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Contents

Editor-in-Chief
URSI Secretary General
Paul Lagasse
Dept. of Information Technology
Ghent University
St. Pietersnieuwstraat 41
B-9000 Gent
Belgium
Tel.: (32) 9-264 33 20
Fax: (32) 9-264 42 88
E-mail: rsb@intec.rug.ac.be

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Telecommunications and Remote Sensing
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Bâtiment Stévin
Place du Levant 2
B-1348 Louvain-la-Neuve
Belgium
Tel.: (32) 10-47 23 03
Fax: (32) 10-47 20 89
E-mail: sobieski@tele.ucl.ac.be

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For information, please contact :
The URSI Secretariat
c/o Ghent University (INTEC)
Sint-Pietersnieuwstraat 41
B-9000 Gent, Belgium
Tel.: (32) 9-264 33 20
Fax: (32) 9-264 42 88
E-mail: inge.heleu@intec.rug.ac.be
http://www.intec.rug.ac.be/ursi

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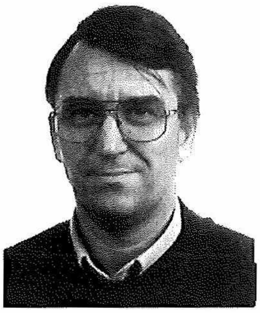
Editorial

Dear URSI Correspondent,

You have in hand the first issue of our bulletin for the year 2000.

We welcome in particular the new URSI Correspondents who will receive, starting from now, the twelve issues of the Radio Science Bulletin covering the URSI inter-assembly triennial period.



The scientific part of our previous issue was devoted to radioastronomy. This time we propose to you three scientific contributions in the field of digital television broadcasting. The contributors come from various parts of the world. One paper is from Japan and is written by Miyasawa, the second one comes from Europe and is authored by Hunt and Doeven while the last one is contributed by Tawil from the USA.

In the administrative part of our Bulletin, announcements about future meetings and conferences are given, as usual. Please note the report from ITU-R in preparation of the next World Radiocommunication Conference (WRC-2000) to be held next June as well as two announcements about the Commission B triennial symposium in Victoria, and the ISSSE meeting in Tokyo.

I wish you a pleasant reading.

Piotr Sobieski, Editor

Letter to the Editor

Comments on "Spectrum Congestion - a Voice in Discussion"

(a letter to the editor by R. Struzak in the December issue of the Radio Science Bulletin)

Paul Delogne
Delogne@tele.ucl.ac.be

I would first like to thank very much and warmly congratulate Ryszard Struzak for providing these very interesting comments. I am seeing these as potentially launching a very interesting discussion inside, and between the radio science and telecommunications communities. I would be very happy indeed if this letter would be the beginning of a lively discussion involving radio scientists and telecommunication engineers on a key issue, i.e. the efficient use of the spectrum. In this game, we are all actors, to variable degrees, either as a victim or as a predator.

Ryszard's letter refers to the tutorial paper presented by Willem Baan and myself at the Toronto URSI General Assembly. As one of the co-authors of this reference paper, I wish to react since Ryszard excessively restricts some view points presented in this paper.

Before starting the discussion, let me however regret that the published paper suffers from edition defaults, which make some equations hardly understandable. More specifically, in equation (9), what should have been a sum operator $\sum_i$ appears as an undefined variable S_j. It is also understood that equation (10) is to be read as

$$(I/N)_i = \sum_{j,j\neq i} t_{ij} P_j / N_i$$

and equation (11) as

$$CS = \sum_{i=1}^{K} C_i = \log_2\left[\prod_{i=1}^{K}(1+a_i q_i)\right]$$

Let us now look at the matter itself. A first remark is that Ryszard's approach confuses spectral efficiency and channel capacity. In his equation (1), C_0 yields the spectral efficiency in bit/s/Hz, not the channel capacity in bit/s. Of course, all specialists will be aware of this and will apply the required correction. My preference would be for the use of the channel capacity, i.e. to include a factor B in the right hand side of equation (1), because this would allow an easier consideration of the bandwidth effect when dealing with interferences between systems using different bandwidths B. Eventually, the bandwidth effect should be made completely visible by expressing the noise power as $N = N_0 B$, where N_0 is the noise power spectral density at the receiver input.

More important however is that capacity evaluations based on Ryszard equation (1) are likely to be very unrealistic. Shannon's equation indeed defines the channel capacity as the maximum information rate which can be achieved under the assumption of infinite coding complexity. This bound cannot be achieved in practice. In the reference paper by W. Baan and myself, we pointed out that the practical information rate can be evaluated by

$$R = B\log_2(1 + q / M)$$

where M is a margin in terms of signal-to-noise ratio against Shannon's limit. The margin M to be used for calculations expresses, to some extent, the coding complexity which can be accepted in practice. We indicated three typical values for M, i.e. 20 (13 dB) for systems without any error correction mechanism, 10 (10 dB) for systems using a classical FEC (forward error correction) technique, and 5 (7 dB) for advanced techniques, such as coded modulations associated with Viterbi decoding.

If this view point is accepted, some equations developed in Ryszard's letter are modified significantly. Including a margin obviously does not change the isolation index, which only expresses the relative importance of noise and interference. But now, for instance, equation (4) should be replaced by

$$R = \log_2(1 + aq / M)$$

and equations (5) and (6) should be modified accordingly. For instance, the relative loss – equation (6) – is now expressed by

$$R / R_0 = [\log_2(1 + aq / M)] / [\log_2(1 + q / M)]$$

Similar modifications are to be brought in equation (11), duly edited as indicated above. The impact of applying a margin M to calculate the achievable information rate or the relative loss may be considerable, depending on the assumed values of q and a, as results from the equations shown above.

Finally, the kind of optimisation proposed by Ryszard should be seen as a first step in the right direction. The equation (11) for the total capacity is however probably too elementary for such purposes. For a realistic approach, it would probably not be enough to include only co-channel interference, but also neighbouring channel interference. Furthermore, applications such as optimising a cellular network would probably need to take into account the total capacity for all available frequency channels, and this would require to include the frequency plan as a parameter to be optimised.

UTC Time Step

On n'introduira pas de seconde intercalaire à la fin de juin 2000.
La différence entre UTI et le Temps Atomique International Tai est :
du 1er janvier 1999, 0h UTC, jusqu'à nouvel avis : UTC - TAI = -32 s
Des secondes intercalaires peuvent être introduites à la fin des mois de décembre ou de juin, selon l'évolution de UT1-TAI. Le Bulletin C est diffusé deux fois par an, soit pour annoncer un saut de seconde, soit pour confirmer qu'il n'y aura pas de saut de seconde à la prochaine date possible.

No positive leap second will be introduced at the end of June 2000.
The difference between UTC and the International Atomic Time TAI is :
from 1999 January 1, 0 h UTC, until further notice : UTC - TAI = -32 s
Leap seconds can be introduced in UTC at the end of the months of December and June, depending on the evolution of UT1-TAI. Bulletin C is mailed every six months, either to announce a time step in UTC, or to confirm that there is no time step at the next possible date.

Daniel GAMBIS
Director, Central Bureau of IERS
Fax: +33 1-40 512291
E-mail: iers@obspm.fr

Planning Considerations for Implementing a Terrestrial Digital Television Service in the United States

Victor Tawil

ABSTRACT - In the fall of 1998, commercial broadcast of digital television (DTV) was officially inaugurated in the United States with more than forty local television stations across the country broadcasting a digital signal. This remarkable and historic achievement is a result of a decade-long cooperative effort between government and industry to transition our uniquely American free over-the-air television system into the digital era. This paper describes a seven-year effort by government and industry to assess the availability of spectrum for digital television within the existing VHF and UHF bands and highlight some of the challenges in developing a DTV assignment plan to accommodate all existing stations in the United States.

1 - Introduction

Television service was first introduced to the American public in the early 1940s. Since that time, television technology has gone through a number of major evolutionary changes in the way it converts pictures and sounds into electrical signals, and then distributes, transmits, and finally restores these pictures on an electronic display. Today, television is the most predominant form of entertainment and information distribution to the American public, with an estimated 200 million television receivers in use an average of seven hours a day.

In early 1987, the Federal Communications Commission (FCC) initiated an inquiry into the feasibility of developing and implementing the next generation of advanced television technologies for the United States. Specifically, the FCC established an all-industry advisory committee, known as the FCC Advisory Committee for Advanced Television Service (ACATS), to develop a technical, economic and public policy record concerning the planning and implementation of a terrestrial advanced television service in the United States and to make recommendations to the FCC. The work of the Advisory Committee was completed in the fall of 1995, with the FCC adopting a DTV (Digital TV) standard in late 1996, followed by the assignment of DTV transitional channels to existing broadcasters in the summer of 1997.

To assist in the work of the Advisory Committee, broadcasters, with the cooperation of the cable television and the consumer electronics industries, established the Advanced Television Test Center (ATTC) for subjective and objective system laboratory testing by experts. The Government of Canada and Canadian broadcasters made a significant contribution to the process by offering to conduct subjective video-quality and impairment testing by lay viewers at their Advanced Television Evaluation Laboratory (ATEL) in Ottawa, Canada. Moreover, broadcasters funded a study program to assess the availability of spectrum for DTV within the existing VHF and UHF bands, and to develop a DTV assignment plan that would accommodate all existing stations in the United States. This paper describes the various computer models developed to carry out studies to determine the availability of spectrum for a digital television system in the United States.

2 - Assignment of DTV Channels

To provide universal television service of the highest quality to the American public, broadcasters in the United States use high-power transmitters, known as full-power, to reach the majority of their urban and suburban audience, while relying on low-power transmitters, known as translators, to reach their rural audience. Currently, there are approximately 1,600 full-power television stations and in excess of 6,000 translators operating on a total of 67 (12 VHF and 55 UHF) channels in the United States. Each channel is 6 MHz-wide. Approximately 40% of the full-power stations operate in the VHF band, while the remaining 60% are at UHF. The average community in the United States receives eleven over-the-air signals and 90% of the nation's households receive seven or more signals.

The current NTSC allotment plan was developed in the early 1950s. The plan uses minimum separation distances to control interference between stations. Specifically, the allotment plan places restrictions on certain channel relationships to satisfy the interference limitations inherent in the NTSC transmission/reception systems. These interference limitations were termed as "taboo"[1] channels

Victor Tawil is with the
Association for Maximum Service Television, Inc.
1776 Massachusetts Avenue, N.W., Suite 310
Washington, DC 20036, USA

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and apply primarily to the UHF band. The original NTSC allotment plan was based on noise-limited service criteria but was modified in certain geographical regions of the United States (such as the east coast) to be interference-limited to accommodate additional stations. Today, more than half of all of the existing stations in the United States have a service area that is limited by interference.

2.1 -Assignment Goals

Seven years ago, the broadcast industry established three basic goals to deal with the assignment of DTV channels. They are:

a. To provide a DTV channel for each current full-power NTSC station.
b. To provide a DTV service area that is at least comparable to the service area of the NTSC station to which it is paired.
c. To minimize the interference to existing NTSC service.

These goals are more complicated than they appear, and in some instances satisfying one of the goals may mean compromising another. For example, the bigger the DTV service area, the lower the number of stations that can be accommodated and/or the greater the interference to the existing NTSC service. In addition, the Commission further complicated these goals by adding an additional requirement that 138 MHz of spectrum be recovered after the transition, thus limiting the number of DTV channels that could be assigned in certain portions of the spectrum. The challenge the broadcast industry faced was how to maximize attainment of all four goals.

2.2 - Assignment Process

Since DTV will be operating in the same spectrum bands as NTSC, the DTV assignment process entails the "squeezing in" of DTV stations among existing NTSC stations without causing greater interference to existing stations or the new DTV assignments. Moreover, in order to allow DTV broadcasting for every existing NTSC station, the DTV station will have to operate at closer co-channel spacing than its NTSC counterpart. Such closer spacing applies to DTV/NTSC and DTV/DTV situations. In addition, the DTV system must be relatively immune to taboo restrictions and be able to operate on the adjacent channels.

The DTV assignment problem is so large and complex as to be almost unmanageable. Theoretically, there are close to an infinite number of ways to assign 67 television channels to the existing 1,600 or so full-power NTSC stations. Even with the help of the fastest computers available today, it may be difficult, if not impossible, to determine the "best" solution from the large universe of possible solutions. The best one can hope for is to find a number of spectrally efficient solutions that best fit or meet the desired goals and objectives established above.

The search for spectrally efficient solutions however was less difficult than anticipated because in areas of high concentration of NTSC stations, such as the east and west coasts of the United States, the availability of assigning DTV channels was very limited. Moreover, the number of possible assignment permutations or plans that can be generated in these areas was also limited. Thus, by focusing our effort on optimizing the assignment of DTV channels in these areas first, we were assured that all remaining stations in the United States could be accommodated, and that the assignment plan would be spectrally efficient.

3 - Model Development

Analysis of spectrum usage for the proposed DTV systems[2] necessitated the development of two computer models — an assignment model and a coverage-and-interference model — to determine the best DTV accommodation results, including the service area expected, for each of the proposed DTV systems. The assignment model was developed to generate spectrally efficient assignment plans for a given set of input conditions. The coverage-and-interference model was developed to evaluate the coverage-and-interference performance of the various plans generated by the assignment model. Improvements were achieved by integrating the two models. The integrated model was used to evaluate and compare the performance of the new Grand Alliance system[3] against the five originally proposed DTV systems, and develop a spectrally efficient assignment plan that was ultimately adopted by the FCC.

3.1 - Assignment Model

The assignment model uses minimum separation distances to determine the number of existing TV stations that can be accommodated with an additional DTV channel under different co-channel, adjacent and taboo channel input conditions. Specifically, the assignment model uses a heuristic approach to explore the trade-off between percentage accommodation and minimum geographic separations and determine the "best" DTV accommodation statistics for a given set of input conditions. This is accomplished by: a) ordering the existing NTSC stations for a given area according to the apparent difficulty of finding a DTV channel; and, b) with the help of mathematical optimization techniques, determining the minimum number of DTV channels that can be assigned to accommodate all NTSC stations for that given area. The output of the model is an assignment table that pairs existing NTSC stations with DTV assignments.

The assignment model is comprised of two basic modules. The first module, the constraint generator module, determines for each existing NTSC station all possible DTV channels that could be assigned for that station based on user-selected minimum co-channel, adjacent and taboo separation distances. The second module, the optimizer/evaluator module, uses a number of the mathematical algorithms described below to iteratively search for the lowest number of DTV channels that could be assigned to accommodate the entire set of NTSC stations for a given area or nationwide.

3.1.1 - Optimization Algorithms

For the last two decades or so, a number of different optimization techniques[4] were developed to solve a variety of large and complex problems dealing with frequency assignment, scheduling, and allocation/distribution of resources. These techniques vary in scope, complexity and performance, and their success depends to a large extent on the type and nature of the problem to be solved.

Two optimization techniques were selected to investigate the DTV assignment problem. The first technique encompasses a number of mathematical algorithms[5], known as successive augmentation algorithms, that use an iterative procedure to solve the assignment problem by ranking the TV stations based on a specified order of assignment difficulty (i.e., LF, SL, RLF, etc.). The second technique uses a general algorithm, known as simulating annealing [Johns 89], that attempts to solve the problem by starting with a random solution and proceeds by repeatedly proposing small changes to the current solution and replacing it whenever the change is an improvement. Improvements are determined using a system of penalties that are closely related to the spacing between stations [Eckert 92]. Both techniques were used to investigate the DTV assignment problem. However, after extensive evaluation, the simulating annealing technique was determined to be superior in satisfying the assignment goals and objectives outlined above.

Evaluation of the successive augmentation algorithms listed in footnote 5 revealed that the Frank Box algorithm almost always achieves the highest DTV accommodation statistics. The Frank Box technique is a heuristic assignment technique that operates on the principle that stations should be assigned channels in descending order of assignment difficulty. Through an iterative procedure, stations that repeatedly fail to be assigned a DTV channel, rise rapidly toward the top of the list of requirements for channels and are accommodated first. The successive reordering of stations by order of difficulty tends to improve accommodation statistics of a resulting solution or plan.

3.1.1.1 – Simulated Annealing Algorithm

When compared with the Frank Box technique, the simulated annealing technique has demonstrated somewhat better DTV accommodation statistics. The algorithm presumes that a "cost" has been defined for every possible solution. The neighbors of a solution are alternatives obtained by making a small change (for example, changing the DTV assignment of a particular station). The likelihood that poorer solutions will be accepted is controlled by a parameter called "temperature", which is reduced after trying a large number of small changes. Initially, the process is started by assigning channels at random, and proceeds to make small changes to the current solution, i.e. reducing the temperature, and eventually accepts a new solution if it has better co-channel and adjacent-channel spacing characteristics. The technique may occasionally accept poorer schemes, depending on the current state of "cooling", but with decreasing probability as the process continues. Spacing characteristics is determined using a set of penalties that associate large penalty values for stations that are at or close to the minimum spacing. Solutions are evaluated based on the sum of all the penalties, i.e. cost. A step-by-step instruction on how the simulated annealing algorithm works is described below:

Step 1. Get an initial solution S.
Step 2. Get an initial temperature T >0.
Step 3. Check to see if process if "frozen" (no improvement).
If not frozen, go to step 4. Otherwise stop process.
Step 4. Perform the following process L times:
a. Pick a random neighboring solution S' of S.
b. Let D = Cost (S') – Cost (S)
c. If D is not greater than 0.0 (improvement), Set S = S'
d. If D is greater than 0.0 (poorer solution), Set S = S' with probability exp (-D/T)
Step 5. Set T = rT (reduce temperature, typically to 95% of previous value).
Step 6. Return to step 1

To effectively apply the simulated annealing algorithm to the DTV assignment problem, some of the control parameters described above (such as the temperature (T), the number of trials (L), the cost of solution, etc.) need to be defined. Definition of these parameters requires extreme care to ensure conversion toward optimum or near optimum solutions. For example, in order to insure that the number of trials at each temperature is adequate, it was set to four times the total number of DTV assignments available for every NTSC station using a minimum DTV to NTSC co-channel spacing of 97 miles. (There were roughly 80,000 such assignments, so the parameter L was set to a maximum of 320,000 trials per temperature). Furthermore, the process was not considered "frozen" until 10% or less of the proposed changes were being accepted, and no improvements were found during the trials for ten consecutive temperature level changes.

Almost every possible DTV assignment has at least a small penalty attached to it. This DTV assignment penalty usually relates to interference caused to another co-channel or adjacent NTSC station and/or DTV assignment, or is a function of a particular DTV channel number. The cost of a solution is constructed from a system of penalties. Penalties are calculated for each DTV assignment in a solution, and the total cost of a solution is the sum of all its penalties. Specifically:

$$Cost(S) = \sum_{n} \sum_{i}$$

(penalty of type i for the n^{th} station)

where n ranges over the number of stations entitled to receive a DTV assignment, and i ranges of the different types of penalties.

Penalties are divided into two separate groups. The first group encompasses penalties that relate to interference caused from other DTV and NTSC stations or land mobile stations operating in the same or adjacent channels. The second group encompasses penalties that are non-interference based and are used to achieve certain policy objectives. Examples of the first group of penalty types are:

a. Co-channel DTV to DTV.
b. Co-channel DTV to NTSC.
c. Adjacent-channel DTV to NTSC.

d. Adjacent-channel DTV to DTV.
e. Co-channel DTV to land mobile.
f. Adjacent-channel to land mobile.

Since each interference penalty type is defined for each pair of stations and the penalty values are a function of their geographic spacing, it is important to establish the shape and boundary conditions of that function. Furthermore, since the various penalty types differ in weight and significance, it may be appropriate to establish weighting functions or factors to prioritize and rank them by order of importance. Specifically:

When i is an interference related penalty type, the penalty attributed to the n^{th} station's DTV assignment is:

$$Penalty\,(i,n) = w(i) * \underset{m}{Max}\, f(i,\, spacing\,(n,m))$$

where $w(i)$ is a weighting function, and m ranges over stations close enough to make the unweighted penalty function greater than zero. The cost includes only the largest penalty for each interference type associated with an individual DTV assignment. If the annealing process is able to eliminate this largest penalty, it will afterward begin to work on the next largest and so on.

To illustrate how a weighted function $w(i)$ may be derived. Let's assume that it is important to develop an assignment plan that emphasizes the future DTV service over the current NTSC service. This can be accomplished by using a set of DTV-to-DTV penalties that will have a greater weight than the set of penalties for NTSC to DTV. Moreover, since adjacent channel situations more severely limit broadcasting coverage than co-channel, the plan can also assign greater weight to adjacent than co-channel penalties.

To further illustrate how an unweighted penalty function was applied to minimize DTV-to-DTV adjacent channel interference within the same service area, a parabolic hill function was used. The function begins at 5 miles from the transmitter, peaking in the middle to unity, and falling again to zero at 60 miles. This function is intended to drive such assignment toward small separations or, beyond 60 miles.

The second group encompasses penalties that are non-interference related but established to meet certain policy objectives, such as recovering broadcast spectrum after the transition and offering additional protection to neighboring countries. These penalties relate to a single or group of channel numbers or a particular set of stations. Examples of these types of penalties are:

a. Not assigning VHF channels 3 and 4 in the same community to protect the existing population of video recorders.
b. Not assigning VHF channel 6 to protect existing non-commercial FM stations in the United States, Canada and Mexico.
c. Severely restricting DTV assignments of UHF channels 60-69.
d. Setting a high penalty value for assigning DTV channels that are co-channel or adjacent channel to Canadian and Mexican stations near the borders.
e. Limiting DTV assignments of UHF channels 51-59 (lower penalty than for 'c').

These penalties were used to develop the "core" spectrum plan adopted by the FCC. [FCC 97]

3.2 - Coverage-and-Interference Model (CIM)

The coverage-and-interference model was developed to evaluate the various assignment plans generated by the assignment model and compare the relative performance of the original five proponent systems. Specifically, the CIM model provides the user with the necessary tools to translate laboratory measured RF receiver interference and noise thresholds for any DTV system into expected geographical service and interference areas. This is accomplished by using agreed upon technical planning factors for DTV reception and use of reliable propagation models [ACATS 93]. The CIM model is used to explore various trade-offs between the coverage areas of new DTV stations and the degree of interference protection afforded to NTSC stations.

The CIM model comprises three basic modules and a number of integration and support modules. The first module, the input module, was designed to allow the user, through the use of menus, to specify the type of analysis desired. The user can conduct a number of coverage-and-interference analyses by manually entering all necessary parameters or retrieving the information from the various databases. For example, the user has the option of conducting coverage and interference analyses for NTSC, DTV, or both DTV and NTSC for two stations or for the entire United States. Station parameters can be either manually entered by the user, selected from an ASCII file specified by the user, retrieved from the FCC engineering data base, or retrieved from an assignment plan. Appropriate default values for various technical parameters are provided, but the user has the option of modifying the default parameters as desired.

The second module, the service contour calculation module, was designed to compute the sets of points that define the service contours of both NTSC and DTV. The calculation uses the FCC(50,50) R-6602 propagation curves [Damelin 66] for the NTSC service and the FCC (50,90) curves for DTV.

The third module, the service/population prediction module, was designed to calculate the coverage and interference area within a specified contour (Grade B for NTSC, noise-limited threshold for DTV). The module was designed to calculate the coverage and interference area using two different propagation prediction methods, FCC R-6602 curves or the ITS Irregular Terrain Model [Hufford 82]. In addition, statistics relating to population served or lost as a result of DTV assignments are also included.

3.3 - Integration of Assignment Model with CIM Model

While many of the assignment models used attempted to develop assignment plans that maximize DTV coverage and minimize NTSC interference, they generally fall short of that objective. The reason for such a poor performance is that all of the optimization techniques used to develop assignment plans rely principally on geographic spacing of the closest co-channel and/or adjacent channel, and ignore contribution from the second and third closest co- and adjacent channels, etc. Use of coverage and interference areas rather than geographic spacing would take into account all affected stations (i.e, first, second and third co-channel adjacent channels, etc.) and thus, would be more appropriate for generating more spectrally efficient assignment plans.

In the fall of 1993, full integration of the assignment model with the CIM model was completed, where the simulated annealing technique was modified to derive the interference related penalties based on coverage areas rather than distance separations. The CIM model iteratively used to calculate these penalties. The integrated Assignment/CIM model was first used to compare the spectrum performance among the five proponent systems for the FCC Advisory Committee, and subsequently used to develop the plan that was adopted by the FCC in 1997.

4 – Conclusion

This paper describes various computer modeling techniques developed by the United States to generate a spectrally efficient assignment plan for digital television. These techniques are system independent and could be easily adapted to different part of the world and/or spectrum allocation problems.

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Footnotes

[1] The second, third, fourth, fifth, seventh, eighth, fourteenth or fifteenth channel removed from (i.e, above or below) the assigned NTSC channel is known as a taboo channel. Taboos include such interference mechanisms as cross- and inter-modulation, sound and picture image, oscillator radiation, and intermediate frequency beat.

[2] Five systems were considered by the FCC Advisory Committee: (1) Narrow-MUSE developed by NHK; (2) DigiCipher and (3) CC-DigiCipher developed by General Instrument Corp. and the Massachusetts Institute of Technology; (4) DSC-DTV developed by Zenith and AT&T; and (5) AD-DTV developed by the David Sarnoff Research Center, North American Philips, Thomson Consumer Electronics, NBC, and Compression Labs, Inc.

[3] The Grand Alliance (GA) system was jointly developed by a consortium of manufacturers involved in the development of four of the five systems initially considered by the FCC Advisory Committee. The new GA system incorporates the best features from each of the previous four systems.

[4] Lagrangian Relaxation, Neural Networks, Simulated Annealing and Successive Augmentation and Graph Coloring Algorithms are a few examples of these optimization techniques.

[5] They include: the LF (largest first) algorithm of Welsh and Powell [Welsh 93], the SL (smallest last) algorithm of Matula [Matula 72], the DSATUR (degree of saturation) algorithm of Brelaz [Brelaz 79], the RLF (recursive largest first) algorithm by Leighton [Leigh 79], and an iterative algorithm by Frank Box [Box 78].

Cohabitation (between systems, between countries) Digital Television Planning Challenges in Europe

K.J. Hunt
J. Doeven

Introduction

Within Europe, as is the case in other parts of the world, the idea of using digital transmissions to supplement or replace analogue transmissions has been developing for many years.

In the broadcasting world, such a trend has been in place for a long time, and, indeed, first implemented so many years ago that people hardly even realise that the digital signals are already in use. Such cases are typified by teletext added to television transmissions and RDS added to VHF/FM radio. Both of these developments were triggered by the desire to add more information to an existing service while retaining compatibility for receivers and not requiring any additional spectrum resources.

A more recent development has been to consider completely new terrestrial digital transmissions which are not compatible with existing analogue transmissions (at least, not at the equipment level) and which are expected, in time, to replace them. However, there is a strong pressure not to require additional spectrum resources because of the extreme pressure on such resources and the competition for them. In the case of radio, it proved impossible to develop a high-quality digital system with the required characteristics which could share spectrum with VHF/FM transmissions and alternative arrangements had to be made. In the light of knowledge of the difficulties caused by this additional burden on spectrum resources, it was quite obvious that digital television would have to share the spectrum used by analogue television. This viewpoint also took into account the fact that the spectrum requirement for digital television is much larger than that for T-DAB.

Indeed, the consideration of how to achieve this sharing, simultaneously ensuring the continued protection of the existing analogue services and achieving satisfactory coverage for the new digital services, was one of the first elements to be dealt with. Certainly, many studies of how much digital coverage could be achieved in different circumstances were undertaken long before there were detailed digital system specifications. Such studies, of course, used a range of generic assumed characteristics for the digital system. This was necessary because it was realised that to add digital transmissions into the European analogue broadcasting world would be particularly challenging. To see why this is the case, it is necessary to consider, at least in outline, the way in which analogue television developed in Europe and to note the political considerations which shaped that development.

Development of Analogue Television in Europe

While the earliest television transmissions in Europe took place in the 1930s, these didn't really affect subsequent use of the spectrum. With hindsight, it is possible to note that they indicated that a multiplicity of system developments would be taking place, as each country developed its own system and standards for these very early trials.

When television transmissions were re-launched in the period just before 1950 and subsequently during the 1950s it was obvious that co-operation would be needed among the various European countries with regard to the spectrum to be used for television and to ensure an equitable distribution of spectrum resources between all the countries involved. In this context, it must be noted that:

- the 1950s were not the best years for achieving dialogue or agreements within Europe;
- the area concerned was really the European Broadcasting Area, including North Africa and the Near East.

It is at this stage that the political elements began to exercise their influence. Within each country there is a need to decide what is to be covered by the television transmissions: just the urban areas or the whole of the

K.J. Hunt is with the EBU Technical Centre
Case Postale 67
CH-1218 Grand-Saconnex (Genève)
Switzerland

J. Doeven is with Nozema
P.O. Box 6
NL-3400 AA IJsselstein
The Netherlands

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country? In practice, every European country selected the option of trying to cover the whole of its territory (or at least the populated parts, which in most countries is almost the same target) but, in many cases there was also a desire to extend the coverage somewhat into neighbouring countries, especially where there was a common language in use. The result is that in border areas there is even more pressure on the spectrum resources than towards the centre of each country. Even the centre of countries were not without this pressure, however. Many countries were already making provision for regional variants of television programmes.

The development of political ideas and technical planning methods continued throughout the 1950s and culminated in the 1961 Stockholm Conference and Agreement. The associated Stockholm Plan remains in force today and is expected to continue in force for several more years. This is not to say that there has been no development in the past 35 or so years. Quite the reverse is true although the Plan itself remains as the basis for most subsequent developments.

The Stockholm Plan provided, with some regional variations, for, effectively, four television coverages in all countries in Europe, although for a variety of reasons there were cases where the channels for one of these coverages was actually allocated to a non-broadcasting service. One of these coverages was usually in the VHF bands:

- Band I, now about 45 to 68 MHz but then with a lower limit of 41 MHz;
- Band II (television), 84 to 100 MHz;
- Band III, 174 to 230 MHz.

The remaining coverages were in the UHF bands:

- Band IV, starting at 470 MHz;
- Band V, ending at 862 MHz.

(There is no real physical boundary between Bands IV and V and it is thus not necessary to quote any internal boundary frequency here.)

However, the idea that the Stockholm Conference was a great success (which is true) doesn't give the full facts. What is hidden is that there were very significant differences of television systems in use in different parts of Europe, that these required different channel widths and that there were also very significant differences in the usage of the spectrum. All of these elements later played, and continue to play, a key role in the development and implementation of a digital television system and services. In addition to any spectrum usage and system differences which existed in 1961, there have been subsequent developments which have acted, generally, to increase the number of system variants. The current situation with regard to systems may be summarised as:

- colour is provided either by PAL or by SECAM;
- video modulation is either positive or negative;
- monophonic sound is either am or fm;
- stereophonic or multi-channel sound is either dual fm or digital.

At least all systems in 1998 use only 625 lines, the earlier 405 and 819 line variants having been eliminated. One reason for the title of this paper can now be seen. All of these multiple systems must live together within the relatively small geographic area of Europe.

Some of the system variations have significant effects on the use of the spectrum. There are two broad categories of channel width, 7 and 8 MHz, respectively (although the use of a digital sound system causes these values to be exceeded to some extent.) These different channel widths result from differences in video bandwidth and the spacing between vision and monophonic sound carriers; 5.5, 6.0 and 6.5 MHz spacings are all in use.

In the UHF bands, it was decided at the Stockholm Conference to have a uniform channel width and spacing of 8 MHz, the channels not being completely filled in the case of systems using 7 MHz bandwidth. In the VHF bands,

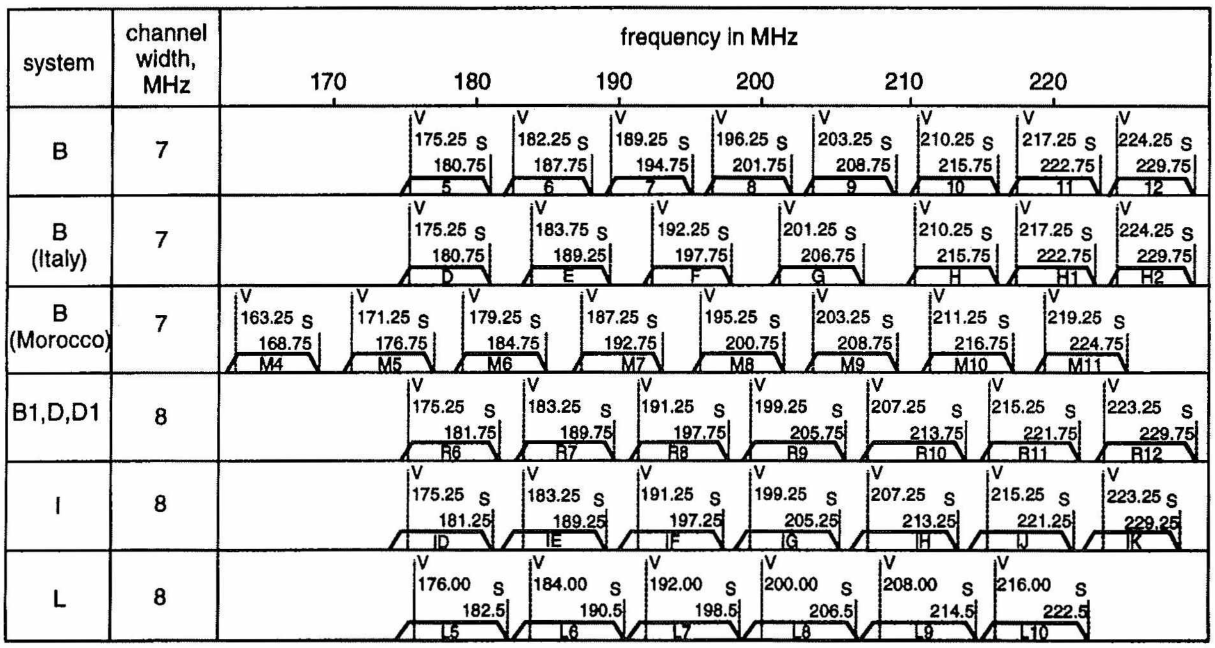

Fig. 1: Channel positions in television Band III

Fig. 2: Current country boundaries in Europe

there was no such agreement and the result is that there are overlapping 7 and 8 MHz channel rasters with several versions of each. The result for Band III is shown in Figure 1. We do not need to consider Bands I and II in the context of this paper as it was decided in 1997 within the CEPT not to implement digital television services in these bands. This is fortunate because the situation with regard to spectrum usage is even more complicated than in Band III.

Geographical and Political Situation

Although it has been noted that there are many countries involved in a European planning situation and that was also true in 1961, no example has yet been quoted. Figure 2 shows the current country boundaries in Europe. These boundaries are not the same as those for which the Stockholm Plan was produced but the allocations from that Plan have been moved appropriately.

In this map, only most of the countries which are also members of the CEPT are shown. Thus, the countries of the Near East and North Africa are not shown. However, interference between some of these countries and the countries in Europe still needs to be taken into account.

The reason for the other part of the title of this paper can now be seen. There are more than 40 countries in Europe which must co-operate to ensure that broadcasting services can be transmitted and received with controlled levels of mutual interference.

Although at this scale, some of the smaller countries may not be obvious, in a political sense all countries have the same rights and the same rights of access to the spectrum. From a spectrum usage point of view, small countries often pose bigger problems than larger countries. This is because interference does not stop at national boundaries and in the case of a small country, interference from all of the neighbours must be taken into account both within and across the country.

It must be remembered that when planning for radio or television services, interference from a given station extends well beyond the coverage boundary of that station. In general terms, for a high power transmitting station, in the VHF and UHF bands, it is necessary to consider interference effects at up to 500 km from the station site and in some cases, even greater distances. Some countries in Europe are less than 500 km across and thus interference is not necessarily limited to only geographically adjacent countries.

It was noted earlier that all countries in Europe have as a goal the provision of television coverage to all parts of their territories. This has involved the construction of a large number of lower power fill-in, or relay, transmitting stations. Most of these stations did not form part of the original Stockholm Plan but they have been co-ordinated in the context of the Stockholm Agreement and thus have the same rights to be protected from interference as the larger stations which were part of the original Plan. In addition, in many countries additional programme chains have been created requiring their own high and low power transmitting stations. Some of these additional stations form part of chains intended to provide primarily urban coverage. Others are intended for national area coverage. However, once co-ordinated, they all enjoy the same legal rights to continued existence and protection from interference.

In addition, in some countries there has been the introduction of a number (sometimes a large number) of additional non-co-ordinated transmitting stations. The legal status may be unclear. The interference from such stations can be very obvious and very damaging.

In terms of the total number of transmitters which are in service or which have the right to be in service (that means that they have been co-ordinated but are not yet in operation) there are now in excess of 75,000 analogue service transmitters in Europe, excluding all transmitters in Russia. Not all of the 75,000 have been co-ordinated but a large majority have been.

The radiated powers of these transmitting stations range from less than 1 watt to more than 1 megawatt. Obviously, there are more stations in the lower power ranges than in the higher power ranges but, once again, all of those which have been co-ordinated have the same rights.

The challenge of finding any opportunities for putting digital transmitting stations in this environment is rather obvious, especially when it is considered that the digital stations must achieve reasonable coverage in order to attract viewers and to create the opportunity for a later transition to an all-digital future after the switch-off of the analogue stations.

Digital Television System Design Constraints

This is not the correct place to go into any detail about the digital television system adopted in Europe, DVB-T. However, it is appropriate to mention some of the design goals which were imposed by the very difficult spectrum environment which exists in Europe. As a starting point, the DVB-T system was required to be very robust with regard to interference from analogue television systems. In this respect, no advantage could be taken of any fixed relationships between the digital channel and the vision and sound carriers of co-channel or overlapping channel analogue television systems. While this is obvious for usage at VHF, as shown in the channel rasters for Band III, it may be less obvious for UHF. However, there are many situations near country boundaries in which a given receiving location may experience analogue television interference from transmissions in different countries. These transmissions may use different vision to sound frequency spacings and different video modulations. It is clearly impractical to have digital television receivers tailor-made for different geographic situations, therefore they must all be capable of operating in adverse conditions. This goal has been achieved with protection ratios (for interference from analogue television transmissions) of only a few dB.

Of course, this doesn't eliminate all problems. It still remains for the frequency planners to chose suitable channel arrangements.

Ideally, one would like the digital television transmissions to have little impact on analogue television reception. However, the digital signal is noise-like and there really isn't anything that the system designer can do about this. This aspect becomes a problem for the frequency planners alone.

It is obvious that there would have to be a large number of cases where digital and analogue transmissions would use adjacent channels in the same reception area. In these cases, the challenge is shared:

- by the system designer, who must ensure that the spectrum of the digital signal is reasonable well constrained;
- by the transmitter manufacturer and installer, who must ensure that adequate filtration is provided to keep radiated signals in the adjacent channels low;
- and by the receiver manufacturer who must ensure adequate rejection of signals in adjacent channels, often at much higher levels than the wanted signals.

The type of spectrum mask for the transmissions which helps to achieve satisfactory performance is shown in Figure 3. This mask is that proposed for use in so-called non-critical interference situations. At band edges or, for example, adjacent to a channel used for radio astronomy purposes, a more stringent specification for the spectrum mask can be adopted (the cost is higher, of course).

The Frequency Planning Process

With the basic elements, described above, in place, or at least well understood, the detailed frequency planning process can be started. As always, when multiple countries are involved, the political considerations must be considered in detail at a rather early stage. In Europe this was achieved at a special conference organised by the CEPT in July 1997 in Chester (UK). The Conference itself was of course the culmination of some two years of discussions and meetings between the various experts who examined both the technical aspects and the procedural implications. The latter were particularly important because it was foreseen that the agreement reached in Chester would be implemented by means of bi-lateral (or multi-lateral) agreements between administrations. These must clearly have an equitable basis and must also take into account that different countries in Europe would need to implement digital services with very different timescales. Thus it was necessary to consider:

- the impact of new digital stations;
- the impact of the conversion of an existing analogue

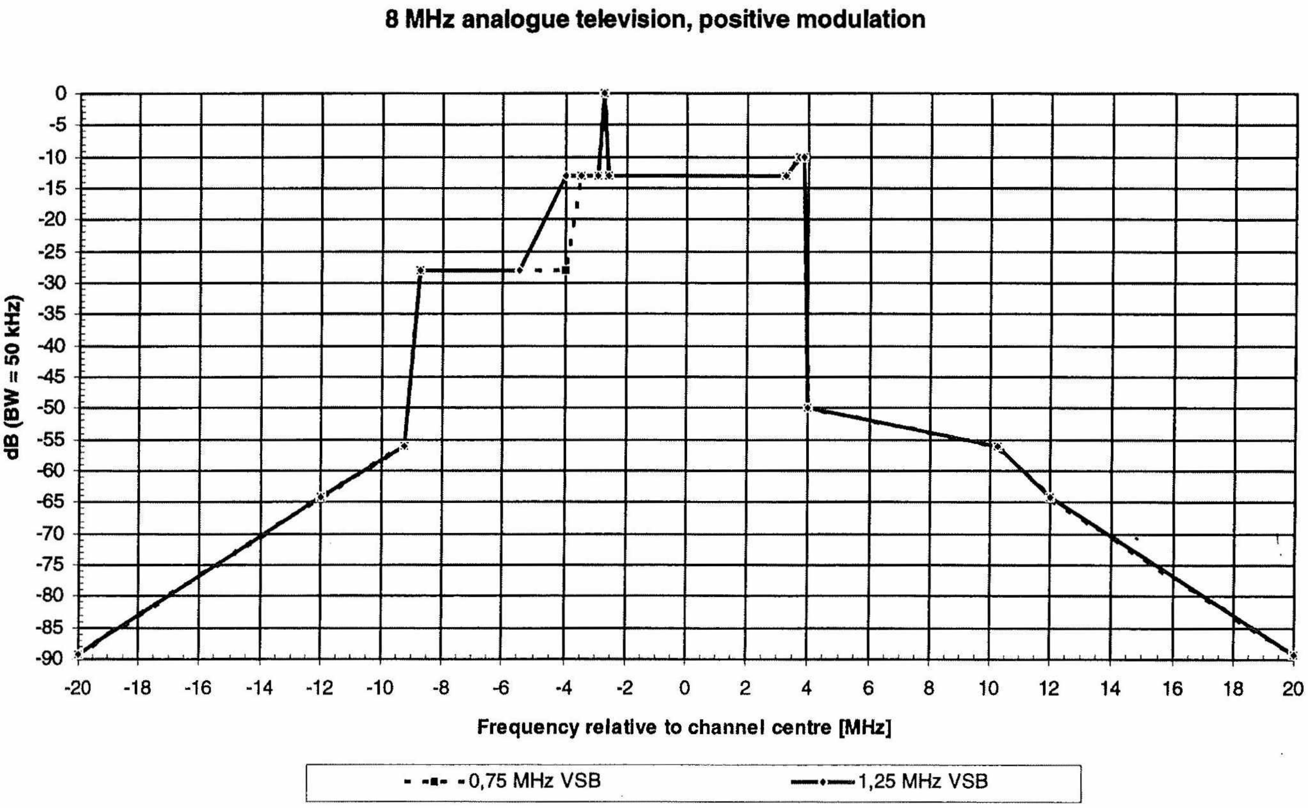

Fig. 3. Spectrum limit mask for 8 MHz analogue television, positive modulation (for P = 39 dBW to 50 dBW)

station to a digital station;
- and even the impact of introducing new analogue stations which could later be converted to digital.

To put the latter point in perspective it must be noted that the interference potential of a digital station can be greater than that of an analogue station. The conversion of a station from analogue to digital is thus a matter of particular concern.

Of course, a conference dealing with general cases, which is what was done at Chester, can only produce procedures which are somewhat generic in nature. During any subsequent bi-lateral negotiations, specific details of the stations concerned need to be considered. This also includes any circumstances which might act to reduce any potential interference problems. An important element here can be the taking into account of the impact on signal propagation of the effect of the terrain. For historic reasons, there are no international agreements on how this is to be done. Within Europe there are several nationally developed methods and these have different degrees of acceptance. This is clearly an area for considerable work activity over the next four years.

As part of the general process of implementing digital television transmissions, the Chester conference considered that it would be important to establish an internationally agreed reference situation which describes the existing analogue coverages. While this is new in an international sense, it is not really new for individual countries. In many cases the coverage of a station in the presence of interference is calculated nationally using specific values of protection ratio, receiving antenna pattern and percentage of time for which interference is acceptable. The achievement at Chester was to get agreement on a set of conditions which could be applied to all stations and all coverage areas in Europe. The particular task of calculating all of the coverage areas on a common basis is still in hand because of the long timescales involved in setting up an agreed database of the analogue transmitting station characteristics needed for these calculations. These characteristics are significantly more detailed than those contained in the Stockholm Plan.

The coverage areas themselves are established in a reasonably conventional manner as a series of radial distances (36) around each transmitter site. Each radial distance is determined by an iterative process which takes into account interference from all co-channel, adjacent channel or overlapping channel stations together with their characteristics, and the level of the wanted signal from the wanted station under consideration. There are complications caused when coverages cross national boundaries or overlap those of adjacent channel stations, but these are matters mainly of administrative concern.

In the longer term, the frequency planning process will also include effecting the transition to the all-digital future and consideration of this has already started, although there is rather a long way to go in developing ideas about the types of service needed and the type of coverage needed.

Digital Coverage Considerations

At present, the planning of television station coverage in Europe makes the assumption that reception is based on nominally fixed receiving antennas mounted at or near roof level and with nominal directional characteristics. The primary benefit of the latter is to provide discrimination against interference, a process which is enhanced in some countries by considerable use of polarisation discrimination. The idea is developing rapidly that one of the benefits of digital transmissions will be to permit high quality reception on portable receivers. Indeed, a number of countries are adopting portable reception as their primary target for digital television.

However, with portable reception, the benefits of a directional receiving antenna are lost. There is a reduced antenna gain, by some 10 to 12 dB, and the loss of the directional properties means that interference effects are increased. In the latter respect, the benefits of using active receiving antennas remains to be evaluated.

In addition to the loss of antenna gain, there is also a propagation loss caused by the need for the digital signal to penetrate any building in which a portable receiver is used.

Together, these effects create considerable problems in terms of achieving adequate coverage and protection against interference. Various solutions are being considered but the indications at present are that it will be necessary to install more transmitting stations and there will thus be a trend towards much denser transmitter networks than are currently used in broadcasting.

Digital Service Considerations

At present, at least in Europe, one of the major advantages seen for digital television is the possibility it provides for multiple programmes in a single rf channel. One of the important features of the DVB-T system in this respect is that it provides a wide range of options for the transmitter operator to choose from. These options range from relatively low capacity (about 5 Mbit/sec) to very high capacity (more than 25 Mbit/sec). These options carry with them varying degrees of ruggedness to interference effects, the lower capacities offering the higher ruggedness.

While it is clear that the initial trends are towards high capacity, multiple programme per channel usage, it is not really clear what the future usage could be. However, it seems possible that the interest in portable reception and an increasing interest in mobile reception could lead to some lower capacity options being used in order to increase the ruggedness. It is also possible that there will be moves towards fewer programmes per channel in the high capacity options in order to transmit higher resolution pictures. These trends are likely to become much clearer as Europe moves towards planning for its all-digital future. While the reality may take 10 to 15 years, the interesting part from the authors' viewpoint will be the preparations and the planning and most of this will occur within the next 5 to 7 years. What we can see in front of us amounts more to evolution than to revolution, but it will be a very rapid evolution indeed.

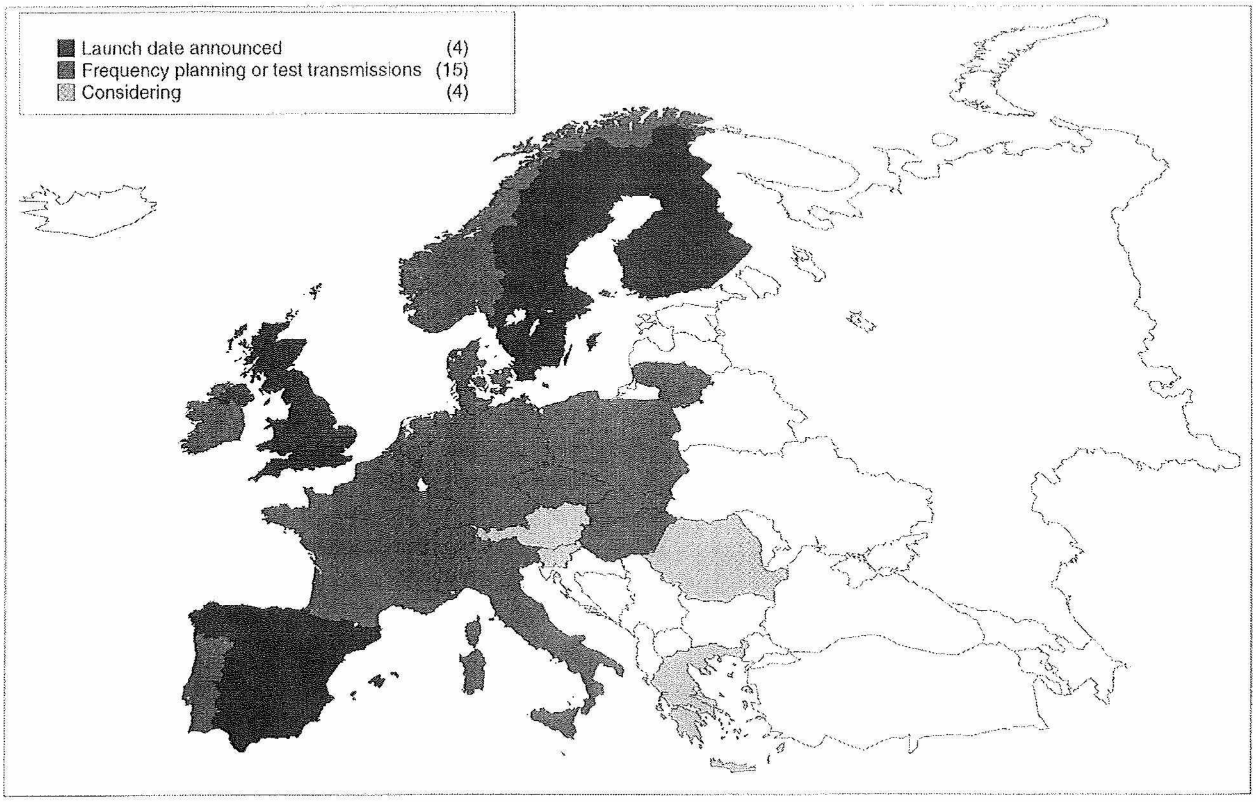

Fig. 4: European countries

Conclusion

The development of the current analogue television coverage in Europe has been one of continued progress over a period of a number of years. Indeed, in some countries the process is not complete because new programme chains are still being implemented.

However, in many countries there is considerable activity with regard to the planning for digital services and a significant number of transmitters is already operating. Figure 4 shows that this activity is primarily concentrated in western Europe but this should only be seen as an initial position.

While it is certain that the transition to digital television will not take as long as the development of the analogue television coverages, it is equally certain that this process will not take place overnight. Indeed, it is likely to be a phased process extending over a number of years in order to take into account the geographic and political realities of an area with very many independent countries.

The Terrestrial Digital Television System in Japan

H. Miyazawa

ABSTRACT - In Japan, the specifications for a digital terrestrial broadcasting system called ISDB-T(Integrated Services Digital Broadcasting for Terrestrial) have been approved by the MPT(Ministry of Post and Telecommunications) of Japan. The basic concept of ISDB-T is to realize flexibility, extendibility and interoperability of digital broadcasting. The experimental equipment for ISDB-T has already been developed and several practical field trials are in progress. The final standard was to be fixed in May 1999.

1 - Introduction

Since 1983, NHK has been engaged in Research and development in the field of Integrated Services Digital Broadcasting and has proposed the ISDB (Integrated Services Digital Broadcasting) concept for digital broadcasting. This concept is common to various transmission media such as satellite, terrestrial and cable media. The basic concept offers flexibility, extendibility and interoperability. We developed the digital terrestrial broadcasting system called ISDB-T based on the ISDB concept.

There are three different systems, ATSC (USA : Advanced Television System Committee), DVB-T (Europe : Digital Video Broadcasting – Terrestrial) and ISDB-T as digital terrestrial broadcasting systems in the world. All system uses a MPEG-2 video coding scheme and the multiplexing scheme of MPEG-2 systems. The bandwidths of their systems are 6 MHz, 7 MHz and 8 MHz depending on those of existing analog television. It is easy to exchange the program by MPEG-2, but the modulation schemes are different of each other. The ATSC system uses the 8VSB-modulation scheme in a single carrier system, but the ISDB-T and DVB-T systems use the OFDM (Orthogonal Frequency Division Modulation) scheme as a multi-carrier system. We have developed the ISDB-T system as extending the DVB-T system.

The ISDB-T system has been developed to target two main services, not only HDTV (High Definition TV) but also Mobile-multimedia. By using Band Segmented Transmission-OFDM, ISDB-T can provide through twelve segments and a one-segment mobile service at the same time. It can also provide many segment configurations including SDTV (Standard Definition TV) mixture services for stationary and mobile reception.

The ISDB-T system providing also the parameters sets for 7 and 8 MHz-bandwidth will be suitable for many countries having various requirements for broadcasting networks.

2 - Requirement for ISDB-T

Today's terrestrial broadcasting accommodates television, FM and AM radio services. While analog modulation is used for the main services, digital technology is used for additional multiplex services such as teletext. Satellite broadcasting in Japan offers HDTV and conventional services as well as digital sound broadcasting services, and under these circumstances it is important to clarify the advantages of digital broadcasting. By offering high-quality video and sound, digital broadcasting can also provide attractive multimedia services. To accommodate these services, the transmission method has to be sufficiently flexible and extendable.

ISDB-T should:

- have the capability to provide a variety of video, sound, and data services,
- have sufficient ruggedness against multipath and fading interference to make portable and mobile reception possible,
- have separate receivers dedicated to television, sound, and data, as well as fully integrated receivers,
- be flexible to accommodate different service configurations and ensure flexible use of transmission capacity,
- be extendible to ensure that future needs are met,
- accommodate single frequency networks (SFN) to achieve effective use of frequencies,
- use vacant frequencies effectively to introduce terrestrial digital broadcasting in a heavily used spectrum context, and
- be compatible with existing analogue services and other digital services.

3 - Overview of ISDB-T

NHK has developed and proposed a Band Segmented Transmission - OFDM (BST-OFDM) scheme for the ISDB-T to meet the above-mentioned requirements [1]. The OFDM method densely multiplexes many carriers while maintaining orthogonality among them in a given transmission band. It utilizes a much longer symbol

H. Miyazawa is with the
NHK (Japan Broadcasting Corporation)
Science and Technical Research Laboratories
1-10-11 Kinuta, Setagaya-ku, Tokyo 157-8510, Japan

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Table 1.: Specification of standard of digital terrestrial television broadcasting.

Video Coding	MPEG-2 Video	Same as Digital Satellite Broadcasting of Japan	
Video Format	1080 I, 480 P, 480 I		
Audio Coding	MPEG-2 Audio (AAC)		
Scramble	MULTI2		
Multiplex	MPEG-2 Systems		
Modulation	BST-OFDM (QPSK, 16QAM, 64QAM, DQPSK)		
	Mode 1	Mode 2	Mode 3
Number of Carriers	1450	2809	5617
Effective Symbol Duration	252 µs	504 µs	1.008 ms
Guard Interval	63 V, 31.5 µs, 15.75 µs, 7.875 µs	126 µs, 63 µs, 31.5 µs, 15.75 µs	252 µs, 126 µs 63 µs, 31.5 µs
Outer Code	Reed Solomon (204, 188)		
Inner Code	Convolutinal code (1/2, 2/3, 3/4, 5/6, 7/8)		
Bandwidth	5.575... MHz	5.573... MHz	5.572... MHz
Data Rate	Up to 23.234 Mbps		

interval than that of a digital modulation method using a single carrier. Multipath interference is suppressed by inserting a guard interval in the time domain. Therefore it enables ISDB-T to operate as a SFN (Single Frequency Network) [2].

The BST-OFDM channel consists of a set of frequency blocks called OFDM-Segments which have a common carrier usage structure. All of the OFDM-Segments have a bandwidth of 3000/7=428.57 kHz. ISDB-T provides several combinations of carrier modulation schemes (DQPSK, QPSK, 16QAM, 64QAM) and coding ratios of the inner code (1/2, 2/3, 3/4, 5/6, 7/8). These parameters can be selected independently for each OFDM-Segment.

The basic standard options for digital terrestrial broadcasting in Japan are illustrated in Table 1. The detailed transmission parameters of ISDB-T are shown in Appendix Table 4, and examples of ISDB-T transmissions are shown in Fig. 1. As shown in Fig 1 two types of receivers are supposed for the ISDB-T system, having full bandwidths of 5.6 MHz (wide-band ISDB-T) and 430 kHz (narrow-band ISDB-T). Basic narrow-band ISDB-T system has only one segment, and extended narrow-band ISDB-T system have three segments.

There are two types of wide-band receivers for these purposes;

(i) an integrated receiver with a 5.6 MHz OFDM demodulator and an HDTV display, which can receive all services,

(ii) a mobile receiver with a 5.6 MHz OFDM demodulator and a small SDTV display.

Narrow-band receivers are also divided into two types;

(iii)a light-weight portable receiver with a 430 kHz OFDM demodulator for sound and data services.

(iv)a highly-functional mobile receiver with a 1.3MHz OFDM demodulator for multi-media service such as simple moving picture services.

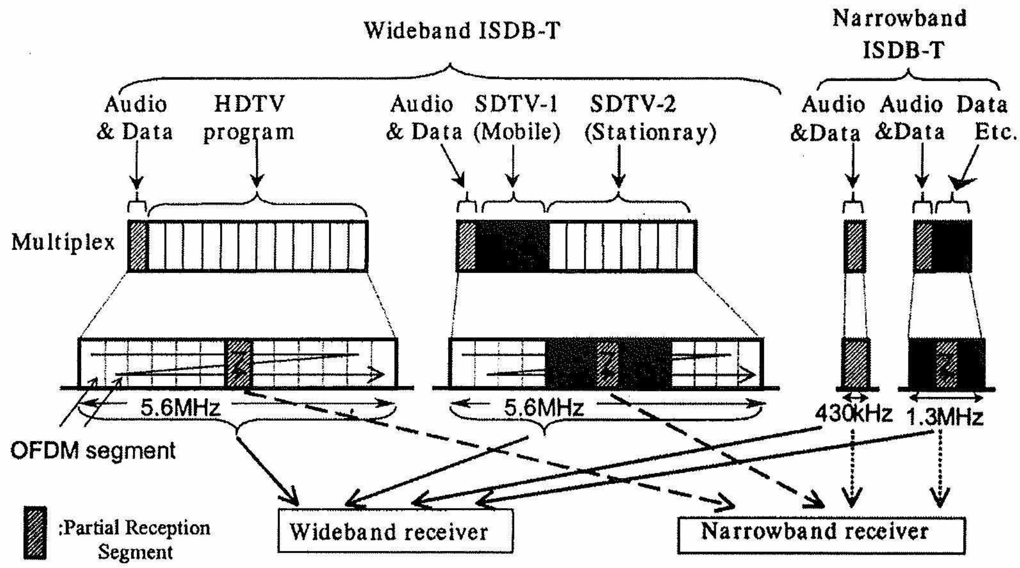

Fig. 1 Examples of ISDB-T transmission

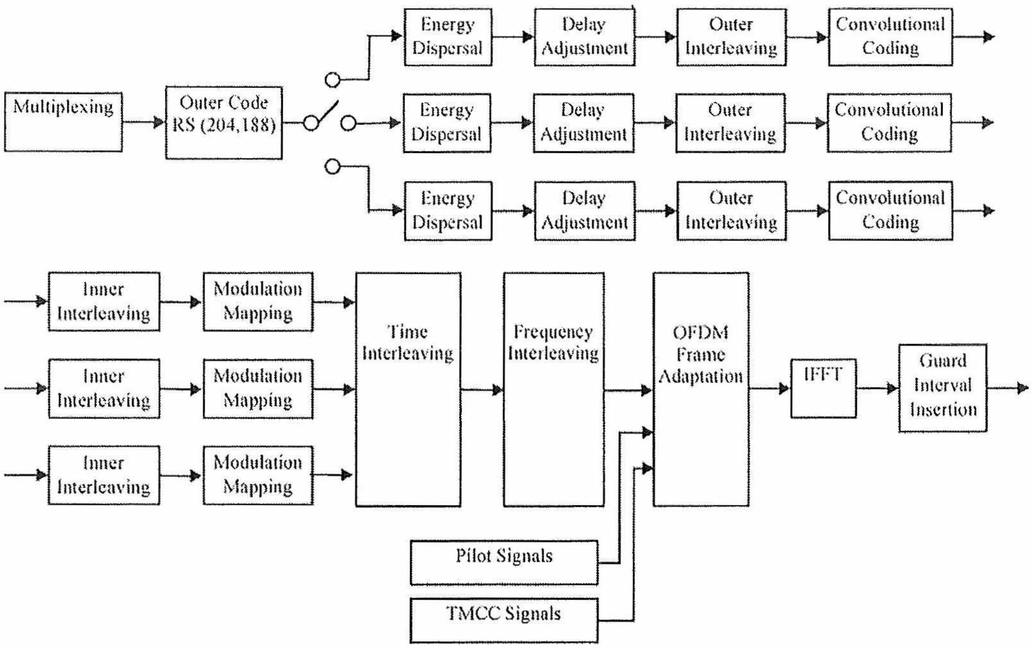

Fig. 2 Block diagram of wide-band ISDB-T transmission system

Wide-band ISDB-T consists of 13 OFDM-Segments. Because it enables hierarchical transmission using a set of OFDM-Segments having different parameters, it can provide HDTV services for an integrated receiver and multi-program services for all types of receivers. Narrow-band ISDB-T is suitable for audio and data broadcasting. Because the FFT size of a narrow band receiver can be several times smaller as that of a wide band receiver, it can be lightweight and inexpensive.

Wide-band receivers can receive narrow-band signals and on the other hand, narrow-band receivers can pick up the central segment of a wide-band signal in the case where the segment is dedicated to partial reception. Segment parameters for 7 and 8 MHz-bandwidth are shown in Appendix Tables 5 and 6 respectively.

4 - Transmission Scheme for ISDB-T

The block diagram of the wide-band ISDB-T system transmitters and receivers are shown in Fig. 2 and 3 respectively. A frame structure is introduced for both the OFDM signal and the transport signal, so that ISDB-T can provide hierarchical transmission flexibly while reducing the complexity of the receivers.

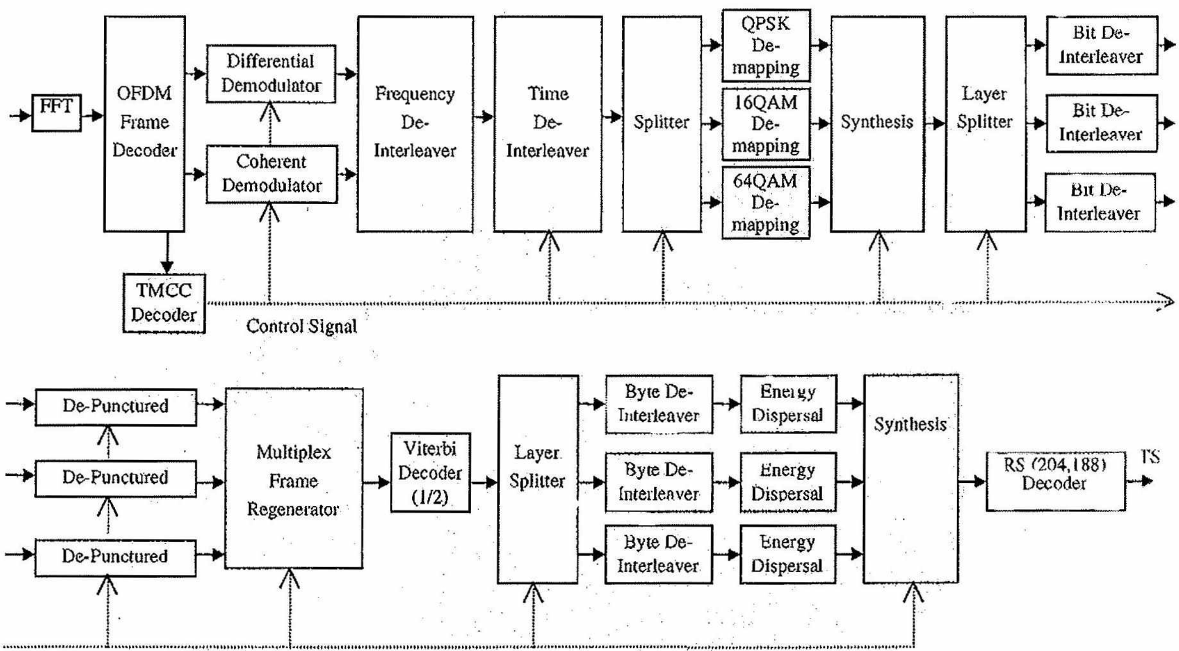

Fig. 3 Block diagram of the wide-band ISDB receiver

4.1 - Multiplexing

Taking advantage of the commonality with other media, the transport signal of the ISDB-T utilizes the MPEG-2 Transport Stream (TS) structure. The TS of the ISDB-T has a multiplex frame so that a single TS can be applied to hierarchical transmission.

The multiplex frame, which is synchronous with the OFDM frame discussed in the next section, is defined to interface a multiplex with an outer code by a single constant clock. Although the number of TSPs transmitted by an OFDM signal varies according to properties of the OFDM segments, the TS can connect a multiplexer to an outer coder at a single constant clock through insertion of an adequate number of null packets.

The allocation of the TSPs in a multiplex frame is specified so that the correct transport stream can be regenerated easily on the receiver side.

4.2 - OFDM frame

After outer coding, a transport stream is divided into layers by the packetizer. The maximum number of hierarchical layers is three.

Signals processed at each layer are combined and interleaved in both the time and frequency domains. Time interleaving is very effective for mobile reception. The bit error rate for a Rayleigh channel is shown in Fig. 4.

The OFDM-Segment has a frame structure for the time domain called an OFDM Frame. The frame is constructed using 204 symbols. The OFDM-Segment can be divided into two types; differential-modulation (DQPSK) and coherent modulation (QPSK, 16-QAM, 64-QAM). Fig. 5 shows examples of OFDM-Segments in the case of Mode 1.

Continual Pilot (CP), Auxiliary Channel 1 (AC1) and Auxiliary Channel 2(AC2) are mainly used for frequency synchronization. Scattered Pilot (SP) exists only in coherent modulation OFDM-Segment and is used for channel estimation.

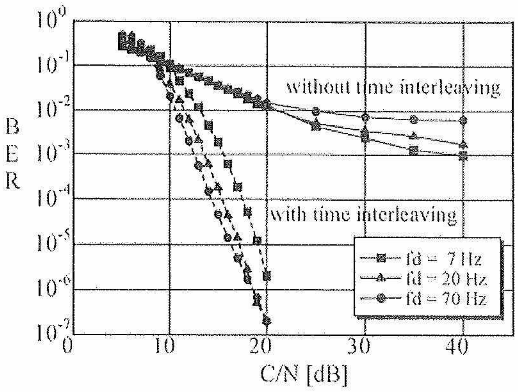

Fig. 4 BER performance of ISDB-T for Rayleigh channel (DQPSK, 1/2 Convolutional code, before RS)

4.3 - TMCC

As shown in Fig. 5 some of the carriers are assigned as control carriers and are called Transmission and Multiplexing Configuration Control (TMCC) carriers. They transmit information on the carrier modulation scheme and the coding rate for each OFDM-Segment. TMCC is also used for frame synchronization. TMCC carriers are modulated by DBPSK. TMCC information is encoded by shorted difference set cyclic code (184,273).

4.4 - Convolutional coding and Viterbi decoder

The inner code of ISDB-T uses a range of punctured convolutional codes based on a mother convolutional code of rate 1/2 with 64 states. The generator polynomials of the mother code are $G1 = 171_{OCT}$ and $G2 = 133_{OCT}$, and the constraint length is seven (k=7).

Because the maximum number of hierarchical layers is three, receivers generally need three Viterbi decoders (one for each layer), each including a de-puncture section. As shown in Fig. 3, however, wideband ISDB-T receivers require three de-puncture sections but only one Viterbi decoder of rate 1/2.

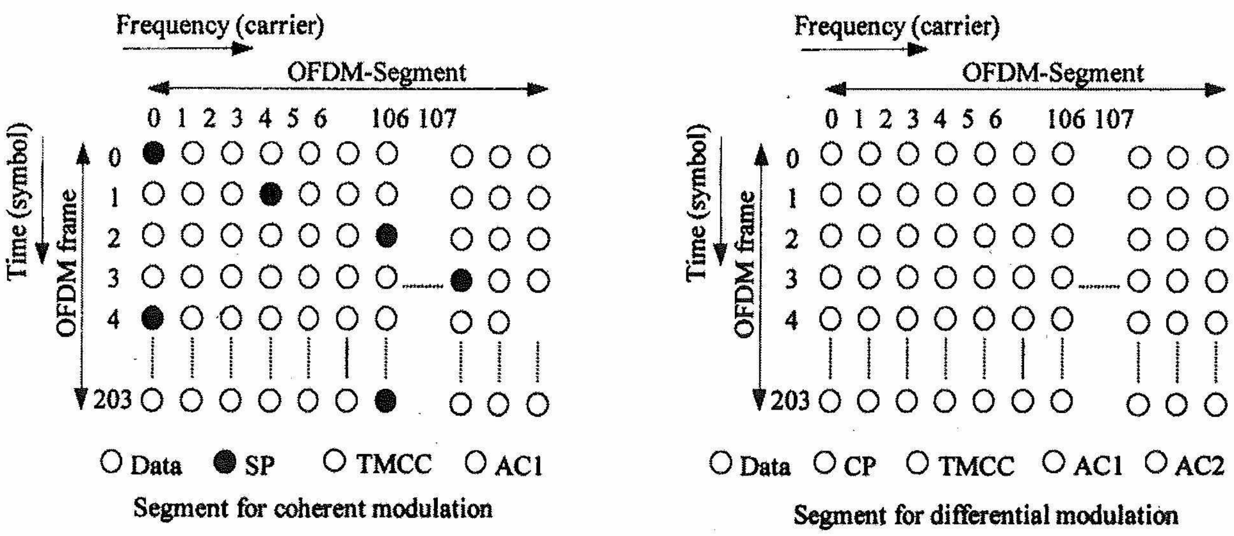

Fig. 5 Example of OFDM-segments for Mode 1.

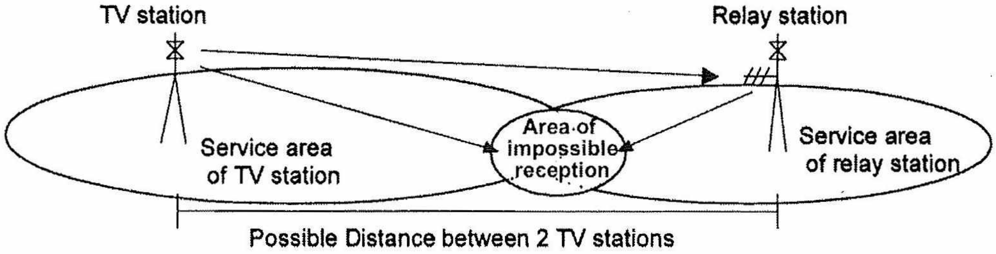

Fig. 7 Concept of single frequency network

The sync-word byte (i.e., 47_{HEX}) of the TS packet is longer than the constraint length (k=7). It is therefore possible to divide a stream encoded by convolutional coding into TS packets by using this sync-word byte, if the location of the sync-word byte can be determined. Since the OFDM frame is synchronous with the multiplex frame, the location of the sync-word byte can be determined easily. Therefore a multiplex frame regenerator can combine the de-punctured data of each layer in 3264 bits (204X8X2), which is the size of a data block of a TS packet encoded by convolutional coding of rate 1/2.

The beginning of the OFDM frame is delayed to multiplex frame by one byte, which means that the sync-word byte can be considered to be located at the end of the TS packet. Because the state of the end of a data block of encoded TS packet is the State 47_{HEX} (sync-word), the Viterbi decoder can close the error-correction process by decoding the surviving path of State 47_{HEX} at the end of the TS packet. Therefore errors can be prevented from spreading to the next TS packet.

5 - Basic Transmission Characteristics

5.1 - Information bitrate v.s. carrier to noise ratio

Fig. 6 shows the information bit-rate and required C/N from DQPSK to 64QAM. Convolutional code of inner code is 1/2 to 7/8 for each modulation scheme. Guard interval is provided from 1/4 to 1//32 , but this graph is for a guard interval of 1/8.

In case of 64QAM, it is possible to carry a HDTV program. QPSK and DQPSK is powerful to correct transmission path degradation, and is especially suitable for mobile reception.

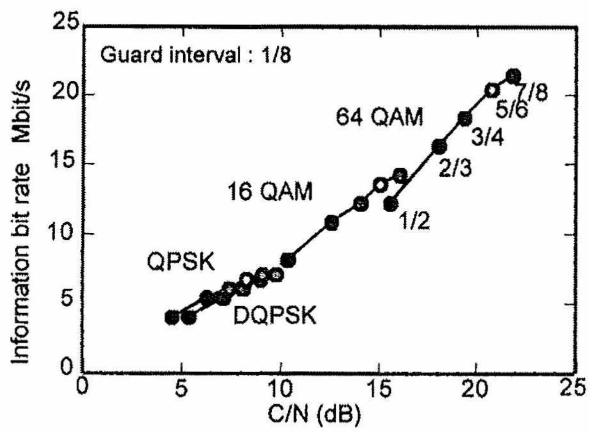

Fig. 6 Information bit-rate v.s. C/N

5.2 - Compatibility of SFN and mobile reception on ISDB-T

The OFDM modulation scheme is suitable for SFN broadcasting, because of its potentially very high robustness against multi-path effects. The required DU (Desired/ Undesired) ratio for an OFDM scheme is almost constant and low as long as the delay difference between received signals is within the guard interval, however, it increases in proportion to the delay time beyond the guard interval. In the case of a SFN construction using existing analog broadcasting networks, the networks may include areas that exhibit multipath conditions with very unfavourable DU ratios, due to very long propagation delays.

Figure 7 illustrates an example of SFN operation using a relay station. Mode 3 has a longest guard interval and is suitable for large area SFN. On the other hand, it requires wider carrier spacing for mobile reception because of the Doppler frequency shift effects. Mode 1 has the widest carrier spacing and is suitable for high-speed mobile reception. Table 2 shows the relationship between location of transmitter span and maximum speed for mobile reception.

Table 2: Constrain of between SFN and mobile reception.

	Mode 1	Mode 2	Mode 3
Distance corresponding to the maximum guard interval	18km	37.5km	75km
Maximum speed in mobile reception condition (770MHz)	200km/h	100km/h	50km/h

5.3 – Comparison between three DTTB systems

Table 3 shows a comparison of features for the three proposed DTTB (Digital Terrestrial Broadcasting) systems. These DTTB systems use almost identical source coding schemes. As DVB-T and ISDB-T use the OFDM modulation scheme, they have the same anti-ghost characteristics for stationary receiving conditions. In mobile reception conditions however, the ISDB-T system is superior to DVB-T, because ISDB-T utilizes not only frequency interleaving but also time interleaving. Regarding an effective use of frequencies, both DVB-T and ISDB-T have a capability to apply a single frequency network. Although DVB-T and ISDB-T provide some flexibility on parameters concerning modulation methods, ISDB-T includes hierarchical transmission options which are not present in other systems.

Table 3: Comparison between 3 DTTB systems

	ISDB-T (Japan)	DVB-T (Europe)	DTV (USA)
Video	MPEG-2	MPEG-2	MPEG-2
Audio	MPEG-2 (AAC)	MPEG (BC)	AC3
Multiplex	MPEG-2 Systems+TMCC	MPEG-2 Systems+TPS	MPEG-2 Systems
FEC	Convolutional (1/2 to 7/8) +RS(204,188)	Convolutional (1/2 to 7/8) +RS(204,188)	Trellis(2/3) +RS(208,188)
Modulation scheme	BST-OFDM	OFDM	8VSB-AM
Interleaving	Time & Frequency	Frequency	Time
Ghost (Multi-path)	excellent	excellent	good
Effective use of Frequencies	excellent	excellent	normal
Mobile reception	excellent	good	normal
System Flexibility	excellent	normal	none

6 - Field Trials for Digital Terrestrial Television Broadcasting

In September of 1998, a joint proposal on the DTTB transmission method was submitted to the Association of Radio Broadcasters (ARIB) by NHK and DTV-Lab. The specifications in this proposal were approved as a provisional draft format by the Telecommunications Technology Committee of Japan's Ministry of Posts and Telecommunications. The experimental equipment for ISDB-T has been developed. Both indoor and outdoor testing is being conducted using a transmission unit based on this draft format, with a variety of data being obtained. The first pilot broadcasting in practical scale has started using Tokyo Tower from October 1998, and the seven largest cities to follow from last spring.

A detailed study has been conducted, including a review of the test results, and minor specification changes have been made. The final standard will be established in May 1999.

Many countries are interested in BST-OFDM, and the transmission tests and lectures have been already carried out or scheduled in some countries. The first overseas transmission tests have been carried out also in Singapore in summer 1999. The fixed and mobile reception test of ISDB-T was conducted by Television Corporation Singapore (TCS) by coordination by DiBEG (Digital Expert Group, ARIB). While the results of transmission tests showed that the same characteristics were gained between DSB-T and ISDB-T in stationary receiving conditions, in mobile receiving condition ISDB-T exhibits superior characteristics than the DVB-T system.

7 - Conclusion

This paper introduced the ISDB-T system for digital terrestrial broadcasting in Japan. Laboratory and fied trials have been conducted by ARIB, and final draft specifications for a terrestrial digital broadcasting system have been established.

An implementation strategy for digital terrestrial broadcasting was discussed by the study committee of the regulatory council, and a final report was submitted by November 1998. In this report, actual broadcasting services are expected at three major region areas of Japan by 2003. The Telecommunication Technology Council is studying network technologies so that ISDB-T can be used in a context of extremely congested frequencies. The Ministry of Posts and Telecommunications (MPT) prepared a preliminary channel plan by the end of 1998 and a final channel plan will provided by the end of fiscal year of 1999.

Digital HDTV will be the central part of the digital broadcasting scheme. As the MUSE-HDTV satellite services already have built infrastructure of high-resolution display in households, Japan is ready for digital HDTV broadcasting. NHK and commercial broadcasters have started to prepare for digital satellite broadcasting in 2000. The DTTB system on BST-OFDM is expected to be a major step for not only HDTV services but also mobile reception services in digital era for the future.

References

[1] T. Kuroda and M. Sasaki, Terrestrial ISDB System using Band Segmented Transmission Scheme, International Television Symposium, ITVS 20, pp.641-654(1977)

[2] S. Nakahara, S. Moriyama, T. Kuroda, M. Sasaki, S. Yamazaki, and O. Yamada, Efficient Use of Frequency In Terrestrial ISDB System, IEEE Trans. On Broadcasting, Vol.42, No.3, pp.173-178 (1996)

Appended tables

On the following pages...

Table 4: Segment Parameters for ISDB-T (6 MHz)

Mode		Mode 1		Mode 2		Mode 3	
Bandwidth		3000/7 = 428.57... kHz					
Carrier Spacing		250/63 = 3.968... kHz		125/63 = 1.9841... kHz		125/126 = 0.99206... kHz	
Number of Carriers	Total	108	108	216	216	432	432
	Data	96	96	192	192	384	384
	SP*1	9	0	18	0	36	0
	CP*1	0	1	0	1	0	1
	TMCC *2	1	5	2	10	4	20
	AC1*3	2	2	4	4	8	8
	AC2*3	0	4	0	9	0	19
Carrier Modulation		16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK
Number of Symbol per Frame		204					
Effective Symbol Duration		252 µs		504 µs		1008 µs	
Guard Interval		63 µs (1/4), 31.5 µs (1/8), 15.75 µs (1/16), 7.875 µs (1/32)		126 µs (1/4), 63 µs (1/8), 31.5 µs (1/16), 15.75 µs (1/32)		252 µs (1/4), 126 µs (1/8), 63 µs (1/16), 31.5 µs (1/32)	
Frame Duration		64.26 ms (1/4), 57.834 ms (1/8), 54.621 ms (1/16), 53.0145 ms (1/32)		128.52 ms (1/4), 115.668 ms (1/8), 109.242 ms (1/16), 106.029 ms (1/32)		257.04 ms (1/4), 231.336 ms (1/8), 218.464 ms (1/16), 212.058 ms (1/32)	
FFT sample clock		512/63 = 8.12693... MHz					
Inner Code		Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)					
Outer Code		RS (204,188)					

*1: SP (Scattered Pilot), and CP (Continual Pilot) can be used for frequency synchronization and channel estimation.
*2: TMCC (Transmission and Multiplexing Configuration Control) carries information on transmission parameters.
*3: AC (Auxiliary Channel) carries ancillary information for network operation.

Table 5: Segment Parameters for ISDB-T (7 MHz)

Mode		Mode 1		Mode 2		Mode 3	
Bandwidth		7000/14 = 500 kHz					
Carrier Spacing		500/108 = 4.629... kHz		500/216 = 2.3614... kHz		500/432 = 1.157... kHz	
Number of Carriers	108	108	216	216	432	432	432
	96	96	192	192	384	384	384
	9	0	18	0	36	0	0
	0	1	0	1	0	1	1
	1	5	2	10	4	20	20
	2	2	4	4	8	8	8
	0	4	0	9	0	19	19
Carrier Modulation		16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK
Number of Symbol per Frame		204					
Effective Symbol Duration		216 µs		432 µs		864 µs	
Guard Interval		54 µs (1/4), 27 µs (1/8), 13.5 µs (1/16), 6.75 µs (1/32)		108 µs (1/4), 54 µs (1/8), 27 µs (1/16), 13.5 µs (1/32)		216 µs (1/4), 108 µs (1/8), 54 µs (1/16), 27 µs (1/32)	
Frame Duration		55.08 ms (1/4), 49.572 ms (1/8), 46.818 ms (1/16), 45.441 ms (1/32)		110.16 ms (1/4), 99.144 ms (1/8), 93.636 ms (1/16), 90.882 ms (1/32)		220.32 ms (1/4), 198.288 ms (1/8), 187.272 ms (1/16), 191.764 ms (1/32)	
FFT sample clock		256/27 = 9.481... MHz					
Inner Code		Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)					
Outer Code		RS (204,188)					

*1: SP (Scattered Pilot), and CP (Continual Pilot) can be used for frequency synchronization and channel estimation.
*2: TMCC (Transmission and Multiplexing Configuration Control) carries information on transmission parameters.
*3: AC (Auxiliary Channel) carries ancillary information for network operation.

Table 6: Segment Parameters for ISDB-T (8 MHz)

Mode		Mode 1		Mode 2		Mode 3	
Bandwidth		8000/14 = 571.428... kHz					
Carrier Spacing		1000/189 = 5.291... kHz		500/189 = 2.645...kHz		250/189 = 1.322... kHz	
Number of Carriers	Total	108	108	216	216	432	432
	Data	96	96	192	192	384	384
	SP[*1]	9	0	18	0	36	0
	CP[*1]	0	1	0	1	0	1
	TMCC[*2]	1	5	2	10	4	20
	AC1[*3]	2	2	4	4	8	8
	AC2[*3]	0	4	0	9	0	19
Carrier Modulation		16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK	16QAM, 64QAM, QPSK	DQPSK
Number of Symbol per Frame		204					
Effective Symbol Duration		189 µs		378 µs		756 µs	
Guard Interval		47.25 µs (1/4), 23.625 µs (1/8), 11.8125 µs (1/16), 5.90625 µs (1/32)		94.5 µs (1/4), 47.25 µs (1/8), 23.625 µs (1/16), 11.8125 µs (1/32)		189 µs (1/4), 94.5 µs (1/8), 47.25 µs (1/16), 23.625 µs (1/32)	
Frame Duration		48.195 ms (1/4), 43.3755 ms (1/8), 40.96575ms(1/16), 39.760875ms(1/32)		96.39 ms (1/4), 86.751 ms (1/8), 81.9315 ms (1/16), 79.52175 ms (1/32)		192.78 ms (1/4), 173.502 ms (1/8), 163.863 ms (1/16), 159.0435 ms (1/32)	
FFT sample clock		2048/189 = 10.835... MHz					
Inner Code		Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)					
Outer Code		RS (204,188)					

*1: SP (Scattered Pilot), and CP (Continual Pilot) can be used for frequency synchronization and channel estimation.

*2: TMCC (Transmission and Multiplexing Configuration Control) carries information on transmission parameters.

*3: AC (Auxiliary Channel) carries ancillary information for network operation.

Book review

Physical Foundations of the Millimeter and Submillimeter Waves Technique

by V.P. Shestopalov
VSP, Utrecht, The Netherlands, 1997

In 1985, a two-volume monograph with the same title was published in Kiev, where the original, extensive theoretical and experimental studies of the author in collaboration with his co-workers were presented. This is a new version of the monograph, translated for western readers, containing however new results obtained in the last decade. It covers the electromagnetic millimeter and submillimeter waves with the lengths 10-1 and 1-0.1 mm. The studies are treated from the single viewpoint of the analysis of physical processes occurring in various devices which are applied in the millimeter and submillimeter technology. They showed that one has to use open resonators as effective electrodynamic structures in this wavelength range. By means of open resonators the fields are concentrated in the given spatiam domains. Open waveguides are used for creating slot (surface) and tearing off (volume) waves. Diffractional gratings transform surface waves into volume waves, and *vice versa*. This two-volume monograph is devoted to fascinating methods and devices.

Volume 1. Open Structures (213 pages)
In the millimeter and submillimeter wavelength ranges, open resonators have dimensions comparable with the wavelength, and wave beams usually have greater diffractional divergence in resonators with small curvature radii. So, the paraxial property is violated and the field is not strictly transversal-electromagnetic because non-zero longitudinal field components appear. In this monograph, the author considers a new type of open electrodynamical structure, a cylindrical slot waveguide formed by a dielectric pivot whose external surface is covered by a metallic film with a longitudinal slot. He establishes theoretically and experimentally that the millimeter and submillimeter wavelength ranges may be effectively mastered with the help of open structures. The volume has three chapters. The first one is devoted to the spectral theory and excitation of waveguides, including the calculation of open resonators, and an experimental study. Then the propagation of electromagnetic waves in open waveguides is reviewed, with the spectral theory of slot and strip waveguides. Finally, diffractional gratings are investigated, both theoretically and experimentally. Essentially, the monograph demonstrates that the millimeter and submillimeter fields may be concentrated in the given spatial regions and that the fields can be canalized, radiated, or transformed by means of these structures.

Volume 2. Sources. Element Base. Radio Systems: Novel Scientific Trends (244 pages)
This second monograph shows that the element base, units, and radio-systems of the millimeter and submillimeter technology may be designed on the basis of open resonators, waveguides, and diffractional gratings. The generator of diffractional radiation is considered by the author as the basic device of the technology. It is a high-coherent source of electromagnetic oscillations, designed in the mid-sixties in Kharkov. In this generator, electromagnetic oscillations are generated and supported by fast (volume) fields, and the inverse communication is provided by an open resonator in the form of a high q-factor resonance contour. The first chapter is devoted to generators of diffractional radiation, describing the structures, excitation, modes, and packing. Then the author describes and investigates the element base, including a variety as devices such a the slot radiator and slot coupler. The last chapter is devoted to radio systems and novel scientific trends. It includes spectroscopy, radiolocation, polarimetry, waves-measuring devices, and millimeter-wave antennas.

Reviewed by Prof. A. Vander Vorst
UCL-Microwaves
B-1348 Louvain-la-Neuve

News from ITU-R

Conference Preparatory Meeting for WRC-2000

The next World Radiocommunication Conference (WRC-2000) will be held in Istanbul from 8 May to 2 June 2000. One of the most important tasks of the ITU Radiocommunication Sector (ITU-R) is to prepare a report containing technical information relevant to the agenda items of the conference. The information comes from the Study Groups of ITU-R and is the result of studies conducted over approximately the past two years. The combined output from the Study Groups is consolidated and agreed by the ITU-R membership at a Conference Preparatory Meeting (CPM), the most recent of which was held in Geneva, 15 to 26 November 1999, to produce the report for WRC-2000. The report, which runs to some 400 pages, represents the best and most up-to-date information available at the time. (The report is available to the ITU membership on http://www.itu.int/brsg/cpm/index.html).

The report contains seven chapters, corresponding to the major themes of the Conference agenda.

Chapter 1 (IMT-2000, maritime and aeronautical issues) deals with spectrum and regulatory issues for advanced mobile applications in the context of IMT-2000 (International Mobile Telecommunications - 2000) and addresses the need for additional spectrum, particularly for the terrestrial component. Possible candidate bands are reviewed, with their respective advantages and disadvantages identified. Also covered is the use of the HF bands by the aeronautical-mobile and maritime-mobile services with a view to protecting operational, distress and safety communications from harmful interference. Advice is also provided on the use of new digital technology by the maritime-mobile service.

Chapter 2 (Mobile-satellite and radionavigation-satellite services) deals with the use of various bands between 1 and 3 GHz allocated to mobile-satellite services. Options are reviewed for additional spectrum for future needs, taking into account the protection of existing services, particularly those associated with safety communications. For mobile-satellite services below 1 GHz, existing constraints on allocations for non-geostationary-satellite orbit (non-GSO) systems are examined together with possibilities for additional allocations. Issues concerning new allocations for the radionavigation-satellite service in the frequency range 1 to 6 GHz are also addressed.

Chapter 3 (Non-GSO FSS issues) addresses the very complex issues concerning the use of bands allocated to the fixed-satellite service (FSS) by non-GSO satellite systems and the required compatibility with other users of the same bands. Examples of the latter are FSS and broadcasting-satellite systems using the GSO. Sharing issues concern the specification of appropriate power limits and protection criteria as well as the development of methodologies for coordinating different services using the shared bands.

Chapter 4 (Space science services and radio astronomy) considers the allocation of frequency bands above 71 GHz to the Earth exploration-satellite and radioastronomy services. The scientific requirements for such allocations are presented and the sharing possibilities with existing services are discussed for various candidate bands with particular regard to the sensitivity of the passive services concerned. Also addressed is the need for a worldwide primary allocation for the Earth exploration-satellite (passive) and space research (passive) services in the band 18.6 - 18.8 GHz - a band having unique characteristics for sensing the Earth's land and ocean surfaces.

Chapter 5 (Appendices S30 and S30A) concerns technical and regulatory issues connected with the possible replanning of the bands allocated to the broadcasting-satellite service around 12 GHz (together with feeder links around 18 GHz). Coordination procedures with existing services using the same bands are also discussed.

Chapter 6 (Fixed and fixed-satellite services) addresses issues concerning terrestrial point-to-point and point-to-multipoint systems in the fixed service when deployed in high number within a given area, (referred to as High-Density systems in the Fixed Service, HDFS). Using frequency bands above 30 GHz, sharing situations with existing services are examined, taking into account the ubiquitous deployment of HDFS stations. Similarly, many complex sharing situations are studied concerning the use of bands around 40 GHz by the fixed and fixed-satellite services and other services, the latter including several of the science services such as radioastronomy in the band 42.5 - 43.5 GHz. Studies are also described relating to high altitude platform stations (HAPS) in the fixed service operating around 47 GHz. The studies largely address the possibilities of sharing with existing services and, *inter alia*, discuss mitigation techniques in relation to potential interference into adjacent radioastronomy bands. The chapter also covers the use of earth stations on board vessels (e.g. ships) operating in the fixed-satellite service in the 6/4 GHz bands and their coordination with other services, and sharing issues associated with feeder links of non-GSO satellite networks in the mobile-satellite service in the 19/29 GHz bands and around 15 GHz, the latter involving protection to nearby bands used by the Earth exploration-satellite and space research services.

Chapter 7 (Other matters) deals with several unrelated items, many of which concern regulatory and procedural matters. Technical issues include a review of the maximum permitted spurious emission power levels given in the ITU

Radio Regulations with particular regard to those for space services. The exemption of deep space spacecraft from spurious emission limits is amongst other proposed amendments. The chapter also endorses the use of a revised procedure for determining the coordination area around an earth station in frequency bands shared amongst space and terrestrial services. The new procedure, destined to replace that currently in the Radio Regulations, contains a revised propagation prediction method covering the frequency range 100 MHz - 105 GHz.

Final meeting of Task Group 8/1

Task Group 8/1 (TG 8/1) is a group of experts from ITU-R Study Group 8 (Mobile services) that has been responsible for developing Recommendations on IMT-2000 (International Mobile Telecommunications - 2000). IMT-2000 relates to the next generation of personal mobile communication system that will provide wireless access to a wide range of services and applications. ITU's aim has been to bring together many related technologies to achieve truly global wireless access through the means of mobile radio. Over a period of 15 years, TG 8/1 has produced 20 Recommendations covering the operational requirements of IMT-2000, spectrum needs, sharing criteria, application in developing countries and the specification of the radio transmission technology.

At its final meeting in Helsinki in October 1999, TG 8/1 finalised the detailed specifications of the radio interfaces of IMT-2000 which are contained in draft new Recommendation ITU-R M.[IMT.RSPC]. The specifications are based on a choice of 5 radio interfaces for the terrestrial and 6 options for the satellite components of IMT-2000, reflecting the flexibility required by existing mobile operators to seamlessly evolve their pre-IMT-2000 networks towards third generation service capabilities, as well as meeting the various specific needs of operators of new satellite and terrestrial systems.

Information on current and future activities of the ITU can be found on its website at http://www.itu.int/.

Kevin A. Hughes

Conferences

U.R.S.I.

CONFERENCE ANNOUNCEMENTS

CPEM 2000

Sydney, Australia, 14-19 May 2000

Topics

Automated systems, software/firmware validation
DC and low frequency
Electromagnetic compatibility
Fundamental constants
International traceability
Lasers and optoelectronics
RF/microwave/millimetre-wave
Cryoelectronics
New sensors
Optical metrology
Power and energy
Quantum metrology
Realisation of units
Time and frequency

Which URSI Commissions are or could be involved?
Commissions A, B, C, D, E, F, J and K

WWW

http://www.tourhosts.com.au/cpem2000

Contact

CPEM 2000 Secretariat
GPO Box 128
Sydney NSW 2001 Australia
Phone: +61 2 9262 2277
Fax: + 61 2 9262 3135
E-mail: cpem2000@tourhosts.com.au

Dr Angela Samuel, Project Leader: International Metrology, APMP Work Program, CPEM 2000, and Thai National Standards National Measurement Laboratory, CSIRO PO Box 218, Lindfield, NSW 2070 Australia. Ph: 61 2 9413 7788 Fax: 61 2 9413 7383 Email: angelas@tip.csiro.au

BIANISOTROPICS 2000

Lisbon, Portugal, 27-29 September 2000

BIANISOTROPICS 2000 will be the 8th International Conference on Electromagnetics of Complex Media. The Conference will be held at the Congress Center of Instituto Superior Técnico, Universidade Técnica de Lisboa.

The meeting will cover from fundamental electromagnetic theory of complex media to applications and novel devices from the microwave to the optical regimes.

The conference will comprise 6 half-day sessions on a variety of research topics concerned with theory and applications of complex (i.e., chiral, pseudochiral, anisotropic, bianisotropic, nonhomogeneous, nonlocal, nonlinear, random) media. The programme will include special talks by key speakers, oral and poster sessions with contributed papers and discussions on hot topics bringing together applied mathematicians, physicists, engineers, material scientists from research institutes, universities and industry.

Schedule

April 22, 2000: deadline for one-page abstracts
May 22, 2000: notification of acceptance
July 5, 2000: reception of final manuscripts and registration

Contact

BIANISOTROPICS 2000
Prof. Afonso M. Barbosa (Conference Organizer)
Department of Electrical and Computer Engineering
Instituto Superior Técnico
Av. Rovisco Pais
1049-001 Lisboa, Portugal
Phone: +351-21-8418482
Fax: +351-21-8417284
e-mail: Bian2000@lx.it.pt
(e-mail should be used for all correspondence)
www.lx.it.pt/bian2000

2001 URSI INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC THEORY

Victoria, BC, Canada, 13-17 May 2001

In a long tradition our Commission B on "Fields and Waves" organises a triennial series of international symposia on electromagnetic theory. The next symposium in this series is the 2001 URSI International Symposium on Electromagnetic Theory, which will be held in Victoria, British Columbia, Canada, May 13-17, 2001.

It is hosted by the Canadian Member Committee of URSI and is organised by a Local Organising Committee at the University of Victoria, in collaboration with the Canadian National Research Council. The scope of the Symposium covers all areas of electromagnetic theory and its applications. The working language of the Symposium is English. There will be a limited number of Young Scientist Awards available for application. Further information concerning these Awards will be given well in advance of the Symposium.

Suggested topics

Contributions concerning all aspects of electromagnetic theory and its applications are welcome.
Novel and innovative contributions are particularly appreciated. Authors are asked to indicate the relevant topic area for their contribution, using the list of suggested topics T1-T22 given below.

T1: New basic theoretical developments
T2: Scattering and diffraction
T3: Inverse scattering and imaging
T4: Time domain methods
T5: High frequency methods
T6: Guided waves
T7: Solutions to canonical problems
T8: Propagation and Scattering in layered structures
T9: Propagation and scattering in complex media
T10: Propagation and scattering in random media
T11: Rough surface scattering
T12: Beam and pulse propagation and scattering in lossy and/or dispersive media
T13: Non-linear phenomena
T14: Antennas: general aspects
T15: Antenna arrays, planar and conformal
T16: Antennas for mobile communications
T17: Numerical methods: general aspects
T18: Numerical methods for integral equation problem formulations
T19: Numerical methods for differential equation problem formulations
T20: Numerical methods: hybrid methods
T21: Interaction of EM waves with biological tissue
T22: Other (suggest area title)

Symposium Time Table

Sept 23, 2000 : Deadline for receipt of summaries
Dec 15, 2000 : Notification of authors regarding acceptance of papers and announcement of the Young Scientist Award program

Jan 19, 2001 : Deadline for applications for the Young Scientist Awards program
Feb 16, 2001 : Notification of the Young Scientist Awards applicants
March 15, 2001 : Deadline for receipt of final papers, pre-registration of authors

Contact

Address general questions about the Symposium and its technical program to:

Prof. Staffan Strom
Chair, Commission B of URSI
Dept. of Electromagnetic Theory
Royal Institute of Technology
SE-100 44 Stockholm
Sweden
Phone: +46-8-790 8195, Fax: +46-8-10 83 27
e-mail: staffan@tet.kth.se

Questions regarding local arrangements can be addressed to:

Prof. Jens Bornemann
Dept. of Electrical and Computer Engineering
University of Victoria
PO Box 3055, Stn CSC
Victoria, BC
Canada V8W 3P6
Phone: +1-250-721-8666, Fax: +1-250-721-6052
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ISSSE'01 - 2001 International Symposium on Signals, Systems, and Electronics

Tokyo, Japan, 24-27 July 2001

"Questing More Significant Harmony and Integration: Systems/Devices and Softwares/Hardwares"

The ISSSE is an international symposium held once in every three years sponsored by URSI Commissions C and D. Historically, Commission C represented signal-, system-, and software-oriented technology, while Commission D represented device- and hardware-oriented technology. In recent years, however, the importance of cooperation between systems and devices, and in other words, software and hardware, has been more and more strongly recognized. In modern radio equipment, even a tiny single device can have a complex system function, and on the other hand, software gradually takes over the role of hardware. The cooperation of Commissions C and D, therefore, is quite timely and meaningful in the present and future URSI activities.

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M.Akaike, *Science Univ. of Tokyo, Japan*
K.Kikuchi, *Univ. of Tokyo, Japan*
Technical Program chairperson
H.Ogawa , *CRL, Japan*

Topics

Software-oriented radio transmitters/receivers
Integrated modules and elements
Wireless channel equalization
Hardware-oriented signal processing and compression
Signal detection and interference cancellation
Advanced technologies for RF circuits
Advanced wireless radio networks
Devices for microwaves and photonics
Hardware/software cooperation in radio equipment
Microwave/photonic integrated devices/systems
Diversity/ RAKE reception
Devices modeling and design
Anti-fading techniques
Numerical and CAD techniques
Radio-frequency synthesizers
Millimeter-waves applications
Digital signal processing
Cooperation of optical and microwave guides
Smart antennas
New materials and devices and their application
Optical signal processing
Full-scale system on a single chip
Large-capacity optical transmission

Special Transactions Issue: A mini-special issue on "Signals, Systems and Electronics" based upon papers presented in ISSSE'01 will be published in IEICE Transactions.

Tentative schedule

Abstract Submission: January 15, 2001
Notification of Acceptance: March 1, 2001
Camera Ready: April 15, 2001

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ISSSE'01 secretariat
Dept.of Elec. Eng., Science University of Tokyo
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May 2000

CPEM 2000
Sydney, Australia, 14-19 May 2000
Contact : CPEM 2000 Secretariat, GPO Box 128, Sydney NSW 2001 Australia, Tel.: +61 2 9262 2277, Fax: + 61 2 9262 3135, E-mail: cpem2000@tourhosts.com.au

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

GPR 2000, Eighth International Conference on Ground Penetrating Radar
Gold Coast, Australia, 23-26 May 2000
Contact : GPR 2000 Secretariat, Dept. of Computer Science and Electrical Engineering, The University of Queensland, QLD 4072, Australia , Fax: +61 7-3365-3684, E-mail: gpr2000@csce.uq.edu.au

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

June 2000

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

July 2000

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

33rd COSPAR Scientific Assembly
Warsaw, Poland, 16-23 July 2000
Contact : Prof. S. Grzedzielski, Executive Director, COSPAR, 51, Bvd. de Montmorency, F-75016 Paris, France, Tel. : +33 1-4525 0679, Fax : +33 1-4050 9827

August 2000

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

September 2000

Bianisotropics 2000
Lisbon, Portugal, 27-29 September 2000
Contact : Bianisotropics 2000, Prof. A.M. Barbosa, Dept of Electrical and Computer Eng., Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal, Tel.: +351-21-8418482, Fax: +351-21-8417284, e-mail: Bian2000@lx.it.pt, www.lx.it.pt/bian2000

October 2000

The First S-RAMP Conference
Sapporo, Japan, 2-6 October 2000
Contact : Dr. Y. Kamide, Solar-Terrestrial Environment Laboratory, Nagoya University, Honohara 3-13, Toyokawa, Aichi 442-8507, Japan, Tel: 81-533-86-3154, Fax: 81-533-86-0811, E-mail: s-ramp@kurasc.kyoto-u.ac.jp

February 2001

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

May 2001

2001 URSI International Symposium on Electromagnetic Theory
Victoria, BC, Canada, 13-17 May 2001
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Tokyo, Japan, 24-27 July 2001
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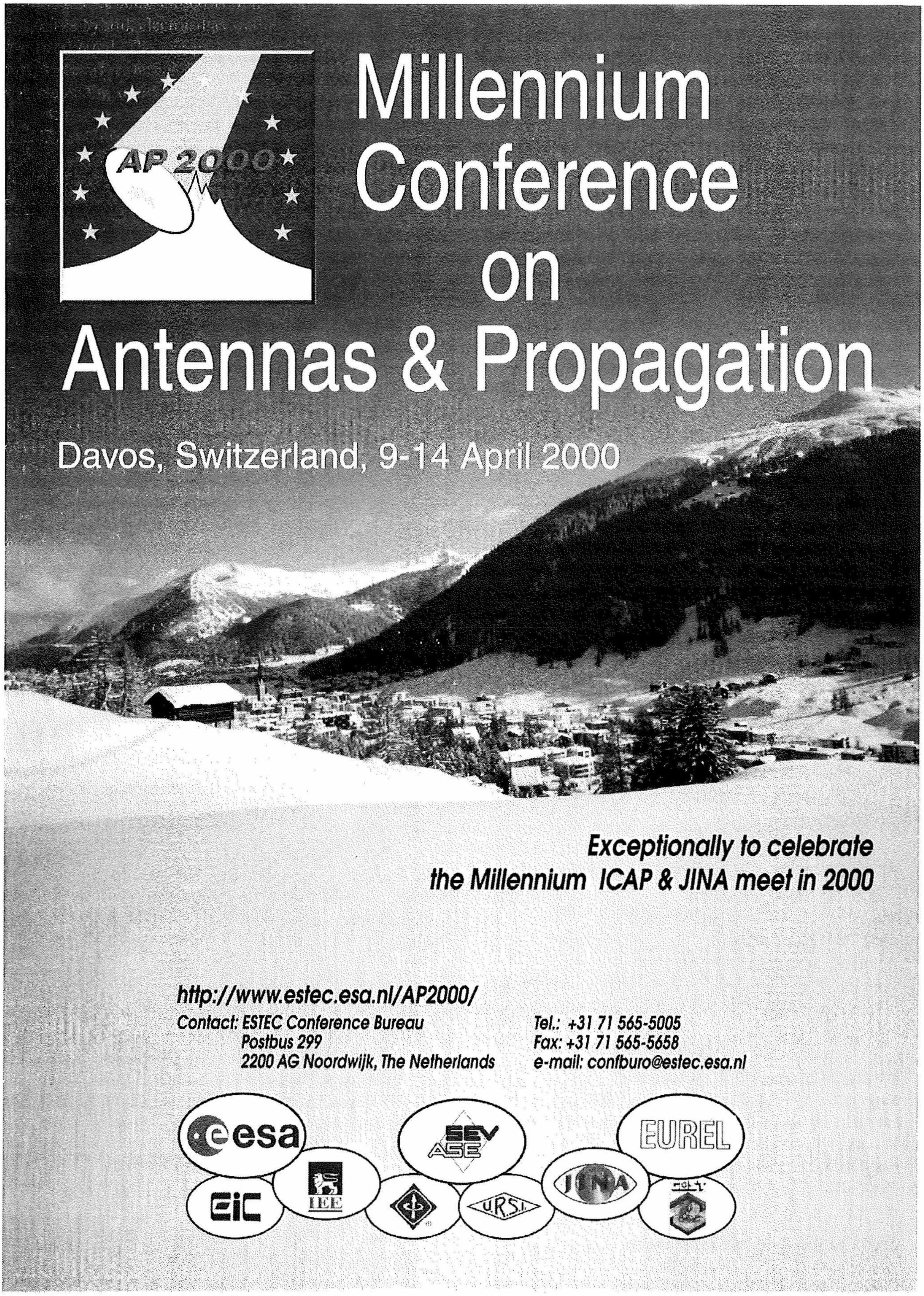
August 2001

Asia-Pacific Radio Science Conference
Tokyo, Japan, 1-4 August 2001
Contact : AP-RASC Secretariat, c/o Dr. Y. Furuhama, Communications Research Laboratory, Ministry of Posts and Telecommunications, 4-2-1 Nukuikita-machi, Koganei-shi, 184-8795 Tokyo, Japan, E-mail : ap-rasc@kurasc.kyoto-u.ac.jp, www.kurasc.kyoto-u.ac.jp/ap-rasc/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News from the URSI Community

AWARDS PANEL

At the first meeting of the new Board Prof. T.B.A. Senior, Past President of URSI, accepted the invitation of Prof. H. Matsumoto, President of URSI, to chair the Awards Panel for the 2002 URSI Awards.

Prof. Senior informed usthat the members of the 2002 Awards Panel are: Prof. T.B.A. Senior (Chair), Dr. John V. Evans, Prof. Akira Ishimaru, Prof. Ronald F. Woodman and Prof. Paul Lagasse (ex officio).

We take this opportunity to thank these distinguished scientists for their willingness to serve on the Awards Panel. For more information about URSI Awards, we refer to our Homepage at http://www.intec.rug.ac.be/ursi/Awards99.htm

BOOKS PUBLISHED BY URSI CORRESPONDENTS

Electromagnetic mixing formulas and applications

by Dr. Ari Sihvola
Electromagnetics Laboratory, Helsinki University of Technology
Email: ari.sihvola@hut.fi

Scope: A definitive treatment of the mathematical analysis of macroscopic dielectric and magnetic properties of geophysical, biological and other materials, including special reference to chiral and nonlinear materials. The effects of structure and anistrophy are discussed in detail, as well as mixtures involving chiral and nonlinear materials. High-frequency scattering phenomena and dispersive properties are also discussed. This book includes analysis of special phenomena that the mixing process can cause, such as the difference in character between a mixture and its constituent parts. Mixing results are applied to different materials in geophysics and biology. References is also made to the historical perspectives of dielectric modelling. Examples are included throughout the text.

Contents: 1: Introduction; 2: Physics behind the dielectric constant; 3: Classical mixing approach; 4: Advanced mixing priciples; 5: Anisotropic mixtures; 6: Chiral and bi-anisotropic mixtures; 7: Nonlinear mixtures; 8: Difficulties and uncertainties in classical mixing; 9: Generalized mixing rules; 10: Towards higher frequencies; 11: Dispersion and time-domain analysis; 12: Special phenomena caused by mixing; 13: Applications in geophysics and composite materials; 14: Concluding remarks; Appendix A: Vector and dyadic analysis; Appendix B: Collection of basic mixing rules; References; Index.

Aimed at students with research interests in electromagnetics or materials science, the book is also useful as a textbook in universities, as a handbook of mixing principles, and as a sourcebook for composite material design.

IEE Publishing, London, October 1999
EW 047, 304pp., ISBN 0 85296 772 1, 1999, £45 / US $79

Electromagnetic waveguides and transmission lines

by Prof. Frank Olyslager
Dept of Information Technology, Ghent University
Email: olyslag@intec.rug.ac.be

This theoretical monograph studies the mode propagation in electromagnetic waveguides and the representation of this eigenmode propagation by transmission lines. First the transmission line equations are derived from Maxwell's equations at low frequencies in the quasi-TEM regime. Then various transmission line models that can be used at arbitrary frequencies are discussed. These concepts are then further genralized to waveguides containing reciprocal and non-reciprocal anisotropic, bi-isotropic and bianisotropic materials. This requires the introduction of the concept of bitransmission lines. In the various chapters a number of properties of the mode propagation in general waveguides and (bi)transmission lines are discussed. The geometry of the waveguides is kept as general as possible throughout the book: closed as well as open, homogeneous as well as hybrid, electrical as well as optical waveguides are considered. The last part of the book deals with the incidence of external fields on waveguides and the corresponding sources in the (bi)transmission lines.

Contents : Introduction, Transmission lines for TEM and Quasi-TEM fields, Transmission lines for full-wave fields, Bitransmission lines for TEM and Quasi-TEM fields, Bitransmission lines for full-wave fields, Incident fields on transmission lines, Incident fields on bitransmission lines, Mathematics.

Oxford Engineering Science Series (science.books@oup.co.uk), ISBN 0-19-856450-3, Hardback, £60, 238 pages, May 1999

IN MEMORIAM

Paul Hontoy
1920-2000

C'est avec beaucoup de peine que nous avons appris le décès, le 28 janvier 2000, du Professeur Paul Hontoy, qui fut Secrétaire Général de l'URSI.

Paul Hontoy est né à Huy (Belgique) en 1920, dans une famille traditionnelle d'enseignants. Il entreprit, à partir de 1938, des études d'ingénieur électricien et mécanicien à l'Université Libre de Bruxelles (ULB). Ces études furent perturbées par la guerre car, en novembre 1941, l'ULB ferma ses portes pour ne pas devoir répondre à certaines injonctions de l'occupant nazi. Paul Hontoy abordait donc, à ce moment, sa quatrième année des études d'ingénieur, qui en comportent cinq en Belgique. Il obtint malgré tout, son diplôme d'ingénieur civil électricien et mécanicien en 1943 (donc sans retard par rapport au plan initial), via une procédure connue en Belgique sous le nom de « Jury Central », permettant de présenter les examens sans suivre les cours.

Malgré une époque troublée, il obtient entre 1943 et 1945 deux nouveaux diplômes d'ingénieur : en construction navales et en radio-électricité. En parallèle avec cela, Paul Hontoy fut enseignant clandestin dans les structures parallèles mises en place par l'ULB pour maintenir une certaine activité malgré la fermeture officielle de l'université. Il s'était déjà profilé, dans cette période difficile, comme un homme exigeant et courageux.

La guerre finie en 1945, le jeune Paul Hontoy est engagé comme assistant au laboratoire de radio-électricité du Professeur Divoire à l'ULB. Tout y était à recréer, l'enseignement comme la recherche, après cinq années d'interruption au cours desquelles la guerre avait considérablement fait progresser la science et la technique : naissance de l'électronique comme discipline distincte de la radio-électricité, maîtrise des microondes, invention du radar, etc. Paul Hontoy passera plusieurs mois aux Etats-Unis pour y apprendre ces nouvelles techniques.

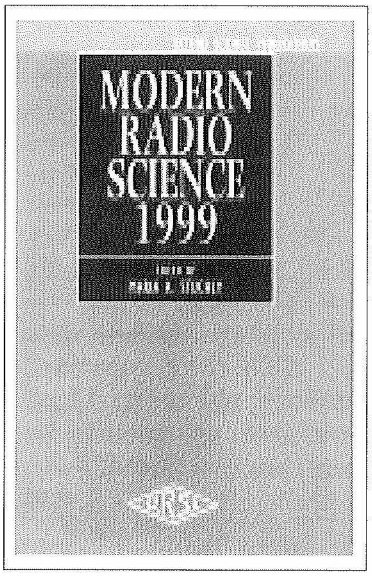
Au cours des années 50, il développe avec le Professeur Divoire un ensemble très complet et hautement apprécié d'enseignement de l'électronique, de la radio-électricité et des hyperfréquences à l'ULB. Il effectue de nombreux travaux de recherche sur l'électronique des télécommunications et la métrologie électromagnétique. Nommé chargé de cours en 1959, professeur en 1961, il prend la succession du professeur Divoire à la mort de celui-ci, comme Directeur de l'Institut des Télécommunications et d'Electronique de l'ULB.

Paul Hontoy a été un membre très actif du Comité Belge de l'URSI à partir de 1961 et il en fut président de 1975 à 1978. Unanimement apprécié par ses collègues, sa cordialité, sa gentillesse et son humour leur sont inoubliables.

A l'Assemblée Générale de l'URSI tenue à Helsinki en 1978, Paul Hontoy est élu Secrétaire Général de l'URSI, prenant ainsi le relais du Dr. C.M. Minnis admis à la retraite. Hélas, il ne pourra pleinement assumer cette fonction ; victime d'une maladie virale probablement contractée à Helsinki, il fut hospitalisé peu après son retour à Bruxelles et l'on craignit le pire pendant plusieurs semaines. Il reprit cependant le travail et organisa notamment en 1979 les cérémonies du 60-e anniversaire de l'URSI. Hélas, la maladie ne le quittera plus ; conscient de son état, il demanda en 1980 à être relevé de sa fonction de Secrétaire Général de l'URSI. Le relais fut assuré par Jean Van Bladel. Pendant de nombreuses années, Paul Hontoy fit face à cette adversité avec un courage qui force l'admiration. Ses collègues du Comité Belge de l'URSI ont eu le plaisir de le voir participer encore à leurs réunions jusqu'en 1994, environ. La souffrance, dont il ne parlait jamais mais qu'on devinait, n'avait pas entamé sa gentillesse.

A son épouse Eve, qui l'a tant soutenu avec amour au cours de ce long et pénible parcours, les membres de la communauté URSI présentent leurs plus sincères condoléances.

URSI Publications



Modern Radio Science 1999

Editor: Maria Stuchly
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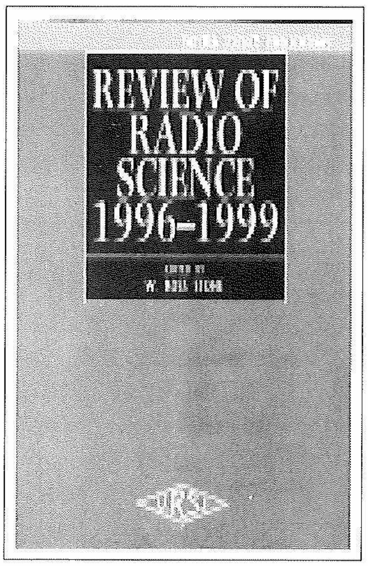

Review of Radio Science 1996-1999

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

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

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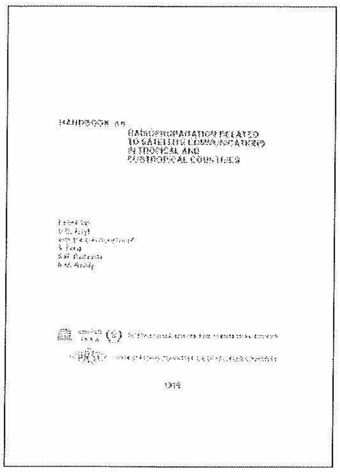

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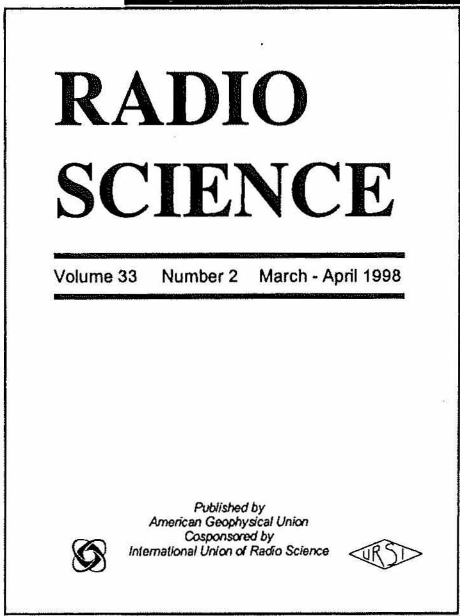
RADIO SCIENCE

Volume 33 Number 2 March - April 1998

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The journal of mobile communication, computation and information

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Aims & Scope:
The wireless communication revolution is bringing fundamental changes to data networking, telecommunication, and is making integrated networks a reality. By freeing the user from the cord, personal communications networks, wireless LAN's, mobile radio networks and cellular systems, harbor the promise of fully distributed mobile computing and communications, any time, anywhere. Numerous wireless services are also maturing and are poised to change the way and scope of communication. WINET focuses on the networking and user aspects of this field. It provides a single common and global forum for archival value contributions documenting these fast growing areas of interest. The journal publishes refereed articles dealing with research, experience and management issues of wireless networks. Its aim is to allow the reader to benefit from experience, problems and solutions described. Regularly addressed issues include: Network architectures for Personal Communications Systems, wireless LAN's, radio , tactical and other wireless networks, design and analysis of protocols, network management and network performance, network services and service integration, nomadic computing, internetworking with cable and other wireless networks, standardization and regulatory issues, specific system descriptions, applications and user interface, and enabling technologies for wireless networks.

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Content

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