prepares the agenda for the meetings of the Council and communicates them to the Member Committees and Associate Member Committees not less than three months before the beginning of the Assembly.

ART. 66 - For each Ordinary General Assembly, the Secretary General prepares :

(a) for the Council, a detailed report on the affairs of the Union, including the accounts of income and expenditure since the previous Ordinary General Assembly, and the budgetary estimates for the three years following the Assembly;

(b) for all Delegates, a general report on the activities of the Union since the previous Ordinary General Assembly.

ART. 67 - The Council has full power to make decisions on any activity of the Union relating to the objects defined in Art. 1.

In particular it has the following powers and obligations :

(a) to review the direction of the affairs of the Union by the Board of Officers since the previous Ordinary General Assembly ;

(b) to elect :
   (i) the members of the Board of Officers
   (ii) the Chairmen and Vice-Chairmen of Commissions,
   (iii) the Chairmen of scientific Committees,
   (iv) the representatives of the Union on other international bodies;

(c) to create and abolish Commissions and scientific Committees and to decide the titles and the terms of reference of these bodies;

(d) to consider and, if thought fit, to approve programmes of work, resolutions and recommendations submitted by the Commissions and scientific Committees of the Union;

(e) on the proposal of the Board of Officers, to examine and, if thought fit, to accept applications for membership of the Union;

(f) on the proposal of the Board of Officers, to examine and, if thought fit, to accept applications for Associate Membership of the Union;

(g) to decide the year and place of the next Ordinary General Assembly;

(h) to appoint a Standing Finance Committee charged with:
   (i) the preparation of a report on the accounts for the period since the last Ordinary General Assembly and the budget for the period until the next Ordinary General Assembly,
   (ii) the submission of recommendations concerning the finances of the Union,
   (iii) the provision of assistance to the Treasurer, when so requested by him, to review the financial affairs of the Union during the period until the next Ordinary General Assembly,

(i) to approve the accounts and the budget, on the proposal of the Finance Committee, and to consider recommendations made by the Committee ;

(j) to decide the unit of contribution defined in Art. 7 ;

(k) on the proposal of the Board of Officers, to approve proposed amendments to the Statutes ;

(l) to take action on any other matter affecting the activities of the Union.

ART. 68 - Resolutions adopted by the Council and the Commissions during a General Assembly are submitted to the closing plenary meeting of all delegates and observers for information only.

ART. 69 - In the absence of any relevant provisions in the Statutes, or in extraordinary circumstances, the Council is authorized :

(a) to make decisions on all matters relating to the activities of the Union,

(b) to make rules for the conduct of the work of the General Assembly.

These decisions and rules must not contain provisions contrary to the terms of the Statutes.

EXTRAORDINARY GENERAL ASSEMBLY

ART. 70 - In special circumstances and with the approval of the majority of the votes of the Member Committees, the President can convene an Extraordinary General Assembly. He must do so on receipt of a request supported by at least one third of the votes of all Member Committees.

ART. 71 - At an Extraordinary General Assembly, there are meetings of the Council as defined in Art. 21, to which the President can invite members of the Board of Officers, Honorary Presidents and Chairmen of Commissions in an advisory capacity.

ART. 72 - The agenda, the date and the place of an Extraordinary General Assembly are communicated to the Member Committees by the Secretary General not less than three months before the beginning of the Assembly.

VOTING PROCEDURE

ART. 73 :

(a) In meetings of the Council, only the Representatives of Member Committees can vote. The number of votes allocated to each Representative is determined by the Category of his Committee in accordance with the schedule given in Art. 7.

Resolutions of the Council are adopted by a simple majority of votes, with the exception of those relating to modifications of the Statutes for which a two-thirds majority is required.

(b) In meetings of Commissions, each Official Member present, or voting in accordance with Art. 31, or his representative, has one vote.

(c) In meetings of the Board of Officers, the Coordinating Committee and Committees, each member present has one vote. A member of the Board of Officers, who receives remuneration for his services to the Union has no vote.

(d) In meetings of the Board of Officers, the Council, the Coordinating Committee, Commissions and Committees, decisions are based on the affirmative and negative votes of those present and taking part in the vote. In the case of equal numbers of affirmative and negative votes, the Chairman of the meeting decides. Votes submitted in writing in accordance with Arts 24 and 31 are admissible only in meetings of the Council and of the Commissions.

QUORUM

ART. 74 - In meetings of the Board of Officers and of the Council, half the membership constitutes a quorum. In meetings of the Coordinating Committee, half the members of the Board and the representatives of half the number of the Commissions constitute a quorum.

ART. 75 - If the members present at a meeting of the Council do not constitute a quorum, the President can convene an extraordinary meeting timed to begin not less than 24 hours later. Under these circumstances twelve members will constitute a quorum notwith-standing Art. 74.

FINANCES

ART. 76 - The income of the Union is derived from :

(a) annual contributions received from Member Committees in accordance with Art. 7,

(b) donations and grants made by Member Committees,

(c) donations and grants from other sources accepted with the consent of the Council.

ART. 77 - Funds derived from donations and grants are used in accordance with the wishes expressed by the donors. All other funds are used to meet the expenses of the Union incurred in accordance with its objects.

ART. 78 - The ordinary expenses of the Union include :

(a) expenses relating to travel, on business of the Union, of the Officers of the Union, Chairmen and Vice-Chairmen of Commissions, and members of the Secretariat,

(b) the cost of editing and printing the publications of the Union.

(c) administrative expenses,

(d) other expenses authorized by the Council.

ART. 79 - In any financial year the Treasurer may authorize additional expenditure not exceeding one third of the balance in the Special Needs Fund at the end of the preceding Ordinary General Assembly. Expenditure in excess of this amount must be authorized by the Board of Officers.

ART. 80 - The financial year of the Union begins on 1 January and ends on 31 December.

MISCELLANEOUS

ART. 81 - The official languages of the Union are French and English. All administrative documents are issued in both languages.

ART. 82 - In any question relating to the interpretation of these statutes, the French text is regarded as authoritative.

Information for authors

Content

The Radio Science Bulletin is published 4 times a year by Radio Science Press on behalf of URSI, the International Union of Radio Science. Besides general and administrative information issued by the URSI Secretariat, the Bulletin includes a scientific section containing articles and correspondence items (short notes, letters to the editor and book reviews). Contributed papers are preferably of a tutorial nature and should be of interest to a wide range of persons belonging to the Radio Science Community. The subject matter should relate to the analysis and applications of Radio Science in areas of principal or broad interest.

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