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REPORT ON THE INTERNATIONAL CONFERENCE ON RADIO SPECTRUM CONSER—ETC(U)
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Report on the International Conference on Radio
Spectrum Conservation Techniques, London,
7-9 July 1980.

*George M. Sokol

31 Dec 1980

*United States Army Research, Development and
Standardization Group, UK

UNITED STATES OF AMERICA

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is a review of the highlights of a conference reviewing the results of recent research in developing improved techniques for reducing the re- quirements for band width in communications. Bandwidth-efficient interference resistant modulation, frequency re-use, cellular organization of short range transmitters, and satellite systems are among the techniques discussed. Areas of interest include mobile radio, broadcasting telephone systems, satellite systems, and spectrum planning, assignment and measurement.		

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REPORT ON THE INTERNATIONAL CONFERENCE ON RADIO SPECTRUM
CONSERVATION TECHNIQUES, LONDON, 7-9 JULY 1980

INTRODUCTION

Most types of air pollution receive abundant attention in the public media, but one type, at least, seldom receives its due even in the appropriate professional publications. Up to now, there has never been a major world forum for exchange of recent information on radio spectrum utilization problems and research issues. And even in July of 1980, when the British Institution of Electrical Engineers organized what it called an International Conference to deal with matters of more efficient spectrum exploitation and spectrum management, with support from the Convention of National Societies of Electrical Engineers of Western Europe (EUREL), participants found themselves at a British meeting with modest contributions from other countries. Of the 36 papers printed in the proceedings, 28 came from the British Commonwealth (and of those, 23 were from within the United Kingdom), 3 from the US, 2 from the Netherlands, and 1 from each of the following countries: Germany, Italy, and Saudi Arabia. Actually 2 additional UK papers were given, tilting the balance even more toward what you might expect to be parochialism.

Parochial? Not in the least! The speakers covered a wide variety of important topics and offered a bewildering array of creative ideas on a variety of different methods for improving spectrum utilization economy. In terms of significance this was an international meeting, and it is much hoped that future meetings will be organized to report what the engineers of other nations are doing to cope with the increasing demand for frequency allocations.

GENERAL

The opening address was international enough in every way. Richard C. Kirby, an American who is at present serving as director of the International Radio Consultative Committee (the CCIR) of the International Telecommunications Union, presented a report on the results of last year's World Administrative Radio Conference (WARC-79) which made major revisions in the Table of Frequency Allocations and adopted and revised certain regulations. The frequency allocation changes included some important increases for fixed satellite service, mobile radio, and earth exploration, largely at the expense of more intensive frequency sharing among the services. Kirby identified a number of regional conferences planned as post-WARC-79 meetings to implement local details. He also identified five technological elements as being of prime importance, and as representing important research thrust areas:

(1) What Kirby referred to as bandwidth-efficient, interference-resistant modulation (perhaps he meant to address the trade-offs between bandwidth efficiency and interference resistance): The impact of digital techniques and VLSI will facilitate spread-spectrum approaches, multi-user communications, packet radio, and television bandwidth compression. Packet radio is, of

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course, a technique, borrowed from computer network technology, for organizing sequential data into groups of characters, or packets, with header and trailer identification so that consecutive packets may travel by different routes requiring different periods of time to reach their destination, and so that at the destination the correct information sequence can be reconstructed.

(2) Frequency re-use, or simultaneous proximate independent use of the same frequency channel: improved understanding of the natural limitations to control of antenna beams and polarization, and cellular organization of area-coverage communications systems will receive attention, and additional propagation research is needed at frequencies below 40 GHz. Other major research issues are in polarization discrimination techniques, extensive maintenance of small antenna beam widths, and anomalous propagation effects like ducting and scintillation.

(3) Satellite systems, especially for rural areas where terrestrial microwave is not yet economically feasible. Related to this are the issues concerning access to the Geostationary Satellite orbit and demands by the developing countries for access to it.

(4) Control of spurious emissions.

(5) The role of the HF spectrum and means for making those systems using this frequency range more interference resistant.

The individual papers were, to a remarkable degree, responsive to the central theme of the conference, and provided useful accounts of specific approaches to spectrum conservation. Indeed, in this report I do not follow my usual procedure of reporting in depth on what I felt to be the best or most important papers of a conference. Instead I provide one or two sentences on almost every paper, identifying little more than the approach to spectrum conservation. Readers desiring more detail on any of the techniques are welcome to write to me. Copies of all papers have been kept, some of them annotated with references to the spoken remarks. Every effort will be made to provide copies of individual papers in response to requests. Since not all of the papers dealt directly with spectrum conservation measures, two sections are offered below. The first section deals with those papers which directly treat spectrum conservation measures. The second treats related matters.

SPECTRUM CONSERVATION METHODS

Spectrum Conservation in Mobile Radio

Dr. M. Darnell (UK Ministry of Defence) offered a brief tutorial on HF design principles for efficient spectrum utilization. He asserted that frequency re-use should be undertaken only after rigorous planning, that frequencies at the upper end of the HF band merit more consideration than they

receive, and that more use should be made of spectrum search and real-time channel-evaluation methods, though he cautioned that, if not carefully and correctly handled, these techniques might well add to the pollution problem. He also warned that error detection and correction techniques increase bandwidth requirements and therefore usually worsen spectrum utilization problems.

Dr. Y.S. Yeh (Bell Laboratories, Holmdel, NJ) advocated the use of space diversity, pointing out that the use of a large number of diversity branches makes frequency re-use feasible with great improvements in spectrum efficiency.

Dr. J.P. McGeehan (Univ. of Bath, UK) described a fast-acting feedforward automatic gain control technique, used in the receiver of a single sideband mobile radio system, which greatly reduces fast fading. This offers a simple and effective alternative to diversity techniques. Thus far, laboratory and limited field tests have produced encouraging results.

Dr. G.B. Lockhart (Univ. of Leeds, UK) offered a paper on the spectral properties of minimum phase signals. His analysis suggests the applicability of band limited minimum phase signals to mobile radio situations where conventional single sideband signal would not be efficient. Dr. Lockhart was prevented by illness from actually giving his paper.

R.J. Samuel (UK Home Office, Directorate of Radio Technology) proposed several schemes for spread spectrum application to achieve spectrum conservation, either by a sharing of spectrum between television broadcasting and slow-hopping land mobile radio, or by use of a small cell distribution scheme for unsynchronized spread spectrum in channels adjacent to television frequencies in nearby use.

Dr. R.F. Ormontroyd (Univ. of Bath, UK) also advocated spectrum sharing between television and land mobile radio using spread spectrum techniques, but he also questioned the general applicability of spread spectrum techniques for spectrum conservation.

Dr. F.C. Schoute (Philips, Netherlands) reported on a packet radio scheme using a slotted Aloha protocol with feedback control to prevent system instability.

K.F. Treen and Q.V. Davies (Univ. of Surrey, UK) brought tears of nostalgia to this writer's old eyes by proposing that leaky feeders can provide good mobile radio communication in restricted areas like large buildings, tunnels, mines, and even highways or railroads (and army posts?) where low-power transmission has the advantage of spectrum conservation and privacy. My introduction to radio was with an undergraduate college radio station that used the AC power distribution system as a leaky feeder for Medium Wave AM.

Spectrum Conservation in Broadcasting

P.A. Ratcliffe (BBC Research Department) provided a tutorial on the various techniques in use and under study for television bandwidth compression. Ratcliffe stressed three techniques which could be used in combination: Blanking-interval suppression; sub-Nyquist sampling; and differential coding. All of these are discussed in the European context of PAL television format.

G.H. Millard (BBC) discussed methods for synchronizing broadcast transmitters geographically separated but broadcasting the same program on the same frequency.

M.E. Bailey (BBC) reported on "CARFAX", a similar scheme, broadcasting over medium frequency in small well-defined service areas, with multiplicity of low-power transmitters operating in a time sharing manner, with a protection ratio of 14 db. CARFAX is designed to broadcast road traffic information to motorists, and the design challenge is one of providing common broadcast material on all transmitters most of the time, with brief local broadcasts of traffic conditions interspersed. The low power transmitter in a local cell is limited in its area of coverage by a simultaneous set of noise burst transmissions from the ring of transmitters in adjacent cells. This technique prevents a frequency-modulated START signal from being detected in the regions surrounding the local zone of interest and assures that the motorist will receive only the traffic data relevant to his current locations.

G.R. Sivyer (Broadcasting Corp. of New Zealand) presented a method for frequency planning.

J.H. Ellis of the UK Government Communications Headquarters advocated the use of small deviation FM, in which the FM signal could be contained within the same bandwidth as AM, or twice the amount of the modulating frequency.

P.J. Munday (Racal Research Ltd., UK), showed how adjacent channel performance for narrow-band FM data transmission could be improved by simulated filtering, thus reducing the transmitted signal sidebands by pre-modulation filtering of the modulating waveform. A major advantage of this approach is that it does not require the addition of any special receiver circuitry.

Dr. A.A. Ali (Riyad Univ., Saudi Arabia) provided an analytical examination of Carson's rule, concluding that for one subcarrier Carson's rule may lead to a waste of spectrum, and for two or more subcarriers it will lead to spectrum waste at low powers and excess distortion at high powers. This paper was not actually delivered at the conference.

Spectrum Conservation in Telephone Systems

M.C. Davies (British Post Office) described the transition from analog to digital facilities in the 4 and 6 GHz bands and told us that this would conserve spectrum. He described several modulation schemes which had been studied (16-state quadrature amplitude modulation; 8-phase, phase-shift keying, and reduced bandwidth, 4-phase, phase-shift keying with decision feedback.) The Post Office analysis found the last of these three, which they call 4-phase RBPSK, to be simplest, cheapest, and less sensitive to multipath fading. What this has to do with spectrum conservation, I don't know, but anyone who can pronounce RBPSK deserves a hearing somewhere!

M.T. Dudek (Hirst Research Centre, GEC Ltd., Wembley, UK) described a new digital technique using a decision feedback equalizer. This technique allows a signal modulated with 140 Megabits/second of Quaternary Phase Shift Key to be transmitted through a radio channel having about half the band width of equivalent unequalized channels with very little thermal noise penalty.

Spectrum Conservation in the Satellite Systems

J.R. Norbury (Rutherford and Appleton Laboratories, Slough, UK) read a paper on transmission possibilities in the millimeter range indicating that the military potential may be better than infrared, especially in geographic areas where very heavy rain is rare, although fog and cloud effects may become important.

Prof. E.D.R. Shearman (Univ. of Birmingham, UK) discussed problems of interference between high-frequency radar and communications, stressing the superiority of swept-frequency CW sounders.

P.R. Miller (Marconi Space and Defence Systems Ltd., UK) described his work (a Ph.D thesis at the University of London) studying cross-polar performance of large paraboloid reflector antennas and various feed systems.

N.J. McEwan (Univ. of Bradford, UK) discussed frequency re-use through orthogonal polarization, and found that sub-optimal adaptive cancellation with unitary cancellers could be quite effective in the 11 to 14 GHz range.

A.L. Marsh (British Post Office) and American colleagues with INTELSAT described evaluation techniques suitable for examining antenna cross-polarization features for frequency re-use.

A.D. Monk (Marconi Research Laboratory) examined methods of improving antenna sidelobe performance. He found offset non-symmetrical geometries technically attractive but quite expensive for large antennas, and not likely to become economically feasible until much more regulatory pressure is applied.

H.J. O'Neill (Independent Broadcasting Authority, UK) described the development of an adaptive cancellation system to reduce cross-polar interference between orthogonally polarized signals. The system was capable of reducing interfering signal levels from 12 dB, where they contributed to severe degradation, down to 40 db where no degradation was experienced.

P.N. Sargeant (Marconi Research Laboratory) reported on comparative studies of various modulation techniques.

Mrs. H.D. Duncan (Plessey Co., Ltd, UK) described a new approach to microwave oscillator design, claimed to provide a cost-effective microwave source with low spurious and harmonic output. The oscillator is well suited to motion detection applications, because its characteristics, including its good sensitivity, are suitable for use in a simple doppler detection system configuration.

SPECTRUM PLANNING, ASSIGNMENT, AND MEASUREMENT

R.W. Lorenz (Research Institute, West German Federal Post Office) described measurement techniques associated with field strength prediction. His work is in connection with German plans to go operational in 1983 with mobile radio in the 150-MHz band. He relied heavily on an existing topographical data bank maintained by the German government.

M.J. Burke (Communications Research Centre, Ottawa, Canada) described a system developed by the Canadian Department of Communications for monitoring mobile radio with stress on the importance of distinguishing between channel occupancy and message occupancy.

G. Sivyer (Broadcasting Corporation of New Zealand) described a broadcast frequency planning technique, using idealized uniform lattice representation of many transmitters, which can provide useful insights into gross spectrum requirement trends.

R.S. Sandell (BBC) gave a pitch for service planning. Sandell is head of the Service Planning Department at BBC, and he described the BBC approach to planning broadcasting services within the UK. He echoed Lorenz's view that collection of more terrain data is necessary as an adjunct to frequency allocation planning.

Professor E. Biglieri (Polytechnic of Turin, Italy) described a computer based system for evaluating the bandwidth occupancy of various modulation schemes. Based on a Markov chain model for the digital signal, the method is quite generally applicable to many modulation schemes. Biglieri emphasized the computation methods, algorithm selection, etc. to keep processor time and storage capacity requirements low.

Dr. G.A. DeCouvretur (Telecommunications Regulatory Service, Ottawa, Canada) described a Canadian management information system for spectrum management. It appeared to be a very ordinary management information system, but he seemed to think it was saving the Canadian government money. He did not give enough facts to prove it.

Peter Sawitz (ORI, Inc., US) gave a general tutorial on the relationship of spectrum and geography in planning the use of the geostationary orbit. Clearly this is a serious problem in international fixed-satellite-service. Sawitz believes that a high density of satellites is necessary to provide efficient spectrum-orbit utilization, but that this is feasible.

CONCLUSION

This was a conference of outstanding value on an important subject.

A copy of the proceedings is on file at this office and further information on any of the papers can be provided.

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