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Select Committee on Small Business
House of Representatives of the United States
Ninety-first Congress
Washington, D.C. 20515

COMMITTEE OFFICE
2361 RAYBURN HOUSE OFFICE BUILDING
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BRYAN H. JACQUES
STAFF DIRECTOR AND GENERAL COUNSEL

July 11, 1969

Mr. James D. O'Connell
Director of Telecommunications
Management
Office of Emergency Preparedness
Executive Office Building Annex
Washington, D. C. 20504

Dear Mr. O'Connell:

An additional day of hearings has been scheduled for Tuesday, July 29, 1969, by the Subcommittee on Activities of Regulatory Agencies Relating to Small Business on the reallocation of radio frequencies.

We will appreciate your appearing before that subcommittee at 11:30 a.m. on that day to give your testimony. Kindly advise whether this date and time is convenient, and whether you yourself will appear or whether you will designate someone else to appear in your stead.

We would appreciate having your statement on file 48 hours in advance of the hearing. Your cooperation will be greatly appreciated.

Sincerely yours,

John D. Dingell

John D. Dingell, Chairman
Subcommittee on Activities
of Regulatory Agencies
Relating to Small Business

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF TELECOMMUNICATIONS MANAGEMENT
WASHINGTON, D.C. 20504

OFFICE OF THE DIRECTOR

June 16, 1969

MEMORANDUM FOR THE DIRECTOR, OEP

SUBJECT: Recap of Hearings Before the House Subcommittee on Small Business on "Allocation of Radio Frequency Spectrum and Its Impact on Small Business", 9-10-11 June 1969

1. Congressman Dingell is Chairman of the Subcommittee on Small Business which has been conducting a series of hearings on the above subject for the past year or more. This week's hearing was another in the series.

2. Small business is a heavy user of "land mobile" radio for such communications as for taxicabs, ready-mix cement trucks, florists trucks, plumbers repair trucks, ambulances, and smaller operations. Small business interests (and the manufacturers of land mobile radio equipment) maintain that their frequency bands are saturated to the point that (a) current services are unsatisfactory, (b) services cannot be expanded, (c) new requirements cannot be introduced, and (d) as a consequence, small business is suffering because more frequencies have not been allocated. Frequencies currently allocated for UHF television would be ideal for land mobile use and heavy pressure is being brought by the land mobile interests to reallocate unused TV frequencies. TV broadcasters object arguing that the unused channels are needed for expansion.

3. The witnesses listed in the attached sheets testified during the 9-10-11 June hearings. Except for the All-Channel Television Society witness, FCC Commissioners, Mr. Novak and Mr. Gifford, the testimony, in one way or another, supported the land mobile interests. The one witness for the TV interests had a very rough time of it. Mr. Dingell as Chairman and the two Committee Counsellors worked him over with the thrust of their questions and comments being along

the line of what has the TV industry done to take advantage of modern technology to make more effective use of the spectrum. The fact that the TV witness presented a statement that was less than good didn't help him.

4. Mr. Novak's testimony consisted of a review and reiteration of that part of the Report of the President's Task Force on Communication Policy pertaining to frequency spectrum management. Mr. Gifford outlined the need to embark on a program to improve substantially the tools of radio frequency management to cope with demands on the spectrum that he estimates will increase ten-fold over the next 20 years. Chairman Hyde presented a statement on frequency management by the FCC and deplored that lack of funds and personnel prevented a better job from being done.

5. In the past, the Subcommittee, and its Chairman particularly, persisted in criticizing the FCC for failing to do its job. At the 9-10-11 June hearings, Mr. Dingell went out of his way to praise the FCC. He included Chairman Hyde with him in a televised news conference that was held on the third day. At one point Mr. Dingell blamed a "stingy BOB" for the FCC's problems. The six Commissioners present were invited to share the raised dias of the hearing room with the Congressmen.

6. The Subcommittee counsel informed the OTM observor (who was present throughout the hearings) that it was the Chairman's intention to resume the hearings in about a month. He expected that witnesses from the Transportation, Commerce, FCC, and OTM would be called to testify on the subject of frequency spectrum management.

7. With regard to paragraph 6, the manner and extent to which the Office should participate in the forthcoming hearing will be the subject of coordination with the White House staff.

J. D. O'Connell

Raish
cc: Mr. Kendall

HOUSE SELECT COMMITTEE ON SMALL BUSINESS
ROOM 2361, RAYBURN HOUSE OFFICE BUILDING
TELEPHONE: 225-4351 or 225-5821

SCHEDULE OF WITNESSES

HEARINGS ON

ALLOCATION OF RADIO FREQUENCY SPECTRUM
AND ITS IMPACT ON SMALL BUSINESS

SUBCOMMITTEE ON REGULATORY AGENCIES

June 9, 1969

10:00 A. M.

1. Mr. Max Guiberson
   President of the Land Mobile Communications Council

2. Mr. Martin Firestone
   General Counsel of the All-Channel Television Society

3. Mr. Jules S. Tewlow
   Director of Special Projects
   American Newspaper Publishers Association Research Institute

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HEARINGS ON

ALLOCATION OF RADIO FREQUENCY SPECTRUM
AND ITS IMPACT ON SMALL BUSINESS

SUBCOMMITTEE ON REGULATORY AGENCIES

10
JUNE 9, 1969
10:00 a.m.

Mr. Richard P. Gifford
Chairman
Joint Technical Advisory Committee

Mr. Alan Novak
Former Director of the President's
Task Force on Communications Policy

Mr. Charles W. Hubley
Chief Electronics Engineer
Associated Press

Mr. Walter R. Key
Law Enforcement Assistance Administration
Department of Justice

Mr. Thomas M. Allebrandi
Chairman, Information and Education Subcommittee
National Committee for Utilities Radio

Mr. Roger Reinke
International Association of Police Chiefs

Mr. William C. Hanna
Chief Engineer
Public Safety Systems Division
General Research Corporation

Mr. J. S. Anderson
Chairman of the Board
Aeronautical Radio, Inc.

Mr. John C. Welch
Maloney Concrete Company

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SCHEDULE OF WITNESSES

HEARINGS ON

ALLOCATION OF RADIO FREQUENCY SPECTRUM
AND ITS IMPACT ON SMALL BUSINESS

SUBCOMMITTEE ON REGULATORY AGENCIES

JUNE 11, 1969
10:00 a.m.

1. Mr. James Evans
   Michigan State Police

2. Mr. George DeMent
   Chairman of the Board
   Chicago Transit Authority

3. Chief Walter Krasny
   Ann Arbor Police Department

4. Eugene L. Nagel, M. D.
   School of Medicine
   University of Miami

5. Mr. Ben Demby
   Director
   Communications Department
   City of Miami

6. Federal Communications Commission
   Honorable Rosel H. Hyde
   Chairman

   Honorable Robert T. Bartley
   Commissioner

   Honorable Robert E. Lee
   Commissioner

   Honorable Kenneth A. Cox
   Commissioner

   Honorable James J. Wadsworth
   Commissioner

   Honorable Nicholas Johnson
   Commissioner

   Honorable R. Rex Lee
   Commissioner

CONGRESSIONAL HEARINGS ON SPECTRUM ALLOCATIONS REFLECT 'SIGNIFICANT PROGRESS' BY FCC, DINGELL SAYS IN COMMENDING HYDE; TRANSPORTATION, COMMERCE DEPARTMENTS TO APPEAR IN ABOUT MONTH; CONGRESSMAN SAYS BUDGET BUREAU IS 'STINGY' WITH FCC

The House Small Business Subcommittee on Regulatory Agencies continued its vigorous exploration of the "allocation of radio frequency spectrum and its impact on small business" and other areas of the country's social and economic life in three intensive days of hearings this week which clearly indicated that the work of the subcommittee during the past couple of years has, in fact, moved the land mobile radio frequency congestion crisis closer to resolution.

Subcommittee Chairman John D. Dingell (D., Mich.), one of the most outspoken Congressional critics of the Federal Communications Commission since his panel began looking into the spectrum allocation situation, prompted a noticeable sigh of relief from a Rayburn Building hearing room packed with FCC Commissioners and staff members, as well as other participants and observers at the hearing sessions, as, at the conclusion of the Commission's presentation, he noted that the "significant progress" which has been made "of late" by the agency is a source of "comfort" to the subcommittee.

Representative Dingell particularly commended and complimented FCC Chairman Rosel H. Hyde for his strong efforts over the past couple of years in concentrating much of the Commission's efforts on the land mobile frequency problem, though he continued his condemnation of the budgeting procedures within the federal government which have resulted in denying the Commission sufficient money and manpower to do its work.

While Mr. Dingell personally directed much of the questioning of a variety of witnesses during the hearing sessions this week, other members of both the Subcommittee on Regulatory Agencies and the parent House Small Business Committee took active roles in the sessions, including the committee's ranking minority member, Representative Silvio O. Conte (R.,Mass.); Representative William L. Hungate (D., Mo.), who chaired a portion of the hearings; and Representatives James T. Broyhill (R.,N.C.), Joseph P. Addabbo (D.,N.Y.), and John C. Kluczynski (D.,Ill.). Parent committee Chairman Joe L. Evins (D.,Tenn.) also made an appearance at the hearings.

In addition, Committee General Counsel Gregg R. Potvin, and Minority Counsel Fred M. Wertheimer played substantial roles in their interrogation of the witnesses.

Witnesses and/or participants during the three days of hearings, paragraphed by days, and in the order of their appearances, were:

Max Guiberson, President of the Land Mobile Communications Council, and C. Michael Meehan, Mr. Guiberson's counsel; Martin Firestone, General Counsel for the All Channel Television Society, assisted by Association of Maximum Service Telecasters Assistant Executive Director Roy Easley, engineering consultant Howard Head, and AMST counsel Henry Goldberg; Jules S. Tewlow, of the American Newspaper Publishers Association; Charles W. Hubley, of the Associated Press;

Richard P. Gifford, Chairman of the Joint Technical Advisory Committee; Alan Novak, former Director of President Johnson's Task Force on Communications Policy; Walter R. Key, of the Law Enforcement Assistance Administration; Thomas M. Allebrandi, of the National Committee for Utilities Radio; Roger Reinke, of the International Association of Chiefs of Police; Harvey G. Ryland, of General Research Corp.; J.S. Anderson, Chairman of Aeronautical Radio, Inc.; John C. Welch, of Maloney Concrete Co.;

Captain Robert Buchanan and R.J. Evans, of the Michigan State Police; George DeMent, Chairman of the Chicago Transit Authority; the FCC Commissioners, with the exception of Commissioner James J. Wadsworth; Chief Walter Krasny, of the Ann Arbor, Mich., Police Department; Dr. Eugene L. Nagel, of the University of Miami School of Medicine; and Ben Demby, Director of the City of Miami Communications Department.

The list of witnesses which had been released by the committee had included Hugh J. Gownley,Deputy Assistant Secretary of the Department of Transportation for Policy & International Affairs, and Robert S. Kirby, of the Department of Commerce. It is understood, however, that the White House asked the committee to excuse these officials from the hearings this week.

When the committee said this week that spokesmen from the Commerce and Transportation Departments would appear before the group in about another month, to discuss their capabilities for managing the frequency spectrum, it led at least one observer to speculate that the wheels in government which are turning on possible government reorganization might be productive of a publicly released proposal by that time. It is understood that the Director of Telecommunications Management will also be given an opportunity to testify at the hearings in another month.

An unusual note was injected into the subcommittee's hearings on Wednesday, June 11, as a number of equipment manufacturers laid out some of the most recent mobile communications equipment developments, and witnesses gave actual operating demonstrations or descriptions of how the equipment operates and the additional frequency demands which the developments will place on the spectrum available to the land mobile radio services, and a televised press conference was held in the hearing room, featuring Mr. Dingell, Chairman Hyde and several of the witnesses.

(The prepared testimony of the witnesses is covered in other articles in this issue of Industrial Communications. The balance of this story will cover the interrogation and comments of the witnesses, and statements by the members of the committee and committee counsel.)

The FCC's appearance before the group on Wednesday, June 11, the Commission's regular meeting day, moved right along without much questioning, following the submission of the agency's statements (see separate story), formal presentation of the "main" statement of the Commission, and oral summaries of the differing views of Commissioners Robert E. Lee and Nicholas Johnson.

When Mr. Lee brought up the subject of the Joint Technical Advisory Committee's recommendation for a pilot regional frequency management program, with the comment that "we tried to get funds this year, and will try again next year," Representative Dingell commented that he has "been trying to find ways of getting your true thoughts" on appropriations, without having to go through "the unresponsive Bureau of the Budget."

A discussion between Representative Dingell and Mr. Potvin noted that the Federal Aviation Administration spends more on communications research in a year than the "entire FCC budget," and the Navy spends "five times the entire FCC budget in just thinking about communications for Polaris Submarines."

Representative Addabbo agreed with Commissioner Lee's observations about a rigid block allocation system being bad, with the comment that a police department, particularly, if there are no remaining available frequencies, should be able to find an unused frequency in some other service, and upon proving that it is not used, get it.

When Mr. Dingell asked Mr. Hyde at one point whether there is "any way the FCC could more efficiently coordinate" communications problems, such as in the handling of state police problems, The FCC Chairman agreed "we must find a way to deal with these problems." In the police service, Chairman Hyde said, "we must find a way to consolidate systems" in a metropolitan area.

Representative Dingell asked at one point whether an overall spectrum allocations study to "provide basic tools" would be worthwhile, and Mr. Hyde said "there is no question" that the Commission needs more information than it currently has, but that the lack of resources at the agency has been a problem. Mr. Dingell commented that "I think you're afflicated with a stingy Bureau of Budget and a stingy Congress."

When the subcommittee chairman inquired as to the cost of a "well-done," comprehensive spectrum allocation study, Mr. Hyde pointed to the "Silent Crisis" report from the Commerce Department which had suggested a budget of $9,000,000 for the first year, and up to $50,000,000 a year after that.

"We need some applied research," Chairman Hyde said, adding again that he strongly supports JTAC's recommendation for a pilot project to "tailor services to a particular area." He told Congressman Dingell that the FCC had estimated that it would cost $1,250,000 for the first year for the JTAC-recommended project.

When Mr. Dingell said he feels that the FCC "should make its own long-range plan," Mr. Hyde said he agrees, but "We haven't been able to get funds for what we know is urgently needed."

Carrying the funds discussion over to Commissioner Johnson's appearance before the subcommittee, Mr. Dingell said he feels that a $20,000,000 to $50,000,000 annual budget for a good spectrum management program in the federal government would be a "good investment."

Commissioner Johnson had related a comment from a Department of Defence spokesman who had once told the Commission that while DoD had significant information in the spectrum management area which would be of help to the Commission, "you don't even have enough money to talk to us." The lack referred to, he said, was in personnel to meet with DoD representatives to learn what the information is and how to use it.

Representative Dingell had opened the hearings on Monday morning, June 9, with the comment that the sessions are "the culmination" of similar hearings held by the subcommittee during the last session of Congress. The "focus" of the hearings, he said, "will be on the additional need for spectrum space created by new technology." As an "historic first," Mr. Dingell said, the subcommittee had been licensed by the FCC as "an explorational and developmental broadcaster," to permit it to be "on the air" during the equipment demonstrations which were to follow.

"An additional task for the hearings," he said, "will be to throw such light as we are able on the issues surrounding dockets 18261 and 18262. It does not appear that this is necessarily a simple task in that I note that both sides to the controversy feel there has been a 'gap' of one sort or another. The Association of Maximum Service Telecasters talks of the 'exploding' of land mobile credibility. The land mobile forces, on the other hand, refer to a 'lack of accuracy'. "Hopefully," he said, "a by-product of these hearings will be to defuse any explosive material and to infuse a higher degree of accuracy."

Representative Conte, for the minority, opened his participation in the hearings with expression of "concern with the serious problem of congestion in the radio frequency spectrum presently allocated for land mobile use. We are concerned with why this congestion exists and with how we can best deal with the problem of correcting this situation. We are also concerned with what the future holds in store in this entire area and how we can best meet the challenges which lie ahead," he said.

Land Mobile Communications Council President Guiberson, as opening witness in the hearings, was questioned by Mr. Conte as to his feelings about the argument that more efficient use of present land mobile frequencies would solve the problem; about findings of the Stanford Research Institute "interim" report; and about changes needed in the spectrum management processes.

The LMCC President suggested that the "final report" of SRI, he feels, will "bear out" the fact that "adequate use is being made of the present land mobile frequencies," and that in the spectrum management area, the land mobile field has recognized the need for improvement and "has gone a long way" in that direction.

When Mr. Conte asked whether the UHF TV stations on channels 14 through 20 should "bear the expense" of moving out of those channels, Mr. Guiberson alluded to several methods of helping to meet the expense. He suggested that the application filing fees which land mobile applicants pay to the FCC could be devoted to the project; or that a federal grant system could be established; or that land mobile licensees needing the particular frequencies involved in the move could pay the cost.

Discussing with Mr. Conte the land mobile position that the FCC proposals in docket 18261 must be relaxed if mobile users are to "set some good out of the frequencies" in the lower seven UHF TV channels, Mr. Guiberson said he feels that the proposals, as issued by the Commission, would result in "very little" interference to television operations, but at the same time, they would result in "very little relief" for land mobile radio.

When Mr. Potvin asked Mr. Meehan about the boundaries of the urbanized areas used to define the 25 centers for which the FCC proposals intend to provide frequency relief, Representative Dingell commented that the lines were "frozen" in 1960, under the rule proposals, and the "1960 census is as out of date as the 1940 census."

Mr. Potvin, turning to the "battle" between AMST and land mobile, referred to the AMST statement that the SRI report "proves" the AMST case, and said he doesn't get that reading from the SRI report, a position with which Mr. Meehan agreed. On the SRI monitoring effort, Mr. Guiberson agreed with Mr. Potvin that "a mere recording by a machine is not sufficient"---that "value judgments should be made" in such a study.

When the Mr. Firestone appeared on behalf of the All Channel Television Society flanked by the three representatives of the Association of Maximum Service Telecasters, Chairman Dingell pointed out that the subcommittee had heard from Mr. Goldberg and Mr. Head, and feels that "their appearance last year was quite complete." It is "not my purpose," Mr. Dingell said, to "bog these proceedings down like the FCC does, with repetitious" statements.

Prepared statements offered by the AMST representatives were submitted to the committee's counsel for a determination as to whether they should be allowed in the record of this week's hearings, while Mr. Firestone went on to read his statement on behalf of ACT.

Going through with Mr. Firestone some of the arithmetic in AMST's filings with the FCC on the spectrum dockets, Mr. Potvin clarified several points by coming up with different results than had been offered by AMST. On one point--the economic study submitted by Robert R. Nathan Associates offering a "shadow pricing" philosophy, Mr. Potvin noted that the Nathan study had said a portion of prime time viewing was worth 50 cents to the home viewer, at one spot in the report, and that a $1 figure was used for the same time at another spot. This difference of 100%, the committee counsel said, "does seem to raise a question as to validity of conclusions" drawn in the report as to the value of the television service.

When Mr. Goldberg suggested that the Nathan firm should furnish the subcommittee an explanation of why the different figures were used, Mr. Potvin suggested that the explanation also be furnished to the FCC staff assigned to analyze the particular study.

Discussing Chairman Dingell's suggestion that ACTS should be "rather hard-put to make a categorical statement that the public is better served by the fifth re-run of 'I Love Lucy' than by having adequate police or fire communications for a major city," Mr. Firestone said he is "convinced there are frequencies available" if the frequencies that are available are used more efficiently by land mobile radio.

Mr. Dingell further suggested that "it's pretty hard to say" UHF channels which are not being used or are tied up in "dead CP's" are "sancrosanct" when there is a shortage of police and fire frequencies, and that ACTS would be "hard put to say there is not heavy use of the land mobile channels."

The subcommittee chairman asked whether ACTS is saying that the FCC's allocation for television "is the best possible plan of allocation which should be engraved in stone for years to come," and getting no answer from Mr. Firestone, offered his own view that "I'm certain the channels could be much better allocated."

"I like the serene way in which broadcasters pick out the channels most suitable to them," Mr. Dingell went on, and then say "land mobile should use the rest." He also hit the fact that "in one breath," the broadcasters "say the FCC has no knowledge in the area of land mobile--I agree with you; they don't have the staff; they've never requested the funds--and on the other hand, you feel that the FCC allocations are right in the TV area."

The subcommitte's position, Mr. Dingell said, "is that something has to be done to allocate spectrum" for land mobile radio, and "I find in your industry a very stiff-necked attitude. . .I admire your dedication that they (land mobile) should use their spectrum effectively, but don't see why broadcast should not also."

Mr. Potvin, receiving Mr. Head's view that television receivers should be improved and that the TV assignment "taboos" could be reduced if they were, went on to the observation, agreed to by Mr. Head, that "then allocations should be changed." Mr. Potvin said "In this case, then, ACTS is saying that reallocations should be made."

Mr. Head told the subcommittee that the "people who make television receivers also make land mobile equipment," and that the problem is thus in their hands.

Representative Dingell, noting that "We have wasteful use by broadcasters," and "we've got land mobile needs," asked "Can't we get together on this problem." Maybe "you can say" there is "bad handling" of their frequencies by the land mobile people, Mr. Dingell said to the ACTS contingent, but "don't you feel you have some burden, too?" He added that "We are going to ask about the government share of the spectrum, too."

The subcommittee chairman said he feels Mr. Firestone has "come a long way" from the "stiff broadcast position of a year ago," but is still "not concerned with the whole problem." This "is the point you're very clearly missing," he said. If the spectrum had been properly allocated in the first place, he said, "we wouldn't be in such a mess." Mr. Dingell said he hasn't heard "any of you (broadcasters) say anything other than 'status quo' should be preserved for TV while we squeeze others."

We have a "major crisis" on our hands, the Congressman said, and "I think you should want to" do something about it now. "You're not going to be able to stave off the impossible much longer," he said.

Mr. Firestone said he does "not disagree" that there is a crisis, but he is "not ready to agree as to how much we should give up."

When Mr. Potvin asked how many of the AMST members also belong to the National Association of Broadcasters, Mr. Goldberg said "a bare majority, if that." Mr. Easley fielded the next question---as to whether the proposed NAB-National Cable Television Association agreement poses a "drastic change" for the entertainment industry--with the observation that "NAB has not yet approved the staff agreement." If the agreement is adopted, he told the subcommittee, it would "have a beneficial effect on CATV's in the top 25 markets," and a "deleterious effect for everybody else."

Mr. Potvin's discussion with the ACTS witnesses of the AMST inference that the land mobile people had "kept hidden" the fact that land mobile "authorized stations" were different from the number of "stations on the air," whereas the fact is that the FCC advises people to apply for more units than they plan to use immediately, drew another comment from Mr. Dingell. "You operate with only one eye open, or with your head in the sand," he said. "If I were in your business," he said, "I'd be embarrassed."

Mr. Head said he "agrees with" Mr. Dingell's "thinking" and "feel you're on the right track, but please bear in mind that it is the receiver manufacturers you have to get after--Motorola, GE and RCA, who not only dominate the land mobile field, but they dominate the TV receiver market." When Mr. Potvin observed that "there is an RCA and an NBC," the line of discussion ended.

Congressman Dingell noted that "You're going to be in big trouble" if "you don't try to help us get the problem straightened out," and Mr. Firestone said "we want to talk about 900 megacycles," but "nobody else does."

When Mr. Wertheimer asked whether he was aware of studies that show that the long-range needs of land mobile are going to require additional spectrum, Mr. Firestone said he "hasn't heard what they will do with 900 megacycles." If the "government decided" that additional frequencies "must be made available," the minority counsel asked, "What then will be your position?" Mr. Firestone said he feels that "that decision has to be a couple of years away."

Mr. Goldberg, injecting the thought that the Kelly Scientific Corp., and others have pointed to "known techniques" that would improve land mobile spectrum unilization, drew a question from Mr. Potvin about the "diametrically opposed" views of the Kelly firm in studies it made before and after it had been retained by the AMST, but Mr. Goldberg said "we think he was consistent."

When Mr. Wertheimer asked Mr. Firestone to "look at the chart showing UHF TV having 50% of the spectrum," and asked "Can't you feel we have to make changes," the ACT counsel said "yes," but not now, while land mobile is "focusing on channels 14-20."

Turning again to the point that Dr. Peter Kelly, before being retained by AMST, had recommended that UHF television spectrum be reallocated to the land mobile field, Mr. Potvin was advised by Mr. Goldberg that "AMST was aware of this." Mr. Easley said that the Kelly firm's "common recommendation" in all the studies it has made is "for a smaller number of larger land mobile systems."

A "simple truth" about Dr. Kelly's studies, Chairman Dingell concluded, "is that if one makes certain assumptions at the beginning of a study, he can usually prove what he wants to prove."

The witnesses from the newspaper field, Mr. Tewlow and Mr. Hubley, drew relatively little questioning from the subcommittee. Mr. Tewlow answered Chairman Dingell at one point that the newspaper industry is "indeed" running in spectrum problems, and Mr. Hubley advised Mr. Potvin that he does not see how use of "common dispatch systems" would help the Associated Press people "at all." Mr. Potvin observed that the fact that broadcasters have adequate remote pickup frequencies, while the press people do not have adequate frequencies "almost smacks of anti-trust considerations," and Mr. Dingell noted that "It is the purpose of the committee to try to get you the spectrum you need."

The subcommittee members were obviously impressed with Mr. Gifford's presentation about JTAC's work in the spectrum management area, and Congressman Huntgate questioned him extensively as to the type of pilot project JTAC has recommended.

Responding to Mr. Potvin's questions about "upcoming advances" in the television industry, Mr. Gifford said there have been "dreams" of three-dimensional TV, and wall-size pictures. He agreed with Mr. Potvin that in the television field, the advances will be more "refinement" than "innovation," and that "innovations" in the electronics field as a whole are coming faster than they are in television.

Asked about "funding" for spectrum management by Mr. Wertheimer, Mr. Gifford said we need "a new level of funding," not "fantastic" in relation to the contribution which the spectrum is making to the gross national product, but "much higher" than at present. Asked about possible government reorganization, the JTAC Chairman said he has found it "no problem" to work with the FCC and the Director of Telecommunications Management on technical questions, and perhaps there could be one common technical body to serve both operations.

He agreed emphatically with Mr. Wertheimer that "we must start now," Particularly, he said, "when I look at what's happened in the past 20 years."

Mr. Novak, having concluded his summary of what President Johnson's Task Force on Communications Policy had recommended, told Mr. Potvin that the "logical contenders" to house the single spectrum management role which the Task Force has recommended, are the Transportation or Commerce Departments, since both have the capability and background. It was at this point that Mr. Potvin noted that both Departments will appear before the subcommittee in about a month, and that "both will have a lot to say."

When Representative Hungate asked about the Defense Department, Mr. Novak said it would "certainly" have the capability, but that he would "personally favor a consolidation" in the executive department. He added that "I don't think we can continue to jerry-rig between DTM and FCC."

The former Director of the Task Force said he feels that the FCC should be funded "much better," but that a regulatory agency has both "friends and enemies" and regulatory problems, such as those involved in the FCC's administration of the broadcast service, tend to keep funding down for the Commission and spectrum management should not be caught in this box.

Asked as to whether the government's Electromagnetic Compatibility Analysis Center (ECAC) at Annapolis, Md., could be used as the consolidated technical respository in an overall spectrum management effect, Mr. Novak said the concept is there, but it would have to be a much different ECAC "than what we have now."

When Representative Hungate referred to the Task Force recommendation that land mobile services should be able to use spectrum in the UHF television bands subject to no interference to TV, Mr. Novak said this recommendation took into account the way the TV allocation system was designed and the stations now in operation.

The "reform" in spectrum allocations, he said, "is certainly long overdue." He said he was "personally struck" during his work on the Task Force by the "potentials for mobile communications used by the public, for police and industry."

Questioned again about the recommendation for a new organization in the government for spectrum management, Mr. Novak pointed out that the 15 "high level government officials" who served as the members of the Task Force "were in agreement" on this point, and there "was virtual unanimity." The DTM "had some reservations" since it needed funds for some of its spectrum studies, and, in effect, didn't want to jeopardize getting those funds.

Asked as to whether the government expenditures would be worth the move, Mr. Novak said the benefits "will far exceed the cost of making the spectrum available." The present approach, he said, "is essentially holding back progress," particularly in the mobile radio area, which is "just waiting to break loose" if adequate resources were made available.

The former Task Force Director rejected the idea that the Defense Department would have difficulty in meeting its spectrum needs under the single manager concept. "Defense has done a tremendous job in their management of spectrum," he said, but "whether they need all they have is another question." He added that "I don't think they would have any problem in getting what they need" in the spectrum field, any more than they have problems in getting what they need in other areas.

In one comment following Mr. Allebrandi's testimony, Representative Hungate said "your examples have put flesh on the bones" of the spectrum problem.

Mr. Reinke, asked by Mr. Hungate to elaborate on one his points, said the International Association of Chiefs of Police feel that the FCC's reservation of the considerable amount of spectrum above 470 megacycles for UHF television is "unrealistic", whereas, "realistically," that band "is where most police agencies are going to have to go."

Mr. Potvin, referring Mr. Reinke to Mr. Key's statement, summarized that he would "like to establish this point with all clarity for the record--in addition to undeniable needs for new uses, your (police) guys on the street today can't get through." The IACP spokesman's response was "exactly."

Asked by Representative Hungate about his reference to the single emergency telephone number, Mr. Reinke said the matter is "of concern" to IACP "because of the way we establish emergency numbers." He said he feels "we're a long way off from a truly universal number, but when, and if, it comes, we're going to have that many more calls to answer by radio."

At the conclusion of Mr. Welch's statement, Representative Conte asked whether the concrete company was experiencing congestion with its radio system, and drew an affirmative answer.

When Mr. Potvin raised his question as to whether a "common user" system would work for the concrete company, Mr. Welch said "we could not go" to a common dispatch system and "would not go. As far as ready mix concrete is concerned," he said, "it would never work."

Mr. Anderson drew relatively little questioning after his statement. He did point out to Mr. Potvin that Arinc's present recognition of the need for 22 megacycles of space in the 900 mc band is in addition to the needs for land mobile frequencies which an air terminal spokesman had told the subcommittee about last year.

The Arinc Chairman said he can "see great usefulness" a plan which would preprocess passengers in the air, as a plane is enroute, so as to ameriorate the "crush" on the ground after they have landed. This would be particularly useful, he said, on international flights, in clearing the passengers through customs, through use of facsimile and well as other communications techniques.

Elaborating on the new Chicago Transit Authority system for Representative Kluczynski, who had welcomed him as a witness, Mr. DeMent said the CTA expects much of the system to be in operation this fall, and to be completely finished by next January. The bus system is currently experiencing three or four hold-ups or other "incidents" a day, now, he said, and CTA feels that it is worth its cost if only the emergency value were considered. The CTA Chairman said "all the bus companies around the country are watching us," and "if we're successful," every system will follow suit, "so there will be a definate need for additional frequencies."

When Representative Dingell asked whether CTA had encountered any difficulty in getting the frequencies it is using, Mr. DeMent answered negatively, noting that the Authority had "found sympathetic ears" at the Commission.

FCC Chairman Hyde, sitting in on the CTA demonstration, commented that the Commission has a rulemaking "going" on vehicle locators, and will be "happy to have the benefit of Chicago's experience.

One point of discussion which came up during Chief Krasny's testimony was that of the growing problem of police radio "eavesdropping" by members of the public, which the Ann Arbor official said is "getting serious." Mr. Evans was called upon to explain "scramblers," which he said same in "two kinds": one which does not request additional bandwidth but whose code can be broken; and one which does provide security of communications but which requires greater bandwidth than the ordinary police radio channel.

Mr. Evans agreed with Mr. Potvin that even if the Michigan legislature appropriated funds for scramblers on the police radio systems in the state, they couldn't be used at the present time because frequencies are not available.

Dr. Nagel's description and showing of the portable radio unit he has developed in cooperation with the Miami Communications Department and the Miami Fire Rescue Service was also a high point of interest for members of the Subcommittee.

The Rescue Service, Dr. Nagel pointed out, has a four-minute response time to emergency calls about heart attack victims, and this is within the time the doctor needs to get the heart functioning again, before brain damage is done. The highly trained rescue personnel, he said are capable of following directions from the doctor to affix the necessary EKG probes, transmit the heart information back to the doctor, and then carry out further instructions of some types.

Dr. Nagel told Congressman Dingell that in a city of 1,000,000 people, there are currently 4,000 deaths per year from heart disease of all kinds, and about half of these victims do not get to hospitals, where they can receive treatment, on time. It is "too early" in his program to say how many victims can be saved through use of the new radio equipment, he said, but a rough guess would be 10-15% of those which the rescue service reached in time.

The doctor emphasized that the procedure has a "tremendous value" in addition to the treating of the heart attack victims. "We are connecting two worlds not previously connected," he said, the rescue service and the doctor-hospital world. In the city of 1,000,000, Dr. Nagel pointed out, there are 400 traffic deaths and thousands of traffic injuries a year, and with the acceptance of the validity of the biological transmissions from the scene of the accidents, doctors will be able to direct the giving of blood on the spot, the administering of drugs, and"many other things."

"If you will give us two-way voice in addition to EKG," he said, "we can do much, much more. I think this is really a sleeping giant."

When Representative Addabbo noted that New York has had to remove medical aides from ambulances because of shortages of personnel in hospitals, and asked where the properly trained personnel can be found, Dr. Nagel said the community has to want the service and want to pay for it. He envisaged that the properly trained rescue service staff should be paid about twice the amount of the average ambulance attendant.

Congressman Addabbo observed on his own that "you couldn't possible share frequencies" for the type of operation under discussion; Dr. Nagel said in the Miami area he is talking about equipping 30 vehicles with the capability; and Mr. Demby translated this to a requirement for five frequency channels.

Mr. Wertheimer expressed the view that the "national implications" of Dr. Nagel's development "appear tremendous."

Asked whether a common user type of system could be used for the EKG operation, Mr. Demby told Mr. Potvin that "we're dealing with lives and time element" and "we can't go through a half dozen people."

Questioned about his own prepared statement on mobile radioteleprinter tests Miami has conducted, Mr. Demby said shared use of a channel, with a voice circuit, was found to be unsatisfactory for Miami, which, he said, would need two channels to initiate a proposed teleprinter system, and two more in two years, just for the printer operation.

As for other frequency requirements, Mr. Demby said "I know we're going to have to have such as color television from scene of accidents" and such, and "our channels are loaded now." Whatever relief the teleprinter channels would provide in reducing traffic on the present voice channels, he said, would still leave the voice channels loaded.

Mr. Demby told Mr. Dingell that Miami currently operates six police channels, four fire channels, and three local government channels. Asked whether this is "enough," he responded that "We've never seen that point." When Mr. Potvin asked whether the 450 mc split channels "helped," he said "yes, but we were in such bad shape before, we're still in bad shape." The Miami official pointed out that none of the UHF channels between 14 and 20 are being used in his area. -END-

JUNE 26 ANNUAL MEMBERSHIP MEETING OF NABER TO BE 'TRUE WORKING SESSION'

National Association of Business & Educational Radio President John Hodgson, of United Air Lines, reported this week that the June 26 annual meeting of NABER, at the O'Hare-Concord Motor Inn in Chicago, starting at 9 a.m., will be a "true working session" of those attending.

After brief reports by committee chairmen, of past actions and future proposals, he said, the items will be opened for general audience discussion, with major attention on things which could be of immediate benefit to business radio users. Mr. Hodgson mentioned a special operating manual, a channel captain program, frequency coordination, "nuisance rules elimination," and relaxation of restrictions on some of the 450-470 mc frequencies as subjects of discussion.

James C. McAllister, of McDonnel-Douglas, will serve as General Chairman of the meeting, and the special discussions will be led by Norman Bach, of Monsanto; William Detwiler, Radio Specialists Co.; Robert M. Johnson; and James Bernhart, Motorola--on technical problems, coordination, local organization, and membership aids, respectively.

The NABER Foard of Directors will hold its annual meeting following the close of the general membership meeting. People interested in attending the June 26 session should contact NABER, 1330 New Hampshire Ave., N.W., Washington,D.C. 20036.

and several other features helpful to the city. The city went from one frequency channel to two, experienced an increased flow of information along with "the greater effectiveness with which we are now able to operate", and reached the conclusion that it "could still further improve its operations and service to the public if we could obtain an additional frequency channel"--to permit car-to-car communications "without the need of tying up our base transmitter", he said.

"Before obtaining our second frequency channel," Chief Krasny said, "we were turned down four times", and in "our attempt to obtain a car-to-car frequency channel, we have been turned down five times because of a lack of available frequencies." He added that "we do not have a single television station on channels 14 through 20 in our area." -End-

TASK FORCE, JTAC OFFICIALS PUT COMPLEX REPORTS IN SIMPLE TERMS BEFORE HOUSE GROUP

Testimony before the House Small Business Subcommittee on Regulatory Agencies this week by Alan Novak, former Staff Director of President Johnson's Task Force on Communications Policy, and Richard P. Gifford, Chairman of the Joint Technical Advisory Committee, was in a class by itself, as both men explained the recent and exhaustive studies of their organizations which have called for a change in the way of life for managers and users of the radio frequency spectrum.

Mr. Novak, submitting the Task Force's chapter on spectrum management for the record of the subcommittee hearings, described how the Task Force had conducted its studies, and noted that the members of the group had found the spectrum task the "most intellectually interesting" subject of those which the Task Force had tackled.

Answering President Johnson's question as to whether we are making the best use of the spectrum, he said, we discovered quickly that "there is indeed, a problem," that we are not making the best use of the spectrum, and that "the increasing mobility of our society is increasing demands beyond capabilities under our present operations."

There is no "shortage" of spectrum, Mr. Novak noted--the problem is that there is "interference," and the question is "how to permit more people to do more things with the spectrum without interference." The "artificial scarcity" which has been created under our present management, he said, has created the "paradox" in the land mobile radio area where "not as many people are applying for use of the spectrum as they might if more spectrum were available."

The conclusion of the Task Force, he said, was that "no single approach was adequate"--that the tackling of the problem requires several attacks. The organization decided, he said that "we could not make a free market of the spectrum," but that we could use added economic incentives." The Task Force was particularly concerned about "spectrum waste," he said, and decided that one way to "curb" this would be to develop a license fee system with more relationship to the value which the licensee gets from his use of the spectrum. Since the government bears the expense of managing the public resource, he said, the Task Force decided that the government should be recompensed for its efforts. This fee system, he added, could also support the spectrum management effort, "such as JTAC recommends."

Mr. Novak pointed out that the Task Force found itself in "substantial agreement" with JTAC on engineering questions. "Our one concern" with the JTAC studies, he said, was that while JTAC has worked to the thrust of "How can we pass the most information by the spectrum," the Task Force conclusions also included a "social value" aspect--"How can we make the best use of the information that is passed."

And, he said, "when we took the economic and engineering results" together, "we decided that it would be no good unless we had a structure which could implement the substantive proposals we had arrived at," and procedures to carry them out.

The first thing we have to assure, Mr. Novak said, is that the government spectrum management effort has the "right institutional structure," and the consensus of the Task Force members was that the "present structure is not adequate." This, he said, led to the recommendation that a single spectrum management entity be established, and properly funded.

For his part, Mr. Gifford summarized that "To put (its) recommendations in succinct and perfectly clear terms, the JTAC is saying that the time has come to get technically organized for the task of managing this fantastic resource in the public interest. Old time administrative conveniences of long term unfilled reservations no longer can be tolerated. We've got to have tools on hand to do special jobs of cutting and fitting services on a regional basis. We've got to have sound technical guidance available to the spectrum managers to push for more efficient use with the passage of time or even to plan ahead to replace old uses with new uses, wherever new technologies create new demands on the spectrum or new substitutes for the spectrum."

For one thing, the General Electric Communication Products Department General Manager said, JTAC was "well aware that industry laboratories were constantly active in research for new ways to use the radio spectrum to provide new services," and "conducted a qualititive survey among leading firms to get an overall peek at the possible tidal wave that would soon be upon the spectrum manager."

The results, he said, were a "quick overview of what is going on in the laboratories of about 100 leading electronic companies. (It shows) there are many ideas in process to use currently allocated frequencies in new ways. Many of these may fail as business ventures," Mr. Gifford noted, "but even assuming only 10% survive all technical, market and business tests, we will find ourselves challenged beyond our current abilities in spectrum management."

"Along the same theme as the JTAC report," Mr. Gifford said, the testimony of the witnesses before the House subcommittee "also amply illustrate that we have every reason to expect demands on use of the radio spectrum to increase ten-fold again over the next 20 years as they increased ten-fold over the past 20 years. While our economy has expanded many times within the past 20 years, the role that this resource plays in terms of the share it supports has more than doubled to where today it accounts for about 2.5% of the Gross National Product."

The JTAC Chairman declared that "The only impediment to that trend continuing, or even accelerating over the next 20 years, is certainly not going to be decay in the imagination and inventiveness of man in finding roles for the spectrum in many more aspects of daily life. The only impediment will be our reluctance to plan ahead--to invest now for a return in the future--to get the technical machinery and human competence in place so that the spectrum managers can be in the position of promoting its use rather than having to cope with its use.

"To do that," he said, "will require an entirely new outlook in funding the technical foundation for management of this resource. The building of a spectrum engineering capability and facility may now be identified as the key to progress in utilization of the radio spectrum in the public interest. The key will be a new expense in our budget but it will unlock new riches in economic and social welfare." -END-

LMCC, ACTS LARGELY REPEAT POSITIONS IN FCC DOCKETS IN PRESENTATIONS TO SUBCOMMITTEE

Land Mobile Communications Council President Max Guiberson emphasized to the House Small Business Subcommittee on Regulatory Agencies this week that present uses of the radio frequency spectrum will shortly completely exhaust the available supply of mobile radio channels, and the myriad of new uses being developed will be denied the American public entirely unless the FCC carries through on its present spectrum proposals and improves them sufficiently to make realistic use of the new growth space possible.

Mr. Guiberson, Equipment Manager for the State of Washington Department of Natural Resources, in which he is responsible for the budgeting, purchasing and operating of all of the Department's $8,000,000 worth of equipment, emphasized that LMCC's comments to the FCC on its spectrum proposals had not stressed the numbers game "in light of the apparent universal acceptance of the need for additional frequencies for land mobile based on present congestion as well as future needs."

When the broadcast interests alleged "that present congestion was a myth and that projections of land mobile growth were grossly inflated," in their discussion of the roughly 7,000,000 authorized transmitters by 1980 projected by the FCC Frequency Relief Committee and the Land Mobile Section of the Electronic Industries Association, however, he said, LMCC ran its own study and concluded that by 1980, 10,800,000 transmitters would be authorized "provided adequate frequency allocations were available to permit free land mobile growth."

The LMCC statement to the House group set out the engineering advances which the land mobile people themselves have recommended, persuaded the FCC to adopt, and carried out;, described the complex coordinating procedures which are in effect in many of the radio services; and discussed the further improvements which they have recommended.

"Even if all of these improvements were fully implemented," Mr. Guiberson said, "this would still not result in sufficient additional space with the existing land mobile spectrum to meet even the most conservative growth estimates."

LMCC, he said, supports the Commission's proposals in the 900 megacycle area as a long-range plan for specialized land mobile requirements, but "what is needed to meet the immediate and long-term land mobile requirements is a block of frequencies close to the existing land mobile spectrum so that equipment now in existance can be readily available with little modification."

The computer studies submitted to the Commission by LMCC, it said, demonstrate the fact that "by applying improvements in frequency utilization and management to the broadcast spectrum, a means of accomplishing adequate relief for the land mobile services does exist, without any diminishing of television service."

The Council believes that the geographic sharing proposal advanced by the FCC "should be adopted, with some modifications, as a necessary but strictly interim step preliminary to the exclusive allocation of the lower seven UHF TV

Telecommunications

September 16, 1969

Dear Mr. Gancie:

Thank you for your letter of September 5 concerning the continuation of the NASA-Comsat arrangements for communications in support of the Apollo program.

The attached copy of a letter of August 6 from the DTM to Chairman Hyde of the FCC expresses the final results of a lengthy period of consideration.

I recognize that there is a real industry concern in this area, and I assure you that the Executive Office is eager to deal with these types of problems as fairly and objectively as possible.

I would be pleased to discuss this matter with you further at any time.

Sincerely,

Clay T. Whitehead
Staff Assistant

Attachment

Mr. Joseph J. Gancie
Vice President
ITT World Communications, Inc.
1707 L Street, N. W.
Washington, D. C. 20036

cc: Mr. Flanigan
Mr. Whitehead✓
Central Files

CTWhitehead:ed

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF TELECOMMUNICATIONS MANAGEMENT
WASHINGTON, D.C. 20504

OFFICE OF THE DIRECTOR

August 6, 1969

Honorable Rosel H. Hyde
Chairman
Federal Communications Commission
Washington, D. C. 20554

Dear Mr. Chairman:

This is with reference to the request of the Communications Satellite Corporation for continuation of the direct contractual relationship between the National Aeronautics and Space Administration and the Communications Satellite Corporation for communications supporting the Apollo project.

The Commission's opinions of July 20, 1966, as amended February 1, 1967, concerning the so-called "authorized user" matter cited this service as an example of a situation "where the requirement for satellite service is of such an exceptional or unique nature that the service must be tailored to the peculiar needs of the customer and, therefore, cannot be provided within the terms and conditions of a general public tariff offering."

Nevertheless, when the question of continuation of this arrangement was raised some weeks ago, it was considered that it might be possible for the service to be handled through one of the terrestrial carriers. However, a number of circumstances have subsequently arisen which make it essential to continue the present arrangement.

The future service requirements in support of Apollo will involve a pattern of operational relationships between the Government, Comsat, which operates the satellites, and the operators of earth (and ship) stations similar to those which presently prevail. The satellite portion of the NASCOM service was established by INTELSAT under a special allotment arrangement, based expressly upon the requirement of the U.S. Government associated with the Apollo missions. Further, these services involve the provision of non-standard circuits of less than CCITT quality. In order to assure that these arrangements are not impaired to the detriment of the space program, and in the belief that the interjection of U S. terrestrial carriers into this pattern would not provide any benefits, we have concluded that the service should continue to be furnished directly by Comsat.

It is therefore in the national interest that the direct contractual relationship between Comsat and NASA for provision of the NASCOM service in support of Apollo be continued. NASA has been instructed to renew or extend its contract with Comsat.

Sincerely,

J. D. O'Connell

THE WHITE HOUSE

WASHINGTON

September 9, 1969

To: Ralph Clark

From: Tom Whitehead

For draft reply.

ITT World Communications Inc. *subsidiary of International Telephone and Telegraph Corporation*
1707 L St N W Washington D C 20036
Joseph J. Gancie *Vice President*

5 September 1969

Mr. Clay T. Whitehead
Staff Assistant
The White House
Washington, D. C.

Dear Tom:

Please find enclosed a copy of a letter to Chairman Hyde of the FCC in the matter of a recent renewal of a contract between COMSAT and NASA for the APOLLO Program.

We do not so much question the final decision in "the National interest" as we do the procedures. The carriers truly had little or no clear-cut opportunity to show their potential.

This is not a "raise the roof" item. You did ask us to present industry problems as they arose. In that frame of reference we are concerned now about such future decisions and hope we can see you to discuss this at an early date.

Sincerely,

Joe Gancie

Joseph J. Gancie
Vice President

JJG/j
Enclosure

Mr. C. Whitehead
White House
Clay:
FYI & background
JJ France

ITT World Communications Inc. subsidiary of International Telephone and Telegraph Corporation

67 Broad St New York NY 10004

J. R. McNitt President

September 2, 1969

The Honorable Rosel H. Hyde
Chairman
Federal Communications Commission
Washington, D. C. 20554

Dear Mr. Chairman:

This is in reference to a letter, dated August 6, 1969, sent to you by the Director of Telecommunications Management ("DTM"). The DTM's letter notified the Federal Communications Commission of his findings concerning the proposed continuation of a direct contractual relationship between the National Aeronautics and Space Administration ("NASA") and the Communications Satellite Corporation ("Comsat") for certain communications services rendered in support of the Apollo project. Based on the DTM's conclusion that it is in the national interest for the services involved to be furnished directly by Comsat, he has "instructed" NASA to renew or extend its contract with Comsat.

While the DTM's letter appears to preclude further investigation of alternatives to the present arrangements, ITT World Communications Inc. ("ITT Worldcom") believes that the Commission should be apprised of the manner in which the overseas record carriers have thus far been denied an opportunity to provide certain of the communications satellite services for the Apollo program. Initially, NASA requested us to demonstrate our ability to fulfill the subject requirements of that agency in a letter dated June 30, 1969, wherein it was recognized that we would need the cooperation of Comsat in the development of a plan for furnishing the service to NASA; and Comsat was informed of NASA's inquiry. At a conference held in NASA's offices in Washington, D.C., the international record carriers were also advised that the preliminary submissions, including proposed charges, requested by NASA's June 30th letter would not be treated as competitive bids. Rather, such proposals would merely serve to inform NASA with respect to the available services and the charges therefor.

Thereafter, ITT Worldcom promptly requested Comsat to quote its charges for the portions of the service which would be furnished to ITT Worldcom by Comsat. To date, information essential to the preparation of our response to NASA has not been supplied by Comsat, and NASA has been so advised. Nevertheless, the DTM has apparently foreclosed U.S. international record carrier participation in this aspect of the Apollo program. Accordingly, by its letter dated August 7, 1969, NASA's request to ITT Worldcom for a technical plan and preliminary cost estimates was withdrawn. The basis for NASA's current negotiations with Comsat has not been made public; and, since a tariff covering the proposed service has not been filed, the Commission may also be unaware of the details.

Under the circumstances, the requirements of the Commission's Authorized User decision have been avoided, if not evaded. At least, it appears that the Commission has been denied an opportunity to give meaningful consideration to the DTM's decision that NASA should deal directly with Comsat. All interested parties, including NASA, have been effectively denied access to necessary information on which a technical explanation of the preference granted to Comsat could be based. Therefore, absent a reopening of the matter by NASA or the DTM, we believe that in this instance the spirit and intent of the Authorized User decision has been frustrated.

In view of the questionable procurement practice adopted by the Government in this matter, and since a serious question remains as to whether this service continues to be the "unique" service contemplated in the Commission's Authorized User decision, the proposed contract terms should be made available to the interested carriers. In any event, the service provided directly by Comsat should not be permitted to extend beyond that originally recognized by the Commission to be "unique" without further consideration by the Commission after the carriers have had an opportunity to comment.

Very truly yours,

J. R. McNitt
President

cc: The Hon. Robert T. Bartley
The Hon. Robert E. Lee
The Hon. Kenneth A. Cox
The Hon. James J. Wadsworth
The Hon. Nicholas Johnson
The Hon. H. Rex Lee

General J. D. O'Connell
Director of Telecommunications Management

Mr. Gerald M. Truszynski
Associate Administrator for
Tracking and Data Acquisition
National Aeronautics and Space Administration

See Thayer - PACEO staff man in our discussions

mtg 7/30
10am

STAFF PAPER

FEDERAL COMMUNICATIONS ORGANIZATION

Our program on communications

President's Advisory Council
on
Executive Organization

11 July 1969

FEDERAL COMMUNICATIONS ORGANIZATION

I. THE PRESENT SITUATION

Following the President's message of August 14, 1967 on Communications Policy, two studies were undertaken. In December 1968, the reports were issued: the Final Report of the (Rostow) Task Force on Communications Policy, (a review of past activities in the field and formulation of national communications policy), and the Bureau of the Budget study of Federal Communications Organization. The second report endorsed most of the major organizational recommendations of the first, particularly on the need for establishing a new executive capability in the telecommunications field. It is likely that we will be asked to comment on these recommendations now that they have reached the stage of a memo for Presidential decision. What follows is a summary of the major organizational recommendations and the objections to their implementation.

II. ISSUES AND PROPOSED CHANGES

A. New Policy Organization -- Both reports recommend forming a new telecommunications policy organization in the executive branch. It would not be concerned with operations. The most controversial aspects of this new organization would be:

1. Consolidating all policy planning and spectrum management functions. This means relieving the Federal Communications Commission (FCC) of all its present policy and management functions in the non-governmental use of communications and leaving it as a solely regulatory body. In addition, the National Communications System (NCS) would give up its policy and management activities in the Federal sphere. The Office

of the Director of Telecommunications Management (DTM) of the Office of Emergency Planning (OEP) which does the policy planning for the NCS and also manages government spectrum frequency would be transferred to the new agency.

a. While both reports suggest reducing the duties of the overloaded FCC and NCS, they would strengthen them in their remaining authority, on the operations side. The FCC should be granted increased common carrier capabilities and the NCS be reorganized and strengthened in its capacity of directing the operations of Federal communications activities. This would include a transfer of major communications functions presently in GSA, to the NCS.

2. Coordinating communications research and development. There is disagreement between the reports over whether to make this a centralized responsibility for all such research or whether it should mean closer use of resources presently available in other agencies and private industry.

B. Placement of the New Organization

The Task Force did not specify where the new policy organization should be placed. BoB considered three alternatives:

1. A separate department : The report contends that the scope of the telecommunications field does not yet warrant this.

2. Place it within an existing Department, e.g.:

a. The Department of Commerce: advantages are availability of research and other resources and freedom from ties to major communications consumers.

b. <u>The Department of Transportation</u>: advantages are staff experienced in dealing with industrial and other competing forces in telecommunications.

3. <u>Within GSA or NASA</u>: present scope of both agencies is too narrow, according to BoB.

The BoB recommends alternative 2, to begin with the transfer of the Office of the DTM to the Department chosen. In a meeting with PACEO, BoB briefing officers expressed a preference for DOT over Commerce, but this does not come out clearly in the BoB report, The new agency could thus begin with the nucleus from the present DTM.

III. OBJECTIONS TO THE PROPOSED SCHEME

A. The FCC objects to the separation of the managerial from its regulatory tasks. The Task Force suggests that the FCC is not equipped for managerial responsibility, and that the new agency would be an aid, not a competitor. Common carriers and other private interests also oppose the change.

B. General James D. O'Connell, Director of Telecommunications Management, appended a partial dissent to the Task Force Report in which he suggested that there was not sufficient proof of the need for the new agency. He would prefer that additional resources be assigned to the Executive Branch and the FCC, which would lead to the necessary improvements in policy and other areas without the necessity of a new agency.

He also expressed a fear that expanded government managerial capabilities would encroach upon an area of decision-making belonging to industry.

C. Joseph Bartlett, former Under Secretary, Department of Commerce, appended a partial dissent suggesting that the research and development authority of the new organization be expanded even to the sponsoring of research, not just its coordination.

IV. A NEW INTERNATIONAL TELECOMMUNICATIONS AGENCY

The Task Force also recommends the formation of a single U.S. entity for international communications, to combine transmission and switching facilities, and to eliminate the present fragmentation of ownership due to the presence of the Federally sponsored Comsat and the private common carriers.

V. ALTERNATIVES FOR PACEO

This subject is approaching Presidential decision. Peter Flanigan, who is handling this issue for the White House, would like PACEO to advise the President on it. The Council has two options:

A. It can anticipate a request for Presidential advice by putting a staff man on the issue full-time for the next month.

B. It can wait for such a request to come before committing major resources. In the meantime, the existing staff can devote time to monitoring new developments in the area.

The staff recommends the first alternative.

SOURCES

1. Bureau of the Budget, Study of Federal Communications Organization; December, 1968.

2. President's Task Force on Communications Policy, Final Report; December 7, 1968.

3. Briefing of PACEO Staff by the Bureau of the Budget, June 19, 1969: Attending: Messrs. Thayer, Rouse, Comarow, Harding, Evans, Auspitz, Paget, William Morrill (BoB), and Seymour Greenstone (BoB).

28 LINTON HOUSE · 11 HOLLAND PARK AVENUE · W11
TELEPHONE 01.727. 7263

Eva Daughtrey,
Administrative Assistant to
Clay T. Whitehead, Esq.,
THE WHITE HOUSE,
Washington.

Thursday,
10th July,
1 9 6 9.

Dear Eva Daughtrey,

The Report of the President's Task Force on Communications Policy arrived a few days ago.

It was most kind of you to send me a copy.

I now have to study it and embody it into a series of lectures on Communications Technology.

Seen from England's point of view, Mr. Nixon appears to be getting to grips with his job and demonstrating that he is a practical and hard working President.

I think it would be correct to say that the British people are now viewing your President as a man who is bringing a lot of good sense and worldly knowledge with constructive leadership to his very difficult and heavy task.

I can only wish him the best of British Luck in all his efforts to bring peace to the world.

Yours very sincerely,

Arthur Cain

Arthur Cain.

(3) Recommendation over

July 10, 1969

(DTM)

To: Marge

From: Tom Whitehead

Please add this Recommendation to the package we sent over last night.

7/10/69

Recommendation

The Office of the Director of Telecommunications Management should be strengthened and expanded to enable the DTM to serve as the focal point for all executive branch telecommunications activities and to be the Administration spokesman on national telecommunications policy issues. The DTM would be expected to be the primary executive branch office for the analysis and formulation of recommendations for both national communications policy and Federal telecommunications procurement. These responsibilities would include:

-- economic, technical, and systems analysis of communications policies and opportunities;

-- taking an increasingly active role in advocating policy to the FCC and through the President to the Congress, to include specific recommendations on spectrum management for non-Government uses.

-- management and allocation of Government spectrum use, to include development of improved spectrum management techniques, and eventual responsibility for unified Government and non-Government spectrum management.

-- guidance and information to Federal, State, and local Government agencies in communications planning and procurement.

-- responsibility for policies and standards for procurement of Federal administrative telecommunications services and/or systems.

A Telecommunications Research and Analysis Center would be established in the Department of Commerce, reporting to the Assistant Secretary for Science and Technology. The Center would be responsible for both technical and economic analysis and research, responsive to the needs defined by the DTM. The TRAC would incorporate the current research program of the Institute for Telecommunications Sciences, as well as appropriate elements of other Commerce activities in telecommunications. Its specific functions would include:

-- establishment and operation of a national electromagnetic compatibility analysis facility.

-- research and analysis of improved spectrum utilization techniques to support the DTM in Government spectrum management and in making recommendations to the FCC on non-Government spectrum management policies.

-- research and analysis leading to the development by DTM of improved technical and operating standards.

-- continuation of basic telecommunication science research and provision of services to other Government agencies and industry.

The DTM should be raised immediately to executive pay level IV and authorized an expanded staff that would include a limited capability for economic, legal, technical, and systems analysis. He would be expected to contract for significant portions of the research and analysis required to support his responsibilities and also to draw heavily on the Commerce Telecommunications Research and Analysis Center.

A NSSM should be issued as soon as the new DTM is selected. This study should define appropriate NSC machinery for dealing with national security and emergency telecommunications issues and should provide general guidance to the DTM on emergency requirements and policies.

Implementation

This recommendation could be implemented almost immediately through the following actions:

A. By Executive Order

-- clarify and bolster DTM authority and eliminate existing patchwork of Presidential memoranda and conflicting Executive Orders.

-- similarly clarify authority and responsibility of the Department of Commerce.

B. By Secretarial Order

-- establish a Telecommunications Research and Analysis Center under the Assistant Secretary of Commerce for Science and Technology.

C. Subsequent Action

Once sufficient capability in the analysis of national communications policy issues and the associated capability for improved Government and non-Government spectrum management is achieved, Government and non-Government spectrum management responsibilities should be consolidated. This almost certainly will require establishment of a new agency outside OEP, either in the Executive Office or in a Cabinet Department.

-- at an appropriate time, introduce legislation to establish an independent office in the Executive Office or in the Commerce Department and transfer non-Government spectrum management from the FCC to the new agency; emergency preparedness functions would remain in OEP.

-- at an appropriate later time, transfer to the new agency by Executive Order responsibility for procurement of Federal administrative telecommunications services and/or systems.

FCO

(2)

Recommendation only

(Commerce recommendation)

July 9, 1969

To: Peter Flanigan

From: Tom Whitehead

This is the paper for our discussion with Stans and for his possible discussion with Secretary Laird.

Attachment

cc: Mr. Whitehead
Central Files

CTWHITEHEAD:ed

THE WHITE HOUSE

WASHINGTON

July 9, 1969

MEMORANDUM

The attached recommendation appears to be the most desirable long-run approach to strengthening the capability of the Federal Government in the area of telecommunications. It is predicated, however, on agreement by the Department of Defense to transfer from the Executive Office of the President to another Cabinet Department of frequency management responsibilities for Government telecommunications. The benefits of having centralized in one agency Government and non-Government spectrum management, Government procurement of administrative communications, and responsibilities for formulating recommended national policies appear to be significant enough to attempt to convince the Secretary of Defense of the appropriateness of the attached recommendations.

Attachment

Recommendation

A Federal Communications Administration should be established in the Department of Commerce. This Administration would be expected to grow into the primary executive branch agency for the analysis and formulation of recommendations for both national communications policy and Federal telecommunications procurement. The functions of the FCA would include:

-- economic, technical, and systems analysis of communications policies and opportunities;

-- take an increasingly active role in advocating policy to the FCC and through the President to the Congress, to include specific recommendations on spectrum management for non-Government uses.

-- management and allocation of Government spectrum use, to include development of improved spectrum management techniques, and eventual responsibility for unified Government and non-Government spectrum management.

-- guidance and information to Federal, State, and local Government agencies in communications planning and procurement.

-- eventual responsibility for procurement of Federal administrative telecommunications services and/or systems, to exclude national security command and control systems and subject to the emergency preparedness requirements of the OEP.

The FCA would incorporate the current research program of the Institute for Telecommunications Sciences and the frequency management activities of the DTM, including the Interdepartmental Radio Advisory Committee. It would be expected to develop a national electromagnetic compatibility analysis facility and to develop the requisite policy analysis capabilities. Each Federal agency would be responsible for design, procurement, and operation of specialized telecommunications systems unique to agency missions, subject only to general standards of the FCA and the requirements of the OEP.

The Director of OEP should be directly assigned all responsibilities for emergency communications requirements and preparedness. With the spectrum allocation responsibility removed from OEP, the roles of DTM and SAPT would be eliminated. OEP should continue to have an Assistant Director for Telecommunications who would be responsible for specification of emergency capacity requirements, priority override features, and survivability capabilities for Government communications.

A NSSM should be issued as soon as the new Assistant Director for Telecommunications is found for OEP. This study should define appropriate NSC machinery for dealing with national security and emergency telecommunications issues and should provide general guidance to OEP on emergency communications requirements and policies.

Implementation

This recommendation could be implemented within a reasonably short time through the following actions:

A. By Executive Order

-- Transfer to Commerce the telecommunications analysis, policy coordination, and spectrum management functions now delegated to the DTM, along with supporting staff and resources.

-- Transfer directly to the Director of OEP those responsibilities and functions of the DTM/SAPT relating to preparedness for national emergency telecommunications.

-- Strengthen NSC-OEP responsibilities and machinery for national security and emergency telecommunications issues.

B. By Secretarial Order

-- Establish a Federal Communications Administration reporting directly to the Secretary of Commerce that would immediately incorporate the Government spectrum management responsibilities and facilities, the appropriate communications-related research activities in ESSA and National Bureau of Standards, the beginnings of a policy analysis and economic research operation, and a group to plan for eventual responsibilities for Federal administrative telecommunications.

C. Subsequent Action

-- After sufficient capability in spectrum management has been attained and demonstrated, introduce legislation recommending transfer of non-Government spectrum management to the FCA, leaving specific non-Government frequency assignments and licensing to the FCC.

-- At an appropriate time, transfer to FCA by Executive Order of Federal administrative telecommunications systems.

(1)

FCO

July 9, 1969

To: Peter Flanigan

From: Tom Whitehead

This is the memorandum to which almost any conclusion can be flexibly attached.

One possible recommendation is the paper we will discuss with Stans. I will have another possible recommendation at our 9:30 staff meeting.

Attachment

cc: Mr. Whitehead
Central Files

THE WHITE HOUSE

WASHINGTON

July 9, 1969

DRAFT MEMORANDUM

There are a number of important problems with respect to Federal telecommunications policies that suggest reorganization:

1. The communications industry is heavily regulated by the FCC and is heavily affected by the communications activities of Federal agencies. However, neither the FCC nor the executive branch have a significant capability for systematic analysis of telecommunications policies and opportunities, their impact, their effectiveness, or their costs. The "cooperation" between the FCC and various parts of the executive branch appears to consist largely of gentlemen's compromises among competing interests and philosophies. The increasingly rapid rate of technological change and introduction of new services makes policy-by-precedent increasingly less relevant and more restrictive.

2. The so-called National Communications System remains a loose confederation of agency systems. In spite of the highly desirable interconnection capabilities that have been developed over the last few years, there has not been adequate specification of emergency capabilities, hardness, and priority override features necessary to permit informed decisions about the adequacy, performance, and cost of the system. No one seems to know what a "unified" NCS means, would cost, or would accomplish.

3. The extremely rapid rate at which communications are growing in the United States has brought about increasing conflicts over the use of various parts of the frequency spectrum and the beginnings of a spectrum shortage crisis.

Federal organization weaknesses:

Since World War II, there have been a number of studies of Federal communications organization and a number of reorganizations and shifts of responsibilities within the executive branch. None has proved particularly satisfactory, and, indeed, there does not seem to be any neat solution to this problem. The lack of a good solution apparently is due to the quasi-independence of the FCC from the executive branch and to the conflicting requirements of Executive Office telecommunications coordination and individual agency mission responsibilities.

The study of the Federal Government communications organization completed in December 1968 by the Bureau of the Budget provides a good statement of the shortcomings of our current organization. The Bureau of the Budget reported a need for:

(1) a strengthened organization for policy planning, formulation and direction of Federal communications activities.

(2) a reorganized and strengthened National Communications System (NCS) within the Department of Defense.

(3) an improved procurement and technical assistance effort in communications on behalf of those Federal agencies which do not now have adequate resources in this field.

(4) unified frequency spectrum management process.

(5) a coordinated technical assistance program for State and local governments in this area.

Current organization for communications policymaking:

The Director of Telecommunications Management (DTM) in the Office of Emergency Preparedness is now charged by Executive Order and Presidential memorandum with the responsibility for coordinating telecommunications activities in the executive branch. The DTM also is designated Special Assistant to the President for Telecommunications. However, the history of the organization reveals that attempts by the DTM to exercise leadership in communications policy have been largely ineffectual. This situation results from a number of factors such as organizational location, inadequate staff, and fragmentation of policy authority among half a dozen agencies with no one having overall responsibility. In view of its claimed responsibilities, the credibility of the DTM is questioned by agencies with operating responsibilities.

There is now no office in the executive branch with the responsibility or the capability to review national telecommunications policies as expressed in legislation and in FCC policies. The antitrust division of Justice has occasionally filed briefs on competitive aspects of decisions before the FCC, but these derive largely from antitrust considerations rather than from familiarity with communications issues. The Council of Economic Advisers has shown almost no capability or interest in telecommunications, and OST is certainly not equipped for addressing the fundamental economic and institutional problems of the industry and its regulation by the FCC. The Administration is therefore largely unable to exert leadership or take initiatives in spite of vulnerability to criticism for FCC policies.

<u>Executive branch responsibilities</u>:

There are six major functions that are the responsibility of the executive branch in the telecommunications area:

1. Assignment of frequencies for Government communications.

2. Research and development.

3. Analysis of technological and economic alternatives and formulation of recommendations for national policy with respect to telecommunications.

4. Definition and assurance of emergency communications capabilities.

5. Policy planning responsibilities for Government communications activities.

6. Procurement of Government communications services and operation of Government communications facilities.

Agency views:

The Budget Bureau study of Federal communications organization made a number of major recommendations (see attached summary) and was recently distributed to the concerned departments. Agency views on the Budget Bureau recommendations have been received (summary attached). These views share a common theme that (1) stronger coordination from the top is required in establishing Government policy for its own telecommunications requirements and that (2) the Federal Government should take a stronger role in the evolution of national telecommunications to deal with the increasingly rapid rate of technological change and industry growth. There is also agreement that a much stronger analytic capability within the executive branch is needed to achieve these goals.

There is, however, no consensus among the agencies about the extent to which the Bureau's specific organizational suggestions will actually advance the above objectives. The history of this area suggests strongly that it will be unprofitable to seek further agreement among the agencies. There is no solution that will represent a desirable compromise, and no solution appears sufficiently strong on its merits that it looms out as the obvious choice.

Alternatives:

A number of organizational arrangements that have been suggested in the Congress or the press can be rejected immediately as impractical or politically infeasible. These include establishment of a Department of Communications, transfer of all DTM functions to an existing Cabinet department, and significant expansion within the Executive Office of the President by creation of a new Office.

Determination of emergency communications requirements clearly must remain in OEP. Major involvement by the executive branch in nongovernmental communications policy matters before the FCC and the Congress could be centered in one of the Cabinet departments -- probably Commerce.

There appear to be three feasible alternatives:

(1) Maintain essentially the status quo, but clarify and strengthen the conflicting Executive Orders through which the DTM derives his authority. If this is done, the office should be strengthened by expansion of staff resources and by raising the DTM to the rank of deputy within OEP. This alternative would leave the Administration largely incapable of dealing with national communications policy problems.

(2) Alter slightly the status quo by strengthening the DTM as in the first alternative, but including in addition a capability for analysis of non-Government policy issues that would enable the Administration to play an expanded role in that area. This alternative could lead toward considerable pressure for a separate independent office in the Executive Offices in a few years.

(3) Create a new organizational unit in the Department of Commerce that would perform the needed analysis of major national communications issues; take an increasingly active role in advocating policy to the FCC and (through the President) to Congress; and eventually be responsible for unified management of spectrum resources for both Government and non-Government users. This alternative would require shifting of spectrum management responsibilities from the DTM, leaving only emergency communications requirements in OEP.

Attachment 1

BOB recommendations concerning Federal communications organization

The Bureau of the Budget report recommended that:

1. The Federal Government should establish a new and strengthened central policy and long-range planning organization for communications in an existing executive branch agency -- either Commerce or Transportation.

2. The NCS staff should undertake implementing studies (a) to transfer the Federal Telecommunications System from the General Services Administration to the Department of Defense for merger with the military administrative communications systems to provide service for all Federal agencies and (b) to appropriately locate and combine the roles and functions of the Executive Agent and the Manager of the NCS within the Office of the Secretary of Defense to provide unified guidance to the NCS from within the Defense Department. An effective mechanism should be provided whereby the member agencies of the NCS can advise and be consulted by the Manager, NCS.

3. The National Communications System staff within the Department of Defense should provide a central source of procurement-related assistance for use by executive agencies.

4. The management of the Government's portion of the frequency spectrum should be a function of the new communications policy organization. If a single manager is provided for the entire spectrum, the total function should be placed in the new organization. The new organization should have a limited in-house research capability to support its frequency spectrum management and general policy development responsibilities.

5. The new communications policy organization should coordinate action on requests to Federal agencies from State and local governments for technical assistance in telecommunication and should provide such assistance to Federal agencies who lack in-house capability.

Attachment 2

Agency views on Budget Bureau recommendations

The Bureau circulated its study report among those agencies having significant telecommunications responsibilities and requested their views. The following is a summary of the agency responses:

-- The Department of Commerce concurred in the report's major findings and recommendations. The Department specifically supported vesting overall management of the spectrum in one executive agency. Its comment on the report's major organizational recommendation -- "The establishment and location of such an agency in an existing Department will enable meaningful Executive Branch participation in the development of comprehensive national policies."

-- The Department of Defense (including the views of the Executive Agent of the National Communications Systems) agreed with the need for a new and strengthened policy and long range planning organization but believes that it should be constituted as a separate office outside OEP but in the Executive Office of the President. The DOD does not concur in the need for an implementing study to transfer the Federal Telecommunications System from GSA to Defense nor does it favor a combination of the roles and functions of the Executive Agent and Manager, NCS within the Department. Instead, it recommends an exploration in depth of the entire NCS structure and concept.

-- The Federal Communications Commission agrees that the role of the Federal Government in communications can and should be strengthened and made more effective but within the organizational framework presently prevailing. The FCC completely disagrees with the recommendation to establish a single radio spectrum manager in an executive agency in that it would adversely affect the Commission's functions.

--- The General Services Administration agrees with all of the study report recommendations except the one that a strengthened NCS should be located in DOD. GSA states that a merger of the civilian and military administrative networks has "obvious merit" but it should not be organized within Defense.

--- The Department of Justice agrees with the formulation of a new communications policy organization. The Department disagrees with the transfer of the Federal Telecommunications System to Defense and questions the feasibility of assigning responsibility for procurement and procurement-related assistance for agencies without in-house capabilities to Defense.

--- The National Aeronautics and Space Administration --- (views not yet received).

--- The Special Assistant for National Security Affairs agrees in general with the study conclusions but does not believe that "policy guidance with respect to the objectives, requirements and composition of the NCS" should be vested in Commerce or Transportation. Further, he believes a National Security Council study should be initiated to re-examine the objectives and alternative system concepts prior to any reorganization.

-- The Office of Emergency Preparedness (including the views of the Director of Telecommunications Management) points out that the study report does not focus adequately on the emergency preparedness aspects of telecommunications management. General Lincoln proposes that the Office of Telecommunications Management remain under OEP until the emergency preparedness implications of relocation are examined thoroughly.

-- The Office of Science and Technology -- (views not yet received).

-- The Department of State has no objection to the study report's proposals from the standpoint of foreign policy considerations and believes that "advantages would flow from a strengthened central policy formulation and planning organization."

-- The Department of Transportation agrees on the need for coordinated policy direction at departmental level, improved procurement and technical assistance, and the unification of radio frequency spectrum management. The Department differs with the study report in that it believes that the Executive Agent role provided by DOD for the National Communications System should not remain within Defense but should be transferred to the policy organization.

July 9, 1969

Mr. Hinchman
Mr. Gabel

These are the conclusions that Mr. Whitehead wants to come up with in the recommendations.

Final point will be that this course of action leaves you the options that in a few years after you strengthen our policy machine -- to transfer the organization to Commerce or to keep it in the Executive Office as a separate office.

CTW

Attachment

MEMORANDUM

THE WHITE HOUSE

WASHINGTON

DTM

Strengthen — authority, staff, NSC link

Upgrade — level IV, deputy

Expand — civilian policy (representation + coordn)

Continue — freq allocation

Commerce

Expand — deputy to Tribus on policy analysis; econ & tech research

NSSM

NCS mgt structure

Emerg commo reports & policies

FCC

Policy analysis budget increase

Policy planning staff (to be used by Chmn)

When Tom wants copies of the Federal Communications organization papers to send to someone---

1. DRAFT MEMO 7/9

2. Commerce recommendation - 7/9 MEMORANDUM (send only the attachment -- Recommendation

3. Recommendation (pencil dated 7/10) D TM

OTP

THE WHITE HOUSE

WASHINGTON

July 9, 1969

DRAFT MEMORANDUM

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Commerce

recommendation)

THE WHITE HOUSE

WASHINGTON

July 9, 1969

MEMORANDUM

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Recommendation

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-- economic, technical, and systems analysis of communications policies and opportunities;

-- take an increasingly active role in advocating policy to the FCC and through the President to the Congress, to include specific recommendations on spectrum management for non-Government uses.

-- management and allocation of Government spectrum use, to include development of improved spectrum management techniques, and eventual responsibility for unified Government and non-Government spectrum management.

-- guidance and information to Federal, State, and local Government agencies in communications planning and procurement.

-- eventual responsibility for procurement of Federal administrative telecommunications services and/or systems, to exclude national security command and control systems and subject to the emergency preparedness requirements of the OEP.

The FCA would incorporate the current research program of the Institute for Telecommunications Sciences and the frequency management activities of the DTM, including the Interdepartmental Radio Advisory Committee. It would be expected to develop a national electromagnetic compatibility analysis facility and to develop the requisite policy analysis capabilities. Each Federal agency would be responsible for design, procurement, and operation of specialized telecommunications systems unique to agency missions, subject only to general standards of the FCA and the requirements of the OEP.

The Director of OEP should be directly assigned all responsibilities for emergency communications requirements and preparedness. With the spectrum allocation responsibility removed from OEP, the roles of DTM and SAPT would be eliminated. OEP should continue to have an Assistant Director for Telecommunications who would be responsible for specification of emergency capacity requirements, priority over-ride features, and survivability capabilities for Government communications.

A NSSM should be issued as soon as the new Assistant Director for Telecommunications is found for OEP. This study should define appropriate NSC machinery for dealing with national security and emergency telecommunications issues and should provide general guidance to OEP on emergency communications requirements and policies.

Implementation

This recommendation could be implemented within a reasonably short time through the following actions:

A. By Executive Order

-- Transfer to Commerce the telecommunications analysis, policy coordination, and spectrum management functions now delegated to the DTM, along with supporting staff and resources.

-- Transfer directly to the Director of OEP those responsibilities and functions of the DTM/SAPT relating to preparedness for national emergency telecommunications.

-- Strengthen NSC-OEP responsibilities and machinery for national security and emergency telecommunications issues.

B. By Secretarial Order

-- Establish a Federal Communications Administration reporting directly to the Secretary of Commerce that would immediately incorporate the Government spectrum management responsibilities and facilities, the appropriate communications-related research activities in ESSA and National Bureau of Standards, the beginnings of a policy analysis and economic research operation, and a group to plan for eventual responsibilities for Federal administrative telecommunications.

C. Subsequent Action

-- After sufficient capability in spectrum management has been attained and demonstrated, introduce legislation recommending transfer of non-Government spectrum management to the FCA, leaving specific non-Government frequency assignments and licensing to the FCC.

-- At an appropriate time, transfer to FCA by Executive Order of Federal administrative telecommunications systems.

Attachment 3

Recommendation

The Office of the Director of Telecommunications Management should be strengthened and expanded to enable the DTM to serve as the focal point for all executive branch telecommunications activities and to be the Administration spokesman on national telecommunications policy issues. The DTM would be expected to be the primary executive branch office for the analysis and formulation of recommendations for both national communications policy and Federal telecommunications procurement. These responsibilities would include:

-- economic, technical, and systems analysis of communications policies and opportunities;

-- taking an increasingly active role in advocating policy to the FCC and through the President to the Congress, to include specific recommendations on spectrum management for non-Government uses.

-- management and allocation of Government spectrum use, to include development of improved spectrum management techniques aimed toward eventual unified Government and non-Government spectrum management.

-- guidance and information to Federal, State, and local Government agencies in communications planning and procurement.

-- responsibility for policies and standards for procurement of Federal administrative telecommunications services and/or systems.

A Telecommunications Research and Analysis Center would be established in the Department of Commerce, reporting to the Assistant Secretary for Science and Technology. The Center would be responsible for both technical and economic analysis and research, responsive to the needs defined by the DTM. The TRAC would incorporate the current research program of the Institute for Telecommunications Sciences, as well as appropriate elements of other Commerce activities in telecommunications. Its specific functions would include:

-- establishment and operation of a national electromagnetic compatibility analysis facility.

-- research and analysis of improved spectrum utilization techniques to support the DTM in Government spectrum management and in making recommendations to the FCC on non-Government spectrum management policies.

-- research and analysis leading to the development by DTM of improved technical and operating standards.

-- continuation of basic telecommunication science research and provision of services to other Government agencies and industry.

The DTM should be raised immediately to executive pay level IV and authorized an expanded staff that would include a limited capability for economic, legal, technical, and systems analysis. He would be expected to contract for significant portions of the research and analysis required to support his responsibilities and also to draw heavily on the Commerce Telecommunications Research and Analysis Center.

A NSSM should be issued as soon as the new DTM is selected. This study should define appropriate NSC machinery for dealing with national security and emergency telecommunications issues and should provide general guidance to the DTM on emergency requirements and policies.

Implementation

This recommendation could be implemented almost immediately through the following actions:

A. By Executive Order

-- clarify and bolster DTM authority and eliminate existing patchwork of Presidential memoranda and conflicting Executive Orders. The Office of Telecommunications Management should be institutionalized as a separate Office within OEP, eliminating the positions of Assistant Director and Special Assistant to the President for Telecommunications. The DTM should be raised to Level IV and should report to the President for all matters except emergency preparedness requirements, for which he would support the Director of OEP.

-- similarly clarify authority and responsibility of the Department of Commerce.

B. <u>By Secretarial Order</u>

-- establish a Telecommunications Research and Analysis Center under the Assistant Secretary of Commerce for Science and Technology.

C. <u>Subsequent Action</u>

Once sufficient capability in the analysis of national communications policy issues and the associated capability for improved Government and non-Government spectrum management is achieved, Government and non-Government spectrum management responsibilities should be consolidated. This almost certainly will require in a few years establishment of a new agency outside OEP, either in the Executive Office, in a Cabinet Department, or as an independent agency.

-- at an appropriate time, introduce legislation to establish a new agency and transfer non-Government spectrum management from the FCC to the new agency; emergency preparedness functions would remain in OEP.

-- at an appropriate later time, transfer to the new agency by Executive Order responsibility for procurement of Federal administrative telecommunications services and/or systems.

DTM

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Recommendation

The Office of the Director of Telecommunications Management should be strengthened and expanded to enable the DTM to serve as the focal point for all executive branch telecommunications activities and to be the Administration spokesman on national telecommunications policy issues. The DTM would be expected to be the primary executive branch office for the analysis and formulation of recommendations for both national communications policy and Federal telecommunications procurement. These responsibilities would include:

-- economic, technical, and systems analysis of communications policies and opportunities;

-- taking an increasingly active role in advocating policy to the FCC and through the President to the Congress, to include specific recommendations on spectrum management for non-Government uses.

-- management and allocation of Government spectrum use, to include development of improved spectrum management techniques, and eventual responsibility for unified Government and non-Government spectrum management.

-- guidance and information to Federal, State, and local Government agencies in communications planning and procurement.

-- responsibility for policies and standards for procurement of Federal administrative telecommunications services and/or systems.

A Telecommunications Research and Analysis Center would be established in the Department of Commerce, reporting to the Assistant Secretary for Science and Technology. The Center would be responsible for both technical and economic analysis and research, responsive to the needs defined by the DTM. The TRAC would incorporate the current research program of the Institute for Telecommunications Sciences, as well as appropriate elements of other Commerce activities in telecommunications. Its specific functions would include:

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-- research and analysis leading to the development by DTM of improved technical and operating standards.

-- continuation of basic telecommunication science research and provision of services to other Government agencies and industry.

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-- establish a Telecommunications Research and Analysis Center under the Assistant Secretary of Commerce for Science and Technology.

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Once sufficient capability in the analysis of national communications policy issues and the associated capability for improved Government and non-Government spectrum management is achieved, Government and non-Government spectrum management responsibilities should be consolidated. This almost certainly will require establishment of a new agency outside OEP, either in the Executive Office or in a Cabinet Department.

-- at an appropriate time, introduce legislation to establish an independent office in the Executive Office or in the Commerce Department and transfer non-Government spectrum management from the FCC to the new agency; emergency preparedness functions would remain in OEP.

-- at an appropriate later time, transfer to the new agency by Executive Order responsibility for procurement of Federal administrative telecommunications services and/or systems.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF EMERGENCY PREPAREDNESS
WASHINGTON, D. C. 20504

OFFICE OF THE DIRECTOR

July 9, 1969

MEMORANDUM FOR HONORABLE PETER M. FLANIGAN,
ASSISTANT TO THE PRESIDENT

Looking through my file I find the attached MR on Starbird. The marked paragraphs do indicate some hope. About two of the three months have passed.

I have reviewed quietly with knowledgeable individuals the possibilities among military people, and General O'Connell has explored for me the interest of the most likely individuals. Generals Lotz and Pickett, both capable individuals, have expressed a lack of interest. General Eddy seems the best bet in that area unless you and Mr. Whitehead could persuade General Starbird.

On April 28, I sent you a memorandum suggesting names for consideration which were available as of that time. So there will not be any question later about consideration having been given to each applicant's case, I am furnishing to Mr. Whitehead, for discussion with you, notes on all the individuals whose applications for the position have now come to my attention.

Concerning General Eddy -- a telephone call to me just now informs me that General Eddy has not yet submitted his retirement papers and gives some indication that whether he does or does not retire will turn on whether he is asked to be Director of Telecommunications Management.

G. A. Lincoln

G. A. Lincoln
Director

Attachment

May 20, 1969

MEMORANDUM FOR RECORD

SUBJECT: Conversations with General A. D. Starbird on Telecommunications

General Starbird organized the Defense Communications Agency and headed it from 1963 to November 1967. He is now Manager of the SAFEGUARD System. There is no more highly respected professional, civilian or military, in government today.

General Starbird commented on the problems and pitfalls of existent and possible organizational arrangements for telecommunications. He said he was not interested in the position of Director, Telecommunications since when he retires from the Army he needs to earn some money for his family (but see below).

General Starbird called me late yesterday in accordance with his promise to suggest names. He gave me half a dozen suggestions with comments on each, rating as to his judgment of their order of competence. He knew only one civilian (now Director of Communications of CIA) whom he felt he could suggest. General Starbird also commented on those he knew among other names that have been furnished for our attention.

General Starbird referred back to my question concerning his interest and commented that:

a. I should not consider him since I probably needed somebody right away and he is not available for at least three months.

b. He would not want the position without some changes in relationships.

I asked General Starbird to keep his mind open on the position and commented that everyone seemed to be agreed that some changes needed to be made in terms of reference -- the problem is, what changes? I said at the minimum the Executive orders and proclamations needed to be put in one document and brought up to date. General Starbird agreed with my comment and said that he was not sure that the original Eisenhower concept is now completely applicable.

I have some hope that Starbird has not completely closed the door on considering the position. If he did take it, his appointment would, I believe, be accepted by all interested parties and acclaimed by most. The Administration is unlikely to find anyone else ~~nearly~~ as competent.

As to Starbird's comment about his financial situation, the possible arrangements may be more attractive than he knows. There is, however, the possibility that the President and/or Secretary of Defense would not wish him to retire.

Finally, since the job now involves being an Assistant to the President I do not think that Starbird will move to a situation of very serious consideration without a talk with Mr. Whitehead and Mr. Flanigan.

SIGNED
G. A. Lincoln
Director

GAL/gh

ALFRED D. STARBIRD
Lieutenant General, USA

General Starbird graduated from the U. S. Military Academy in 1933 and received a degree in Civil Engineering from Princeton University in 1938.

Prior to World War II, General Starbird served on various Engineer assignments; was a member of the U. S. Olympic Pentathlon Team in 1936; and served as an instructor at the United States Military Academy.

In 1942 he was assigned to the War Department General Staff. He served on temporary duty with the 1st Division Staff during its landings in North Africa and with the Fifth Corps during its landings and early operations in Normandy. He commanded an Engineer Combat Group in the Third Army from January through June 1945 and then returned to the War Department General Staff.

Since World War II, General Starbird has served in various assignments in the Pacific, CONUS and in Europe where he served as Secretary of SHAPE. After two years in the Office of the Chief of Engineers he was named Director of Military Applications of the Atomic Energy Commission and served in that assignment from 1955 to February 1961. In November 1961 he was called from his assignment as Division Engineer, North Pacific Engineer Division to organize Joint Task Force EIGHT and to command it during the planning, preparation and execution of Operation DOMINIC, the 1962 nuclear test series. In October 1962, he was named Director of the Defense Communications Agency and, on August 21, 1963, the additional function of Manager, National Communications System. In November 1967, General Starbird was selected to be the Manager of the SENTINEL System, now the SAFEGUARD System.

Copy for Mr. Whitehead

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF TELECOMMUNICATIONS MANAGEMENT
WASHINGTON, D.C. 20504

OFFICE OF THE DIRECTOR

July 8, 1969

MEMORANDUM FOR THE DIRECTOR:

In accordance with our current procedure, I am pleased to transmit this report of the significant activities of this office for the period ending July 7, 1969.

J. D. O'Connell

Encl.

July 8, 1969

WEEKLY ACTIVITY REPORT NO. 73

FREQUENCY MANAGEMENT

1. NAE Support

On July 2, OTM personnel met with the Panel of the National Academy of Engineering which is exploring ways to define the economic and social values of the radio frequency spectrum. The purpose of the meeting was to examine a draft report on the first phase of the contract effort, due for submission to the OTM prior to August 31, 1969.

2. Contract Progress

On July 3, OTM representatives met with contractor personnel from the Illinois Institute of Technology Research Institute -- currently engaged in a study to define the data base necessary at the national level in the area of radio frequency management. The results of this effort will form the basis for the entire frequency management area of the future, including frequency assignment, frequency allocation, and electromagnetic compatibility.

3. IRAC Meeting

On July 8, the 970th meeting of the Interdepartment Radio Advisory Committee took place. The agenda included:

a. Review of the Committee's work programs for FY 70.

b. Consideration of NASA's proposals bearing on TV broadcasting from satellites (experiment with India).

c. Review of OTM/OEP data processing support of the Committee's activities.

d. Continued preparation with respect to the forthcoming World Administrative Radio Conference on Space Telecommunications.

e. Initiating action in response to queries from the International Telecommunication Union, Geneva, in the areas of maritime, oceanographic, and aeronautical radio services.

f. Proposal by the State of California to establish a DECCA Radio Navigation System; operates in a radio frequency band wherein interference problems may be created due to existing government communications systems.

4. Development of Unified Usage Reporting Program

OTM staff members have been developing measures for determining actual use of the spectrum by all Government agencies. Procedures for the band 4-30 MHz, the first in Government history, were promulgated by the DTM on April 1, 1969. More recent efforts relating to six bands above 30 MHz, have determined that certain additional data must be added to the data base in order to derive more meaningful information on the actual use of these bands.

5. Procedures to Speed Up Data Processing

On July 2, a study was started of the use of existing facilities to transfer unclassified data electrically from the OTM Computer Support Section in Frostburg, Maryland, to the NRAC computer site. The initial investigation indicates a good probability of a two to three day reduction in data handling time for this portion of the ADP system. The postal system is now used to transfer data between these two sites.

6. Progress in the Updating of Government Frequency Assignments

In May 1968, a program was implemented to ensure the review, updating, and rejustification at least every five years of each Government use of the radio spectrum. A review of the year's effort shows that good progress is being made. For example, as of July 1, 1969, there has been a 30% reduction in the number of frequency assignments bearing a review date prior to 1967.

7. Northwest Passage Arctic Tanker Test

Work with the Radio Technical Commission for Marine Services (RTCM) has developed interesting information with regard to the design and test of tankers to transport crude oil from the newly discovered major oil reserve on the northern coast of Alaska. The Humble Oil and Refining Co. is project manager for an industry experiment that will send a specially configured 146,000 ton tanker through the Northwest Passage with the object of proving the feasibility of using super tankers 12 months a year to traverse the Arctic route to the Atlantic and Pacific Oceans. The experimental tanker purportedly will contain the most complex state-of-the-art electronic navigation, communications, data gathering, recording and analysis systems ever assembled on a non-governmental ship. The test is expected to commence around early August of this year.

FEDERAL-STATE TELECOMMUNICATIONS

* 1. New Jersey Telecommunications Coordination

As a result of a statewide survey of government operations, telecommunications resources and requirements, the New Jersey telephone industry submitted to Governor Richard J. Hughes a report titled "State of New Jersey Telecommunications Study Summary." This document has been accepted by Governor Hughes who has issued instructions to begin implementation of the report's recommendations. In addition to ordering certain changes in the industry's telecommunications system used by the State government, the Governor, by Executive Order No. 54, has established an Office of Telecommunications Management for the statewide coordination of telecommunications activities. Information received on July 8 indicates that Mr. Mathew Mansfield will be the Administrator of this office. The DTM instrumental in stimulating this New Jersey program and he continues to provide advice and assistance in this regard.

*2. Massachusetts Telecommunications Coordination

At Governor Francis W. Sargent's direction, the telephone industry has conducted a statewide survey and analysis of Massachusetts government operations, telecommunications resources and requirements. The results of this study are contained in a document titled "Communications for the Commonwealth of Massachusetts." No information is available on the acceptability of the study, but it points to a potential one million dollar annual saving by 1976 -- a saving to be achieved while a considerable increase in telecommunications capability is obtained. The DTM was instrumental in stimulating the study and continues to provide advice and assistance to cognizant state government personnel on the overall state telecommunications program.

* 3. Highway Telecommunications

On July 3, OTM representatives were briefed by representatives of Communications & Systems, Inc., on an analytical study program which the company will be conducting for the Federal Highway Administration. The objective of the program is to define the requirements and standards for the development of a nationwide highway telecommunications system to serve the needs of the highway administrators and users. The meeting was requested by C&S, Inc., and was for the purpose of obtaining OTM thoughts on the task at hand.

TELECOMMUNICATIONS EMERGENCY PREPAREDNESS

* 1. Restoration Priorities for Leased Intercity Private Lines

Protracted discussions of deficiencies to be overcome in the announced DTM/FCC System of Procedures for Restoration of leased intercity private lines for use during an emergency have resulted in a proposal by the Federal Communications Commission for the elimination of certain stringent eligibility requirements in applying for restoration priorities. This proposal is now being coordinated with the Executive Agent of the National Communications System. Subsequently, it will be coordinated with cognizant OEP staff elements before any change to the existing procedures is effected.

*2. NATO Civil Communications Planning

An OTM representative attended a NATO Civil Communications Planning Committee (CCPC) Meeting in Brussels, June 23-26.

* 3. Inventory of International Communication Circuits

An updated "Inventory of Non-Government International Radio, Satellite and Cable Circuitry" has been received from the printer and is being issued to Federal agencies. This document serves as a planning guide to Federal agencies for determining mobilization communication requirements.

SATELLITE COMMUNICATIONS

1. Preparatory Committee Meeting for INTELSAT

The views of the OTM concerning the crucial issue of the Manager for INTELSAT were provided Governor Scranton, Chairman of the U. S. Delegation, in a memorandum on July 7, 1969. The memorandum suggested the U. S. Delegation table a statement explaining the rationale behind our view of the importance in retaining the structure created by the Interim Arrangements, including the retention of the Communications Satellite Corporation as Manager. In addition, a draft Article was furnished which would call for a comprehensive Organizational Survey to be conducted by the Governing Body to examine the alternative ideas for Structure and Functions of the Organization.

July 8, 1969

Mr. Nader
American Association of
Junior Colleges

I am sending your two copies of the Rostow Report in separate envelopes.

Eva Daughtrey
Secretary to
Clay T. Whitehead

Phone: 456-2786

Attachment

Telecommunications

July 7, 1969

Dear Mr. Kirby:

Thank you for the copies of the materials prepared by Mr. Kenneth A. Norton.

I have retrieved a copy of the draft book you refer to from the Rostow Committee library. This certainly is one of the more important problems in telecommunications and one to which we will be turning our attention more and more.

Thank you again.

Sincerely,

Clay T. Whitehead
Staff Assistant

Mr. Robert S. Kirby
Consultant
Institute for Telecommunication Sciences
Environmental Science Services Administration
Research Laboratories
U. S. Department of Commerce
Boulder, Colorado 80302

cc: Mr. Whitehead
Central Files

CTWhitehead:ed

U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
RESEARCH LABORATORIES
BOULDER, COLORADO 80302

July 3, 1969

IN REPLY REFER TO:
R60/rsk

Tape

Institute for Telecommunication Sciences

AIR MAIL

Dr. Clay T. Whithead
Executive Office of the President
Washington, D. C. 20506

Dear Dr. Whithead:

Mr. Kenneth A. Norton asked me to send you copies of some reports he had prepared while he was a member of our laboratory. In particular, he would like you to read his brief paper, "Optimum use of the electromagnetic spectrum resource", dated January 30, 1969. He discussed some of his ideas on telecommunications with you on the telephone earlier this week.

You may have a copy of his draft book "The Five-Dimensional Electromagnetic Spectrum Resource - A Major Economic and Engineering Research Responsibility of the Federal Government (or the Silent Crisis Screams)", Volumes 1 and 2. A copy was in the Rostow Committee Library. If you do not have a copy, I would be happy to send you one.

Sincerely yours,

Robert S. Kirby

Robert S. Kirby
Consultant

Enclosures -
Optimum Use ..Resource, Jan. 1969
The ABC's of EMC, July 1968
A Flexible Dynamic....July 1968
Electromagnetic Spectrum Utilization -
The Silent Crisis, Oct. 1966
Copy of letter Norton to Dr. Dubridge, March 1969

March 7, 1969

Dr. Lee A. Dubridge
Director of the Office of Science and Technology
Room 200, Executive Office Building
Washington, D. C. 20506

Dear Dr. Dubridge:

As you know, one of the basic responsibilities of the Federal Government is the conservation of our natural resources. One of these resources is the electromagnetic spectrum. The fact that this is an international resource complicates the problem of its conservation nationally. Enclosed herewith is an essay entitled "Optimum Use of the Electromagnetic Spectrum Resource".

I hope that you personally take the time to read this brief essay. An extra copy is enclosed so that this will be feasible.

Although we met briefly when you were Director of the Radiation Laboratory at MIT, I doubt if you remember me. Consequently I have enclosed a biographical sketch. Most of my 38 years with the Federal Government has been spent on this conservation problem.

I am at present retired and I am currently seeking a position with some non-government agency so that I can continue my work on this problem as a Guest Worker at NBS in Boulder.

Also enclosed herewith are:

1. Letter dated Jan. 7, 1969 to Secretary Designate Stans

2. Letter dated Feb. 5, 1969 from Dr. John W. Townsend, Jr., Deputy Administrator of ESSA

3. Report of Subcommittee No. 5 to the Select Committee on Small Business of the House of Representatives on "The Allocation of Radio Frequency and its Effect on Small Business"

4. Testimony of K. A. Norton to the above Subcommittee

5. Magnuson Bundle

Representative John Dingell has introduced three bills, HR 3057, 3058, and 3059 in the present session of the Congress and these bills are consistent with the approach recommended in the enclosed essay.

I have asked my former supervisor, Mr. Robert S. Kirby (not to be confused with Richard C. Kirby) to transmit this letter and its attachments to you.

If you consider that my advice would be useful I would be pleased to assist you as an expert consultant either on a part time or full time basis.

With best personal regards,

Sincerely,

Kenneth A. Norton

Kenneth A. Norton, Formerly
Consultant to Robert S. Kirby,
Director of the Tropospheric
Telecommunication Laboratory

January 30, 1969

OPTIMUM USE OF THE ELECTROMAGNETIC SPECTRUM RESOURCE

by

Kenneth A. Norton

Although never enunciated explicitly in these terms it has always been the policy of the Federal Government in the United States to make "optimum use" of the electromagnetic spectrum resource. There is at this time no unanimity either in the United States or abroad as to a definition of optimum use nor as to the procedure which should be adopted in order to approach the achievement of such a goal. In this brief essay an operationally useful definition of optimum use is first given together with a flexible dynamic procedure which should be adopted by the Federal Government in the U. S. and later by the International Telecommunication Union (ITU) in order to approach the achievement of this clearly desirable non-partisan goal. Recommendations are then given for a Federal Government organization designed to carry out such a procedure.

Optimum use of the electromagnetic spectrum resource is its employment in that set of uses such that any different allocation could not make any individual inhabitant of the world better off in terms of his own preferences without making some other individual inhabitant worse off in terms of his. In other words, the optimum allocation is that one such that no further trading of their resources, including the spectrum resource, between the world inhabitants will appear to be desirable in terms of their preferences. This definition of optimum use is simply the application to the spectrum resource of the concept of economic efficiency (see Bibliography).

Throughout this essay the term allocation means the assignment of input rights to radiate from specified locations specified electromagnetic energy levels having specified polarizations during specified intervals of time in specified frequency bands and in specified directions.

The Consultative Committee on International Radio (CCIR), the technical advisory branch of the ITU, adopted Resolution No. 1 unanimously at its Xth Plenary Assembly in Geneva, 1963; this Resolution on "Optimum Use of the Radio-Frequency Spectrum" established an International Group of Experts (IGE) of the C.C.I.R. and appointed the author as its chairman. When the CCIR unanimously adopted at the XIth General Assembly in Oslo in 1966 the first report prepared by this IGE: Report No. 414 on "Efficient Use of the Radio-Frequency Spectrum," they adopted the following general engineering principle:

"that efficient use of the radio-frequency spectrum for telecommunications can be achieved only when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception"

The use by spectrum managers of the above general engineering principle will lead to much larger increases in the "efficiency" of use made of the spectrum resource than can be achieved by any other means.

The "effective service sum" (see Bibliography) provides a numerical, and thus a scientific, measure of the efficiency of use made of the spectrum at any point in time, and it has been shown that this efficiency of use may actually be maximized for any given set of spectrum users by an appropriate allocation of input rights to these users.

Since both the engineering means for achieving various uses of the spectrum and the preferences of individuals change with time, a dynamic procedure must be used in order to approach the achievement of optimum use of the spectrum resource.

If it were possible now to know what the preferences of each of the individuals in our society would be at some pre-selected future point in time, if it were also possible now to predict the value of the effective service sum for each of that infinite number of spectrum allocations which are consistent both with these individual preferences and with the state of the engineering art at that future time, and if it were possible now to begin to implement these allocations in such a way that they would all be in operational use at that future time, then that particular allocation of the spectrum for which the effective service sum is a maximum would constitute optimum use of the spectrum resource at that pre-selected future time.

It should be clear from the above discussion that optimum use of the spectrum resource is an inherently unattainable goal. A scientific definition of the efficiency of the use made of the spectrum at any point in time is the dimensionless ratio of (1) the effective service sum corresponding to that spectrum allocation actually in use at that time to (2) the inherently unknown effective service sum corresponding to that particular spectrum allocation for which this sum has its maximum value. Although the numerical magnitude of the above defined efficiency of use of the spectrum is an inherently unknown number between zero and one, this does not at all reduce its operational utility as a scientific means for systematically improving the efficiency of use of the spectrum resource. Thus, if the effective service sum is predicted to be larger at some pre-selected future time for one proposed allocation of the spectrum than for any of several alternative allocations, then (1) this proposed allocation is expected to be more efficient than any of these alternative allocations and (2) the predicted relative efficiencies of the several allocations are directly proportional to the predicted values of their effective service sums.

It follows from the above discussion that an essential requirement for improving the use of the spectrum resource is the ability to make accurate predictions of all of the factors: engineering, economic, and social, which enter into the evaluation of the effective service sum.

The largest improvements in the accuracy of predicting the performance of radio systems lie in the engineering area and, in this area, radio wave propagation is the most important aspect of radio system design on which to conduct additional research with the object of improving the accuracy of prediction of the effective service sum.

The prediction of the economic and social preferences of individuals may be accomplished by cost-benefit studies and, or, by polling representative samples of the population. However, a generally better, and almost always more accurate, method of revealing the preferences of individuals is by leasing the spectrum to its users, both within and outside of the government.

If the following politically realistic recommendations for reorganization of the Federal Government in the field of spectrum management were adopted, the author expects that:

(1) Large improvements will be achieved in the efficiency of use of the electromagnetic spectrum resource,

(2) The direct value to the taxpayers of these expected improvements in the use of the spectrum resource will be several times as large as the additional cost to the taxpayers of this recommended spectrum management organization, and

(3) The ultimate translations to international use of the spectrum management procedure herein described will result in indirect benefits to the taxpayers with an even greater value than that of its direct benefits.

Recommendations

I. The Federal Government should establish at the earliest practical time a Telecommunication Allocation Research Organization (TARO) having as its primary objective the improvement of the overall effectiveness of utilization of the electromagnetic spectrum resource through the allocation of the spectrum to that combination of coordinated uses which will more nearly achieve at any point in time those continuously changing social goals which, in the aggregate, constitute both the national and the international welfare.

II. The TARO should conduct engineering, economic, and social research studies leading to the more accurate prediction of the many parameters which enter into the numerical evaluation of the effective service sum.

III. The TARO should develop internationally acceptable units, terminology, and standard practices in the field of telecommunication.

IV. The TARO should provide advice and assistance to other agencies, both government and non-government, in the solution of their telecommunication problems. This service should be supplied at cost in the same way that it has been supplied by the Central Radio Propagation Laboratory (CRPL--1946 to Oct. 11, 1965) and by its two successors, the Institute for Telecommunication Sciences and Aeronomy (ITSA--1965 to Nov. 19, 1967) and the Institute for Telecommunication Sciences (ITS--1967 to date).

V. The TARO should be established initially in the U.S. Department of Commerce (DOC) with its principal offices and laboratory in Boulder, Colorado and all of the employees in the DOC, particularly those now in the Environmental Science Services Administration (ESSA) and in the National Bureau of Standards (NBS), who are qualified to conduct such operational research and wish to do so should be permitted to transfer to the TARO.

VI. The Director of the TARO should be appointed by the President with the advice and consent of the Senate and he should cooperate closely with the Assistant Secretary for Science and Technology in the DOC primarily relative to the transfer of personnel and facilities to the TARO.

VII. At some designated time in the future, possibly as much as one year after the initial organization of the TARO, some of the telecommunication responsibilities of the Director of Telecommunications Management (DTM) and the frequency allocation and treaty responsibilities of the Federal Communications Commission (FCC) together with the FCC Chief Engineers Office, the FCC Laboratory, FCC monitoring facilities, etc., should be transferred to the TARO. The time designated for these transfers of responsibility should be sufficiently far in the future so as to cause a minimum of disruption to the present spectrum management activities of the Federal Government.

VIII. Upon the assumption by the TARO of the responsibilities described in Recommendation VII, the TARO should be transferred from the Executive to the Legislative branch of the Federal Government with its Director then reporting to a Joint House-Senate Committee.

IX. Some of the responsibilities of the State Department relative to the technical work of the ITU should be transferred to the TARO.

Bibliography

My partially completed book: The Five-Dimensional Electromagnetic Specturm Resource (The Silent Crisis Screams) includes the following extensive further discussions of the concepts and principles given in this essay:

(1) The rationale for the concept of economic efficiency, which provides the basis for my definition of optimum use, rests on a rather lengthy chain of reasoning which is not well understood by the average layman. This chain of reasoning is given in Appendix 12 which is itself an appendix to the book "Efficiency in Government through Systems Analysis with Emphasis on Water Resource Development" by Roland N. McKean.

(2) Part III contains a comprehensive discussion of the nature of the engineering and economic research which should be conducted by the TARO. The economic concept of cost-benefit analysis is involved in the effective service sum, and this is discussed in Part I and appendices 9, 10, 11, 12, 13, and 21 while Appendix 3 contains a discussion of the word "scientific" as used in this essay.

(3) The author first proposed spectrum leasing as the most practical means for determining the highest valued uses of the spectrum in a memorandum dated December 25, 1964; this memo is Appendix 10. See also the book "Correspondence re Spectrum Leasing".

(4) Appendix 1 contains a discussion of the need for internationally acceptable units, terminology, and standard practices.

The effective service sum was first described in two draft documents of the U. S. Preparatory Committee (USPC) for Study Group III---Document III/32: The Service Probability; and Document III/34: Optimum Use of the Radio Frequency Spectrum, which I prepared (in April, 1966) as the Chairman of the International Group of Experts of the CCIR. The existence of an optimum set of input rights for radio systems sharing the use of the spectrum resource was established in the paper, "On the General Problem of Frequency Sharing," by William J. Hartman and George A. Hufford (members of the staff of the Tropospheric Telecommunications Laboratory in ITS) which was published in the August 1966 issue of the Journal of Telecommunications, Vol. 33, No. 8, pp. 287-293.

A very brief discussion of the effective service sum is given on pages 47 and S8-94/99 of the Report: Spectrum Engineering--The Key to Progress, prepared by the Joint Technical Advisory Committee (JTAC) of the Institute of Electrical and Electronic Engineers (IEEE) and the Electronic Industries Association (EIA).

Recently, at the request of the Committee on Telecommunications of the National Academy of Engineering, I prepared the paper, "A Flexible Dynamic Scientific Procedure for Achieving More Efficient Use of the Electromagnetic Spectrum Resource." This paper, together with one of its annexes: "The ABC's of EMC," gives my most recent discussion of the effective service sum. My letter dated August 15, 1968 to Mr. David R. Hull, Director of Engineering, Electronic Industries Association, contains a further discussion of the problem of spectrum management generally and the use of the effective service sum specifically.

The idea of transferring some of the present spectrum management responsibilities from the Executive to the Legislative branch of the Federal Government was first proposed by the author in his statement to the House Small Business Subcommittee on February 21, 1968. This idea was independently suggested and developed in more detail by FCC Commissioner Robert T. Bartley in a very imaginative address entitled "Let's Abolish the FCC" given on May 23, 1968.

323 Bellvue Drive
Boulder, Colorado 80302

January 30, 1969

Dr. John W. Townsend
Deputy Administrator, Axl
Environmental Science Services Administration
Rockville, Maryland 20852

Dear Dr. Townsend:

Enclosed herewith is the brief essay on Optimum Use of the Electromagnetic Spectrum Resource which you requested in a recent telephone call. It is longer than the two pages which you asked for but is nevertheless as short as I was able to make it and still have the essential ideas developed without reference to other reports. The bibliography attached should be helpful to any especially interested reader in obtaining a better understanding of the concepts developed in this essay, particularly the concept of the effective service sum. In the interests of brevity no reasons were given for adopting the particular recommendations given rather than any other of the alternative approaches to a Federal Government spectrum management organization. Some of the reasons are available in the reports listed in the bibliography and I can, if you wish, supply you with the reasons for adopting each of the nine recommendations given.

I wish to thank you for making your request for this essay, and I hope that the ideas I have expressed may prove to be of value both to the Administration and to the Congress in their development of an improved Federal Government organization for spectrum management.

Sincerely,

Kenneth A. Norton

Kenneth A. Norton
Formerly Consultant to
Mr. Robert S. Kirby,
Director of the Tropospheric
Telecommunications Laboratory
in ESSA

Enclosures:
3 copies of the Essay
Magnuson Bundle

July 3, 1968

Lecture No. X.2
Electromagnetic Propagation Course
of the University of Colorado and the
Environmental Science Services Administration
Boulder, Colorado

THE ABC's OF EMC

by
Kenneth A. Norton

The electromagnetic spectrum is a valuable natural resource. The spectrum itself has only a single dimension, which is frequency. However, when considered as a resource to be allocated to various users, this resource has five independent dimensions: frequency, time, and the three dimensions of the locations in space at which the resource is used. A portion of the spectrum resource is used when this portion is occupied by some form of wanted electromagnetic energy. It is a limited resource but its use can be shared nationally and internationally. It is an unusual resource in that it is not depleted by use. However, its value at any specific time can be drastically reduced by misuse. It is unusual in another sense in that frequency assignments to specific users are currently made without a use charge and with no accurate quantitative measure of its value to the national or international welfare.

Electromagnetic compatibility is a measure of how well some particular spectrum using system is designed so that its use for this application does not limit the use of the spectrum for other applications. In the broadest engineering context electromagnetic compatibility is the engineering design of spectrum using systems so as to maximize the number of simultaneous interference-free spectrum users. Since the spectrum is a limited resource it is not possible to accommodate all of the potential users. Thus, if we are to allocate this limited resource to its highest valued uses, it becomes necessary to establish their relative values. In view of the great difficulty involved in the establishment of these relative values it should not be surprising that the rather casual procedures now in use do not lead to much confidence in the allocation decisions reached either by the Interdepartment Radio Advisory Committee (IRAC) or by the Federal Communications Commission (FCC).

The FCC has a representative on the IRAC and this committee not only decides the fractions of the spectrum allocated for use in the Private Sector and by the Federal Government but also makes specific frequency band assignments to the Federal Government users. On the other hand, the FCC decides on the fractions of the spectrum allocated to the various kinds of Private Sector uses of this resource and also makes specific frequency band assignments to each of the users of this fraction of the spectrum. Note that the FCC allocation and assignment of frequency bands to the Private Sector include those to both state and local government agencies.

Considering the fact that the Federal Government, which currently produces only 17%* of the Gross National Product of goods and services, now uses more than half of the spectrum resource it seems clear that a less biased group than the allocators in the IRAC would almost certainly have assigned a larger portion of this resource to the Private Sector. I do not have any proof more definitive than the above prima facie evidence that the Federal Government is using more than its appropriate share of the spectrum resource but I do not believe that conclusive proof can be obtained without comprehensive engineering and economic studies of all of the uses of the spectrum. Such studies are clearly in the public interest and

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* This 17% of the $817 billion 1968 FY GNP includes 8% for goods and services not related to National Defense and 9% for National Defense of which 3% is for the Vietnam war; data from The Budget in Brief, FY 1969. Most of the transfer payments, which are items in the budget not allocated to the production of goods and services, have been excluded from the computation yielding the 17% figure. The resulting estimate, although clearly somewhat crude, is nevertheless useful.

should be made and continually kept up-to-date by the kind of independent research organization which was proposed by the Telecommunication Science Panel in their report "The Silent Crisis."

As I pointed out in the partially completed book "The Five-Dimensional Electromagnetic Spectrum Resource" or "The Silent Crisis Screams" very little, if anything, has been done either by the IRAC or by the FCC to establish in a scientific way the relative values of the various current and potential uses for the spectrum resource. If the spectrum were leased to its users, as is the case with almost all other resources in the United States, then these relative values would be automatically established in what most economists believe is the most satisfactory way. Unfortunately leasing the spectrum is such a revolutionary idea that it is likely to be many years before it is widely adopted either in the United States or internationally. In the meantime an alternative scientific method for arriving at relative values for various uses of the spectrum resource is cost-benefit analysis. This latter method is discussed in Part I, and in Appendices 9, 10, 11, 12, 13, and 21 of "The Silent Crisis Screams."

Resources have value only if they are capable of being used to produce some benefit. The value of a benefit should always be measured in dollars or their equivalent in some other currency such as francs, guilders, marks, pesos, pounds, rubles, etc.; only in this way can the values of various systems, or kinds of systems, be properly measured and compared. The present dollar value of a specified resource (or set of resources) is derived from the predicted value of future benefits expected from the employment of the resource (or set of resources) in a specified set of all future uses. One of the basic advantages of determining these values by leasing the spectrum to its users is that the value of the future benefits expected from the employment of those portions of this resource leased to a particular user will be predicted by this user, whereas, if these values are determined by cost-benefit analyses made by government spectrum managers, then the value of the future benefits will be predicted by the spectrum managers. The individual spectrum user will almost certainly predict more accurately than the spectrum managers the value of the future benefits he expects from leasing a particular portion of the spectrum resource. The other basic advantage of leasing the spectrum to its users is the fact that these payments for its use provide a direct incentive for the individual lessees to use it more efficiently.

Assuming that relative values for the various uses of the spectrum have been established in one or the other of the above ways we may return now to a more detailed discussion of the engineering problem of providing, in priority order, for the maximum number of simultaneous interference-free spectrum users. Presumably this is the problem with which students of electromagnetic propagation are primarily concerned. However, it cannot be emphasized too strongly that the use of the spectrum resource cannot be optimized, in the sense of best serving the over-all public interest unless optimum solutions are obtained of <u>both</u> the economic problem of assigning relative values and the engineering problem of maximizing, in priority order, the number of interference-free spectrum users. It is my opinion that the public interest can best be served only by having an interdisciplinary team of engineers and economists working cooperatively on the problem of optimizing the use of the electromagnetic spectrum resource.

When the CCIR adopted Report No. 414 on "Efficient Use of the Radio-Frequency Spectrum" at the XIth Plenary Assembly meeting in Oslo, 1966, they adopted the following general engineering principle:

> "that efficient use of the radio-frequency spectrum for telecommunications can be achieved only when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception."

To understand the above principle we need the following definitions:

Satisfactory reception will exist during some particular short interval of time, T_s, for some particular receiving system if the median value of the "instantaneous" wanted signal power, available at the standard reference terminals of the receiving system, exceeds that operating threshold of this receiving system corresponding to the required grade of service, g_R.

The short period of time, T_s, will have a duration of, say a few minutes up to an hour, and must be sufficiently long (a) so that a meaningful determination can be made of the grade, g, of service provided and (b) so that the received wanted and unwanted signals may be expected to fade over ranges typical of the short term phase-interference fading expected over the propagation path and yet (c) sufficiently short so as to eliminate most of the longer term power fading.

"Instantaneous" signal powers, either wanted or unwanted, are actually mean values averaged over a length of time $(1/\nu)$ equal to one period of the radio frequency ν so as to eliminate the pulsations in power associated with the factor $\cos^2(2\pi\nu t)$; it can be shown that averaging the wanted and unwanted signal powers over this very short time interval $(1/\nu)$ does not modify the number of bits of information which can be interpreted without error when detected at the output of the receiving system.

For a radio receiving system, which includes the receiving antenna in its operating environment, any transmission line to the receiver, and the receiver itself which amplifies the received signal and converts it to an approximate facsimile of the transmitted message, the standard reference terminals are the terminals of a loss-free receiving antenna which is otherwise equivalent to the actual lossy receiving antenna.

Both the wanted signal power and the unwanted signal power available from the radiation resistance of the receiving antenna will, in general, depend upon the directivity of the receiving antenna; this is one of the reasons for defining the operating threshold as a median value of the wanted signal power at the terminals of an equivalent loss-free receiving antenna rather than as a required field strength. The most important reason for choosing the reference point at the terminals of an equivalent loss-free receiving antenna is the fact that this is the only reference point which provides a proper and unique measure of the operating noise-threshold of the receiving system; the argument leading to this conclusion is given in CCIR Report 413 on "The Operating Noise-Threshold of a Radio Receiving System." In practice measurements are made at accessible terminals and referred to the terminals of an equivalent loss-free receiving antenna. This reference point is also the most natural reference point for separating studies of propagation from studies of receiving systems.

The operating threshold of a radio receiving system is determined by: (1) the levels at the receiving antenna terminals of the available powers of the additive unwanted radio signals and additive radio noise with which the wanted radio signal power must compete; (2) the fading of the wanted radio signals; (3) the fading of the unwanted radio signals; (4) the fading of the radio noise; and (5) the grade of service which the receiving system is required to provide.

Several types of additive unwanted radio signals and additive radio noise may influence a particular receiving system at a given time.

Unwanted radio signals are characterized by having emission characteristics such that they are capable of causing potentially harmful interference only in limited portions of the spectrum; thus their regulation can be achieved by requiring (1) that their emissions be confined to certain specified frequency bands, periods of time, and locations, and (2) that the levels of these emissions be sufficiently low so that they do not cause harmful interference to wanted signals occupying these same frequency bands. Examples of additive unwanted radio signals are:

(1) Co-channel or adjacent channel radio signals from licensed radio systems which share the spectrum at the location of the radio receiving system under consideration.

(2) Unlicensed radio signal generating devices such as electronic garage door openers, electronic toys, electronic heaters, diathermy machines, and the oscillator signals from radio receiving systems.

(3) Harmonic radiation from either licensed or unlicensed radio transmissions.

Additive radio noise powers, as distinguished from the additive unwanted radio signal powers described above, have spectral energy distributions which vary more or less uniformly with frequency over several decades of the radio-frequency spectrum. Additive radio noise may also be distinguished from other unwanted signals by virtue of the fact that, in the design of radio systems intended to make more efficient use of the radio spectrum resource, the levels of its power flux density incident on the receiving antenna are considered to be given as a function of time, radio frequency, and location, and thus beyond the immediate control of the radio spectrum manager. Radio noise may be classified in terms of its source:

(1) Examples of natural sources of additive radio noise are:
   - (a) Atmospheric
   - (b) Galactic
   - (c) Solar noise from antennas pointing at the sun
   - (d) Noise re-radiated from any absorbing media through which the wanted radio signal passes in its transit from the transmitting to the receiving antenna.

(2) Examples of man-made sources of additive radio noise are:
   - (a) Power lines or power supplies
   - (b) Automotive ignition systems
   - (c) Fluorescent lights
   - (d) Switching transients
   - (e) Electric razors
   - (f) Doorbell buzzers

The operating noise-threshold of a radio receiving system is the operating threshold in the absence of any additive unwanted radio signals. If a receiving system is very sensitive, its operating noise-threshold is low.

In the presence of phase-interference fading arising from multipath propagation, the operating noise-threshold is that median value of wanted signal power, available at the terminals of a loss-free receiving antenna, which is required to provide a specified required grade of service, g_R, in the presence of noise, but in the absence of any other unwanted signals. The receiving system includes the receiving antenna in its operating environment, any transmission line to the receiver, and the receiver itself.

The phase-interference fading of the wanted signal, in addition to its influence on the operating threshold, may introduce a multiplicative (or convolutional) type of radio noise; the reduction of the system performance caused by this multiplicative kind of noise is largely independent of the wanted signal level and, for a given propagation path and a given frequency assignment, is very difficult to control.

Just as dollars are used in cost-benefit analyses as a necessary common measure of the many diverse economic benefits and costs associated with various kinds of telecommunication systems, the number, S, of bits of information which can be transmitted without error in a given time interval Δt, provides the necessary common measure of the information available at the output of any kind of telecommunication system. The symbol S is here adopted in honor of Claude E. Shannon who developed a general theory of information transmission. The presence of multiplicative noise places a maximum limit, S_M, on the number of bits of information, S, which can be transmitted without error over the propagation path in a given time interval, Δt. Since S is directly proportional to $\Delta t \Delta \nu$ where $\Delta \nu$ denotes the bandwidth of the radio frequency channel used for the transmission, the upper limit S_M imposed by the presence of multiplicative noise can alternatively be expressed as a maximum limit $\Delta \nu_M \equiv \nu_u - \nu_\ell$ to the bandwidth of the given propagation path which is useful for the transmission of radio frequencies ν, expressed in Hertz, which lie between a lower bound ν_ℓ and an upper bound ν_u.

This maximum useful bandwidth $\Delta\nu_M$ will vary with time since the multipath conditions on the propagation path, which cause the multiplicative noise, vary with time. The maximum useful bandwidth $\Delta\nu_M$ will be different for amplitude modulation systems than for frequency modulation systems since the multipath conditions generate different amplitude and phase modulated components of multiplicative noise. Unless the information transmitted over the propagation path is confined at all times to a radio frequency channel which lies entirely within the relevant maximum useful bandwidth $\Delta\nu_M$, the maximum grade of service which can be provided by the radio system will vary with time.

The operating threshold of a receiving system depends on the required grade, g_R, of reception of the wanted signal, and therefore on the kind of service. For example, the quality of a teletype or voice service may depend on the percentage of correctly interpreted received characters. The quality of television may depend on subjective observations which lead to one or more precisely determined grades of reception such as "excellent" or "passable." In the case of a television service it will be desirable to have separate determinations of the operating-noise thresholds for the sound and vision channels, since these, together with other system considerations, may be expected to lead to an optimum choice for the sound-to-video transmitter power ratio.

Receiving systems which are "noise-limited" will in general have much lower operating noise thresholds and thus much better sensitivies than receiving systems which are "gain-limited." In a gain-limited receiving system the gains of the successive stages of the receiver are not sufficiently large to provide enough noise power at the predetection output of the receiving system so that this noise has any appreciable influence on the grade of service provided. The operating noise-threshold of a gain-limited receiving system is thus dependent <u>only</u> on the signal power level.

In a noise-limited receiving system the gains of the successive stages of the receiver are sufficiently large to provide enough noise power at the pre-detection output of the receiving system so that the operating noise-threshold depends upon the levels of both this noise power and of the signal power at the pre-detection output of the receiving system.

The operating threshold of a radio receiving system depends not only on the kinds and the relative values of the additive unwanted radio signals and the additive radio noise with which the wanted radio signal must compete but it also depends on the level of the radio noise generated in the receiver itself. The magnitude of this latter noise is conveniently measured by the noise factor of the receiver.

In the most commonly encountered case of a noise-limited receiving system it is useful to express the operating-noise threshold power of the entire receiving system in terms of an operating noise factor f_{op} for the approximately linear portion of the receiving system, together with an effective noise bandwidth b and that value $r_{op}(g_R)$ of operating signal-to-noise ratio at the pre-detection output of the receiving system which is required to provide a given required grade of service g_R.

When the wanted signal power is subject to phase-interference fading arising from multipath propagation, the operating threshold will depend on the nature and degree of this fading and on any multiplicative noise generated by this fading. The operating noise-threshold power will also be influenced by spurious receiver responses; however, in a well designed receiver their effects may almost always be reduced to negligible proportions.

The primary reason for using a receiving system with a minimum practicable operating noise-threshold is economic. Thus the required transmitter power is directly proportional to the operating noise-threshold power and it is often desirable to use a relatively expensive receiving system with a low value of operating noise-threshold power so as to reduce the cost of the transmissions. However, in the case of a broadcasting system involving many thousands of receivers for each transmitter, economic considerations will usually dictate the use of the largest practicable transmitter power.

Since the radio spectrum resource is not depleted when it is used, the basic engineering principle "That efficient use of the radio-frequency spectrum for telecommunications can be achieved only when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception" is based on the fact that its optimum use implies its use by the maximum number of simultaneous interference-free users; and the achievement of this goal is dependent only upon the relative values of the effective radiated powers of the various transmitters and is essentially independent of their magnitudes, provided these are sufficiently large that radio noise does not limit the reception at any of the receiving locations, i.e., provided the operating noise-thresholds are, say 5 dB or more, below the operating thresholds at all receiving locations.

It is desirable at this point to review the definitions and concepts so far developed. The operating threshold of a radio receiving system system is that median value $w_a(T_s)$ of the instantaneous wanted signal power available during some short time interval T_s at the standard reference terminals of the receiving system, which is required to provide some specified required grade of service, g_R, in the presence of interference from unwanted radio signals and radio noise. The required median value

$w_a(T_s, g_R)$ may be expressed in watts. Let $w_u(T_s)$ denote the median value of the instantaneous unwanted radio signal plus radio noise power available at the standard reference terminals during the same short interval of time, T_s, and then the ratio $r_R \equiv w_a(T_s, g_R)/w_u(T_s)$ is the predetection ratio of wanted-to-unwanted signal power which is required to provide a grade of service, g, equal to the required grade of service, g_R. The predetection ratios r_R will vary with the nature of the telecommunication services associated with the wanted and unwanted signal powers and also with the kinds of signal modulation and demodulation employed. These ratios will also vary with the nature of the fading of the wanted and unwanted signals during the short time interval, T_s. Potentially very large reductions may be made in these required predetection ratios, r_R, by the methods discussed by Dr. Baghdady in his lecture IX.12. To the extent that these techniques are reduced to practice and extensively used, they will indeed make large contributions to the problem of making more economical use of the radio spectrum resource. However the decision to use these potentially valuable techniques should be based on realistic cost-effectiveness analyses made either by the spectrum users or by the spectrum managers. Unfortunately realistic cost-effectiveness analyses are particularly difficult to make at the present time since no accurate quantitative measures exist of the values to the national or international welfare of each of the presently usable portions of the spectrum resource.

The operating threshold of a particular radio receiving system is given by:

$$w_a(T_s, g_R) = r_R w_u(T_s) \text{ watts} \tag{1}$$

The operating noise-threshold $w_{an}(T_s, q_R)$ of a radio receiving system is the operating threshold in the absence of any additive unwanted radio signals and is thus the special case of (1) for which the median power $w_u(T_s) \equiv w_{un}(T_s)$ consists entirely of radio noise.

If we adopt the convention of using lower case letters to denote power in watts, or power ratios, and capital letters to denote their decibel equivalents, we may express the operating threshold $W_a(T_s, g_R)$ and the operating noise-threshold $W_{an}(T_s, g_R)$ of a radio receiving system by (2) and (3) respectively:

$$W_a(T_s,\ g_R) = R_R + W_u(T_s)\ \text{dBW} \tag{2}$$

$$W_{an}(T_s,\ g_R) = R_R + F_{op} + B + G_o - G_s - 204\ \text{dBW} \tag{3}$$

where F_{op} is the median value expressed in dB of the operating noise factor of the receiving system, B is its effective noise bandwidth expressed in dB above one hertz and G_s and G_o are the decibel signal gains of the linear portions of the receiving system under operating conditions and for a c-w signal tuned to the maximum response of the receiving system, respectively. The best presently available derivation of (3) is given in CCIR Report 413.

Since $W_u(T_s)$, F_{op} and, to a small extent, R_R each vary with the time $t \equiv t_o + i\,T_s$, where i is an integer which measures the time in units each equal to T_s, it follows from (2) and (3) that the operating thresholds $W_a(T_s,\ g_R)$ and $W_{an}(T_s,\ g_R)$ will also vary with time. Thus each of these operating thresholds must be considered to be a discrete-time random process as a function of $i\ [i = 0, \text{ to } \infty]$ and thus of the time t. This random process reflects the power fading of any additive unwanted signal power and of the additive and multiplicative noise power and any changes with i of the statistical characteristics of the short-term fading of the wanted and unwanted signal powers.

In order to predict radio telecommunication system performance in the presence of unwanted radio signals, additive radio noise, and multiplicative radio noise in a useful way it is necessary to have a quantitative definition of harmful interference.

Harmful interference is defined to exist for some particular receiving system if the telecommunication system fails to achieve its propagation service objective.

The propagation service objective is achieved if the propagation reliability q is greater than or equal to its required value q_R during some specified future period of time T, i.e., if the propagation time availability qT is greater than or equal to its required value $q_R T$. The required propagation reliability q_R, which may be any specified number between zero and one but is usually chosen to be larger than 0.9, is simply that fraction of the time T that service of some specified grade g_R, or better, is required at the particular receiving system under consideration in the absence of outages caused by any non-propagation factors such as failures in either the transmitting or the receiving equipment. Thus we see that the specification of the propagation service objective requires the quantitative specification of its three parameters g_R, q_R, and T.

It is also necessary to define a system reliability q_s; if $(1 - q_e)$ denotes the fraction of the time T that equipment or other failures occur, which are not caused, either directly or indirectly, by changes in the propagation of the wanted or unwanted signals or of the noise, and if the assumption is made that these propagation and non-propagation failures occur independently in time, then:

$$q_s = q_e q \tag{4}$$

If the above usually reasonable independence assumption is not valid then the author has described methods which may be used for making allowance for any correlation in the times of occurrence of the propagation and non-propagation failures.* It follows from (4) that the required propagation reliability q_R must be greater than the required system reliability q_{sR}, i.e., $q_R = q_{sR}/q_{eR} > q_{sR}$, in order to achieve any given system reliability objective q_{sR}. Ideally, realistic cost-benefit analyses should be used to determine the best values for the fractions $(1 - q_R)$ and $(1 - q_{eR})$ of the time that propagation and equipment failures are permitted. Unfortunately, since those who presently use the spectrum resource are not directly charged for its use, it is common practice to require that $(1 - q_R)$ be much less than $(1 - q_{eR})$ and this practice often leads to inefficient use of this valuable resource.

Since we are here concerned with the prediction of an inherently uncertain future, it is clearly possible to determine quantitatively only a Service Probability that harmful interference will not exist, i.e., that the telecommunication system will achieve its propagation service objective and thus the system reliability objective as well since q_R is chosen, as discussed in the previous paragraph, so that $q_R = q_{sR}/q_{eR}$.

In Lecture No. VI.8 Barsis gives examples of methods for estimating the Service Probability and includes in his Section 8 "Correlations in Irregular Terrain" a brief discussion of some of the complications which arise in determining the service available when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception,

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* Norton, K. A. (April 1962), Efficient use of the radio spectrum. NBS Tech. Note 158.

i.e., when the operating noise threshold power $W_{an}(T_s, g_R)$ is, say 5 dB or more, less than the operating threshold power $W_a(T_s, g_R)$. The proper determination of the Service Probability in this case becomes considerably more complicated and, although I have made some progress on the problem of determining this probability $Q(g_R, q_R, T)$ in this general case, the details have not yet been published.

Finally, although a definitive discussion is not presently available, you may find the concept of an effective service sum of some interest and I will outline briefly how it may be used to maximize the number of interference-free users of some specified portion of the spectrum resource. A simple example of the effective service sum will be described which should serve to illustrate the nature of the concept. For this example we will assume that the portion of the spectrum resource under consideration is to be used to provide some kind of telecommunication services simultaneously to m different receiving systems throughout a period of time T equal to one year. Let $\hat{B}_{(r)}$ denote an estimate of the annual dollar value of the telecommunication service supplied to the r^{th} receiving location [r = 1 to m] and assume that the m values $\hat{B}_{(m)}$ represent the order statistics of these dollar values at the m receiving locations:

$$\hat{B}_{(1)} \geq \hat{B}_{(2)} \geq \ldots\ldots \geq \hat{B}_{(r)} \geq \hat{B}_{(r+1)} \geq \ldots\ldots \geq \hat{B}_{(m)} \qquad (5)$$

Furthermore let $Q_{(r)}(g_R, q_R, T)$ denote the Service Probability that service of the required grade g_R will be delivered to the r^{th} receiving location with the required propagation reliability q_R during the time T. Now the effective service sum for these m receiving systems is defined by:

$$\hat{B}_{(m)} \equiv \sum_{r=1}^{m} \hat{B}_{(r)} Q_{(r)}(g_R, q_R, T) \quad \text{(dollars)} \qquad (6)$$

The Service Probabilities $Q_{(r)}(g_R, q_R, T)$ are to be evaluated on the assumption that there is no radio noise; on this assumption these Service Probabilities, and thus the effective service sum $\hat{B}_m$, will depend only on the relative values of the powers radiated from the transmitting antennas which provide the m receiving systems with service. It can be shown that a unique set of these radiated power ratios can be determined for which the effective service sum achieves its maximum value $\hat{B}_M(m)$. If each of the resulting values of the Service Probabilities $Q_{(r)}(g_R, q_R, T)$ [r = 1 to m] in the maximized sum $\hat{B}_M(m)$ exceeds 0.95, then the number m of receiving locations can be increased to m′ and a new maximum $\hat{B}_M(m')$ can be obtained.

It could be argued that the required value for the Service Probability here proposed to be fixed at 0.95, should also be one of the parameters of the systems analysis to be selected by the spectrum manager to reflect the importance of the service under consideration. However, the author believes that the relative importance of various services are better allowed for in terms of their required grades of service g_R and their required equipment, service, and propagation reliabilities q_{eR}, q_{sR}, and q_R.

It is important to note that the Service Probability allows only for the errors in the prediction of the telecommunication system performance and that such prediction errors are always present in greater or lesser degree in every frequency management decision; thus these decisions affect only the future and this is never known with certainty. However as progress is made in the science of system performance prediction based on an improved understanding of radio wave propagation and of methods for measuring the effects of various sources of interference, and especially as more extensive quantitative data on the operating thresholds of receiving systems in the presence of both unwanted signals and noise become available, these errors of prediction will be reduced and then smaller decibel allowances for these prediction errors can be made and correspondingly lower transmitter powers can be used with no reduction in the Service Probability below its required value 0.95.

Let m' denote the maximum number of receiving locations for which each $Q_{(r)}(g_R, q_R, T)$ in $\hat{B}_M(m')$ exceeds 0.95. Finally, keeping the set of maximizing radiated power ratios constant, the radiated powers from the transmitting antennas are increased until the median wanted signal powers are enough greater than the operating threshold powers $W_a(T_s, q_R)$, which now include the effects of the radio noise, for each of those short-time intervals $T_s[i = 0 \text{ to } (q_R T/T_s)]$ so that $Q_{(r)}(g_R, q_R, T)$ is equal to or greater than 0.95 for $r = 1$ to m'. Under these circumstances it will be found that each of the values of the operating noise-threshold powers $W_{an}(T_s, g_R)$ will be, say 5 dB or more, below the operating threshold powers $W_a(T_s, g_R)$, i.e., the ineluctable limit to satisfactory reception will be interference from other signals rather than noise, and thus our assignment plan will satisfy the general engineering principle:

> "that efficient use of the radio-frequency spectrum for telecommunications can be achieved only when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception."

If the resulting total value $\hat{B}_M(m')$ of the telecommunications services provided is greater than their total estimated cost $\hat{C}(m')$, including a realistic estimate of the dollar value of the portion of the spectrum resource used, then this assignment plan may clearly be called an optimum plan. It is important to note, however, that this is simply an optimum plan and that it is based on the use of a particular specified set of the following parameters:

1. Nominal frequency assignments.
2. Transmitting system locations including the antenna heights.

3. Transmitting system signatures, i.e., the radiated emission spectrum characteristics including any spurious emission spectra.

4. Transmitting and receiving antenna characteristics.

5. Receiving system locations including the antenna heights.

6. Spurious response and emission spectra of the receiving systems.

7. Operating noise thresholds of the receiving systems in their actual environments, which thus make appropriate allowance for the effects of both man-made and natural noise.

8. Required values of wanted-to-unwanted phase-interference median signal powers for all unwanted signals which could potentially cause harmful interference to the wanted signal; these protection ratios include appropriate allowances for reductions in the effects of fading achieved by the use of diversity reception and coding.

9. Distributions with time of the phase-interference median basic transmission loss for the wanted and all of the unwanted signal propagation paths.

10. Transmission line and antenna circuit losses.

11. Correlations, if any, between the phase-interference median transmission losses on the wanted and on each of the unwanted propagation paths.

12. Path antenna power gains for the wanted and all of the unwanted propagation paths; these path antenna power gains include allowances for antenna orientation, ground absorption, polarization coupling and antenna-to-medium coupling losses.

13. The spurious emission spectra of man-made noise sources such as those noted in CCIR Report 182.

14. Assigned hours of operation of each wanted and each unwanted emission.

If new values of $\hat{B}_M(m')$ are determined for various alternative sets of the above parameters, and if $[\hat{B}_M(m') - \hat{C}(m')]$ is determined for each of these alternatives, then that plan for which this dollar difference between benefits and costs is a maximum would ordinarily be chosen.

Although the above approach to the problem of spectrum management would have been considered too complicated for practical use in the past, the recent advent of modern digital computers has made this approach entirely practical at the present time.

It might be argued that the improvements in spectrum use likely to be achieved by the above method will be too small to be of much value. However, in this connection, I would like to cite the very large potential improvement, in the use of the VHF portion of the spectrum now allocated for use by television stations, which Mr. R. S. Kirby and I demonstrated in Appendix 18 of "The Silent Crisis Screams." We are continuing our analysis of this kind of plan and, as discussed above, expect to examine many alternative solutions.

If you don't remember anything else after reading these lecture notes, I expect you to remember the important general engineering principle which was first presented at the bottom of page 4, since this was also given several other times in these notes. I have here adopted the tactics of Sir Winston Churchill who once said:

> "If you have an important point to make, don't try to be subtle or clever. Use a pile driver. Hit the point once. Then come back and hit it again. Then hit it a third time -- a tremendous whack."

The author is at present a Consultant to Robert S. Kirby, Director of the Tropospheric Telecommunications Laboratory (TTL) of the Institute for Telecommunication Sciences (ITS) of the Institutes for Environmental Research (IER) of the Environmental Science Services Administration (ESSA) of the U. S. Department of Commerce (DoC).

I will be pleased to receive inquiries relevant to these lecture notes from any of you students or from any others who may read these lecture notes. My present addresses and telephone numbers are:

Office Address:	U. S. Department of Commerce 325 Broadway Boulder, Colorado 80302
Office Telephone:	303-447-1000, ext. 3623/3181/3070
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Official Organ of the International Telecommunications Union

telepersonality

34 — KENNETH A. NORTON

THROUGHOUT HIS LONG career as a research physicist in the United States National Bureau of Standards (NBS), as an allocations engineer at the Federal Communications Commission (FCC) and as an operational analyst during World War II, Kenneth Alva Norton, now 56 years old, has won a notable reputation for dedicated and pioneering hard work and for unflagging persistence in the defence of the higher interests of the branch of science to which he has devoted his life.

Born at Rockwell City, Iowa, on February 27, 1907, he first studied in his native town and then pursued his studies at the University of Chicago where he received his Bachelor of Sciences degree in physics in 1928. Even during his high school years he showed a great interest in the application of physical principles in the solution of engineering problems and in July, 1929, he joined the staff of the radio section of the National Bureau of Standards in Washington, where his first assignment was the study of the fading of radio waves. To pursue the study of radio wave propagation, he spent a year at Columbia University, New York City. He then returned to NBS, where he developed methods for the measurement and prediction of ground-wave and sky-wave field strengths as a function of distance, frequency and ground constants. It was during this period that he discovered the now-famous error in Professor Arnold Sommerfeld's formula for the attenuation of ground waves.

In 1934, Kenneth Norton joined the FCC where he was responsible for a study of clear-channel broadcasting and the initial studies leading to the allocation of frequencies to television broadcasting. During World War II, he was Assistant Director of the operational research group and a Consultant on radio propagation in the Office of the Chief Signal Officer, Washington; he also spent a year and a half in the United Kingdom in 1943 and 1944 as a radio and tactical counter-measures analyst in the operational section of the Eighth Air Force. Shortly after his return to the United States, his testimony in hearings before the FCC was in large measure responsible for the assignment of the band 88 to 108 Mc/s to FM broadcasting in his country. This is one of the few instances in the development and use of the radio spectrum in which a band of frequencies was allocated which is optimum from the standpoint of its propagation characteristics.

Since 1946, Mr. Norton has been in the Central Radio Propagation Laboratory of NBS where he organized and was Chief of the Frequency Utilization Research Section. Now, as Chief of the Troposphere and Space Telecommunications Division at Boulder, Colorado, he is concerned with radio-guidance systems for space satellites, with space satellite communications, and with predictions of transmission loss and path antenna gain at frequencies throughout the radio spectrum.

As delegate to several international radio conferences, he has, since 1948, represented the United States at the Provisional Frequency Board and at meetings of the International Radio Consultative Committee (CCIR) and the International Scientific Radio Union (URSI), the latest occasion being the 1963 CCIR Plenary Assembly in Geneva.

For his distinguished work on radio propagation and FM and television frequency allocations, Mr. Norton was awarded the Stuart Ballantine Medal in 1954 by the Franklin Institute. In 1960 he received the Institute of Radio Engineers (IRE) Harry Diamond Memorial Award, the highest award offered to a United States government official in the field of radio and electronics. Later, in 1962, the United States Department of Commerce awarded him the Exceptional Service Award for "outstanding contributions and leadership in the field of radio propagation research".

Currently he is interested in developing methods for the efficient use of the radio spectrum. He has defined optimum use of the spectrum to be that use which will lead to the assignment of adequate frequency bands to the maximum number of simultaneous users in such a way that none of these users will suffer harmful mutual interference.

A member of several scientific societies, the author of many technical articles, Mr. Norton is one of the few outstanding figures of our time in the field of radio propagation research.

A. Z.

(Original language: English)

The Sommerfeld Error in Sign *

Professor Arnold Sommerfeld published a series of papers [1909, 1910, and 1926] which gave formulas for the expected values of the vertical electric field strength as a function of the distance over a plane earth from a transmitting antenna radiating a specified power. Using Sommerfeld's equations as the basis Bruno Rolf [1929, 1930] developed a series of graphs which could be used for determining these expected field strengths for a wide range of radio frequencies and ground constants. I have reproduced page 395 of his March 1930 paper on page A.2. This page includes Fig. 1 and illustrates the peculiar behavior of the field strength as predicted by Sommerfeld's 1909 formula.

Mr. Samuel S. Kirby [the father of Mr. R. S. Kirby] and I published [1932] a paper on field strength measurements made at frequencies from 285 to 5400 kHz and at distances ranging from only a few wavelengths from the transmitting antenna out to a maximum of about 400 km. In spite of the error in Rolf's graphs we were able to use them with some degree of satisfaction for explaining these measured data. However, in a series of observations made with a field strength meter mounted on a boat, we made an attempt to verify some of the unusual features of Rolf's graphs by a series of measurements made as the boat navigated the Potomac River between Washington, D. C., and Alexandria, Virginia. It was at this point that I first become suspicious of the Sommerfeld formula.

In a Letter to the Editor of Nature [1935] I discussed the error in sign in Prof. A. Sommerfeld's original 1909 paper. This letter is given on page A.3. Although the correct sign was given in Prof. Sommerfeld's

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* This Annex has been included as a result of a request by one of the students.

values of $(u^2+v^2)^{1/2}$ on a logarithmic scale. The numbers inscribed on the various curves are the values of $b = \arctan [(\epsilon+1)/(6\lambda\sigma 10^{16})]$. The tangent of b is thus roughly proportional to inductivity of the soil divided by product of wavelength and conductivity, a fraction which

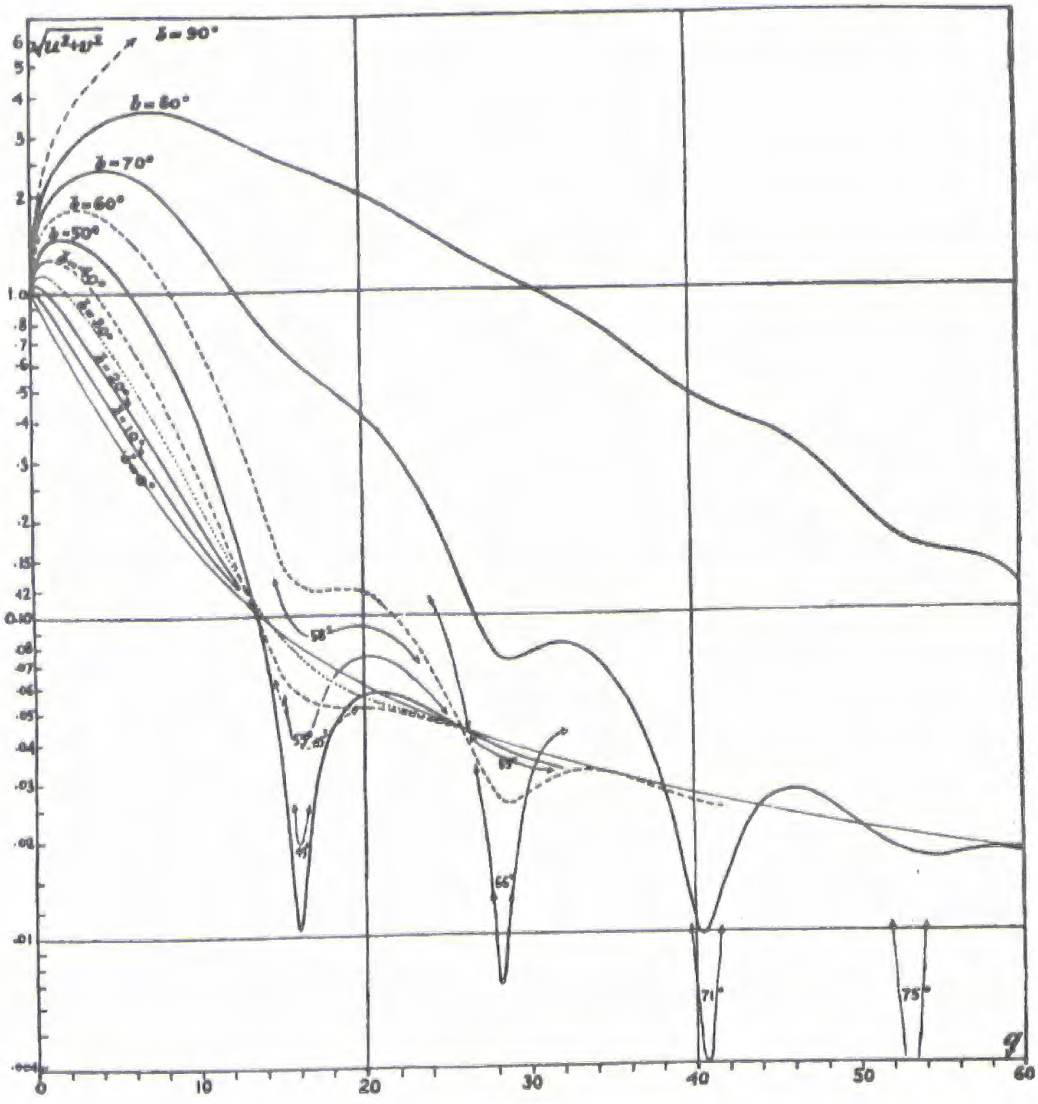

Fig. 1

determines the *shape* of the attenuation curve. When the fraction $(\epsilon+1)/(6\lambda\sigma 10^{16})$ grows greater than, say, unity, that is when the wavelength is sufficiently short, or the conductivity of the soil sufficiently low, we gather that the attenuation curve shows up more and more curious features.

First, the attenuation near the transmitter becomes *greater* than unity, i.e., the field weakens *less* rapidly than required by the inverse distance law; in fact, for sufficiently great values of tan b, i.e., short

NATURE

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Saturday, June 8, 1935

Propagation of Radio Waves over a Plane Earth

The purpose of this letter is to point out an error in sign in Prof. A. Sommerfeld's original paper (1909) on the attenuation of radio waves[1]. This error in sign has recently been reflected in Bruno Rolf's graphs[2] of the Sommerfeld formula, predicting dips to zero in the field intensity at finite distances from a radio transmitter and other anomalous phenomena. This error in sign has been corrected in Prof. Sommerfeld's 1926 papers[3] and also does not occur in the derivation by B. van der Pol and K. F. Niessen[4]. In this latter paper an exact expression is given for the potential of a vertical infinitesimal dipole (equation 21). After expanding this expression, I found that most of the terms are negligibly small at moderately low frequencies for distances from the source greater than a wave-length, giving for the potential function of a vertical dipole over a plane earth:

$$\Pi(r, 0) = \frac{e^{ik_1 r}}{r}\left[1 - 2\sqrt{p}\, e^{-p}\int_{i\infty}^{\sqrt{p}} e^{w^2}dw\right]$$

$$\text{where } p = ik_1 r\left[1 - \left\{1 + \left(\frac{k_1}{k_2}\right)^2\right\}^{-1/2}\right] \equiv p_0 e^{ib} \quad (1)$$

and $k_1 = \frac{2\pi}{\lambda}$, and $k_2^2 = k_1^2(\varepsilon + i2c\lambda\sigma)$,

where ε is the dielectric constant of the ground referred to air as unity, σ is the conductivity of the ground in electromagnetic units, c is the velocity of light in cm. per sec., λ is the wave-length in cm. and r is the distance in cm.

In the above equation, p is the 'numerical distance' as defined by van der Pol and Niessen and is slightly different for high frequencies from the 'numerical distance' used by Sommerfeld; this difference makes the above formula accurate for large values of the parameter b and free from the errors which Rolf[5] made by using the Sommerfeld 'numerical distance'.

Rolf used equation (1) with the lower sign reversed on the integral for computing the field intensity from a distant radio transmitter. Correcting this error in sign, I have found that the following empirical formula for the field intensity may be determined from equation (1):

$$F = \frac{c}{r}\sqrt{P}\left[f(p_0) - \sin b\sqrt{\frac{p_0}{2}}\, e^{-\frac{1}{2}p_0}\right] \quad \ldots\ldots (2)$$

This formula gives the field intensity, F, in microvolts per metre when the radiated power from the transmitter is P kilowatts and is applicable for $b < 30°$, that is, for frequencies less than about 10,000 kc./s. for transmission over ground of average conductivity about 10^{-13} E.M.U. The quantity in the square brackets is the 'attenuation factor' and reduces to $f(p_0)$ in the case $|k_2^2| >> k_1^2$. This was the case discussed by Sommerfeld, and values for $f(p_0)$ are given by Rolf in his first paper—van der Pol[6] also gives the following empirical formula for $f(p_0)$:

$$f(p_0) = \frac{2 + 0{\cdot}3p_0}{2 + p_0 + 0{\cdot}6p_0^2} \quad \ldots\ldots\ldots (3)$$

Formula (2) is limited in this application to a plane earth, the actual ground wave field intensity being influenced by the curvature of the earth at the greater distances, this effect being the predominating influence at sufficiently low frequencies.

K. A. Norton.

Federal Communications Commission,
Washington, D.C.

March 8.

[1] *Ann. Phys.*, 28, 665; 1909.

[2] Ingeniörs Vetenskaps Akademiens, Handlingar No. 96; 1929. *Proc. I.R.E.*, 18, 391; 1930.

[3] *Ann. Phys.*, 81, 1135; 1926.

[4] *Ann. Phys.*, 6, 273; 1930.

[5] See criticism by W. H. Wise, *Proc. I.R.E.*, 18, 1971; 1930.

[6] "Jahrbuch der Drahtlosen Tel. und Tel.", 37, 152; 1931.

1926 paper, he made no mention of any change in sign. If Rolf was suspicious of the results given on his graphs he may have been reassured by the fact that Prof. Sommerfeld himself published some graphs in his 1910 paper which were also based on the use of the incorrect 1909 sign and which were in agreement with Rolf's subsequent much more extensive graphical analysis. Page 171 of Prof. Sommerfeld's 1910 paper is here reproduced on page A. 5.

I have reproduced on pages A. 6, A. 7, and A. 8 a letter I received from Prof. Sommerfeld in 1937, a translation of this letter, and my reply.

Jahrb. d. Drahtl. Tel., 4, 157-176.

der Figur sind die Ordinaten zu den Punkten $\varrho = \frac{1}{10}, \frac{1}{4}, \frac{1}{2}$ und 1 berechnet. Für die ersten beiden genügt es, in Gleichung (7) die Glieder bis α^2 beizubehalten und dementsprechend w nach Gleichung (9) zu berechnen. Bei $\varrho = 1/2$ muß man bis α^7 gehen; bei $\varrho = 1$ legt man besser die summierte Formel (55) meiner früheren Arbeit zugrunde, da die Konvergenz der Reihen hier bereits zu schlecht wird.

Die Kurven beanspruchen keine große Genauigkeit, zeigen aber deutlich folgendes Verhalten: Das Vorhandensein eines imaginären

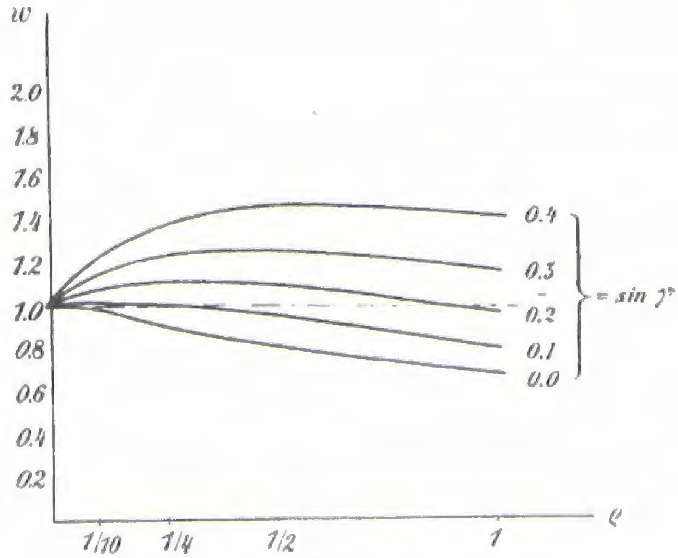

Fig. 1.

Teiles in α verzögert den Abfall der Kurven erheblich, vergrößert also die Reichweite derart, daß die Kurven für größere γ ganz oberhalb derjenigen für kleinere γ verlaufen. Während die Kurve für $\sin\gamma = 0$ ihr Maximum $w = 1$ für $\varrho = 0$ hat, steigt das Maximum für größere γ merklich über $w = 1$ und rückt zugleich gesetzmäßig zu größeren ϱ.

Sehen wir von der ev. komplexen Beschaffenheit von k_1 ganz ab, so rührt, wie eingangs erwähnt, das Auftreten des Winkels γ von der Dielektrizitätskonstante des Bodens her. Bereits Zenneck[1]) hatte aus anderen Gesichtspunkten auf die günstige Wirkung dieser Konstanten hingewiesen. Setzt man nach Gleichung (1)

1) l. c. Ann. d. Phys. **23**. Vgl. auch desselben Verf. Leitfaden der drahtlosen Telegraphie, Kap. IX Fig. 201.

A. 6

zur Zeit: Zimmerhof, Süd-Tyrol
5. September 1937

*) Nach München 23
Dunantstr. 6

Lieber Dr. Norton!

Ich danke Ihnen bestens für Ihre Note über das Radio-Feld. Darf ich Sie auf meine letzte Darstellung des Problems aufmerksam machen in Frank-Mises (früher Riemann Weber), letzte Auflage, etwa vom Jahre 1932, 2^t Band, wo ich ein Kapitel über drahtlose Telegraphie geschrieben habe. Ich glaube, dass die dort gegebenen Formeln richtig sind. Aber Ihre Formeln (1) und (2) sind wohl allgemeiner und übersichtlicher als meine. Ich bin in den Ferien und kann daher unsere Resultate nicht vergleichen. Ich wäre Ihnen dankbar, wenn Sie dies tun würden und mir darüber schreiben wollten*), vielleicht auch darüber, ob Sie mit den letzten Arbeiten von Niessen (Ann. der Phys., 1937) übereinstimmen.

Sehr interessant ist Ihre letzte Bemerkung, dass die Oberflächenwellen nun doch zur Überwindung der Erdkrümmung beitragen sollen. Das war meine ursprüngliche Meinung; ich hatte sie aber aufgegeben, weil sie mir durch die Austin'schen Messungen über „long distance waves" nicht bestätigt zu sein schienen. Ich werde mich freuen, wenn durch Ihre genaueren Rechnungen die Oberflächen-Wellen wieder rehabilitiert und von den Raumwellen getrennt werden können.

Mit bestem Dank bin ich Ihr

A. Sommerfeld.

TRANSLATION

Zirmerhof, Tyrol
5 September 1937

*) Nach Munchen 23
Dunantstr 6

Dear Mr. Norton:

I thank you very much for your note concerning the radio field. I permit myself to call your attention to my last work on the problem which appeared in Frank-Mises (formerly Riemann Weber), last edition, volume 2, where I have written a chapter on wireless telegraphy. I believe that the formulas presented there are correct. However, your formulas (1) and (2) are more general and easier to interpret than mine. I am here on vacation and therefore cannot compare our results. I will thank you if you will write* to me regarding the comparison of our formulas and also whether they agree with the latest work of Niessen (Ann. der Physik, 1937).

Your last remark that the surface waves are not much affected by the curvature of the earth is very interesting. That was my original idea, but I had since given it up because it did not agree with the measurements of Austin on long waves. I am glad to notice that your accurate equations make possible the separation of the space and surface waves.

With best thanks, I am yours

A. Sommerfeld.

September 20, 1937

Professor Arnold Sommerfeld,
31 Gold Plank - Med. Munchen 23,
Duantstr - 6, Germany.

Dear Dr. Sommerfeld:

I have made the comparison between the formula for the wave potential of a vertical electric dipole which you obtained in Frank-Mises book and the expression which I obtained in my paper which appeared in the Proceedings of the Institute of Radio Engineers for September 1937. Your formula is limited in two ways, (1) to short distances above ground, $z << r$ and (2) to low frequencies, $|k^2| >> k_0^2$. In this case, the Fresnel reflection coefficient may be written

$$R_v = \frac{(kz/k_0 r) - 1}{(kz/k_0 r) + 1} \tag{1}$$

and your equation (42) page 939 in Frank-Mises may be written

$$\Pi_0 = \frac{\exp(ik_0 R)}{R}\left\{1+R_v+(1-R_v)(1+i\sqrt{\pi}\,w\exp(-w^2)-2w\exp(-w^2))\int_0^w \exp(y^2)dy)\right\} \tag{2}$$

The above equation (although not as general) is identical in form to equation (49) in the Proceedings of the Institute of Radio Engineers paper which forms the basis for the equations for E, H, and S as given in my Letter to the Editor of the Physical Review.

I was able to remove the first limitation mentioned above, $z << r$, by using results for Π_0 obtained by Dr. van der Pol in Physica, August 1937. I removed the second limitation $|k^2| >> k_0^2$, by a trick which is justified only by the results which I was able to obtain and not by rigorous mathematical processes. Dr. Wise obtained (Bell System Technical Journal, October 1929) an exact asymptotic expression for Π_0 which agrees exactly with the solution obtained by the use of the reciprocal theorem applied to dipoles near the earth and far away. In order to make van der Pol's expression (which had been simplified by several approximations) agree asymptotically with Wise's exact asymptotic expression, I arbitrarily introduced the factor $\sqrt{1-k_0^2\cos^2\Psi/k^2}$. By this means I obtained exact equations for the space wave (the known expressions for the space wave having already been obtained by the use of the reciprocal theorem) and an exact asymptotic expression for the surface wave and its forward tilt and polarization (the exact asymptotic expressions for the surface wave having already been obtained by Wise). In addition, my results for the surface wave agree (as closely as his graphs can be read) with Burrow's graphs of Wise's exact expressions for the surface wave at any distance and for any frequency or set of ground constants found in practice. A comparison of my results with these other results, which are known to be exact, has shown only the following limitation - in the case that k^2 is real, my formulas do not produce the small ripples in the field intensity which occur at distances of the order of a wavelength in Burrow's revised graphs of Wise's formula (October 1937, B. S. T. U.).

Recently Niessen has given results for the surface wave at distances greater than one wavelength from the transmitting dipole. Equations (57) and (117) in my Proc. I. R. E. paper agree with his results as closely as I can read his graphs. In addition, my equations may be used at distances less than one wavelength although formally they should not be used at distances less than several wavelengths. My results may be used at such short distances due to the happy circumstance that the portion of the formula which is approximate becomes a negligible part of the total expression for the field at these distances.

In view of the fact that my formulas are expressed in closed form and are completely general, I believe that the trick which I used is justified. However, now that simple and general formulas have been obtained by approximate methods, it is to be hoped that some mathematician will be able to derive, by rigorous methods, formulas which will be equally simple and general.

With best regards, I am

Very truly yours,

K. A. Norton.

P. S. I am enclosing a graph showing the phase of the ground wave attenuation function. I expect to publish this in an early forthcoming paper. I will send you reprints of my latest papers when they become available.

ANNEX TO ANNEX

There was insufficient time, prior to the deadline for printing, to finish the ANNEX. This annex to the annex will supply the missing parts. Continuing on page A.4:

Charles R. Burrows [Aug. 1936, Feb. 1937, June 1937] published the results of a series of measurements made at a frequency of 150 MHz over a deep fresh water lake. These data proved, more conclusively than did the earlier data S. S. Kirby and I had obtained [1932] in measurements over the Potomac river, that Sommerfeld had, in his 1909 and 1910 papers, made an error in sign. These data did not, however, have anything to do with the existence of a surface wave as Burrows erroneously implied. Note, in this connection, the comments in the last paragraph of the letter dated 5 September, 1937, from Prof. Sommerfeld.

More recently Wait [Dec. 1957, 1964, Sept. 1967] and Wait and Schlak [Sept. 1967] have shown that the Sommerfeld formula with the incorrect sign is useful for explaining the results of propagation over certain kinds of stratified surfaces. Thus, although the Sommerfeld 1909 formula and Rolf's graphs are in error for the surface conditions they were considering, Wait has shown that they may still be useful for other kinds of surfaces which are sometimes encountered in practice.

In view of the above fact, it appears that Burrows overstated the case when he said [Aug. 1936]:

> "It seems evident that a revision of the Sommerfeld-Rolf curves is required for propagation over all types of ground for which the dielectric constant cannot be neglected."

A good summary of the above plane homogeneous-earth results was presented by the author [Nov. 1942] in a report prepared for the National

Defense Research Committee. This was written while the author was recovering from an appendectomy.

The curvature of the earth is of importance at the larger distances and the formulas and graphs in my 1941 paper have been found to be useful at all radio frequencies and distances for propagation over an homogeneous earth.

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July 15, 1968

A Flexible Dynamic Scientific Procedure for Achieving More Efficient Use of the Electromagnetic Spectrum Resource

by

Kenneth A. Norton

1. Introduction

The United States is conceded to have by far the most, the largest, and the best telecommunication systems in the world. However, the technological and sociological progress during the past 50 years has created the desirability of having still more, even larger and substantially better systems. A large number of the present telecommunication systems are dependent upon the use of the electromagnetic spectrum resource. The spectrum itself has only a single dimension, which is frequency. However, when considered as a resource to be allocated to various users, this resource has five independent dimensions: the frequency ν, the time t, and the three dimensions of the locations ℓ at which the resource is used. A portion $[\Delta\nu, \Delta t, \ell]$ of the spectrum resource is <u>used</u> at a receiving location ℓ when this portion is occupied by electromagnetic energy, either some kind of <u>wanted</u> energy in the form, for example, of a telecommunication signal or electronic heat <u>or</u> some kind of man-made <u>unwanted</u> energy generated incidental to the operation of some useful device. Examples of useful devices whose operation generates <u>unwanted</u> electromagnetic energy are automotive ignition systems and fluorescent lights. The harmonic radiation from a transmitter of <u>wanted</u> telecommunication signals also constitutes an <u>unwanted</u> kind of electromagnetic energy. Atmospheric or cosmic electromagnetic noise energy is used in some portions of the spectrum resource by radio astronomers and by other scientists but the presence of this noise energy does not <u>otherwise</u> represent a beneficial use of these portions of the spectrum resource since, in contrast to those man-made components of unwanted electromagnetic energy described above, the generation of this noise energy does not occur incidental to the operation of some useful device and, in any case, its generation is completely beyond the control of the spectrum manager.

The spectrum is a limited resource but its use can be shared nationally and internationally. It is an unusual resource in that it is not depleted by use. However the value of some portion of the resource can be drastically reduced by misuse. In fact the spectrum management procedure described in this essay is simply a rational method for essentially eliminating the conflicts of interest which arise from the potential existence of harmful interference when more than one portion $[\Delta\nu, \Delta t, \ell]$ of the spectrum resource is used during the same time interval Δt. The spectrum resource is unusual in another sense in that allocations to specific users are currently made with zero charge for its use and with no accurate quantitative measure of its value to the national or international welfare.

On the assumption that our society is willing to pay a substantial price for the cost of achieving marginal engineering and economic improvements in the efficient use of this resource, a description is given in this essay of a flexible dynamic scientific procedure for achieving these improvements. Although the direct costs to the Federal Government of using this procedure will be very large, I personally believe that the value of the marginal benefits that will ensue from its adoption and use will far outweigh these costs. It will be shown in the sequel that this procedure may be implemented in such a way that it will not only expedite the adoption of valuable technological innovations without destroying the great values inherent in our present uses of the spectrum resource but will also ensure a steady increase in that portion of the Gross National Product attributable to the use of this valuable resource.

Although the direct costs to the Federal Government will be larger, the present costs to spectrum users of acquiring a license to use one or more portions of the spectrum resource will be greatly reduced by the adoption of this procedure. Furthermore, when the Federal Government adopts the policy of making positive charges for the use of the spectrum resource as is strongly recommended in this essay, the income from this source will be many times larger than the costs of using the procedure here recommended and will thus provide an additional legitimate source of revenue which may be used to defray other Federal Government costs. In order to minimize the impact on the present spectrum users of this desirable change in Federal Government policy of making positive rather than zero charges for the use of the spectrum resource, these charges should be levied only gradually over a period of, for example, ten years, with charges of only 10 % of the ultimate charge the first year, 20 % the second year, etc. When these charges finally reach their ultimate values, many present users of the spectrum resource will no longer be able to continue their use of this heretofore free resource but this will merely ensure that each of the portions of this valuable resource will be used at that future time only for achieving its highest valued uses.

The procedure described will not only lead to large improvements in both the engineering and economic efficiency of spectrum use but it will also provide a means for continuing to achieve by means of appropriate subsidies, those social goals which the Congress of the United States decides are in the best interests of the public. It is obvious that the necessity for the Congress to appropriate funds needed to subsidize such socially desirable telecommunications as television broadcasting will lead to a more careful consideration of the proper magnitudes of these subsidies than the indiscriminant present practice of subsidizing all users of the spectrum resource by making a zero charge for its use.

Recently the author prepared lecture notes entitled "The ABC's of EMC" for the Electromagnetic Propagation Course sponsored jointly by the University of Colorado and the Environmental Science Services Administration of the U. S. Department of Commerce. These lecture notes are reproduced as Annex I to this essay and they include a brief description of the flexible dynamic scientific procedure, i.e., the effective service sum, which is the subject of this essay. Reference is made in Annex I to a partially completed book "The Silent Crisis Screams" which now includes an amplification of some aspects of the spectrum management procedure discussed in this essay. In this book the economic concept of cost-benefit analysis is discussed in Part I and in Appendices 9, 10, 11, 12, 13, and 21 and Appendix 3 contains a discussion of the word scientific as used in this essay; this definition of the word scientific was given most eloquently by Lord Kelvin (Sir William Thompson) in his 1883 Lecture on "The Practical Applications of Electricity":

> "I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the state of <u>science</u>, whatever the matter may be."

2. The Effective Service Sum

The effective service sum $\hat{B}_S$ is defined by:

$$\hat{B}_S = \sum_{r=1}^{m} \hat{B}_{(r)} Q_{(r)} \qquad \text{(dollars)} \qquad (1)$$

where $\hat{B}_{(r)}$ denotes an estimate of the <u>true</u> dollar value $B_{(r)}$ of the benefits expected during some <u>future</u> period of time $\Delta t_{(r)}$ from the use of the r^{th} portion $[\Delta\nu_{(r)}, \Delta t_{(r)}, \ell_{(r)}]$ of the electromagnetic spectrum resource.

The effective service sum $\hat{B}_S$ is simply the weighted sum of the m dollar values $\hat{B}_{(r)}[r = 1 \text{ to } m]$ of the benefits expected from the use of these particular portions of the spectrum resource during a future time interval Δt_S. Each of the time intervals $\Delta t_{(r)}[r = 1 \text{ to } m]$ must lie within Δt_S but they need not necessarily occupy this entire time interval. For example Δt_S might represent one year and $\Delta t_{(3)}$ might be simply the hours from 6 a.m. to 12 p.m. on each Monday through Friday throughout the year. Note that $\Delta\nu_{(r)}$ might be the same frequency bands at different receiving locations $\ell_{(r)}$. For example $\Delta\nu_{(r)}[r = n' \text{ to } n' + p']$ might be TV Channel 7 and $\ell_{(r)}[r = n' \text{ to } n' + p']$ might be all of the receiving locations in the United States, Canada, and Mexico at which TV Channel 7 is used. Similarly $\Delta\nu_{(r)}$ might be different frequency bands at the same receiving location. For example $\Delta\nu_{(r)}[r = s' \text{ to } s' + 6]$ might be TV Channels 2, 4, 5, 7, 9, 11, and 13 and $\ell_{(r)}[r = s' \text{ to } s' + 6]$ might be a single receiving location in downtown New York City. Although these examples refer to a television broadcasting service, the effective service sum is applicable to the analysis of all kinds of radio systems: fixed, mobile, aeronautical mobile, etc., and all kinds of sharing. An appreciation of the kinds of telecommunication systems now occupying the spectrum resource can be obtained by reading Part II and Appendix 16 of "The Silent Crisis Screams." The weight assigned to the r^{th} estimated dollar value $\hat{B}_{(r)}$ in this sum is the dimensionless Service Probability $Q_{(r)}$ that the use of the r^{th} portion of the spectrum resource will actually achieve the benefits expected from this use. For example, if the benefit expected from the use of the r^{th} portion of the spectrum resource is some kind of telecommunication service, the Service Probability is the probability $Q_{(r)}(g_R, q_R, \Delta t_{(r)})$ that the telecommunication system will achieve its propagation service objective, i.e., will provide a service of the required grade g_R, or better, for a fraction q_R of the time $\Delta t_{(r)}$, i.e., with a propagation reliability q equal to its required value q_R. As discussed in Annex I the required value q_R for the propagation reliability is chosen so as to ensure that the required value q_{sR} of system reliability which includes allowances for both propagation and equipment failures, will also be achieved.

As discussed in Annex I the Service Probability $Q_{(r)}$ depends only on the errors of predicting the relative magnitudes of the median values $w_{(r)(c)}(T_s)$ [c = 1 to m] of the instantaneous wanted and unwanted signal powers available at the standard reference terminals of the receiving system associated with the use of the r^{th} component of the spectrum resource during each of the short intervals of time T_s [defined in Annex I] within the period of the time $\Delta t_{(r)}$ that this r^{th} component is used. Note that $w_{(r)(r)}(T_s)$ denotes the median wanted signal power and the $(m - 1)$ components $w_{(r)(c)}(T_s)$ with c different from r denote the median unwanted components of power which may cause harmful interference to the use of the r^{th} component. We will see in the sequel how the effective service sum can be used to effectively eliminate the $m(m - 1)$ conflicts of interest which potentially exist as a result of making simultaneous use of m components of the spectrum resource within the same time interval Δt_S.

3. Choice of the m Portions of The Spectrum Resource Included in The Effective Service Sum

The choice of the m portions of the spectrum resource included in some particular effective service sum is made by an iterative procedure and the execution of this procedure will, as a practical matter, require the use of an electronic computer. It is assumed that a data file is available which includes numerical values for all of the parameters [such as, for example, those enumerated on pages 19 and 20 of Annex I] which are relevant to all of the present uses of the spectrum resource. A prototype of such a data file is presently available to the Department of Defense (DoD) at the Electromagnetic Compatibility Analysis Center (ECAC) at Annapolis, Maryland. Appendix 7 in "The Silent Crisis Screams" is the final report of a DoD Panel established to "Review the Mathematical Modeling in Use by the Department of Defense Electromagnetic Compatibility Program" and this panel concluded that this ECAC data base "appears to be the best and most comprehensive data base available to the EMC community in the U. S. A."

Suppose now that we wish to use the effective service sum for improving the use of some specified contiguous portion $\Delta\nu_S$ of the spectrum resource during some future specified period of time Δt_S such as, for example, one year. The first m' portions of the spectrum resource to be included in the effective service sum are all of those portions $[\Delta\nu_{(r)}, \Delta t_{(r)}, \ell_{(r)}]$ $[r = 1 \text{ to } m']$ which expect to occupy some portion of the frequency band $\Delta\nu_S$ during some portion of the time interval Δt_S at one or more of the receiving locations $\ell_{(r)}[r = 1 \text{ to } m']$.

The next m'' portions of the spectrum resource to be included in m are those with values of $\Delta\nu_{(r)}$ which lie <u>outside</u> of the band $\Delta\nu_S$ and which have a potential for interfering with the use of at least one of the first m' portions of the spectrum resource.

Let $\Delta\nu_{S''}$ denote the contiguous frequency band $\Delta\nu_S$ plus the bands $\Delta\nu_{(r)}[r = m' + 1 \text{ to } m' + m'']$; note that $\Delta\nu_{S''}$ will not necessarily be a contiguous band of frequencies since one or more of the m'' portions of the spectrum resource may represent subharmonics of frequencies within $\Delta\nu_S$. The next m''' portions of the spectrum resource to be included in m are those with values of $\Delta\nu_{(r)}$ which lie <u>outside</u> of the band $\Delta\nu_S$ and which have a potential for interfering with the use of at least one of the m'' portions of the spectrum resource. It is anticipated that $m' > m'' > m'''$ etc., so that $m = m' + m'' + m''' + \ldots$ will not be so large that it will be impractical to use an electronic computer in analyzing $\hat{B}_S$ in the manner described in the sequel.

4. Estimating the Dollar Values $\hat{B}_{(r)}$ of each of the Benefits [r = 1 to m] Expected During the Period of Time Δt_S from the Use of those m Portions of the Spectrum Resource Included in $\hat{B}_S$.

In Part I of "The Silent Crisis Screams" I stated that the benefits $\hat{B}_{(r)}$ expected from the use of the spectrum resource should always be measured in dollars or their equivalent in some other currency such as francs, guilders, marks, pesos, pounds, rubles, etc.; only in this way can the values of various systems, or kinds of systems, be properly measured and compared in a scientific way.

Some have objected that dollar valuations are impractical in this application and I am sure that this question will continue to be debatable in the future as it has been in the past. One of the most eminent mathematicians in modern times, John von Neumann, considered this problem and the first seven pages of the now famous book "Theory of Games and Economic Behavior" by John von Neumann and Oskar Morgenstern consider some of the pros and cons of this question. The following quotation from this book, which was first published by the Princeton University Press in 1944, argues quite persuasively for the position I have taken:

> "It is not that there exists any fundamental reason why mathematics should not be used in economics. The arguments often heard that because of the human element, of the psychological factors etc., or because there is -- allegedly -- no measurement of important factors, mathematics will find no application, can all be dismissed as utterly mistaken. Almost all these objections have been made, or might have been made, many centuries ago in fields where mathematics is now the chief instrument of analysis. This 'might have been' is meant in the following sense: Let us try to imagine ourselves in the period which preceded the mathematical or almost mathematical phase of the development in physics, that is the 16th century, or in chemistry and biology, that is the 18th century. Taking for granted the skeptical attitude of those who object to mathematical economics in principle, the outlook in the physical and biological sciences at these early periods can hardly have been better than that in economics -- mutatis mutandis -- at present.

> "As to the lack of measurement of the most important factors, the example of the theory of heat is most instructive; before the development of the mathematical theory the possibilities of quantitative measurements were less favorable there than they are now in economics. The precise measurements of the quantity and quality of heat (energy and temperature) were the outcome and not the antecedents of the mathematical theory. This ought to be contrasted with the fact that the quantitative and exact notions of prices, money and the rate of interest were already developed centuries ago.
>
> "A further group of objections against quantitative measurements in economics, centers around the lack of indefinite divisibility of economic quantities. This is supposedly incompatible with the use of the infinitesimal calculus and hence (!) of mathematics. It is hard to see how such objections can be maintained in view of the atomic theories in physics and chemistry, the theory of quanta in electrodynamics, etc., and the notorious and continued success of mathematical analysis within these disciplines."

Unless <u>all</u> of the benefits and <u>all</u> of the costs of the associated resources are assigned dollar values by some clearly appropriate procedure, then the policy makers will be forced to make their decisions subjectively, i.e., they will supply their own ad hoc judgments regarding the values of those resources and potential benefits and this will clearly lead more often to incorrect decisions, i.e., to the more frequent adoption of economically inefficient methods for producing telecommunication service. Although uncertainties in the numerical values used in the proposed cost-effectiveness analysis will often lead to the adoption of incorrect courses of action in much the same way that is expected from the use of incorrect subjective judgments, it seems obvious that a thoughtful search for the best available dollar values of various options will on the average lead to the adoption of fewer incorrect courses of action than complete reliance on the less sophisticated intuitive judgments.

While readily conceding the fact that the establishment of dollar values to the benefits and costs associated with the use of the spectrum resource is a most difficult task, I see no reason to believe that these difficulties will be inherently any greater in this application than for many other kinds of publicly owned resources such as water rights, public lands, etc. In fact the large uncertainties in the dollar values of any resource, whether publicly owned or not, will be comparable to those arising in spectrum management and this fact indicates to me simply that we need to face these inherently difficult problems squarely and devote more conscious effort to them rather than pretend that efficient use of the spectrum resource will be assured by reliance on the intuitive economic judgments of the FCC Commissioners and the Director of Telecommunication Management who have essentially no guidelines except, in the case of the FCC, the "public convenience and necessity." At the September 11-12, 1967, Airlie House Conference on Use and Management of the Radio Spectrum [to be published] one of the FCC Commissioners was quoted as stating:

> "... one of the most frustrating things about trying to function as a public official in this area is what seems to me to be the total absence of any standard. And with all respect I really find the 'public convenience and necessity' more a charade -- somewhere between a charade and criminal fraud -- more than I do a useful standard. I mean it is absolutely devoid of meaning so far as I am concerned. And I find it somewhat unsettling to have really nothing to cling to in making these judgments."

5. Externalities and Monopoly

One of the problems of simply permitting the economic forces of the market place to guide the allocation of the spectrum resource is the presence of "externalities," i.e., of benefits or costs which affect the public interest as a whole but which would not represent a benefit or a cost to the entrepreneur who would, in the market place, make the decision. Two aspects of this problem of externalities were discussed at the Airlie House Conference;

If television broadcasters were required to bid against other prospective users of the spectrum, would the interests of viewers be adequately represented by the bids of the broadcasters?

One economist argued that there was no necessary relation:

> " ... the value (of television time) to the advertisers is reflected in what he is willing to pay for the time, and the value to the broadcaster of having that time to sell to the advertiser is reflected in what he is willing to pay for the spectrum if it were put up for bid. But it is not true ... that the value of the viewing opportunities thereby afforded the viewer is reflected in those prices. Very indirectly this may be true in the sense that what the viewer is going to pay for advertised products may depend on how much he likes the program, but I sure wouldn't want to push that argument very far.
>
> "In this circumstance it cannot be presumed that willingness to pay more for spectrum use reflects a higher social use. The presumption falls to the ground when there are a group of people bigger than any other whose interests cannot be, or at least are not under present arrangements, represented in the prices anybody is willing to pay."

In response to this argument, three points were made:

> "First, it is possible that advertisers do adequately represent viewers, since program success results in product success and the latter increases the revenues of the advertiser. This possibility was discussed, but no one was prepared to urge it strongly.
>
> "Second, it was noted that 'no one has suggested that because TV is supported by advertising that we ought to give them antennas ... That is to say, we do require that the TV stations buy the resources which they use even if they are supported by advertised TV.'
>
> "Finally, it was urged that a market mechanism would facilitate the growth of subscription television if the interests of viewers proved to be inadequately represented by advertisers.
>
> "... If we got into a market system we really don't know what kind of broadcasting services would develop. And it might be that we would have pay TV services growing .. where the people would have the choice of paying directly for a service or being serviced through advertisers.
>
> " ... Because of the way television has been allocated we have a kind of advertiser-supported system. In a market there is no presumption that that would be the case."

The original spokesman on this point anticipated this final argument, observing that pay television was not necessarily the best solution because "it takes some resource use to internalize the benefits to reflect them in the prices viewers pay. And there is no presumption, although it may well be true, that that resource cost is worth incurring." In short, the allocational and other advantages of pay television may be offset by the costs incurred in establishing a system for tabulating the programs watched, computing the amounts payable, and effecting collections of those amounts.

An analogous point was made with respect to frequencies employed by government agencies for police protection and the like: that such frequencies were not used in producing goods or services to be sold for a profit, and that the government's bids for such services might not reflect their value in augmenting police protection for the public. The opposition to this line of reasoning was summed up in the query: "Is this factor input any different than any other (that) the police or land mobile user has to use and bid for? A government official responded:

> "I would think there is a very great difference. I would think when the police department in the City of Los Angeles needs spectrum, they need it. And they need cars. They can go out and buy cars (and pay for them). Because the public never owned the cars. But the public does own the spectrum.
>
> "Now, the police feel ... that it would be a great anomaly to say to the police in Los Angeles that they should bid in competition with businessmen to get back some part of what started out in the public domain ..."

At least some of the economists were unpersuaded:

> " ... While the police themselves and public safety ... are a public good, spectrum is in essence no different ... Spectrum is no different than any other factor of input. And the fact that the public happened to own the spectrum and may choose ... to buy it from themselves and give it to the police is a matter of conscious public decision and a perfectly appropriate one.
>
> "It is not at all clear that giving away frequency ... is the sensible way to subsidize police. (It may be desirable) to give the police money instead of frequencies, since it is quite possible that there

"is a mis-allocation of resources as a consequence of the fact we do this, because if they had the money they would buy other things than frequencies."

The discussion of governmental functions focused on police operations at the local level. At the national level, government payments for spectrum use would involve, in the first instance at least, payments back into the federal treasury. While the payment here would be a transfer from one pocket to another, the process is not necessarily pointless since presumably there would be budgetary review of spectrum expenditures as well as other expenditures. In the case of state and local governments, there would be a transfer of funds to the national government in the event of a lease or purchase of spectrum rights from a federal authority.

With respect to "public service" uses of the spectrum, some participants thought that the place to intervene was in the bidding process rather than through allocation of the spectrum to particular uses: "If educational TV is so important and we want to be sure we have some spectrum use for it, ... the educational TV entity (should) bid enough to make sure that it has that spectrum."

Since I expect the effective service sum which I am recommending would be administered by the Federal Government and since reliance on the government represents the traditional way of coping with externalities, my proposed procedure for introducing economics more fully into spectrum management can readily cope with these problems in much the same way that they are resolved at present. Coping with externalities is certainly the kind of activity that the government would naturally undertake. It would meet Abraham Lincoln's test that the legitimate object of government is "to do for the people what needs to be done, but which they can not, by individual effort, do at all, or do so well, for themselves."

As I mentioned on page 3 of this essay, if the presence of significant externalities are of sufficient importance to jeopardize the public interest, then the Congress should subsidize those particular uses of the spectrum resource which otherwise might not be used in such a way as to satisfy the overall public interest. For example, if the land mobile spectrum users were given the opportunity to pay for their use of the spectrum resource as I strongly recommend in this essay and if they were willing to pay more for the unrestricted use of UHF Channel 14 than the TV broadcasters who currently use this particular channel and if the Congress decided that the continued use of this channel by these broadcasters was of sufficient importance to the overall public interest, in contrast to its use by the land mobile spectrum users, then the Congress could ensure that this TV channel would continue to be used in what they consider its highest valued use to be, simply by subsidizing the TV broadcasters by the difference in the prices which the land mobile users and the TV broadcasters were willing to pay.

Another objection to a market system in spectrum rights is that such a system would lead to monopolistic practices in the use of the spectrum. It is my personal opinion that such a monopoly now exists in the use of the 12 VHF channels available for TV broadcasting. These monopolists have so far been able to convince the FCC that the wide geographical spacings now required between these stations somehow provide both more and better TV service than would be possible with the shorter geographical spacings which I have been recommending for the past 18 years. Although these monopolists piously maintain that rural televiewers would no longer be able to obtain satisfactory service if the geographical spacings between the stations were reduced, I maintain that exactly the opposite would be true. Those readers interested in the details of this particular spectrum usage issue will find this matter discussed in much greater detail in Appendices 2, 17, 18, and 21 of "The Silent Crisis Screams."

As regards this particular problem of TV assignments to specific users I recommend that the FCC should adopt the following procedure:

1. Abandon the present practice of the comparative proceeding.

Hardly anyone believes that the great costs of these proceedings both to the applicants and to the FCC can be justified in the sense that the winners of these contests would serve the public interest enough, if any, better than any other applicant as to justify such costs.

At the Airlie House Conference an official charged with responsibility for resolving such cases described the comparative hearing as "an absolute masterpiece in chaos and frustration ... where there essentially are no standards for selecting between equally qualified applicants. So you resolve it in a long hearing in the hopes they will all buy each other out or faint of exhaustion." However, another official felt that in some comparative cases "you can make a rational judgment" and select a winner who would not necessarily have prevailed if competitive bidding were employed."

2. Establish well defined qualifications that a prospective TV broadcaster would have to meet. These would most likely be based on factors of the kind now considered in the comparative hearings.

3. Establish rules, similar to those now in use, for the prevention of monopolistic practices. For example a limit on the number of stations which can be owned by one operator, etc. My personal view is that the present FCC rules in this regard are too restrictive. Larger organizations might well provide better service to the public than the smaller organizations which the present FCC anti-monopolistic rules now foster.

4. Use the effective service sum concept to prepare several alternative TV channel assignment plans. For example, one of these plans could involve shorter geographical spacings than the others.

5. Establish a list of qualified bidders in each of the market areas where channels would be available in accordance with the assignment plans described in item 4.

6. Permit competitive bids by qualified bidders only for input rights similar to those now assigned by the FCC to use for a three-year period, or alternatively for five years, one or more of the assignments described in item 4.

7. Adopt the assignment plan for which the annual total dollar value of the bids throughout the United States was the largest. By permitting either three-year or five-year licensing as one of the alternatives, the bidders themselves would decide which of these two alternatives would lead to the more efficient use of those resources devoted to television broadcasting.

8. Repeat the above procedure at three-, or five-, year intervals with changes which would allow for those technological or social changes which will almost surely take place during any three-year interval.

In proposing the above procedure to the FCC I have purposely avoided the added problems which would arise when full advantage is taken of the concept of the effective service sum to engineer the use of a particular band of frequencies for use by more than one kind of service; for example, the use of certain TV channels for land mobile use in geographical areas where they would not normally be used for TV. However it is clear that there is no basic reason why the assignment plans contemplated in item 4 above should not provide for the assignment to the land mobile users of rights to use some portions of the spectrum resource if the use of the effective service sum concept established the engineering and economic feasibility of such assignments. However, the concept of the effective service sum cannot be used until extensive research is conducted to determine the operating thresholds of both TV and land mobile receiving systems in the presence of interference from both TV and land mobile transmissions.

6. Input Rights Versus Output Rights

Some economists, and even some engineers, have argued that the present practice of assigning input rights to the use of the spectrum greatly hampers, if it does not indeed actually prevent, the attainment of the improvements in the efficiency of spectrum resource use which could be achieved by the assignment of output rights. It is my personal view that the assignment of output rights to the use of the spectrum resource does not, as claimed by its proponents, have much, if any, advantage over the assignment of input rights in terms of economic considerations and, even if it did, that the use of output, instead of input, rights would so hamper the possibilities for improved engineering use of the spectrum resource that the effect of their adoption would be a net loss in the overall efficiency in spectrum resource use.

Before discussing in any more detail the differences between input and output rights to the use of the spectrum resource, it will be useful to make a few comments about property rights in general. The economic theory of property rights is far from complete and, as a consequence, no very firm or profound pronouncements in this field can be made. A good summary of the present status of the theory is given in Chapter 24 of the Second Edition (1967) of the book "University Economics" by Armen A. Alchian and William R. Allen of the University of California at Los Angeles. This chapter is entitled "Economic Roles of Government Activity" and examines the interplay between government activity and the specification, enforcement, and exchange of property rights.

Property rights are the expectations people in the United States, Canada, western Europe, and a few other places) have that their decisions about the use of certain resources will be effective. The stronger those expectations are upheld, in one way or another (custom, social ostracism, or government punishment of violators) the stronger are the property rights. Two basic elements of private property are exclusivity of right of use and voluntary transferability or exchangeability of that right. Another important aspect is the transactions costs of safeguarding these property rights. For a better understanding of the above, I urge the reader to read the above chapter in the Alchian-Allen book.

At present the rights to use the radio spectrum are defined as input rights, i.e., the transmitting antenna characteristics, its geographical location and height, the effective radiated power, the kind of modulation, etc. In contrast output rights would be defined in terms of permissible power levels at receiving locations. The basic advantage, if there is one, of defining output rather than input rights is the basic fact that the spectrum is actually used only at these receiving locations so that all conflicts of interest will necessarily take place there and, except for co-site problems, not at the transmitting locations. However it is important to remember that property rights are actually only expectations about the future and this can be estimated only by predicting the fraction of the time that service of some specified grade, or better, may be expected at each receiving location. The Service Probability $Q_{(r)}$ in the effective service sum allows for the errors in these predictions.

The proponents of output rights claim that input rights cannot be made transferable from one use to another. In the following section I will describe how I believe government management of the spectrum resource should be reorganized in order to use the concept of the effective service sum effectively so as to achieve the very large improvements in both the engineering and economic efficiency of spectrum resource use which are inherent to the adoption of this concept.

7. Government Reorganization for Improved Use of the Electromagnetic Spectrum Resource

My proposed reorganization is intended to follow the concepts established in the United States Constitution which provides for three independent branches of the government: the Executive Branch, the Legislative Branch, and the Supreme Court. In a copyrighted article "My Political Philosophy," President L. B. Johnson (1958) stated "I regard waste as the continuing enemy of our society and the prevention of waste -- waste of resources, waste of lives, or waste of opportunity -- to be the most dynamic of the responsibilities of our Government."

We are here dealing with the conservation of the spectrum resource and, as described above, the resolution of the potential conflicts of interest which arise from the use of this resource. In view of the nature of the problem it is, in my view, most desirable that several independent groups be established to achieve the best interests of the public in spectrum use. In my appearance before the Dingell Panel (see Annex I) I proposed that a telecommunication research organization be established by a Joint House-Senate Congressional Committee. In a recent very imaginative address entitled "Let's Abolish the FCC" Commissioner Robert T. Bartley endorsed my proposal. Since I expect to endorse most of his proposal in this essay, I am enclosing his address as Annex 2 to this essay.

I agree with Commissioner Bartley that both the Executive Branch and the Congress have important roles to play. Each of these branches should use the concept of the effective service sum for making improved use of the spectrum resource and these two branches should, in fact, compete with each other in devising better ways of dividing the use of the spectrum between government and private sector use of the spectrum resource.

This competition should occur in addition to their respective responsibilities for preparing and assigning input rights to use the spectrum resource.

I also agree with Commissioner Bartley that the FCC should be replaced by three new independent commissions with responsibilities for Broadcasting, Common Carrier, and Safety and Special Radio Services.

8. Summary

I have outlined in this essay and in its Annex 1 a specific procedure, the effective service sum, for making better engineering and economic use of the spectrum resource. I expect the largest improvements in spectrum use to be of an engineering nature. This expectation is based on the fact that the effective service sum fully exploits the general engineering principle:

> "that efficient use of the radio-frequency spectrum for telecommunications can be achieved only when interference from other signals rather than noise provides the ineluctable limit to satisfactory reception."

However, it cannot be emphasized too strongly that the use of the spectrum resource cannot be optimized, in the sense of best serving the overall public interest unless optimum solutions are obtained of both the economic problem of assigning relative values and the engineering problem of maximizing, in priority order, the number of interference-free spectrum users. It is my opinion that the public interest can best be served only by having several interdisciplinary teams of engineers and economists working competitively on the problem of optimizing the use of the electromagnetic spectrum resource.

ELECTROMAGNETIC SPECTRUM UTILIZATION— THE SILENT CRISIS

A Report on
Telecommunication Science and the Federal Government

by the

Telecommunication Science Panel
of the
Commerce Technical Advisory Board

U.S. DEPARTMENT OF COMMERCE
October 1966

NOTICE

This is a report of a panel of non-government experts, advisory to the Department of Commerce. The information and recommendations presented are for consideration by the Federal Government and do not necessarily represent the views or policy of the Department of Commerce or the Agencies which cooperated in the study.

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Office of Director of Telecommunications Management
Federal Communications Commission
Department of Defense
Department of Commerce

October 18, 1966

U.S. DEPARTMENT OF COMMERCE

JOHN T. CONNOR, Secretary

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FOREWORD

Most people know that radio, television, long distance telephone, radar, police radio, etc., play important roles in their daily lives. Many of the more thoughtful are aware that telecommunication services are important, indeed essential, participants in all facets of the growth of our nation and even of our civilization. Relatively few, the technically inclined, know that telecommunications depend on a national resource -- the electromagnetic frequency spectrum; a technical concept which put the word "wireless" into our vocabulary.

The electromagnetic spectrum has become a silent partner vital to all our national enterprises. If it were suddenly to disappear we would have calamitous confusion and would have to retrogress many aspects of our society by as much as half a century before we could begin to function as a nation again. It is doubtful if anyone fully comprehends either the full impact on modern society or the interactions of all the technical, economic, social, and political complexities of our silent partner. The select groups who have attempted, during the past forty years, to achieve some level of understanding, have repeatedly warned us that our silent partner is ailing. In recent years the warnings have become more urgent and the symptoms have become more numerous and even obvious to those sectors of our industrial life which need to extend the use of this silent partner for the benefit of their business.

Take these news items:

-- A house burns to the ground in Los Angeles because crowding of a radio channel prevents fire-fighting equipment from being properly dispatched.

-- Our scientists and engineers develop a sophisticated communications satellite for which there are no suitable unallocated frequencies available--the problem is only partly solved by the sharing of frequencies already used by ground microwave services.

-- The operator of a delivery service in New York cannot improve his efficiency because he cannot obtain a mobile radio frequency. If, after long delays, he is fortunate enough to obtain one he finds he is sharing a party line with as many as fifty other active enterprises.

Indeed, our silent partner is suffering from a disease which we can identify as "accelerating paralysis". At present, there is no known cure and very little effort to find one. It is a malignant disease and costly. It is already having a slowing effect on the growth of our economy, slight at present, but inevitably increasing in the future.

Obviously, we must take some action -- now!

The electromagnetic spectrum usable for telecommunications is an extremely valuable, in fact essential, but also limited resource, which must be shared nationally and internationally. It is an unusual resource in that it is not depleted by use. However, its value at any specific time can be drastically reduced by misuse. It is unusual in another sense in that it is currently allocated without a use charge and with no quantitative measure of its value to the national welfare. It is a resource which can be increased in value to some limit (as yet indeterminate) by creative research and development and by skillful management.

Telecommunications, and hence the demands on the frequency spectrum will continue to grow indefinitely until limited by saturation of all or portions of that spectrum. Only effective planning, based on more knowledge that is now available, will ensure that the nation makes optimum use of this resource. The recognition of the potential threat to the continued growth of the nation led the Chairman of the Commerce Technical Advisory Board, Dr. J. Herbert Hollomon, to establish ad hoc the Telecommunication Science Panel. The study was initiated with the concurrence of the Secretary of Commerce, with the cooperation of and also for the benefit of the Director of Telecommunications Management (Executive Office of the President), the Federal Communications Commission, and the Department of Defense. The Panel sought to study the status and trends in the technology and use of the electromagnetic spectrum and to examine various methods of increasing the telecommunication capabilities of the nation through more effective use of the electromagnetic spectrum. The Panel members, who provided a variety of backgrounds, are leaders in the field; several had devoted many years to the development of methods for more effective spectrum utilization.

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Mr. Ross Bateman, Telcom, Inc.
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The study was supported by liaison and staff from the cooperating agencies.

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I. INTRODUCTION

"After three thousand years of explosion, by means of fragmentary and mechanical technologies, the Western World is imploding. During the mechanical ages we had extended our bodies in space. Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned. Rapidly, we approach the final phase of the extensions of man -- the technological simulation of consciousness, when the creative process of knowing will be collectively and corporately extended to the whole of human society, much as we have already extended our senses and nerves by the various media. . . .

. . . The tendency of electric media is to create a kind of organic interdependence among all the institutions of society, emphasizing de Chardin's view that the discovery of electromagnetism is to be regarded as a 'prodigious biological event'. . . ."

Marshall McLuhan
Understanding Media
McGraw-Hill, N.Y. 1965

TELECOMMUNICATION SINCE WORLD WAR II

There is no escaping that the vitality of the American economy, the agility of our defense, and indeed the level of our civilization, depend organically and profoundly upon electromagnetic means to obtain and convey information. The dependence is growing, and rapidly becoming critical.

The telegraph introduced the new technology of electromagnetic telecommunication to advance the speed and efficiency of transportation and information media. Radio brought the era of instant global communication, and the means for navigation which empower modern sea and air commerce. Most of the technology in use in telecommunications today we did not possess before World War II. The past two decades have brought immense growth of the numbers and kinds of telecommunication technology and applications now vital to the commercial, industrial and cultural life of the nation, as well as to national objectives in defense and space. Radar and television, and a variety of measurement and control applications in industry and science, are only a few of the applications.

The United States has the most advanced and widely available telecommunications in the world. We use half the world's telephones and more than 7 million transmitters licensed by the FCC or operated by the Government. The number of broadcasting and television stations has increased sixty percent, to nearly 8,800, in the seven years since 1958. Radio in industrial, land transportation and citizen's services--and other safety and special services such as fire and law enforcement--have grown more than three times in the same period, to more than 5.3 million licensed transmitters. Manufactures of transmitting and receiver equipment for communication, radar, navigation, etc., (not including broadcasting and television receivers or telephone/telegraph equipment) increased two and one-half times in this period, to over \$6 billion per year. The growth rate is several times that of the Gross National Product.

Telecommunication has a strong research base. The National Science Foundation Survey of 1964[1] showed about \$1½ billion research and development in components (more than half federally supported). Among the most significant developments have been: <u>wideband transmission and relay methods</u>, including new cable technology, communication satellites, lasers and millimeter wave technology; <u>solid state electronics</u>, especially recent microelectronics and integrated circuitry, reduce power requirements, cheapen complex circuits, and enable sophistication of a variety of telecommunication functions; and, <u>electronic computers</u>, for which much future significance to telecommunication has come into view quite abruptly during the past few years.

THE ELECTROMAGNETIC FREQUENCY SPECTRUM

In view of the apparent vitality of telecommunication services, research and technology in the United States, why a question about "telecommunication science and the Federal Government"?

About one half of telecommunications between fixed points, and all broadcasting, mobile communication, radar and radionavigation services transmit through the atmosphere, radiating in various regions of the electromagnetic frequency spectrum. A $20 billion annual portion of telecommunications in the United States is estimated[2] to be comprised of manufactures and services involved in transmission through the atmosphere, that is, excluding the wire and cable applications.

The electromagnetic frequency spectrum is, from the point of view of administration and utilization, a natural resource enabling telecommunication. Interference among radiations of various users can impair or disable effective use; the resource must be allocated and shared nationally and internationally. There are limited regions of the spectrum technically suitable for various applications. It is a unique resource in that it is not depleted or depreciated by use. However, its value at any time may be drastically reduced by overuse or misue. The resource is given a degree of tangibility by allocation, agreements, assignments and licensing of rights to use. For such assignments, radiation in the spectrum has the dimensions of frequency bandwidth, time and space, as well as intensity (power flux density).

More than 80 percent of today's spectrum uses have come into being in the short period since World War II. Limited availability of prime frequency-regions of the spectrum already constrains the introduction or growth of important services. Some critical areas have already developed. In 1964, the Joint Technical Advisory Committee Report[3] observed:

> "We now have all areas of the usable radio spectrum allocated and, to varying degrees, in service.
>
> We have observed the potential of various segments of the spectrum to perform different and specialized tasks.
>
> We have been overwhelmed by the popularity and need for the 'product' obtained from radio spectrum utilization.
>
> We find far reaching changes of allocation of spectrum difficult to make because of fixed investments not fully amortized. . . ."

A prime example of growing pressure for new kinds or increasing capacities of telecommunication services is the urgent need for increased mobile radio communication to serve land transportation, distribution and construction industries, utilities, mining and forestry, and many other industries as well as to facilitate the increasing speed and volume of air traffic, marine communications, and growing safety and law enforcement requirements. In major metropolitan areas, the havoc and interference from congestion of mobile radio limits present usefulness and prevents expansion.

Arguments used against expansion or introduction of business owned, private or cooperative radio systems include limited availability of frequency spectrum and questions of efficient frequency utilization; the issue is in sharp focus today as a result of business interest in private microwave systems, and new proposals for domestic satellite communications.

The full promise of data transmission and information processing networks calls for communication capabilities not now in general existence, including satellites. Other advancing national objectives as in defense, high speed ground transportation, highway safety, oceanography, and law enforcement are generating new telecommunication technology with vastly increasing demands for use of frequency spectrum.

The electromagnetic frequency spectrum has been called the "6th natural resource." Just as land, water, minerals, forests and energy sources are husbanded as essential resources for a nation's development, use of the electromagnetic frequency spectrum must be "conserved", "developed", and allocated for the greatest value and yield to the nation's economy, welfare and defense.

The present utilization of the electromagnetic spectrum is intimately related to the accepted practices for the allocation and assignment of frequencies for various telecommunication services, and to the systems standards established for these services. The complex allocations and assignment procedures occur at three levels. There is, first, a subdivision of the spectrum by international agreement into bands for particular services. This action is guided by the desire to communicate between countries and to minimize harmful interference beyond national boundaries. A finer allocation of the spectrum is made on a national basis for domestic as well as international services. Finally, there is an assignment procedure which designates the precise channels to be used by specific systems within the bands allocated to the services provided by the systems.

Frequency allocation and assignment in the United States, and the establishment of policies and regulations for use of the spectrum are the responsibility of the Federal Communications Commission for non-government uses, and of the Director of

Telecommunications Management, Executive Office of the President, for Federal Government uses. The need for technical coordination and management of uses of the spectrum was recognized in the United States in 1922, when the Secretary of Commerce convened the first of the National Radio Conferences, which led to new allocations of frequencies, and to establishment of a Federal Radio Commission. Later, the Communications Act of 1934 created the Federal Communications Commission (FCC) "to regulate interstate and foreign commerce in communication by wire and radio." Also resulting from the first conference was the Interdepartment Radio Advisory Committee (IRAC), for Executive Branch coordination and technical standards for frequency utilization by Federal Agencies. The Communications Act formally established the dual system of control of the frequency spectrum. The work of IRAC continues today advisory to the Director of Telecommunications Management. The Department of State is responsible for the international negotiations, mainly through the International Telecommunications Union (ITU), concerning frequency allocations and radio regulation, and is advised primarily by the FCC and the DTM. Government-industry committees also advise, especially in technical matters such as considered by the International Radio Consultative Committee (CCIR) of the ITU.

While there are optimum frequency ranges for various telecommunications services, with few exceptions these tend to be broad ranges. Thus, there is usually considerable flexibility in the initial choice of a frequency for a given service. Once a band is allocated and its frequencies assigned, however, the capital investment involved in its subsequent exploitation is often of such magnitude that future flexibility in the use of the assigned frequency is greatly restricted.

THE PRESENT STUDY

The present study was initiated to identify national needs and federal responsibilities for telecommunication science, on the premise that it is of essential government concern to increase the telecommunication capabilities of the nation by fostering technical means for more effective utilization of the electromagnetic frequency spectrum.

The scope of telecommunication science considered includes research and technical services concerning electromagnetic wave propagation, transmission media, antennas, information transmission and noise, as well as the operational and economic analysis, engineering data and methods needed for efficient frequency utilization and sharing. The study was intended to assess the extent to which present programs and organizational relationships are meeting the needs, and to identify possibilities for significant improvement.

The specific questions set out for study were:

"1. What research and technical service programs directed toward more efficient utilization of the electromagnetic frequency spectrum for telecommunications are needed:

(a) on behalf of telecommunications policy and management executed by the Federal Communications Commission and/or the Director of Telecommunications Management, and

(b) to facilitate growth and development of telecommunication services vital to the government, the national economy and public welfare?

2. What are the present research and technical service programs and what opportunities or responsibilities are not being fully met?

3. What recommendations are required for new or continuing programs, emphasis, organizational relations, legislation and budget?"

The technical problem, in its broadest sense, is to facilitate increase of capacity of the spectrum, by technical means for more intensive utilization, as well as by extending the usable regions. Technology may be advanced to accomplish desired telecommunication services using minimum frequency bandwidth, time, radiated power and spatial distribution of the emission. Frequency bands may be shared increasingly intensively by measures which reduce the necessary signal-to-interference protection ratios, by use of improved propagation predictions for estimating transmission parameters and interference probability, and by careful optimization of radiated power, bandwidth, directivity, and geographical separation of services. Exploitation of unused higher regions of the spectrum may be stimulated by increasing understanding of the propagation characteristics as well as by research leading to devices and systems capable of effective use of the new regions.

The Panel invited reviews from the cooperating agencies and from a number of experts in telecommunications research, planning and operations from government, industry and universities, to provide an up-to-date overview of the status, trends and problems of telecommunication services and the research and technology in the various frequency ranges. The technical programs and recommendations of the cooperating agencies were reviewed by means of briefings and discussions of the Panel, with the liaison representatives. Additional survey reports and documents were reviewed. Listening and discussion sessions were devoted by the Panel to the telecommunication services, research and technology in the frequency regions of the spectrum (a) below 30 MHz,* (b) 30 MHz to 15GHz, and finally, (c) above 15GHz to optical regions. At the conclusion of these sessions, the Panel set aside two meetings for deliberations leading to recommendations. Appendix 1 lists the oral presentations contributed to Panel meetings.

RELATED STUDIES

Appendix 2 gives a summary of other study activities in this field which were reviewed by the Panel. Over the years many studies have been made and several are currently in progress concerning both technical and policy aspects of spectrum utilization. Though primarily related to allocations and management, they necessarily covered much of the same information as the present study, and their considerations or conclusions usually had some relevance to the present study. Most closely related to the present study are the work of the Joint Technical Advisory Committee (EIA/IEEE) and the continuing intergovernmental study programs of the International Radio Consultative Committee (CCIR). The JTAC Report Radio Spectrum Conservation (1952),[4] reviewed technical factors involved in radio frequency allocations, gave a critique of allocations at that time, and posed some technically ideal allocations and principles of spectrum conservation. The subsequent JTAC Report,[3] Radio Spectrum Utilization (1964) updated the review of the technical factors and made a number of recommendations of a technical-administrative nature for revised allocations and improved standards. Current JTAC studies[5] are considering the technical problems and approaches to "electromagnetic compatibility", i.e., increased spectrum sharing through technical measures to reduce mutual interference. While the JTAC study is a current one, the Panel has had the benefit of its progress through reports, and the active participation of the chairman of this JTAC study, Mr. Richard P. Gifford, as a Panel member. This study has been one of the most valuable sources of guidance in the technical complexity of the problems and to perspectives on solutions.

The Panel also reviewed the scope of the study of the FCC Advisory Committee for Land Mobile Radio Services. Though the final conclusions were not available during the course of the Panel's study, the Advisory Committee's characterization of the land mobile communication problems and identification of important topics for study were considered.

The Recommendations of the ITU Panel of Experts (1963)[6] on "ways and means of relieving the pressure on the bands between 4 and 27 Mc/s" were noted, as were the current extensive CCIR recommendations, reports, questions and study programs bearing on efficiency of spectrum utilization (Geneva, 1963). These questions and study programs provide a major and intricately developed framework for technical studies in telecommunications.

Also of interest was the activity of the Frequency Management Advisory Council of the Director of Telecommunications Management, which is studying the methods and bases for formulation of telecommunications policy for the Executive Branch of the Government. The Council has noted the need for technical and economic studies in support of frequency management activities of the Government, made known by the Director of Telecommunications Management and reflected in recent budget requests. Two members of the Advisory Council, Dr. C. M. Crain and Mr. Richard P. Gifford, are also members of the Telecommunication Science Panel, and additional liaison was provided by DTM and Commerce staff. Of special interest, particularly in light of the conclusions that this Panel finally reached, was the draft proposal of the Office of the Director of Telecommunications Management for long-range planning for allocation and use of the radio spectrum. The material proposing this function "to provide a feasible and continually available guide for the orderly development and exploitation of the radio spectrum" had been submitted by the Director for review by the Frequency Management Advisory Council. In this proposal there was further evidence that specific recommendations and action on spectrum allocation cannot be undertaken

* Hz, abbreviation for Hertz, the unit of frequency (cycles per second); with prefixes: KHz, Kilohertz (thousands), MHz, Megahertz (millions), and GHz, (billions).

without a continual input of technical and socio-economic data, analyses and planning alternatives.

A report of the Interdepartmental Committee for Atmospheric Sciences, on "Atmospheric Science Required to Facilitate Electromagnetic Telecommunication" was a useful source of summary data on the economic significance of telecommunications using the electromagnetic spectrum.

II. SPECTRUM UTILIZATION—STATUS AND TRENDS

A striking index of the growth of telecommunications is given by the Census of Manufactures[7] of radio and TV communication equipment. The 1965 manufactures were in excess of $6 billion compared to $2.38 billion in 1958--two and one-half times growth in seven years. These values are essentially for equipment using the electromagnetic frequency spectrum, except for broadcast and television receivers; neither are regular telephone and telegraph equipment included.

The Interdepartmental Committee for Atmospheric Sciences, of the Federal Council on Science and Technology, published[2] in 1965 a survey of the economic significance of the portion of telecommunications which uses atmospheric transmission and involves radiation in the electromagnetic frequency spectrum. This analysis showed a 1962 "annual expenditure" of $17 billion which, projected to 1965 is estimated to be considerably in excess of $20 billion. Table I from the ICAS Report shows a breakdown of such expenditures as sales, revenue (or operating costs in the case of non-revenue services), and other expenditures for electromagnetic telecommunication equipment, operations or services. Table II estimates $26 billion as the 1963 depreciated U. S. investment in systems, equipment, and research and development facilities, related to the use of electromagnetic frequency spectrum for telecommunication. Table III shows the estimated employment in these activities.

The FCC Annual Report[8] for 1965 reports 5.3 million transmitters for the uses of radio for industrial, land transportation, aviation, citizens, and other safety and special services. This represents more than a fourfold growth from 1.3 million in 1958. Broadcasting authorization grew from 5,405 to 8,771 in the same period and produce an annual revenue of $2.8 billion (1965). At the end of 1965 there were more than half a million radio frequency assignments of record to U.S. radio services. FCC assignments as of August 1966 totalled over 392,000, representing a growth of more than 40,000 during the year.

The nation's airways simply could not function without radio means for communication, navigation, and control. It is estimated that 35,000 employees and $750 million of the annual budget of the Federal Aviation Agency directly provide these facilities and services. The airlines themselves devote an substantial portion of their budgets and operations to telecommunications; the ground communications network alone is massive and the requirement is growing--the airlines recently obtained proposals for a nationwide private microwave system which would tie together about 260 locations in the United States, over 23,000 route miles. The system would provide about 3 million channel miles of voice circuits, and 2 million channel miles of teletypewriter and data circuits. Besides the 260 microwave terminal sites, there would be 640 repeater stations.[9]

The transportation and public utilities industries,[10] as well as the petroleum industry, now have major investments in extensive and intricate radio services, for information and control vital to the services and economic life of these activities. Both point-to-point systems and 150,000 mobile radios comprise the nerve systems of power companies ranging from the the giant Bonnevilles and TVA's to statewide private networks, to the smallest REA cooperatives. The petroleum industry relies on point-to-point radio for linking refining and pipeline distribution operations, and another 100,000 two-way radios in all phases of operations from exploration and drilling to production, refining, and distribution by barge, ship or truck. Railroads use extensive private radio systems. Southern Railway is developing its own internal communications net using microwave links for an information processing network for its operational and management needs. This is said to be the largest privately owned microwave communication system outside the communications industry, involving $30 million acquisition of communications equipment and computers. Trucking lines also propose major new private or cooperative microwave facilities, and even use of satellite communications. All facets of the transportation industry, rail, bus, taxis, trucks and planes use more than 350,000 two-way mobile radios. Personal telephone paging units, a substitute for personal portable telephones, are growing in use; there are 2,000 units in the Washington area alone.

Use of radio has tripled in the past five years in local government agencies. From large highway maintenance departments to small rural school districts, local governments are using radio to improve service and reduce expense. Especially in

I. Estimated annual sales, revenue, or expenditures for electromagnetic telecommunication equipment, operations, or services, 1962

	Millions
Manufacturing (value of shipments at manufacturers' prices)	$ 5 600
Wholesale and retail trade in electromagnetic telecommunication equipment and components (estimated markup or net revenue)	850
Installation and repair services	1 400
Electromagnetic telecommunication operations and maintenance expenditures or revenues	8 350
Research and development expenditures not included in other categories (industry, government laboratories, universities, and other nonprofit organizations)	800
Total	$17 000

III. Estimated employment in electromagnetic telecommunication activities, 1963

	Thousands of Employees
Manufacturing	
Government and commercial telecommunication equipment	270
Television and radio receivers	115
Electronic components	160
Operations and maintenance	
Government	
Department of Defense, including Armed Forces and civilian personnel	400
Other federal agencies	60
Nongovernment	
Broadcasting	100
Safety and special services	140
Common carrier	40
Government facilities operated by private contractors	30
Research and development	
Government, industrial, educational, and nonprofit R&D laboratories, not included elsewhere	40
Wholesale and retail electromagnetic telecommunication equipment distribution	
Television and radio receiver distribution	70
Other: commercial equipment and parts distribution	15
Repair and installation services	
Television and radio repair shops	80
Other: commercial equipment repair and installation services	20
Total	1500

II. Estimated U.S. investment in electromagnetic telecommunication systems, equipment, and R&D facilities, 1963

	Depreciated Value, millions
U.S. Government	
Department of Defense and other National Security Agencies	$ 9 000
Federal Aviation Agency	635
National Aeronautics and Space Administration	250
Treasury (Coast Guard)	450
Commerce (Maritime Administration, Weather Bureau, National Bureau of Standards, etc.)	70
U.S. Information Agency	90
Others, including Atomic Energy Commission, Agriculture, Interior, Justice, Tennessee Valley Authority, Veterans Administration, St. Lawrence Seaway, etc.	75
Manufacturing, net fixed assets	1 000
Non-U.S. Government communications services, facilities, and equipment	
Broadcasting	
Television	370
Radio	260
Common carrier	1 700
Safety and special services, including state and local government	1 500
Research and development, equipment and facilities not reported elsewhere	
Government, industry, and educational and other nonprofit institutions	350
Repair and installation services, and test and measuring equipment and facilities	300
Wholesale and retail trade	450
Consumer electromagnetic telecommunication equipment	
Television receivers	5 500
Radio receivers	4 000
Total	$26 000

Booker, H. G. and C. G. Little (1965), Atmospheric research and electromagnetic telecommunication--part I, IEEE Spectrum, Vol. 2, No. 8, 44-52.

fire departments and law enforcement, the use is growing, having doubled in the past five years. Traffic safety studies have shown that an important contributor to fatality statistics is inadequate post-crash communications for summoning and coordinating aid; new concepts in highway communication and vehicle control are being considered for widespread use, many involving uses of spectrum.

Federal government uses of telecommunications are led by military uses for command, control and guidance of forces and weapons, for detection, surveillance, deception and destruction of hostile weapons and forces. There is almost $8 billion "electronics" content in the 1967 budget of the Department of Defense. Approximately 70 percent of electronics is estimated to be comprised of the telecommunication activities and equipment using the frequency spectrum. The requirement for increasing sophistication and capabilities of defense telecommunications is best illustrated by the programs for development of satellites for electromagnetic applications. Satellites are to be exploited for heavy communication routes to Europe, Africa and the Western Pacific, as well as for tactical-mobile field communications. Satellites also provide for measurement of radiation background and operation of nuclear test detection sensors for surface, high altitude and deep space nuclear tests, as well as navigation capability and geodetic observations. In addition, advanced ground-based radar provides for surveillance of space objects and diagnostic information on our own satellites in orbit--new radars capable of high resolution and using much greater power and frequency bandwidth are under development and coming into use. A family of Over-the-Horizon radars capable of detecting aircraft and missiles far beyond the radar or line-of-sight horizon has been developed. These new systems will bounce radar signals off the ionosphere and send them to the surface of the earth several thousand miles beyond the horizon, overcoming earlier limitations of radar capabilities to detection of objects within line of sight. To obtain more efficient use of high frequency transmission, extensive "oblique sounder" networks are being developed in a common user configuration for Defense Communication, and pilot studies of "short term prediction" of usable frequencies have been undertaken.

Meteorological satellites of NASA and ESSA are introducing automatic picture transmission systems for global and local weather surveillance. International "World Weather Watch" and "Natural Disaster Warning" are essentially telecommunication concepts in advanced environmental science and services, requiring extensive networks and a variety of sensors and communication capability.

International broadcasting by the Voice of America is a $30 million annual activity, with a plant investment of approximately $110 million. Over the next three years, an additional $50 million plant investment has been authorized. Some 120 radio transmitters throughout the world, primarily in the high frequency band, beam to all continents information on United States and world events. The Voice of America's keen interest in new technology and increased capabilities is reflected in a technical research program of several hundred thousand dollars annually, most of which is concerned with improving effectiveness of broadcasting utilization of the high frequency spectrum. There is a trend toward an immense increase in radiated power (transmitters of 1 to 5 million watts), as well as consideration of use of satellites.

The ICAS Report[2] listed present uses of the spectrum in (approximately) descending order of annual expenditure or revenue as follows:

1. Military uses for the command, control, and guidance of friendly forces and weapons, for the detection, surveillance, deception, and (if necessary) destruction of hostile weapons, activities, and forces.
2. Television broadcast
3. Mobile communication to and from aircraft, ships, and land vehicles.
4. Navigation
5. Long-distance radio relay of telephone calls
6. AM and FM broadcast
7. Public safety by law enforcement agencies, fire services, civil defense, etc.
8. Space telecommunication
9. Geodesy
10. Atmospheric research by remote electromagnetic probing
11. Voice of America broadcasts

12. Citizens' band

13. Amateur radio

14. Dissemination of time and frequency standards

One of the main features of changing technology and growth of telecommunications has been the trend to higher frequencies in the spectrum. As radio telecommunication usage has increased, the International Telecommunications Union has found it necessary to extend specific regulatory control to higher and higher frequencies. The upper limits of the ITU coverage are given in Table IV below:

TABLE IV

Upper Limits of International Telecommunications Union Allocations of Frequencies

Year	Maximum Frequency of Allocations Cycles Per Second
1927	6×10^7
1938	2×10^8
1947	1.05×10^{10}
1959	4×10^{10}

Some of the more important specific growth areas and problems of spectrum utilization and frequency mangement are discussed in this chapter. The rapid evolution of technology itself creates potentials and affects the character of growth. Finally, some of the major areas of latent demand which have come to the attention of the Panel are noted briefly.

SERVICES AND APPLICATIONS

Satellites

The clearly dominant consideration for future spectrum utilization is the advent of the communication satellite. Reliable transmission or relay is possible over areas of the globe within "line of sight" of the satellite, using the vast regions of the frequency spectrum above about 100 MHz. Before satellites, only the region of the spectrum below about 25 MHz was useful for transoceanic, intercontinental transmission--less than one percent of the portion of the spectrum technically usable via satellites, and transmission was variable. Satellite use of frequencies to about 15 GHz is feasible with present technology, and the range is potentially extendable by order of magnitude. Intercontinental television became practical by satellite relay, along with reliable high-capacity trunks for telephone, telegraph and data. Satellite transmission appears to be more economical than present cable transmission for great distances, besides offering flexibility and potential connection to many ground locations.

The great distance range over which satellites are useful poses the corollary problem of interference to and from ground services. Most technically usable regions of the spectrum had been allocated to short-range ground services prior to the advent of satellites. The International Telecommunications Union in 1963 reallocated some bands for satellite and space applications, both exclusive and shared. It is clear, however, that imaginative and economic possibilities for satellite telecommunication applications vastly exceed the allocated frequency bands.

The Director of Telecommunications Management has said[11] "if we are going to use satellites for all of the things being advanced, if we are going to fully exploit this new technology, then we are going to have to do some long range planning," as far as the frequency spectrum in concerned. He has suggested that unless "a lot of thought is devoted to this subject, the frequency limitations will ultimately deter the use of this capability." He foresaw a serious problem as early as 1970, and the need for an "all out research and development effort to enable us to make better use of the spectrum."

The Communication Satellite Act of 1962 laid down objectives and Federal responsibilites for satellite communication activities in the United States. The Communications Satellite Corporation was established as a regulated private-enterprise monopoly to excercise United States participation in a "single global commercial satellite system." The International Telecommunication Satellite Consortium (INTELSAT) was created in August 1964, and now includes more than 50 countries. During 1965, commercial service began via Early Bird, the world's first commercial communication satellite. Ground stations used in experiments with TELSTAR, the AT&T experimental satellite, were converted for commercial service with the Early Bird satellite. The Federal Communications Commission has responsibility for authorization and domestic regulation of commercial satellite communication service, rates, and frequency allocations.

The Report of the Director of Telecommunications Management to the Communication Subcommittee, Committee on Commerce, U.S. Senate, in August 1966, stated with respect to commercial satellite services:

> "There is increasing reliability in the launch and emplacement of communication satellites in precise orbits and geographic positions. The maintenance of stability and the precise positioning of space satellites over extended periods is proving possible. The channel capacity and life of the satellites has been steadily increasing...
>
> For the first commercial communications satellite launched (INTELSAT I) the estimated life in terms of circuit years was 240 x 1.5 or 360 circuit years. . . The satellites being launched this year (INTELSAT II) are designed for 240 x 3 circuit years, or 720 circuit years. . . The Satellites for launch in 1968 (INTELSAT III) are being designed to accommodate 1,200 x 5 circuit years, or 6,000 circuit years.
>
> Multi-purpose satellites are now in conceptual development to meet the needs of the aeronautical, maritime, point to point, and distribution communication services, including television, voice and data. Multiple access techniques permitting many earth stations to operate with single satellites on a concurrent basis are proving feasible.
>
> The recent experiment in gravity gradient stabilization indicates that at synchronous altitudes. . . this technique is usable. . . This will clear the way for higher antenna gains, increased effective radiated power, and more effective control of the geographic area covered by the satellite radiated signals."

Two U. S. Government programs initially to lease major communication satellite service have been the NASA-APOLLO Program, for voice and data circuits between the U.S. and NASA tracking stations throughout the world, and the Department of Defense for trans-Pacific circuits from Hawaii to Japan, the Philippines, and Southeast Asia.

In May 1966, the United States sponsored, under the auspices of the International Telecommunication Union an international seminar to stimulate interest in international satellite communications and acquaint representatives from foreign nations with current capabilities in earth station technology for use of commercial satellites.

Besides the international communication satellite activities, a number of proposals have been made to the FCC for domestic private systems. Among the parties so far urging the FCC to authorize non-common carrier satellite communication facilities are the broadcasting networks, the American Trucking Association, the American Petroleum Industries, National Association of Manufacturers Communications Committee, and educational broadcasting interests. Perhaps the most intriguing of the proposals has been made by the Ford Foundation, which would propose a non-profit satellite television distribution system. The system would carry commercial television network broadcasting at a cost estimated by the proponents to be lower than present revenue carriers now provide, and would apply the earnings to subsidize nationwide educational television programming and distribution. There are a variety of other proposals, including some for direct television broadcasting.

Available frequency space, and interference from proliferation of systems and ground stations, are among the arguments cited by opponents of such authorizations.

Besides commercial satellite communication systems, there are extensive developments[12] and initial applications for government use, though it is "the policy of the Federal Government to make maximum practicable use of the commercial facilities of the INTELSAT Global Communications Satellite System."

The Initial Defense Communications Satellite Project (IDCSP) is regarded as developmental, but will be increasingly employed to pass high priority operational traffic. The IDCSP will consist of about 15 satellites randomly spaced in near synchronous equatorial orbits, spin stabilized, with lifetime of one and one-half to two years. The 7 and 8 GHz bands will be used, and surface terminals will be located on the East and West Coasts of the United States, in Europe, Africa, Hawaii, the Philippines, Okinawa and on Navy ships. At present there are two fixed ground terminals and four transportable terminals deployed and ready for operation. During 1967, 18 additional earth terminals will be deployed. An advanced Defense Communication Satellite Project (ADCSP) is planned as the operational system which will replace the IDCSP in the 1970's. A DOD Tactical Satellite Communications Program anticipates the feasibility of satellite relays to meet tactical mobile communication needs even where high mobility is required--in field echelons, and with ships and aircraft. The VELA Satellite Program is designed to provide a satellite-based nuclear detection capability for events occurring on the earth's surface to the outer reaches of space. A Navy Navigation Satellite System, operational since 1964, has led to installation of receivers aboard attack aircraft carriers operating in Southeast Asia. Various efforts are underway related to future uses of such systems; long-term ephermeral predictions for ship board use are being prepared, and development of receivers is underway for differential positioning in aircraft and smaller ships.

Other major government applications include aeronautical communications and meteorological surveillance. The FAA participated in a joint government-industry experiment using SYNCOM III which demonstrated the feasibility of satellite relay stations for long-range aeronuatical communications; FAA is also exploring the possible use of such stations for navigation and data-acquisition functions in the air traffic control system. The first ESSA operational meteorological satellite system was launched in 1966, to be followed by satellites equipped with automatic picture transmission system cameras. Some 30 nations of the World Meteorological Organization are equipping to receive transmission from this system, as a phase of the World Weather Watch.

The potential demands for space and satellite communications warrant serious concern for the possibilities for accommodating them in the frequency spectrum. The Director of Telecommunications Management has initiated a study of the requirements of government agencies and industry anticipated for use of satellite telecommunication, called the "Space Service Spectrum Saturation Study!" The results of this study are expected in late 1966.

It is inevitable that much of the spectrum required for satellite communication must be obtained by sharing with already crowded ground microwave (point-to-point) services. Technical standards for this sharing are complex and controversial, each service striving for margin to provide for future expansion. Microwave services alone are already congested in approaches to major metropolitan centers as New York and Los Angeles, where access requires several extra hops or "dog legs."

Mobile Radio

The FCC Chairman's year-end statement of December 28, 1965, makes the observation that, "The growing need for more frequency space to relieve congestion in these (the land mobile). . . services is one of the Commission's most pressing problems." The FCC Annual Report for 1965 states that, "The ever increasing use of radio in the land mobile services and the need for frequency space to accommodate this growth have been under intensive study by the Commission as well as by the Industry. The overall problem is being considered by the Advisory Committee for Land Mobile Radio Services established by the Commission more than a year ago. The committee is composed of over 200 representatives of industry, commerce, state and local government, and user groups througout the country...."

The land mobile services comprise four basic categories: public safety, land transportation, industrial, and common carrier. The public safety usage includes not only police dispatching, but fire vehicles as well as portable use in directing fire-fighting, use by foresters, highway departments in construction, maintenance, and rescue operations, and many other applications. Land transportation uses include two-way radios in railroads, taxis, buses and trucks. Industrial uses range from direction of material-handling vehicles to the control of missile testing; from the repair of broken power cables and the coordination of pipeline operations to small businessmen's dispatch of delivery and repair trucks. The common carrier mobile telephone system provides service for individuals on the move, such as doctors.

The FCC Annual Report, after summarizing the present studies of the means to provide for this service, observes that, "Meanwhile, more requests for additional frequency space have been filed by land mobile users, many for new uses of radio. For example, the Automobile Manufacturer's Association has requested that a new service be established, a highway emergency location plan radio service (HELP), to provide emergency radio communication for the motorist. Also, the Forest Industries Radio Communications Association has requested a number of additional frequencies. . . ."

From 86,000 licensed transmitters in 1948, the number of Land Mobile Radio equipments have grown to 2.3 million in 1965. This growth was possible largely through successive improvement of technical standards, including "channel splitting." Channels which began with 120 KHz spacing, are now, after several steps, operating with 15 KHz separation and coordinated geographic location. Other technical improvements facilitated this increased intensity of frequency sharing.

Today, in almost all the major metropolitan areas, there is considerable interference. In Los Angeles, for example, frequencies may be shared by as many as 50 to 60 users, operating 500 or 600 mobile units. all in the same geographical area. A recent FCC inspection trip to New York City confirmed intense congestion there. The manufacturers contend that "the channel splitting process is just about finished . . . we think we are at the end of the line."

Projected demand for Land Mobile transmitters shows a growth from the present 2.3 million to 3.7 million in 1970, and 5 million in 1977. The FCC review of this subject for the Panel said,

"There is no doubt that pressures by the land mobile services . . . will increase. Despite the efforts of the Advisory Committee for the Land Mobile Radio Services, the insatiable demands for mobile radio probably will rapidly out-distance their efforts, technically, operationally, and administratively. As can be seen . . . the growth of the land mobile services has been far greater than the population growth of the country, averaging about 12 percent per year since 1961, though it is expected to level off during the next two years, probably because of saturation of the frequency bands.

"What are some of the measures being taken to provide some degree of relief? . . . Under consideration is the sharing of frequencies by services other than those to whom the frequencies are allocated . . . The reduction of channel spacing is still another possibility. The common carriers are making increased use of paging techniques using tone signalling where the individual, on receipt of a signal, calls a prearranged number by wire-line . . . the demand for such service is illustrated by the 2,000 customers of the still developmental service in Washington, D. C. . . . The use of a computer to make better geographical allocations might produce a few more usable channels in crowded areas . . . These measures can be considered short-term relief at best. Long term relief must continue to be sought not only from within the Commission, but from the Federal Government, the industry and the scientific community in general. An overall review of the use of the spectrum between 25-960 Mc/s has been suggested . . . Another step, theoretically, would be a review of the technical standards for television systems, with a view to making them more rigid . . . to free spectrum for reallocation to mobile services. However, any change which would obsolete existing receivers in the hands of the public probably should be regarded as a practical impossibility . . ."

The JTAC Report[3] of 1964 is rather pessimistic about the possibility of further technological aid to the needs of mobile service:

"In order to meet these needs, either additional allocations must be made or new operational techniques, or both. Tests conducted by various engineering organizations confirm that 1000 Mc/s is a practical high limit for land mobile systems. The increasing inefficiency of practical omnidirectional mobile antennas at high frequencies, coupled with increased propagation losses . . . make this limit one that is likely to stand for some time. Finding additional frequencies below 1000 Mc/s will of course be a great challenge . . . . As for the possibility of developing new operational techniques . . . much has already been achieved in going to very narrow band FM, with large dynamic range capability in receivers. Further improvements via single sideband or suppressed carrier double sideband have been carefully studied and found to hold no promise for improvement in spectrum utilization. There is, however, a good chance that the use of computers in making better geographical allocations could produce a few more channels in crowded areas. Also, where the service to be rendered permits, it might be possible to make use of multichannel coordinated base stations systems and multiple receiver pickup with a resulting saving in frequency spectrum. Both of these possibilities should continue to be investigated."

Studies have been made of concepts for efficient queuing of calls, i.e. trunking with computer-allocated time sharing, as well as "cell" concept of use of multiple weak transmitters each covering a small area of a grid. The indication for the cell concept is that there is excessive signal fluctuation within the cells caused by irregular terrain and building obstacles.

Broadcasting

Television and radio are the most pervasive media of present day American lives for entertainment, information on events, and cultural influence. Broadcasting also accounts for about 82% of the non-government allocations of the spectrum below 1000 MHz. The direct economic values of broadcasting exceed $10 billion. Station revenues in 1965 were approximately $2.8 billion; growth has been about 10% per year for the last ten years. Manufacture (value of shipments) of radio and TV receiving sets is estimated at $3.6 billion in 1966, compared to $1.5 billion in 1958 (even accompanied by reduction in the wholesale price index). Retail and installation would multiply these figures by 1.4. Annual servicing expenditures are estimated at $3 billion for 1965.

It was noted earlier that authorized stations have grown more than 60% during the past seven years, to a total of 8771, distributed as follows:

Commercial AM	4097
Commercial TV	689
TV translators	2023
Educational TV	125
Commercial FM	1565
Educational FM	272

Commercial AM broadcasting stations continue to increase, though at a slower rate during the past two years. The JTAC[3] has recommended enlarging the standard broadcasting band by extending to frequencies below 540 KHz. Many local and regional stations would like to extend hours of operation beyond present sunrise-sunset limits, but because of potential interference cannot obtain authorization. A number of "clear channel" stations would propose increasing power from present 50 kilowatts to 500 or 750 kilowatts, improving service and extending coverage to vast rural areas which do not have adequate night time radio or television service. There are both technical questions of the extent of coverage and interference, and unknown potential economic effects on smaller stations. If listeners were appreciably drawn away from smaller local and regional stations, some localities might ultimately be deprived of local radio service.

The growth of commercial FM stations is increasing markedly, from 1092 stations in 1961 to 1564 in 1965. There are now 7-1/2 million receivers in the U.S. Over half the homes in New York City have FM receivers, and similar proportions down to a low of 1/3 are found in nine other major cities. Important factors are the nighttime service given by FM (the only satisfactory nighttime service in many localities), the advent of stereophonic broadcasting, the decreasing cost of FM receivers, and increasing uses in automobiles. About a third of FM broadcasting stations are authorized to furnish additional <u>multiplexed</u> communication service, such as background music for commercial establishments.

Growth rate of TV stations has been smaller than that for radio stations in the past five years. Increase must be provided for largely by UHF channels. In localities where VHF stations exist, UHF competition may be uneconomic because of poor transmission characteristics. It is an objective and expectation of the FCC to provide for full development of "all channel" broadcasting. If the proliferation which characterizes AM broadcasting were to be realized, the TV channels would, using present standards, be fully utilized. Pay TV, and "CATV" could drastically affect the picture. Interest in noncommercial educational TV continues to increase, with 15 new stations authorized in 1965. Nearly every major city in the U.S. now has at least one educational TV station. The FCC has reserved 621 VHF and UHF channel assignments throughout the nation for non-commercial educational operation. An airborne educational ETV operation has been conducted from a plane circling over Indiana by the Midwest Program for Airborne Television Instruction. The operation has been the subject of controversy; because of the high altitude of the transmitter, the transmission precludes the use of same and certain other channels for ground-based UHF TV assignments over a wide area. While the FCC has recognized the quality of these programs and a valuable service to small schools in rural areas, which could not otherwise afford ecuational TV, the present judgment is that the operation on a regular basis would deprive communities of the opportunity for regular UHF stations, both commercial and educational. This controversy is a precursor of the problem posed for direct satellite broadcasting.

Pay television concepts are also under consideration; the FCC has permitted limited and trial operations to aid ultimate decisions as to any regular pay-TV service. Only one such operation is presently being conducted. Another significant development of TV services is the "community antenna television" (CATV); CATV systems may be highly important not only in the present concept of retransmitting broadcast programs, but also as potential forerunners of all-cable television (including programming) for metropolitan areas. CATV systems presently pick up programs of TV broadcasting stations by means of an antenna, or bring them in by cable and microwave radio relay. The signals are distributed to the homes of subscribers by a coaxial cable system which can carry up to a dozen or more channels. There are competitive effects on broadcasting stations, especially local TV stations.

It is interesting to compare the present dollar yield of spectrum utilization of the various broadcasting services, using only the index of total station revenues per MHz bandwidth of spectrum allocated. These striking contrasts are not altered appreciably even allowing for manufacturing, servicing, and other expenditures related broadcasting services. AM broadcasting revenues in 1965 were $0.8 billion for a 1.07 MHz bandwidth. The FM band produced $23 million for 20

MHz bandwidth. The television bands, allocated 492 MHz bandwidth, produced $2.0 billion. The comparison, revenue per unit bandwidth, is:

	$Million per One MHz Bandwidth
AM	750
FM	1.1
TV	4.0

TV revenues are growing several times more rapidly than radio revenues, and from a base now 2½ times larger. Present use of the VHF television portion of the spectrum yields about $50 million per MHz bandwidth, allowing for sales and services along with revenue.

There have been recommendations, including those of JTAC[3], that growth of TV might be provided for by more efficient utilization of the spectrum.

". . .In the U.S., . . . there are three separate TV bands with a total frequency ratio of almost 20 to 1 from the highest to the lowest channel. Differences in propagation, antenna effectiveness and receiver performance between the various bands--particularly between the VHF and UHF bands--have led to relatively heavy use of the lower frequency channels with little use of the higher channels.

"There is no doubt that a single relatively compact TV allocation would lead to more even distribution of utilization and economies in equipment construction that could then be 'reinvested' in improved technical performance. Hardly any changes have been made over the past 15 years in the spectrum utilization standards of TV systems.* Studies of what improved receiver performance, or improved antenna systems might offer toward providing the required potential number of TV stations within a more limited total allocation should also be thoroughly explored in the laboratory and field.

Work on evaluation of the need and toward improving utilization efficiency should go on even though at the outset it would appear that existing investments in stations and receivers might dictate perpetual maintenance of the status quo. The situation in the 30-1000 Mc/s band is definitely too far out of balance to freeze earlier decisions without continual investigations and field trials of many different technical approaches. . ."

In Panel discussions of this problem, it was suggested that improved receiver standards alone would not appreciably increase accommodation of TV assignments, as most interference problems are co-channel. The adjacent-or-other channel "taboos" limit only close spacings or co-locations, and the usual distribution of assignments is claimed to remove this factor as a limit to overall utilization of the TV band.

Analysis presented to the Panel by ITSA gave an example alternative assignment plan for VHF which would reduce geographical spacings by taking into account antenna directivity, alternating vertical and horizontal polarization for adjacent assignments, precise frequency offset, and acceptance of interference-limited coverage rather than noise limited. It is estimated that the plan would, for example, provide an increase from 19% to 41% of the percentage of communities ("market areas") which can have 3 or more VHF television services, and from 9% to 36% the communities which have 4 or more services, and so on. The FCC observes, however, that the effectiveness of some of the elements of such a plan are not yet proven, as, for example, the advantage of cross-polarization discrimination. Furthermore, the plan, while increasing the number of services available to the public, would reduce the coverage of some stations with probable consequent revenue losses.

Other possibilities for increased accommodation of television within limited allocations might also lie in major changes of transmission technical standards, perhaps involving (as yet impractical) bandwidth reductions. Without marketable advances in performance of equipment, there would be little incentive for industry to expend efforts on such standards.

<u>Aeronautical and Marine Telecommunications, Radar, Navigation, Guidance, and Radio Measurement Systems</u>

A broad, and probably the most rapidly intensifying, aspect of spectrum utilization for commerce and defense concerns aeronautical and marine communication and control, radar and radio navigation applications, the launching and tracking of space vehicles, and radio measurements used in geophysical or environmental probes, such as meteorological sounding, with their telemetering and control functions. Equipment manufactures for these applications, excluding the air/ground and ship/shore communications, rose from values of $1.4 billion in 1958 to $4.5 billion in 1963, a compound growth rate of 25% per year.

Such systems provide the surveillance, control and response functions for the

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*This statement does disregard the provision for color television within the original assigned bandwidth for black and white transmission. The color television provision is a remarkable example, along with stereophonic FM multiplex broadcasting, of improved technical efficiency of spectrum utilization where industrial incentive exists. Not much incentive is apparent to reduce the total bandwidth of television transmission for the purpose of accommodating more stations within the allocation; indeed, for the broadcasting industry itself, the consequence would be increased competition.

defense of the nation, and the maintenance of safety and order of commerce. Second to television broadcasting, they utilize the next largest proportion of the prime regions of the frequency spectrum below about 1000 MHz. Aviation and marine uses of radio require intricate coordination among government agencies and industry, as well as with a number of technical and policy-making groups, and with other countries. The Radio Technical Commission for Aeronautics (RTCA) has a number of technical committees and studies concerned with the problems and radio services for aviation in the United States, and the International Civil Aviation Organization (ICAO) devotes extensive efforts to planning and coordination of uses of radio for international aviation.

Overocean aircraft communication, relying on densely used high-frequency channels, has been called the weakest link in transoceanic aviation. A survey of the use of regional and domestic air route high frequencies was made in 1964 preparatory to revision of the high frequency allotment plan for aeronautical mobile radio services at the 1966 ITU Extraordinary Administrative Radio Conference concerning aeronautical radio frequencies. The Communication Satellite Corporation plans to provide soon an "Aerocom" satellite, intended to provide by 1968 an increase in reliable air/ground communication capacity over the North Atlantic; the service must use for aircraft/satellite connections the already allocated VHF aeronautical bands.

The coexistence of satellite signals and ordinary VHF aeronautical communications in the same bands may present some problems. Studies are being made to determine possible methods for sharing bands with normal VHF communications which use amplitude modulation; frequency modulation will be used via satellite, with channel spacings of 50 KHz as planned by FAA and the ICAO. Communication is only one of the functions that satellites may eventually perform in air traffic control systems. Overocean traffic surveillance by synchronous satellites, as well as navigation aids, and meteorological surveillance for air routes are also developing.

About 60,000 civil aircraft use the 75 MHz marker beacons located throughout the U.S., and 100,000 use the air traffic control services. Some 30,000 are estimated to use the "glide-slope" service, and 15,000 the VORTAC/DME (a positioning system) service. The FAA has reported that its traffic control towers in 1965, using radio and radar, handled nearly 38 million aircraft operations. These operations account for 17% of all U.S. government radio frequency assignments. While the ultimate value of the services is not known, an example is provided by the estimate of $400,000 cost to airlines of a single radar maintenance shutdown in Chicago.

The review of aeronautical communication and navigation for the Panel stressed that accommodation of operational requirements was being increasingly limited by the level of use of the crowded bands. Close spacing of frequencies has been improved by making receivers more stable and selective; however, this trend is now being limited by the functional requirements of the emission and bandwidth needed to obtain the necessary system resolution. It was noted that "further spectrum advantage is obtainable by the form of time sharing possible in pulsed systems using repetitious code combinations for coherent response."

Besides the congestion of these services in their allocated bands, there are external sources of interference to air navigation. The FCC Annual Report[8] notes: "In the Far West, garage door openers produced interfering signals that invaded vital aviation and navigation frequencies. . . 285 offending units had to be located and removed from the air . . . in the Southeast, three instances of interference to air navigation frequencies were traced to radiation from malfunctioning intruder alarms. Such signals are difficult to hear on the ground because of their rapid attenuation, but are audible in aircraft up to 15 miles from the source. Several hundred alarms are already in the hands of the public and proposals to relax further the manufacturing requirements promise a bigger problem in the future."

Future requirements involving increased airspeed and numbers of aircraft will focus sharply on spectrum limitations. Height finder radars are an important element not yet incorporated in the air traffic control system. Study and tests are in progress on collision avoidance systems as well as comprehensive airborne transponder systems connected to traffic control for automatic exchange of flight data on position, altitude, fuel, speeds, and ground control signals.

A large volume of marine communication is now handled in the high frequency bands, well suited to the longer range operations, but accruing a great deal of congestion from use also for short ranges in coastal and inland waterways. The ITU

Panel of Experts[6] has recommended complete conversion to single-sideband operation, and the JTAC[3] has recommended transfer of short-range operations to the VHF bands. Newly developing prospects for data transmission in commercial shipping, and for automated operations on shipboard, will increase communication requirements on the seas and in harbors. The use of satellites, again, may meet some of these needs. Electronic replacement or supplement of the "bow lookout," and bridge-to-bridge communication for navigation in congested waters, are areas of active development for the maritime services.

Long-range navigation systems account for much of the use world-wide of the low frequency portion of the spectrum, say from 10 to 130 KHz, because of the uniquely stable, low loss transmission. This use is expanding greatly, with the introduction during the past decade of new systems such as Loran C, Decca and Omega.

A wide variety of radar applications is one of the most important factors in future spectrum utilization. Radars are used not only for defense surveillance and air traffic control, but aboard ship and aircraft for weather and traffic surveillance, for police control of traffic, and for precise geodetic and seismological applications. There are potential applications in commercial security.

Present radars occupy about 30% of the spectrum between 1 and 10 GHz and many use wide frequency bandwidth to achieve target resolution. Information reviewed by the Panel suggested that increasing applications and advancing technology will require greater concentration in allocated bands, and probably additional frequency space. Some important developments for future radars appear to be increasing the bandwidth requirement. The trends appear to include high power, say 10 megawatts average power, pulse duty factors of 1% or greater, greater resolution capabilities (a foot or less) using bandwidths of possibly 500 MHz, and great agility of the radiated beam, either using multiple beams or beam switching rates of a few microseconds. From these parameters, the output power density of such a high resolution radar might reach 20,000 watts per MHz bandwidth. Though the number of such super-power systems may be necessarily small there would appear to be an impending concentration near 5 GHz. Frequency utilization of radars is closely related to effects of the atmosphere and response to "clutter." Weather-surveillance radars and clear-air turbulence detectors must operate at frequencies effectively coupled to atmospheric scattering or absorption; target-detection radars must avoid these effects as far as practicable.

Even at an 8 percent growth per year, the equipments in this overall class of navigation, search and detection, and radio measurement, would increase 15 fold in the next 35 years. Perhaps this cannot be realized; will aircraft navigation and control equipment really increase 15 times? Can an orderly environment exist which would require such an increase to be feasible, reduction in airspace separation is a necessity, as would be a tremendous increase in the traffic handling capabilities of air terminals. These requirements would in turn demand corresponding increase in resolution capabilities of the navigation, surveillance, communication and control facilities.

The evolution of transport serves to illustrate also the telecommunication coupling of environmental measurements and observations with the operations of commerce. Planning is underway for the supersonic transport. Efficient and economical operation of the supersonic transport is achieved only by direct flight from departure to destination. Complete flight details along the entire route must be known pre-takeoff. A landing slot must be reserved in advance, taking into account all other traffic. The calculation of a pre-takeoff flight plan may include meteorological conditions over half the distance around the earth. These must be accurate, timely, and in sufficient detail for interpretation and use. Data collection and dissemination for weather and oceanography are examples of the growth in use of the spectrum that would appear to lie ahead in this class of services.

Latent Demand

There are other potential demands not really represented in discussion of existing telecommunication services.

Commercial information processing networks may be one of the most important such examples. A Report[13] prepared for the National Commission on Technology, Automation, and Economic Progress (1966) observes that:

> "The electronic computer is gradually becoming a common and major ingredient of all our traditional communication and information systems. Rapid developments during the past two decades have yielded a computing technology with present

capabilities that would have staggered the imagination of the early pioneers in this field only 20 years ago . . .

"A current development that promises to be of great importance and one that represents a dramatic advance over the past 20 years is the rapidly increasing worldwide capability to give ready and economical access to many computers . . ."

According to a report published by the American Federation of Information Processing Societies, today's U.S. investment of $8 billion in 35,200 working computers will rise by 1975 to more than $30 billion and 85,000 computers. One of the most important concepts in the future schemes for computers is the commercial information processing network for high capacity storage, processing and transmission. Project MAC (Multiples Access Computer) at MIT typifies the state of the art and present thinking regarding such a "computer utility." Good discussions have been published[14,15] on the concept of such networks and their applications in business, engineering, medicine, education, and research. These capabilities will depend on vastly increased communication capabilities, not now in general existence. Whether all-out development is undertaken early remains to be seen. However, the potential demand and trend for extensive wide-band interconnection of computers seems clear. The requirement for spectrum vs. cables is an economic question in many applications.

An ocean data system[16] has been proposed which might provide consolidated acquisition and transmission of data for worldwide oceanographic and ocean meteorological programs. The system has involved extensive planning for efficient frequency utilization, (primarily HF so far), and is being considered cooperatively by the Intergovernmental Oceanographic Commission, the World Meteorological Organization, and World Weather Watch. The proponents suggest sharing international maritime frequency bands, and present maritime users are concerned with increasing congestion. Very high utilization of small bandwidths are planned for the ocean data for this service. R&D is also proposed to increase further the effectiveness of frequency utilization.

The experimental High-Speed Ground Transportation program has encountered difficulty in providing adequate telecommunications, i.e., communications and control, for the high speed train studies, due to limited available landmobile frequencies. A project is being initiated to study feasibility of guided transmission along trackside which can be effectively coupled into a moving train. Similar investigations are underway in Japan and England. The concept of guided transmission, using surface transmission lines or leaky wave guides, may also be important to future highway applications. Communication and control has been cited as a significant factor in highway traffic safety.

The role in law enforcement of new telecommunication technology and increased capacities is being studied intensively by the President's Commission on Law Enforcement and Administration of Justice. The growing crime rate, as well as court decisions upholding rights of individuals, have increased the need for rapid access to crime information. Identification of individuals and property must be accomplished quickly because of their high mobility. Means for public communication with appropriate agencies in emergencies, tactical and administrative communications between elements of a law enforcement agency, and regional or national channels interconnecting law enforcement agencies and central data sources, are examples of the expanding communication needs.

Some public notice has been given to "picture phone" experiments, and demonstration service has been set up in three major cities. It was indicated to the Panel that "for the telephone system to provide one percent of its subscribers with picture phone service would require doubling present plant facilities!"

Less costly and possibly more imminent is the concept of the "home communication center," for financial transactions, ordering of goods and services, document transmission, and many record communications provided today by mail.

Not all new telecommunication services, or even these few examples, will entirely employ transmission through the atmosphere using the frequency spectrum. Most must certainly be realized through cable or wave-guide transmission. But the technical and economic exchangeability of wire and radio media, and the occurrence of many situations in which use of the spectrum is a more economical approach, may be expected to increase future pressures for spectrum utilization.

FREQUENCY MANAGEMENT

It was noted earlier that the Communications Act of 1934 gives the Federal Communications Commission responsibility for regulation of non-(Federal) Government* interstate and foreign telecommunication, including frequency utilization. The Act provides that radio services belonging to and operated by the U.S. Government shall be assigned and regulated under the authority of the President; this authority is delegated[17] to the Director of Telecommunications Management, who also coordinates policies and standards for telecommunication of Government Agencies. Apart from the question of balance of allocations between government and non-government users, there appear to be strong bases advanced for this separation. The separation is rooted mainly in the direct responsibility of the President for national defense and the missions of the Federal Agencies. The administration of non-government telecommunications in the national interest requires processes which provide adequate public representation of economic and political forces.

In any case, the Panel was not charged to consider the regulatory and policy structure for telecommunication management, except as research and engineering may be effectively related. Indeed whatever may be said** of the United State's unique and traditional dual frequency management, the benefits derived by the U.S. from spectrum utilization appear to exceed, by any meaningful index, those of any of the most advanced nations. Growth toward saturation, however, brings into focus problems of basic technical, operational and economic nature, many common to or affecting both government and non-government spectrum utilization.

Frequency assignments of record in the United States were approaching the number 500,000 at the end of 1965. (Some 104,000 of these were government assignments). The growth of FCC assignments was noted earlier at 10% per year. Forty-seven percent of the spectrum below 40 GHz is allocated for government use, *34% for non-government, and the 19% balance is shared. At frequencies below 1 GHz, the government has 28%, non-government 61%, and the 11% balance is shared.

The most apparent trend is to the use of higher frequencies, illustrated by progressive extension of international allocations to 40 GHz (shown earlier in Table IV)--there are a few operations at higher frequencies, mainly of an experimental nature. The trend is being intensified by demands for satellite applications and microwave trunks. A statement to the Panel from the ODTM, that, "judging by the activity in frequency assignments, 68% of the growth is above 25 MHz" suggests, however, that continued concern is justified for the region below 25 MHz, if indeed this saturated portion of the spectrum is absorbing the 32% balance of growth! A special IRAC discussion[21] of the future of HF utilization reported to the Panel, emphasizes that, while point-to-point trunk and some mobile uses of HF will decline in favor of cable and satellite transmission, marine and HF broadcasting requirements are expected to continue to increase, and new applications such as Over-the-Horizon Radar are also to be reckoned with.

Non-Government Frequencies

Reviews for the Panel, and the FCC Annual Report, identify major issues in future non-government spectrum utilization as the need to provide for satellite communication, mobile radio, microwave systems for both common carrier and private uses, to develop UHF television, and to optimize the emerging role of CATV operations. Specific discussion of most of these problems has been given earlier in this Section.

Attention of the Panel was drawn to a number of questions of technical standards and other technical information which is becoming increasingly desirable in the regulatory and planning activities of the FCC. A tabulation of these topics is included in Appendix 3. Some of the more important questions concern land mobile radio, as optimum modulation and channel width, intermodulation and transmitter noise problems,

*"non-Government" used in the text means non-Federal Government.

**Much has been said. See, for example References 18, 19, and 20

*Direct correlation is not evident between allocated bandwidth and numbers of frequency assignments, probably because a preponderance of wideband radar assignments are for government use.

multiple access systems, techniques for "flutter" reduction and the general problems of utilization of higher frequencies, background electromagnetic noise limitations, and methods for multiplexing and compressing information transmission. A more general need is expressed for advisory standards for complete systems for all services, which might be used as a reference in FCC rules, or as assumed standards for a service. Characteristics of transmitters, receivers, antennas, etc., would be included. Additional emphasis is placed on the need for electromagnetic noise information, data and methods of measurement for such interference or "radio smog" from electrical equipment in industry, homes, and vehicles. There are questions of resolving and reconciling various standards and methods of measurement of noise nationally and internationally. Measurement and analysis of the level and growth of such noise as a limitation to radio uses are needed. Monitoring and analyzing uses of the spectrum and sources of interference are becoming enormously complex. While some mass survey techniques are employed, each case of interference has its own peculiarities, and actions required must be carefully and individually evaluated. Moreover, existing law does not permit the control of manufacture and sale of interference producing devices except for functionally radiating equipment; interference from electrical equipment must be located and dealt with as individual occurrences.

The FCC Annual Report notes that:

> "The plethora of non-licensed radio frequency devices continues to pose major problems. The numbers and types of such devices grow at an explosive rate. Typical are radio controls, wireless microphones, radio and TV receivers, electronic intruder alarms, gadgets and toys, appliances, industrial heaters, medical equipment, and ultrasonic devices used in industry and home . . . an estimated 500,000 residential garage door openers are in use today, and 90 to 100 thousand are being manufactured annually."

The FCC at present has no authority over the manufacture of most electrical equipment capable of causing such interference; legislation has been proposed.

Of the FCC's 1,500 employees and $17 million current annual budget, about 25 engineers and approximately $280,000 of the budget are engaged in the technical research and development area. The Commission relies for technical guidance largely on advisory committees, research of other agencies, industry research, technical publications, and data developed through the public inquiries and rule-making proceedings. Current FCC study programs include: (1) the experimental UHF TV transmission and analysis in New York City, (2) studies of noise related to the Land Mobile Advisory Committee work, (3) occurrence of off-path microwave interference from scattering, (4) automated retrieval of terrain data for use in computation of frequency sharing, (5) study of trans-equatorial field strength in the standard AM broadcasting band, related to regional sharing of channels, and (6) automated spectrum monitoring. Laboratory programs have been set up for studying the characteristics of receivers, transmitters, as well as interference and its suppression. For example, recent studies have been made on a proposal for audio filters to permit increase in AM broadcast station powers without increased interference to adjacent channels, the characteristics of FM receivers currently manufactured, and various devices proposed for selective ringing of shipboard radio-telephone installations. The laboratory also tests radiating equipment for "type approval," as transmitters, diathermy, industrial ultrasonic equipment, etc.

The FCC frequency assignment records are maintained on punched cards which facilitate analysis and printing. The proposal for a new frequency use is made by the prospective user, and examined by the FCC, considering existing station operations to avoid causing or receiving interference. Some work has been done in the computer generation of frequency assignment plans for broadcast services; there is interest in these possibilities for other services such as land mobile and microwave.

U. S. Government

The ODTM identified for the Panel also the major issue of future provision for "space services." The intra-government Study of Space Service Spectrum Saturation was outlined to determine the needs of the Space Services between now and 1980, and the means of their satisfaction in the light of "potential spectrum saturation." Results of this study are expected in late 1966.

Technical support indicated needed for frequency management included: (1) automated frequency assignment and sharing procedures, and (2) development of technical standards for frequency management features of government transmitting and receiving equipment and antennas. The examples of urgent current technical questions cited by the ODTM were: (1) Can there be more current frequency assignments in the HF portion of the spectrum? Currently, processing time is about 17 weeks for routine frequency assignments. Is it reasonable to look forward to "real time" propagation information and assignments? (2) What are effective standards for earth-station siting and interference protection for the space services?

Technical standards are developed largely as a cooperative voluntary effort of the using agencies, in the IRAC's Technical Subcommittee, in which the FCC also participates. Effective rules have been developed for government operation of low power devices and ISM* equipment which are compatible with long-standing FCC rules in this area. In more complex and costly areas, such as radar design, and HF transmitters and receivers, progress has been slow and partial in achieving standards which contribute meaningfully to efficient spectrum utilization. The ODTM has developed and issued recently the first codification of regulations and procedures for frequency management by government agencies. ODTM studies support developments for computer processing in frequency administration. The current ODTM staff comprises approximately 60 people; the Fiscal Year 1967 budget of $1.6 million includes $425 thousand for research.

INTERNATIONAL PROBLEMS

Important, often controlling, international aspects of spectrum utilization relate to frequency allocation, radio regulation, system standards, operating procedures and tariffs.

The International Telecommunication Union (ITU), a treaty organization, periodically holds Administrative Radio Conferences which revise the Table of Allocations in accordance with negotiations based on needs expressed by governments for radio services and frequencies throughout the world (See Appendix 2). Each country as well as regional groups establish subdivisions of the allocation table as needed. An intricate framework of radio regulations is necessary to avoid harmful interference and achieve effective international communication. Allocation by service provides a degree of international compatibility, and permits efficiencies in frequency sharing among fairly homogeneous classes of service.

It was the ITU Administrative Radio Conference in Geneva in 1959 which adopted regulations extending the allocated frequency spectrum to 40 GHz. A new Master International Frequency Register was established; the International Frequency Registration Board (IFRB) now maintains a fully computerized file of international registration and for new notifications, reviews circumstances indicating interference with existing uses. For high frequency broadcasting, countries now provide seasonal broadcast schedules to the IFRB in advance of their implementation. The Board is responsible for suggesting time and frequency adjustments needed to improve reception and reduce interference. The 1959 Conference also set up the ITU Panel of Experts to study means of reducing congestion in the high frequency band; a report containing 38 recommendations was issued in 1963. Appendix 3 contains three of the recommendations pertaining to technical studies.

An Extraordinary Radio Conference in 1963 made allocations of bands for space (including satellite) communication and Radio Astronomy. A further World Administrative Radio Conference on Space Communications can be recommended by the ITU Administrative Council when developments and demands warrant. The 1963 Conference used technical information prepared by the CCIR for establishing feasibility and conditions for sharing of microwave bands with space services. It is clear that the applications of satellite technology and the needed frequency allocation will dominate issues in international telecommunications for some time in the future. Potentially critical issues lie in the possibilities for internationally competitive proliferation of satellite communications systems, as well as international satellite broadcasting.

The CCIR role in studying technical and operating questions is well illustrated by the space-services sharing recommendations. The CCIR comprises fourteen international study groups, organized corresponding to various classes of services, plus transmitters, receivers, and propagation. CCIR recommendations, while not obligatory, carry great weight. The Radio Regulations provide that choice of apparatus, techniques and measurements shall be in accordance with CCIR recommendations. Developing countries, an increasing factor in international frequency utilization, often specify CCIR recommendations as the basis for equipment to be procured for such new systems. The

* Industrial/Scientific/Medical.

international system standards which are implicit in CCIR recommendations can affect both spectrum utilization and international marketability of equipment manufactured.

Some of the more important CCIR programs related to spectrum utilization are reproduced in Appendix 3. A resolution adopted at Geneva in 1963 exhorted studies of "optimum spectrum utilization;" improved information is sought on tolerable wanted-to-unwanted signal ratios, as well as statistical methods for assessing the probability of interference and for maximizing the effective sharing of frequency bands. Another recent action has been the drafting of an international handbook on antennas, to give design guidance which fosters improved antenna directivity for reduction on interference.

The CCIR provides the most effective medium for technical guidance and advancement of international telecommunications, and potentially for achieving increased efficiency of spectrum utilization. In the U.S., participation in the work is largely voluntary by industry and government organizations, with coordination by the Department of State. There is a natural emphasis on topics and positions of interest to the participants, their mission and competence, or products and services. The strength of the system is seen in many original, sophisticated, and practical technical contributions. But there are major gaps in contributions, for example, on bandwidth compression, signal-to-interference ratios, and broad questions of overall efficient utilization of the spectrum. The ITSA and FCC among the government agencies are most active in CCIR work.

The International Scientific Radio Union (URSI) is an effective forum for international discussion of the scientific basis of radio communication. Its activities in information theory, antennas, tropospheric propagation, solar control of ionospheric propagation, and natural noise sources over the entire frequency spectrum are pertinent to questions of efficient frequency utilization.

III. SCIENCE AND ENGINEERING

The Panel has reviewed broadly the status of technology, and projections for research, in major fields of telecommunication science related to utilization of the various regions of the frequency spectrum.

Certain "common denominator" kinds of research can be identified which lead to increased capabilities throughout the spectrum. These concern information theory, propagation, and noise, some fundamental problems in networks, filters, and frequency stability, and studies of alternative media such as waveguides and cables. This section discusses some of the more important of these research topics considered by the Panel, as well as topics in engineering methods, technical standards, and operations analysis related to frequency management.

INFORMATION TRANSMISSION TECHNOLOGY

An intrinsic requirement for bandwidth is the width of the signal spectrum which must be preserved in order to render the sampled signal waveform reproducible sufficiently undistorted. In addition, because of the response characteristics of physical networks, and frequency instability, additional frequency range or guard space is also required. Total frequency space assigned to a channel includes the entire band, the intrinsic bandwidth plus guard space. For the past thirty years there has been considerable development and increasing application of new systems of modulation such as frequency modulation and pulse code modulation. These have the interesting property that it is possible to exchange bandwidth for signal-to-noise ratio. This means, in effect, that we can transmit the same information in the same time with less signal power, provided we are willing to use more bandwidth. If the signals are quantized, as in pulse-code modulation, the converse is true, that is, we use less bandwidth at the expense of more signal power. The notion of conserving bandwidth alone is inadequate to optimize spectrum use; it is just as meaningful to conserve energy density radiated, even though extra bandwidth may be required.

In a very practical sense, the performance of information transmission techniques is judged by the criteria of bandwidth and signal-to-noise ratio required to transmit information at a given capacity (bits/sec.). Obviously, the smaller the bandwidth and the signal-to-noise ratio to transmit a given capacity, the smaller the demand on the spectrum. Effective transmission in this sense can be achieved by (1) maximizing the capacity of the link for given bandwidth and signal-to-noise ratio, and by (2) compressing the information to be transmitted.

Insight to "channel capacity" has grown profoundly since Shannon's introduction in 1948 of the concept and basic theorem of bounds on information capacity for transmission related to limiting noise. Many practical applications have been stimulated, and are showing capabilities of several-fold increase of capacity and/or accuracy of transmission in given channel widths as compared to present day radio operating practices. Further progress in these techniques is especially important to uses in the prime portions of the spectrum below 15 GHz which are already becoming congested, and may be of critical importance to mobile radio applications which, for reasons of physical limitations, may be required to continue development at frequencies below 1 GHz.

An article by J. R. Pierce[22] illustrates the orders of magnitude of transmission capacity which might be gained...

"... Shannon's equations demonstrated for the first time just how wasteful most communication channels are. He showed for example, that a letter of English text contains only about one bit of information, if due allowance is made for letter frequencies in English words and the predictable constraints that exist in all written languages. In other words, with an efficient coding scheme, one should be able to transmit ordinary English text with an expenditure of one bit per letter. Thus the information contained in a typical 300-word page of typewritten text is only some 1,800 bits. To transmit 300 words with ordinary data encoding techniques, however, requires the expenditure of about 12,600 bits (a seven bit code group for each letter). To transmit a page of text by facsimile requires about a million bits. In this case, of course, the entire page is transmitted as a picture, which is mostly white space. If the page were read aloud over a pulse-code modulation telephone channel one would need more than 11 million bits to transmit it. Finally if the same page were transmitted by television for the time needed to read it aloud, say three minutes, more than 10 billion bits would be required. An obvious way to reduce the number of bits transmitted in this case would be to send the picture once, which would take only a thirtieth of a second, and then send a few bits of information containing the message, 'Hold picture on screen for three minutes'....."

Compare these information rates, also, with estimates[23, 24] of the human capacity of less than 50 bits/sec to assimilate visual or oral information.

Channel Modulation and Coding

In studies of channel modulation and coding, a widely used measure of "efficiency", and the objective of much research, is in terms only of the required ratio of signal energy to noise power per Hz of bandwidth (E/N_o) to derive one bit of information. The more efficient the system is in terms of E/N_o, however, the greater bandwidth required. Contemporary coding and modulation techniques operate over a wide range of E/N_o values. For example, for an error rate of one per 10^5 bits, a 16-level SSB transmission, using a bandwidth of about ¼ Hz per bit/sec information rate, may require about 500 times the theoretical minimum E/N_o. Other effective modulation/coding schemes, using bandwidths of 5 to 10 Hz per bit/sec information rate, reduce the required E/N_o to 2 to 5 times the theoretical minimum.

While minimum signal-to-noise ratio is not an adequate criterion of efficiency when the spectrum is shared with other services, neither is minimum bandwidth. Rejection of interference may be increased by use of wider bandwidth, and the increased rejection allows closer geographical spacing of services. For example, the 200 KHz bandwidth assigned to FM broadcasting channels could be reduced, without loss of fidelity or service, at the expense of increased transmitter power and greater geographical separation of stations in crowded areas. Newer "spread spectrum" systems are effective from the point of view of contributing reduced detectable interference per unit bandwidth, and with proper coding and sufficient bandwidth they can work well in strong interference.

Current research reflects adequate awareness of the problems of maximizing the capacity of a system for limited signal power without critical constraints on bandwidth--the power limitations of space probes, surveillance radars, and scatter communication links have emphasized this need. On the other hand, the problem of overall optimization of bandwidth and signal powers for a number of services sharing a band appears to have had less if any serious attention. This is much more complex, requiring some valuation of the bandwidth in the exchange for signal-to-noise ratio, and posing difficult definitions of optimization where an aggregate of services is involved. Emphasis on bandwidth compression alone, by frequency management authorities and CCIR, largely reflects traditional assignment patterns.

Further, much of the work so far has used highly idealized characterization of the transmission channels. Increased capacity of channels is most critically needed in the lower frequency portions of the spectrum, which depend upon ionospheric and tropospheric transmission media. Unfortunately, the propagation and noise characteristics of these channels do not correspond to the usual "mathematically convenient" models. Reviews for the Panel stressed the need for emphasis on time-varying dispersive channel models truly characteristic of ionospheric and tropospheric transmission media. Specific recommendations were noted for:

(1) Channel measurements aimed at testing and quantifying channel disturbances in terms of the kinds of mathematical models used in system theory, representing both convolutional ("multiplicative" or time-varying dispersive disturbances) and "additive" noise.

(2) Laboratory simulators of physical channels, capable of representing real channel behavior and disturbances.

(3) Signal design (modulation and coding) for maximizing the efficiency and reliability of using the spectrum in the presence of real channel disturbances, for effective diversity and combining techniques, and multi-level (M'ary coding) to determine their tradeoffs in spectrum utilization.

(4) Signal separation techniques and receiver design for multi-signal environments; real-time and quasi-real time pattern recognition techniques for improving signal separation capabilities.

(5) Adaptive source-data compression techniques.

Source Encoding or Information Compression

In "source encoding," statistical characteristics or redundancy in picture and speech (or even teleprinter) transmission can be exploited to reduce the bandwidth or time required for transmission. Advantage can be taken of the "activity statistics" in multiplexing an ensemble of transmissions. "Vocoders" (speech bandwidth compressing techniques) have achieved some success; it seems likely that the

50,000 bits/sec capacities required for normal speech via pulse-code modulated systems could be reduced to perhaps 10,000 bits/sec by multiplexing large groups, and further, by the use of vocoder, to 1,000 to 2,000 bits/sec per voice channel. The compression coding of TV has not been so rewarding and the future is not clear. Techniques have been simulated on computers which permit rate reductions of two to three times over conventional transmission. In theory, reductions of several hundred times are suggested. Research on reduction of picture bandwidths appears to have diminished to very low activity. This is understandable, though nonetheless disappointing, in view of the large portions of the spectrum devoted to picture transmission, and probable increasing demands. Bandwidth occupancy is perhaps the one dimension of spectrum utilization in which a ten-fold or greater intensification of spectrum use may reasonably be sought. Studies of both channel capacity and source encoding should be fostered vigorously in relation to overall improvements in spectrum utilization. Independent progress in "integrated circuitry" and storage devices of large capacity is being achieved rapidly and will likely make economical in a few years signal processing applications for which the complexity now results in prohibitive cost. Development of signal separation (interference rejection) techniques related to anti-jam principles may also be an important modulation/coding topic for increased spectrum utilization.

Much of the emphasis on realistic channel characterization stresses the need for closer relation of research on information transmission to that on propagation.

The urgency with which the ITU regards the need for advances in bandwidth compression is expressed in a number of questions and study programs of the CCIR, and also by a recommendation of ITU Panel of Experts.

PROPAGATION DESCRIPTION AND PREDICTION, NOISE AND ANTENNAS

The dependence of telecommunication on propagation of electromagnetic waves along the ground and through the atmosphere, and descriptions of the various mechanisms of propagation, have been developed extensively by the JTAC and ICAS Reports[3, 2]. Approximately two thirds of the JTAC text is devoted to propagation, noise and antenna factors in spectrum utilization, with descriptions and data for line-of-sight, ground-wave, ionospheric and tropospheric propagation. The ICAS Report discusses atmospheric research relevant to the various propagation mechanisms. The Panel considers it pointless to duplicate the contributions of these surveys, which are recent, assumed to be available, and are commended to the reader. Propagation prediction and description has been considered by the Panel in the perspective of overall science and engineering efforts related to efficient spectrum utilization.

A knowledge of transmission loss and dispersion characteristics of the transmission medium, with their time variation and relation to terrain and atmospheric conditions, is essential to effective system design and spectrum sharing.

In planning systems the designer is faced with crucial problems in selecting sites, choosing frequencies, and in determining the power and antennas required, the modulation, coding, and diversity systems to be employed, and the performance to be expected. Transmission loss for nearly all paths is variable, and the development of sound models for prediction is of fundamental importance. Besides transmission loss, the characterization of dispersion, and fading with its time, frequency and spatial relationships, is essential to design of modulation and diversity methods. In the absence of accurate knowledge of propagation capabilities and limitations, systems must be built by expensive cut-and-try or overdesign. An important aspect of optimization is the avoidance of unnecessary interference. Historical examples of expensive retro-fit in spectrum utilization include the reallocation of FM and TV channels from the frequency range 42-50 MHz to much higher portions of the spectrum as the result of interference; the 1948-52 freeze of television assignments in the U.S. was precipitated by belated discovery of strong interference fields.

International negotiations for frequency allocations and sharing arrangements especially require a strong base of propagation understanding for rational agreements, protection of national interests, and maximizing the possibilities for exploitation of the spectrum as an international resource. Examples of some propagation-related questions pending before the ITU in the CCIR concern: (1) communication-satellite systems sharing the same frequency bands as microwave radio relay and other terrestrial radio systems, as well as frequency bands for re-entry communications, (2) atmospheric absorption and refraction effects for line-of-sight transmission at frequencies above about 10 GHz, (3) means for obtaining diversity for line-of-sight relay and tropospheric scatter systems (e.g., is frequency diversity necessary and justified on economic grounds, as compared to space diversity which does not involve redundant spectrum occupancy?), and (4) the capabilities of HF inospheric propagation for high-rate data transmission and error control with related questions for international system design.

The unique and essential role of propagation information in the international aspects of spectrum utilization commends continued vigorous support and direction of research in this field by the government.

An order of priority for propagation research by regions of the spectrum is problematical. Transmission at frequencies above 15 GHz, through millimeter to optical waves, is least known and stirs the greatest hopes for ultimate expansion of wide band telecommunications; however, atmospheric attenuation is a limiting factor, and physical limitations of components make technological development expensive and slow. Tropospheric and line-of-sight transmission from 30 MHz to 15 GHz are much better understood, but important improvements of engineering predictability are still needed. Challenging research questions remain. This portion of the spectrum is clearly absorbing the greatest present expansion of services, including satellite and mobile radio services. Finally, the long range capabilities of ionospheric transmission at frequencies below about 30 MHz have established the status of this region of the spectrum as a unique international resource; the most severe and growing congestion of this portion of the spectrum led to the special ITU Panel of Experts study in 1963. The U.S. investment per MHz of bandwidth is greater below 30 MHz than in any other region of the spectrum.

The possibilities over the next twenty years of expansion to higher and higher frequencies have led the Panel to consider the importance of effort in the following order:

Region Above 15 GHz

Constituents of the atmosphere, including water vapor, oxygen, rain and snow are known to attenuate electromagnetic waves, especially at frequencies above about 15 GHz, and also to result in noise radiation at these frequencies. In addition, the refractive index structure of the troposphere is known to affect the bending and coherence of the wave front. Present estimates of attenuation for one way transmission through the atmosphere[25] are given in Figure I. Examples of recent experimental[26] communication studies include transmission of television signals over a 19 Km path in California at about 94 GHz (3.2 millimeter), and show the scintillation and attenuation effects for various weather conditions. High quality television and voice transmission were reported obtainable even during moderate rainfall.

Reviews for the Panel suggested that the water vapor attenuation effect is not fully understood at millimeter wavelengths. It turns out that there is a stronger attenuation by water vapor in air than one would predict on the basis of laboratory measurements of pure water vapor. Attenuation is stronger near the oxygen resonance (5 mm) than away from it. As far as using the wide bands of frequencies near 18, 30, and 100 GHz is concerned, the major restriction is rainfall. Statistics on rainfall--the sizes of heavy showers and their occurrences, are inadequate for prediction of performance of propagation paths and planning of alternate routes. It appears that technological developments of sources and detectors is lagged by understanding of transmission. As far as optical wavelengths are concerned, attenuation and beam broadening (scintillation) effects in clear air are encountered, and rain, fog and snow can interrupt transmission. Optical transmission may be significant in studies of clear air turbulence.

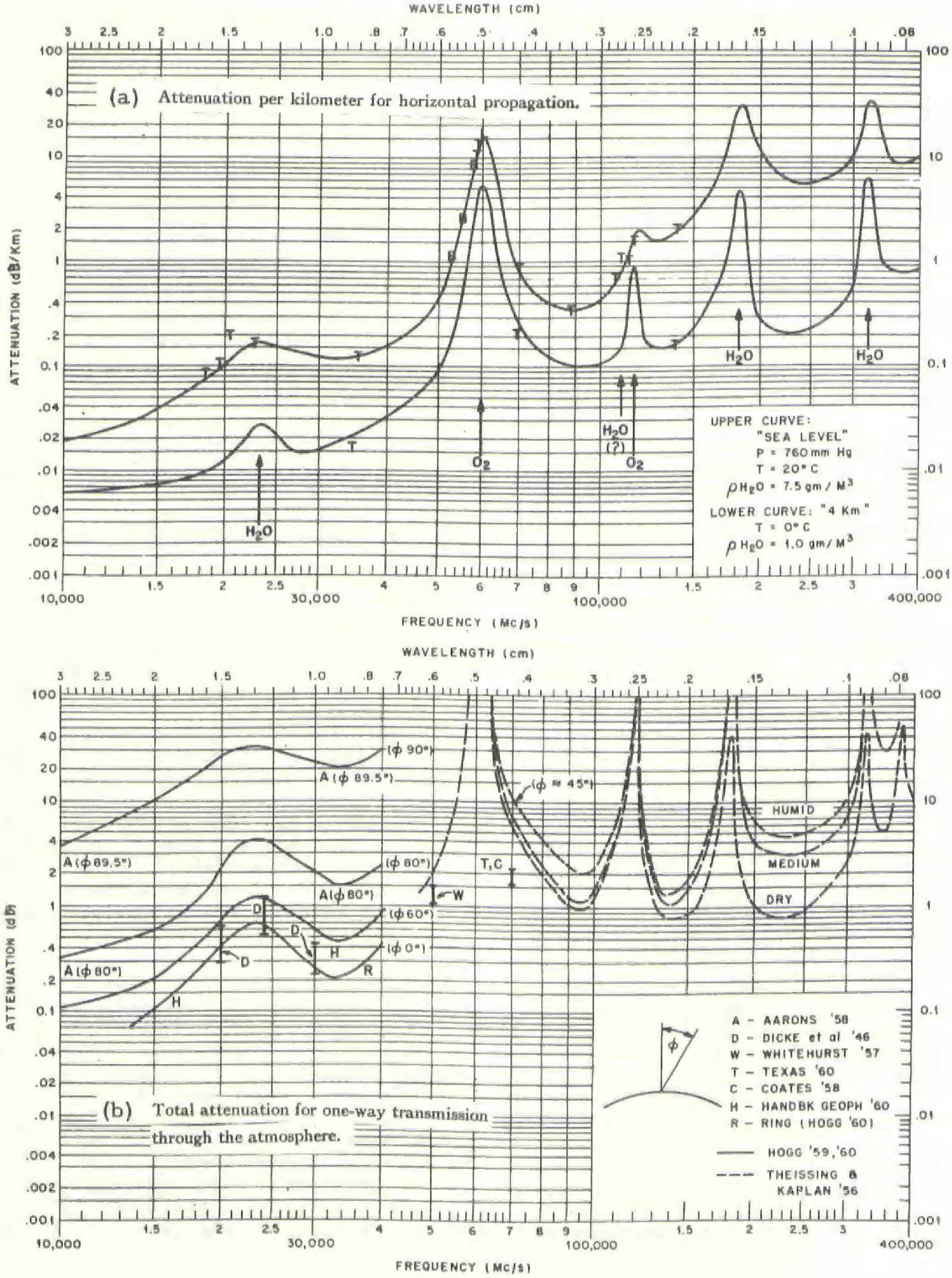
A CCIR Study Program on Tropospheric Absorption and Refraction (Geneva, 1963) effectively summarizes the studies needed:

"1. the measurement and development of methods of prediction of the attenuation of radio waves passing through the troposphere, as a function of frequency, angle of elevation, geographic location, time and constituents of the troposphere, including oxygen, water vapor, water droplets, the distribution of the sizes of the drops and rainfall rate, etc.,

2. the measurement and development of methods of prediction of the refraction, scintillation and coherence of the wave front of radio waves passing through the troposphere as a function of frequency, angle of elevation, geographic location and time.,

3. the measurement and development of methods of prediction of the noise radiation from atmospheric gases, clouds, and precipitation."

The ICAS Report summarizes related atmospheric science studies needed for optical and infrared telecommunication:



Meyer, James W. (1966), Radar astronomy at millimeter and submillimeter wavelengths*, Proc. IEEE, Vol. 54, No. 4, 484-492.

*Quoted from: Rosenblum, E. S. (1961), Atmospheric absorption of 10-400 kMcps radiation, Microwave J., Vol. 4, No. 3, 91.

Figure I

"1. The space-time variations of density and temperature of atmospheric constituents, and the consequent space-time variations of refractive index,
2. The telecommunication characteristics of electromagnetic signals propagating via the same region of space,
3. The relationship of the refractive index structure and consequent telecommunication capability to the much more widely available information on weather and climate,
4. The absorption of electromagnetic waves by atmospheric constituents,
5. The non-linear processes occurring at high power fluxes."

Region From 30 MHz to 15 GHz

Most of the development of use of this portion of the spectrum has come since World War II; the rate of increase of use has been such that approximately 80% of the total national expenditure on spectrum usage is now concentrated here. Propagation is affected by the lower atmosphere (troposphere) and terrain. Climate, weather, atmospheric structure and turbulence, and terrain irregularities play important roles in determining the strength and fading properties of tropospheric signals. While absorption is not of major importance, refractive and scattering effects are. Estimates of the propagation loss, long and short-term variability, and structure of the signal, are essential to design of point-to-point relay, satellite, broadcasting, navigation and guidance systems. It is important to be able to predict the weakest signal levels, exceeded for large percentages of the time, to estimate probability of service and required power; on the other hand, strong signals, exceeded for small percentages of time, impose the interference limitations. At present, predictions of long term median values of transmission loss, derived empirically from many hours of measured data obtained under various conditions of climate and terrain, can be made with a standard error of about 4 decibels. This means, however, costly over- or underestimate of the median value by a factor of 10 times for a significant number of paths; much greater errors are involved in the estimate of weak and strong signal statistics.

Besides transmission loss data, refractive effects limit navigation and guidance systems, dispersion and fading effects affect design for bandwidth which can be transmitted, and "off-path" scattering by aircraft, hail, and precipitation can be a limiting factor in interference.

Another CCIR Study Program, on Tropospheric Propagation Factors Affecting the Sharing of the Radio Frequency Spectrum by line-of-sight radio relay systems, space communications, etc. specifies the need for the following studies:

"1. Measurements, for different path lengths and for at least as long as one year, of the cumulative distributions at hourly median transmission losses for each month of the year;
2. measurements for different path lengths of within-the-hour cumulative distributions of signal levels;
3. measurements for different path lengths of the cumulative time distributions of fading below specified amplitude levels above and below the hourly median level;
4. long term measurements, at appropriate frequencies above 100 Mc/s and up to at least 20 Gc/s of the cumulative amplitude and fade duration distributions of transmission loss over representative wanted and unwanted signal propagation paths, between highly directional antennas oriented at various angles in elevation and azimuth away from the directions of maximum path antenna gain;
5. the transmission loss measurements referred to in 4 above should be related to the location and size of aircraft, hail, or other reflecting object near the propagation path;
6....
7. measurement of correlation over long periods of time between hourly median transmission losses on wanted and unwanted propagation paths with a common terminal;
8. determination of the effects of the common terminal terrain and climate on the correlation of errors of prediction of the hourly median transmission losses exceeded for various percentages of the time for the wanted and unwanted signal propagation paths ...."

Similar study programs are urged by CCIR for use in international spectrum and system planning on the effects of tropospheric refraction, for prediction of tropospheric scattering beyond the horizon, and for investigation of multipath and fading characteristics of tropospheric transmission. One of the most urgent problems concerns the sharing of satellite systems with surface systems. Scattered interference from thunderstorm cells and other sources pose an, as yet, unevaluated limit to such sharing.

A most fundamental problem concerning tropospheric propagation prediction is the present poorly understood physics, not only of electromagnetic propagation through an irregularly stratified, turbulent, refractive medium, but of the structure of the atmosphere itself in terms of fluid mechanics. Hour-to-hour field strength variations are largely uncorrelated with any presently known and observed physical changes in the atmosphere--the long term "climatic" correlations are of the crudest sort.

In the long run, more than electromagnetic research needs to be done. Fluid mechanics research on the atmosphere is needed, on a dimensional scale that is only of secondary interest in weather forecasting and weather modification problems. Traditional radio studies have been concerned with the refractive index of the atmosphere. The refractive index depends upon both temperature and humidity, and these elements affect the dynamics of the atmosphere quite differently. Separate studies of the temperature and humidity variations are essential for understanding the cause of the fluctuations. Additional support for such fundamental research should probably be directed to competent fluid dynamics workers brought to close relationship to the radio studies.

Some newly identified electromagnetic problems may be expected to be of increasing importance as systems of increased sensitivity are employed, especially for space communications. One example is the attenuation and noise temperature of the clear earth atmosphere. The noise limitation is now observed to be other than discrete radio sources--there is an additional background radiation amounting to about 3.5 degrees K, believed related to expansion of an oscillating universe. Thus, wherever we point an antenna beam--toward a space probe or satellite--it sees this radiation in addition to our own atmosphere. There is also an observed unexplained attenuation, greater than theoretical, by the earth's atmosphere at frequencies about 2 GHz. It is not known if the losses are higher at lower frequencies, nor what is the explanation. The coherence limitations for a wavefront passing through the atmosphere from a source in space are not well known; this question affects how large an antenna array can effectively be used on the ground before suffering from atmospheric distortions.

Region Below 30 MHz

This is the most densely congested portion of the spectrum, the oldest from the point of view of usage, and the most favored for research in earlier years. Point-to-point heavy trunk circuits, and even some mobile applications, will transfer to satellite relay and cables. At the same time, increased broadcasting and maritime use is indicated, and even point-to-point applications where great flexibility is required. New technology is emerging to exploit this region of the spectrum, such as detection systems and "over-the-horizon radar" mentioned earlier. Effective new digital transmission systems are being introduced to provide good transmission quality for narrow band links or spurs connected to cable or satellite main trunks. Some requirements are uniquely well suited to HF, as a portion of the "ocean data" system. VLF transmission penetrates the sea surface for submarine communication, and provides for very long-range navigation systems and world-wide standard time and frequency services because of good phase stability; the LF region provides good ground wave coverage for broadcasting and for the most accurate radio navigation systems. The whole concern of the International Panel of Experts Study (1963) was for the frequency band between 4 and 27½ MHz; along with recommendations for transfer of some services to other portions of the spectrum, continuing increase of congestion was foreseen.

Regular long-term ionospheric predictions for frequency planning at present provide estimates of median values of usable frequencies on a world-wide basis, which appear to be good when transmission is by F2 layer, or E or F1 layers. Neither the variation about the median, nor effects of sporadic-E ionization nor the effective heights of reflection are well predicted. Sporadic-E and elevation angle predictions are of first order importance in planning of frequencies and antennas; there are a number of examples of costly transmitting and receiving installations which could obtain more effective performance, and cause less interference, if design of antennas and choice of frequencies could be based on improved predictions.

An interest is developing for short-term predictions to allow effective exploitation of a regional pool of frequencies under common control. The Defense Communication System employs "oblique sounders" in a common user configuration to provide current observations of usable frequencies on a few selected paths. Both the DCA and the Navy have sponsored studies at ITSA in short-term predictions which make use of pooled observations in a region, with correlation techniques and ionospheric indices used to predict conditions a few hours forward. These are far from operational systems; to provide reliable short-term predictions even for a limited region requires a significant development of prediction technique, indices and sensors. For high-frequency broadcasting applications techniques are being developed for current observation of coverage areas and usable frequencies. Their operational usefulness will depend on possibilities for flexibility and coordination internationally.

Perhaps the most important, and possibly most difficult, series of problems requiring study in the HF band are those of describing propagation of waves traveling through the dynamic, irregular ionosphere, and of determining the characteristic disturbances and perturbations imposed. Answers to these problems are especially important to the effective use of this portion of the spectrum for detection, direction finding, and radar systems, as well as for "signal design" for transmission.

An intriguing and potentially important phenomenon at HF concerns "low-angle" transmission. Where antenna design has been such as to radiate and/or receive effectively at low elevation angles, there have been observations of significantly increased reliability and strength of signals. Typical HF antennas do not respond effectively at low angles, except where high sites are involved, or vertical polarization is used over sea water (relevant to ship and buoy application). So far the phenomenon is not well enough understood to permit reliable estimate of the advantages obtainable in frequency utilization or system performance.

A number of these problems might be investigated using a large, highly directive, steerable antenna array, capable of operating in a bi-static or mono-static radar mode. Such an array, with the necessary instrumentation, has been suggested as a possible national facility for ionospheric telecommunication research; it would provide the experimental sensitivity and flexibility for investigation of many of the specific questions discussed above, such as the "low angle" and "irregularity" problems. The system would have to be capable of high resolution, steerable in azimuth and elevation, with sufficient transmitter power and receiver sophistication to achieve a new level of sensitivity and resolution in ionospheric propagation studies.

At frequencies below about 1 MHz there is continuing strong interest in propagation studies in relation to navigational systems employing pulses or phase comparison, as well as for communications and standard time/frequency transmission. Geophysical observation and exploration make use of frequencies all the way from fractional cycles per second through medium frequencies (above 1 MHz). The basic limitation on the performance of VLF navigation and frequency dissemination systems is the phase fluctuation imposed by irregularities in the lower ionosphere. Little is actually known about the properties of the fluctuations, or about the irregularities causing them. There is especially a need for descriptions of the correlation of the fluctuations in space, time, and frequency. At medium frequencies the behavior of the ionospheric wave is still not very well understood for some practical needs--for example, a good understanding of the reflection coefficient in the standard broadcasting band as a function of frequency and geometry is lacking. This lack prevents confident prediction of extended frequency sharing extended through sunrise-sunset hours for AM broadcasting.

Electromagnetic Noise Environment

The minimum signal level required for satisfactory reception in the absence of interfering signals is determined by the ambient electromagnetic noise. Throughout most of the usable radio spectrum, in built-up areas of population and industry where telecommunication services concentrate, man-made noise is usually the limiting factor, assuming good receiver design. In lower regions of the spectrum, natural noise limitations may prevail but are now well known. At frequencies below about 25 MHz, atmospheric noise usually limits; the atmospheric noise has been studied throughout the world for a number of years, and the CCIR has issued reports which serve adequately for most spectrum utilization considerations. An exception is the need for directional characteristics of the noise for new high-resolution systems at HF. At frequencies between about 25 and 150 MHz, galactic or solar noise is usually limiting in quiet receiving locations, but these levels are also adequately established for most telecommunication purposes.

Man-made noise originates in electrical equipment and lighting, transportation, industrial and power systems, auto ignitions, and many other sources including spurious emissions from radio receivers and transmitters. While some measurements are available, information on the level and effects of man-made noise is quite sketchy; at present, results obtained by different investigators are even difficult to compare because of differences in measurement techniques and conditions. An important deficiency in knowledge of electromagnetic noise as a limitation to telecommunications, and the main pollutant of the frequency spectrum, has been cited by other principal studies. The presence of such noise may require in cities a hundred to thousand times the transmitter power, in many applications such as mobile radio, compared to limitation by natural or receiver noise. The use of such higher transmitter power itself contributes additional interference through introduction of non-linear effects. Determination of the sources and levels of man-made electromagnetic noise, and prediction of the future increase with growth of population and industrialization, as well as of the effects of this noise on telecommunications systems, is needed to guide effective utilization of the spectrum and to consider counter-action, including the possible needs for legislation or regulation. The CCIR programs and FCC questions (Appendix 3) suggest specific technical data and methods of measurement needed.

Antennas

Directional confinement of radiation and reception is another dimension and technique for spectrum conservation. In some regions of antenna design, however, where large structures are involved, it is often economical to invest in transmitter power rather than costly antenna directivity or advances of technology for obtaining antenna directivity economically. Important examples are at frequencies below 1 GHz, but especially below 100 MHz.

A great deal of antenna research in industry and government carried on toward specific system objectives is also highly relevant to efficient spectrum utilization. Research in antenna principles is also an attractive and natural field for academic work. A fostering of a portion of such studies on behalf of the broadest objectives of efficient spectrum utilization, as well as interpretation of the relevance of the results of many laboratories active in this field, should be an important feature of an adequate government program for spectrum conservation.

In the reviews presented to the Panel, it was indicated that large phased (including non-uniform) arrays and wire grid lens antennas offer promising characteristics for applications to many services in the lower frequency portion of the spectrum. Special attention to side lobe control is needed, which is often deemphasized in design of non-radar systems because of costs incommensurate with direct benefit to the using system. In the higher frequency portions of the spectrum, work on the focal region of large reflector antennas could lead to directional capabilities comparable to optical telescopes, with implications for reducing time and bandwidth in radar systems, and orders of magnitude improvements in information and range capacity of communication circuits. Other important possibilities exist in the adaptive or data processing antennas of both array and reflector types.

NETWORKS AND NON-LINEAR EFFECTS

A really major technical constraint on density of utilization of the spectrum is the problem of avoiding interference to a weak signal received in the presence of strong signal, at a different frequency or even in a different band, emitted nearby geographically. Ideally, wave filters might prevent such interference, except for the cost of advancing the technology for adequate filters, the requirements of which are made severe by non-linear characteristics encountered in receivers. Spurious emission from transmitters, and its reduction by filtering and improvement of linearity of networks, is an analagous problem.

Advances in economical linear, narrow band filters, introduced in future equipments with commensurate improvement in frequency stability, could permit significantly greater density of utilization, especially at frequencies above 100 MHz.

TECHNOLOGY FOR MILLIMETER WAVES AND BEYOND

The technology of sources, detectors, antennas and components for millimeter waves today corresponds roughly with that of microwave technology early in World War II. The potential utility of millimeter wave systems has long been hoped for, but research has not been really intensive. Progress is slow, and most serious applications are scientific. At frequencies much above 100 GHz, "breakthroughs" are awaited to advance both source and detector technology into really useful power and sensitivity ranges.

At frequencies below 100 GHz, substantial increases in power levels and efficiency of sources have been realized since 1960, especially using electron tube sources. Powers of the order of 100 watts (CW) or more can be obtained at 100 GHz, decreasing to less than a tenth of that at 150 GHz. A sub-millimeter gas laser using water vapor excited by pulsed electrical discharge, and several other gases using either CW or pulse, produces powers of the order of a watt in the 100 to 1000 micron region. (300 GHz). Gas laser research in this frequency range is very young, with relatively few experiments done on a limited number of gases, with most of the effort so far to identify emission rather than optimize power. Gas lasers appear to represent a hope for useful generation of power at submillimeter waves. Power generation by transistor, varactor multipliers and chains, appears to be at about the 10 to perhaps 100 milliwatt level at 100 GHz.

Point-contact diodes familiar in early radio and microwave uses remain in various forms the principal millimeter detector, modulator, and parametric amplifier. Overall receiver noise figures of about 15-20 dB are attainable at 50 GHz. As frequency is increased, fundamental limitations are encountered due to the diode's inherent barrier capacitance, spreading resistance, and parasitic lead inductance. Thus the minimum dimensions reached lead to fragility, short life, and poor noise figure. Alternative possibilities which show some promise include use of the distributed structure of bulk semiconductor. Some maser experiments have been done, and theoretical work on "quantum detectors" using paramagnetic materials, to down-convert the high frequency energy to microwaves where sensitive detectors are available.

Millimeter wave antennas are primarily parabolic reflectors, Cassegrain systems, and lenses. While some surface tolerance problems arise because of the small physical dimensions, these antennas can have greater directivity and much larger gain per unit cost than lower frequency microwave antennas. Atmospheric absorption noise tends to reduce the criticality of antenna noise (losses and side lobes).

Reviews for the Panel stressed the need for greater attention to thermionics and power supplies for tubes, but suggested that solid state research was adequately supported. The importance of development of reliable solid-state repeaters to enable any extensive telecommunication use was indicated.

The Introduction to a Special Issue on Millimeter Waves and Above of the Proceedings, IEEE, April, 1966, noted that "The potential of millimeter waves for a variety of uses has long been recognized. However, repeated disappointments at the slow progress of technology have tended to inhibit a favorable evaluation of any single step forward. The attendant lack of interest has fostered a correspondingly small scale of effort."

It would appear that a major incentive for great strengthening of research and development for "millimeter waves and beyond" lies in the objective of fostering overall improvement of spectrum utilization.

ALTERNATIVES: CABLE, WAVEGUIDES

Confined media, such as cable and waveguide, are technical alternatives to radiation in the spectrum. Point-to-point services already make extensive use of cables, with the choice determined on economic grounds which depend on the transmission circumstances. There are, technically, other potential applications for cable, as for broadcasting/television distribution in populous areas. "Leaky waveguides" or surface transmission lines are possibly feasible media for high capacity communication and control for trains, and motor vehicles along main routes.

ENGINEERING METHODS, TECHNICAL STANDARDS, OPERATIONS ANALYSIS FOR SPECTRUM MANAGEMENT

The engineering methods and technical standards related to the allocation and assignment process are primarily concerned with the avoidance of interference--propagation, antennas, bandwidth, protection ratios, selectivity of receivers, frequency stability and spurious emissions from transmitters. These nowadays are topics in "electromagnetic compatibility." There are a number of technical possibilities for realizing increased utilization--the JTAC studies have endeavored to define this very complex problem, to identify important approaches, the need for careful dimensioning of spectrum utilization, and the need for a vast amount of data to describe actual usages in a useful way. Reviews presented to the Panel by the FCC, the DTM, Commerce ITSA, and the Defense ECAC all stressed the importance of sophisticated computation for frequency sharing, the need for advancing (in some cases just defining) technical standards, and the potential usefulness of operations analysis applied to administration of telecommunication utilization of the spectrum. The suggestions will be reviewed briefly. However, the Panel has considered carefully the question of the potential value of any or all of such technical measures, and is convinced that the assessment of such values would require extensive data and analyses of a cost-benefit character; the needed analyses have not been done, and were not feasible in the present study--much of the needed basic data is not readily available or has not been collected.

The JTAC has characterized the general engineering aspects of spectrum administration as involving:

-- assignment of frequencies

-- short-term compatibility planning

-- spectrum utilization policing

-- requirement of improved equipment specifications to reduce spectrum used

-- resolution of overloading problems experienced in the field

-- solution of interference problems experienced in the field

-- provision for additional equipment deployments

Engineering Methods Including Computer Applications for Frequency Sharing

The DTM has outlined a program to apply computer techniques to frequency management; programming of an initial phase is scheduled for completion in the next few weeks, intended to support day-to-day frequency assignment activities, providing magnetic tape, file maintenance and information retrieval, and related printing and publication functions. An "engineering model" proposed for later incorporation into the system would provide central engineering review of frequency assignment requests for HF point-to-point services.

The FCC maintains a computer file of non-government frequency assignments, providing data on punched cards. The International Frequency Registration Board maintains magnetic tape records of frequency uses notified by various countries. The ECAC of the Department of Defense represents the present most detailed and comprehensive effort to establish a data base and analytic capability for assessing frequency sharing, including environmental files (present utilization), equipment characteristics filed (nominal characteristics and spectrum signatures from measured data) and terrain data filed.

The JTAC[5] has identified present dimensioning of spectrum utilization as completely inadequate for really effective analutical efforts toward frequency sharing. Dimensioning is primarily in terms of frequency, and that provides only a small segment of the total picture. Usually, only an inference of the geographical space utilized is obtainable from the power, antennas, and geographical data supplied. R. P. Gifford[27] has observed the need for a standard unit of spectrum space utilization that is based on a specified level of radiated energy density over a specified bandwidth over a specified geographical area; the allocation of a natural resource seems difficult to administer without careful attention to meaningful standard units of measure.

These approaches are potentially of enormous complexity and cost (consider ECAC, for example) and suggest the need for vast amounts of data, highly sophisticated analytical methods, and large, intricate computing programs. Progress has been slow and to date barely penetrates the potential technical depth and breadth of the problem.

Technical Standards

Both the FCC and the DTM have cited the need for better defining and further advancing standards of performance and methods of measurement for systems using the spectrum. Included are topics such as optimum channel width for particular service; possible adjacent carrier interleaving; performance characteristics of receivers, transmitters, and antennas; radio frequency interference from non-telecommunications devices; monitoring and measuring of emissions. At present, FCC must rely on industry guidance and limited laboratory evaluations for technical standards. DTM interest in technical standards for government utilization give some emphasis here to radar engineering design objectives; other important topics concern spurious emissions, basic characteristics of single sideband equipments, narrow band FM transmission standards, and minimum performance requirements for transmitters, receivers and antennas operating in the various classes of service. The DTM information on technical standards is obtained largely from the user-agency members of IRAC.

Operations Analysis

The Panel has observed that many of the problems of frequency utilization are administrative, or administrative-technical, rather than purely technical. Scientific assistance in these areas is also available; it is likely that systems analysis and operations research would be as useful to the administering of the utilization of the electromagnetic spectrum as they have been found to be in industrial and military administration.

It would require study, of course, to determine how useful these tools could be in providing guidance to the allocating and regulatory authorities, and to develop more appropriate techniques if needed. There is a qualified group in existence at the National Bureau of Standards, which could carry out some of this study and could contract out other portions as deemed necessary. The investigations should, of course, be carried on in close collaboration with the allocation and regulatory authorities, with one or more of their staff as a part of the team carrying out the analyses.

By bringing to bear the techniques of communication theory, probability, and operations research, such questions as measures of value of various parts of the spectrum, and measures of effectiveness of utilization could be investigated, and procedures to share efficiently the spectrum in time, space, and frequency. These studies might also suggest ways in which modern computers could assist in data gathering and analysis, and could assist decision making by using computer simulation to try out the consequences of various possible sharing and allocation schemes.

IV. FINDINGS AND RECOMMENDATIONS

IMPROVING EFFECTIVENESS OF SPECTRUM UTILIZATION

The Panel recognized early in its study that there were several ways by which additional research might lead to the overall effectiveness of utilization of the electromagnetic frequency spectrum. The most obvious examples of these are listed below--the first four are evolutionary technical steps:

(1) The extension of the usable regions of the spectrum. This involves doing the research and development necessary to make new regions of the spectrum available to new or existing services.

(2) Increasing the "technical" capacity of given telecommunications channels. This involves research in the fields of propagation, telecommunication systems, and information theory in order to obtain the transmission of the maximum number of bits of information in a given time through a given channel used by an aggregate of systems.

(3) Increasing the efficiency of operation of a given telecommunication function. This involves the objective analysis of the telecommunication function to be performed in order to minimize the amount of transmitted information needed to accomplish the function.

(4) Vacating the spectrum by transferring the telecommunication function to a non-atmospheric form of transmission.

(5) Optimizing the use of the total complex of telecommunications capabilities on the basis of the overall value to the nation.

The presentations made to the Panel during its study made it clear that there is a variety of natural incentives to provide continuing progress on the first four of these examples. Defense and other agencies of the Federal Government and the scientific and business communities of the nation are all expending considerable effort which will ensure that this progress will continue into the future. Furthermore, it is possible to establish some quantitative evaluation of that progress in technical or economic terms if the evaluation is restricted to a sufficiently specific situation. It is also to be noted that while the approaches indicated in the first four examples are important components of the overall optimization of the use of the spectrum, they have tended to be executed independently of it.

In contrast, however, under example (5) there is a clear lack of adequate natural incentives to provide an "evolutionary" optimization and an almost complete absence of the quantitative means needed to provide a logically determined optimization.

ECONOMIC ASPECTS OF OPTIMUM SPECTRUM UTILIZATION AND RELATED RESEARCH

The first charge to the Telecommunication Science Panel was to answer the question:

> "1. What research and technical service programs directed toward more efficient utilization of the electromagnetic frequency spectrum for telecommunications are needed . . .?"

The key word in that question is "efficient." Clearly some cost benefit relationship must ultimately be the decisive factor in choosing alternatives for advancement of system technology, intensification of frequency sharing, or exploitation of new regions of the spectrum. The relevance of technical advances, and the incentive for fostering them, are mainly economic. In order to specify what research and technical service programs will result in more efficient utilization of the frequency spectrum, one must have a criterion or criteria for distinguishing more efficient configurations from less efficient ones. Early in its deliberations, the Panel found itself struggling with that question in a variety of forms.

Perhaps the most apparent of these is the problem of competing uses for frequencies. Although reallocation was not a subject for consideration by the Panel, a number of briefings contained explicit or implicit suggestions that the need for research and more stringent technical measures could be partly alleviated by providing certain services more spectrum space at the expense of others. Such suggestions run squarely into the criterion problem. How does one decide whether it is more "efficient" to allocate fewer frequencies to broadcast TV, and more to land mobile service, or vice versa?

More subtle, but also more relevant to the Panel's deliberations is the question of whether, or to what extent accommodating more users through research and development is equivalent to more effective use of the spectrum. Research and development is not a free good. It always entails a cost, and the spectrum is being used more effectively only if in some meaningful sense the value of the rights created exceeds the R&D costs.

Even if the R&D costs are ignored, many suggestions for more intensive use of the spectrum impose costs on current users either in a form of modifications to existing equipment, or in increased levels of interference, and some criterion is required if one is to say whether the additional use compensates for these costs imposed.

Frequently, criteria are explicitly suggested with little appreciation for what their acceptance implies. One rule often advocated, for example, is that no service should use the frequency spectrum if it is possible to provide that service without utilizing it. If this rule were taken seriously, many current uses of the spectrum would be forbidden. For example, it is physically possible to supply broadcasting services to homes and buildings entirely through wire systems, and similarly telephone could be provided entirely through wire and cable systems.

Two other unworkable criteria that are sometimes suggested deserve mention. One of these is "maximizing the use of the spectrum;" another is "minimizing interference." An ultimate minimum of interference is achieved when there is absolutely none, and it is difficult to defend that situation as optimal. (Indeed the heart of the problem of criteria is in a sense trying to specify what is the optimal amount of interference.)

Maximum utilization of the spectrum is an equally empty concept, since it also gives no hint as to what level of interference is acceptable. A more sophisticated criterion, often proposed in suboptimization of systems, is that of maximizing the flow of information through a channel in a given period. Taking that dictum seriously implies that costs are irrelevant, since at some cost one can almost always increase the amount of information put through a channel per unit time.

All of these examples of the difficulties encountered in considering the criterion problem are simply a reflection of the fact that the right to radiate energy, i.e., use of the frequency spectrum, represents use of a scarce economic resource. In recent years there has been a growing recognition of this fact, and more and more attention has been focused on efficient or optimal use of the spectrum. The 1964 JTAC report states ". . . today we find ourselves faced more than ever before with the problem of how to use the spectrum efficiently and effectively for the greatest possible good." Unfortunately, such statements have generally not been accompanied by clear declaration how one decides what is optimal, i.e., what is more or less efficient.

Recognition that frequency spectrum is an economic resource immediately raises the question of what criterion is applied in deciding how other economic resources will be used. For example, what criterion is applied in deciding whether a particular parcel of land is used for production of corn or wheat, or whether a particular hour of labor will be used to produce automobiles or refrigerators. The answer to this question has been the subject of intensive study by economists at least since the days of Adam Smith. They have developed a criterion that is widely accepted not only among economists but as an integral part of the organization of our economic system. This is not the place for detailed discussion of how the economic system operates, but a general statement about how means of production are allocated among competing uses is central to the criterion discussion.

Generally speaking, individuals and firms have rights in resources like land, labor and capital--rights that are transferable. Gains or losses resulting from the way these resources are used accrue to or are imposed on the individuals and firms to whom the rights belong. Because individuals and firms bear the consequences of their actions, they have an incentive to use the resources at their command in a way that will maximize their value. Moreover, since rights are transferable, individuals and firms can make exchanges if such exchanges are deemed to be advisable by both parties to the exchange. The result is a tendency for resources to be employed where their value is a maximum. If a parcel of land is more valuable in the production of corn than in the production of wheat, some corn grower will acquire the right to use the land and will employ it in growing corn. The same statement holds for other means of production. In general, resources tend to be attracted into the production of those commodities in which the value of the resources is a maximum.

Thus, for most of the nation's resources, the criterion that is used to discriminate less efficient configurations from more efficient ones is the value of the resource in the particular use in question. More efficient use coincides with higher value and less efficient use with lower value.

Of course, the extent to which the economic system achieves optimal utilization of resources, i.e., utilization that maximizes the value of resources available, is a question of fact, but we are not concerned here with how closely that objective is approximated, we are only concerned with what criterion is employed in deciding how other resources will be used in our economy.

Frequency spectrum regarded as an economic resource is in no important respect different from most other economic resources. What is different is the way individual rights to radiate energy are defined. It is important to recognize that individuals and firms do acquire rights in frequencies just as they do in other resources. The primary distinction is that rights to radiate usually are not transferable. The major exception is broadcast rights which are defacto transferable as a part of the sale of stations. Because of the limitation on transferability, it is difficult or impossible in most instances to determine the value of any particular piece of the spectrum. For other resources, the transfer of rights from one firm to another or from one individual to another reveals the value thereof. A measure of the value of any particular parcel of land, or a barrel of oil, or a ton of steel, is generated in the process of selling these resources. No comparable measure of value is available in the case of frequency spectrum.28 It is this deficiency that lies at the heart of the problem faced by the Panel, and has been largely responsible for the Panel's recommendation that an organization be established which would include economic studies in its program. One of its primary assignments would be to elicit ways for assessing the value of individual units of frequency spectrum, i.e., of specific rights in radiation.

It is important to emphasize that it is the marginal value of frequency rights that is relevant in making decisions about utilization, rather than aggregate value of the spectrum. The aggregate value of water to our society is no doubt very large. If water were so scarce that it was used only for drinking, the price of a gallon of water would be very high. In truth, however, while water is a scarce resource it is nonetheless plentiful enough to be used not only for drinking but for bathing, laundry, maintaining lawns, etc. The value of a gallon of water is thus determined by what people would pay for an additional unit in any one of these uses. The water example parallels the case of the frequency spectrum. The relevant criterion in deciding the frequency utilization or efficiency question is the marginal value of spectrum in various potential uses, not the aggregate value of spectrum.

If the Panel had had at its disposal information regarding the marginal value of spectrum in various uses, it would have been in a much better position to make recommendations about alternative R&D programs. When the inherent uncertainty about how particular R&D programs will turn out is compounded with the lack of a measure of value of the spectrum, the task of intelligently evaluating alternative programs is beyond the bounds of reason.

In summary, the Panel's study led to certain observations with regard to the allocation and assignment procedures.

(1) While economic and social considerations, as well as matters of national interest and security are undoubtedly part of individual specific frequency assignment deliberations, normal economic processes cannot operate in this situation to achieve a natural optimization of the overall use of the spectrum. The resource is dispensed essentially without charge for its use. Filing fees do no more than cover some of the administrative costs of issuing and recording the licenses and do not reflect the economic value of the use of the resource. The domestic organizations which have the responsibility for the allocation and assignment of frequencies also have the responsibility for optimizing the overall use of the spectrum on the basis of the value to the nation. Unfortunately, in addition to having inadequate natural forces tending to bring about an optimum distribution of use, they lack the tools needed to develop the objective analyses which must precede any logical and deliberative determination of the optimum.

(2) Science and engineering play important roles in the allocation and assignment procedure. They make newly-usable regions of the spectrum available for allocation, but also develop new

services which make additional demands on the already allocated parts of the spectrum. They establish the technical standards which the allocation and assignment processes must respect if a telecommunication service is to operate at tolerable levels of harmful interference. However, while science and engineering originate the possible alternatives for allocation and establish the technical constraints which must be satisfied, they have relatively little leverage in the final choice among alternatives and therefore exercise minor influence on the optimization of the overall utilization of the spectrum. At the same time, the allocation and assignment process with its attendant establishment of technical standards and of investment generated inflexibilities, tends to remove any incentives for making technological contributions which would lead to more effective overall spectrum utilization. In fact, the total amount of research activity in technology seeking primarily to increase the overall effectiveness of spectrum use is exceedingly small relative to its potential national significance.

(3) Procedurally the allocation and assignment process appears to be quite adequate for the purpose of improving the overall effectiveness of the spectrum. In fact, if the regulatory agencies could be provided with appropriate information and analysis their procedures can provide considerable incentives for specific technological developments for improvements in spectrum utilization.

The Panel's hope is that the organization recommended here will not only lead to a balanced research program but will provide interested agencies estimates of the value of spectrum that can be employed in making policy decisions.

TECHNOLOGY AND SPECTRUM UTILIZATION

There are many and varied scientific and technological programs in progress in the nation which have some impact on the utilization of the electromagnetic spectrum. The Federal Government, industry, and the universities, all participate in this activity. The objectives of the work are extremely diverse and range over such fields as satisfaction of a large military mission requirement to the generation of additional commercial business and to the desire to acquire greater scientific understanding.

The impact on the overall utilization of the spectrum can vary widely. For instance, it can result in the provision of additional service within a specific assigned channel as in the case of the various multiplexing schemes being applied in FM broadcasting, or it can require the exclusive use of enormous regions of the spectrum as in the case of some special high definition radars.

While appreciable scientific and technical effort is directed to improving the effectiveness of a specific service within specific frequency channels, a very small part of the total technical effort is directed to the problem of improving the overall use of the spectrum.

The Panel had little difficulty in identifying a number of projects, reviewed in Section III, which might be component parts of a research program to correct this situation. However, all its attempts to develop a recommendation for a rational and balanced program (or even a very rough approximation to one) ended in complete frustration. A program could have been developed which might very well have been accepted on the strength of the recommendation of the Panel. In truth, it would have been no more than an unsubstantiated group opinion. The difficulty here, as in the allocation and assignment procedures, lies in the dearth of quantitative data necessary to make value judgments as to the total magnitude of the required program or as to the relative emphasis and therefore, support to be given the component projects.

CONCLUSIONS

On the basis of the data accumulated, and of the relevant discussions, the Panel reached certain basic conclusions:

(1) Means of improving the overall efficiency of utilization of the electromagnetic spectrum are urgently needed--in fact, the situation is critical. This confirms similar conclusions reached by other study groups.

(2) It is inevitable that further portions, if not all, of the electromagnetic spectrum will become saturated. Better organized and more informed judgments as to the relative values of the various telecommunications services to the nation will be required for the spectrum allocation process and for the organization of research

projects directed primarily to more effective overall spectrum utilization.

(3) It is essential that planning and research be organized now in economics and sociology, and be expanded in science and technology, if the nation is to have the tools it will need to make intelligent decisions with regard to spectrum utilization in the future.

(4) The absolute value of the electromagnetic frequency spectrum to the national welfare is enormous. For instance, the part of the GNP produced directly by the manufacture and operation of just those telecommunications systems which use the atmosphere for transmission is estimated to be approximately $20 billion per year. The total significance of telecommunications to our society, economy, and national security is obviously much greater than this basic figure would indicate. Air transport is a typical example among the several industries in which the present operations and future development are critically dependent on the use of the electromagnetic spectrum.

(5) The development of the electromagnetic spectrum as a national resource has many facets and there are many incentives in government, industry, and universities to continue its development. But the total research and engineering expenditure on the specific problem of increasing the overall effectiveness of the spectrum, particularly of the already exploited frequency ranges, is remarkably small, being only a few hundredths of one percent of the value of the dependent industry.

(6) The inflexibilities resulting from the allocation procedures operating in an environment from which important natural economic processes are absent, the many dimensions involved in the basic judgments affecting the situation and the absence or unavailability of many data necessary to the formulation of intelligent recommendations, give this problem a magnitude and complexity which take it beyond the possibility of resolution by the Panel or any other *ad hoc* group.

PANEL RECOMMENDATION

The preceding summary of the Panel's deliberations and the supporting information contained in the full report show that the Panel identified and focused on two very basic shortcomings in the present situation:

(1) Completely inadequate quantitative measures of the relative value to the nation of existing and future telecommunications services.

(2) Grossly inadequate technical programs aimed specifically at improvement of the overall effectiveness of the utilization of the spectrum.

On the basis of these findings, the Panel makes the following recommendation:

That the Federal Government develop a research organization which has as its primary objective the improvement of the overall effectiveness of utilization of the electromagnetic spectrum; that the recommended organization be operated and financed at levels commensurate with its potential value in the national interest; and that the recommended organization will:

(1) Provide the Director of Telecommunications Management, the Federal Communications Commission, the Department of State, and all the other government, industrial, and academic institutions having interest in telecommunications, with the economic, social, and technical information and analyses necessary to provide a valid basis for judgments which affect the overall effectiveness of use of the spectrum.

(2) Identify and stimulate those technical research programs which are essential to the improvement in the overall effectiveness of the use of the spectrum and execute or sponsor those which, for any reason, are not likely to be included in the related scientific and technological research programs of the nation.

FURTHER RELEVANT DISCUSSION CONCERNING THE PROPOSED ORGANIZATION

General

The Panel envisions a research organization highly motivated to perform its mission of developing the tools which are indispensable to the deliberative determination of the optimum use of the spectrum, but which do not presently exist. The organization will perform its mission in cooperation with, and as a service to, its "customers," viz:

(1) Government policy-making and regulatory agencies.

(2) The telecommunication industry.

(3) The "telecommunication user" organizations in government and industry.

(4) The research and development community in government, industry, and academic institutions.

This organization must be differentiated from the large number of other organizations with related missions by its dedication (a) to research on the overall problem of spectrum utilization--not on any specific segment of it, and (b) to the development of the necessary tools--not to their application.

Proposed Program

The Panel's concept of the nature of the proposed organization can probably be communicated most easily by describing, in quite general terms, the program which the Panel considers appropriate for it:

(1) Identify the specific activities in the nation in which telecommunications play a role and develop an understanding of the role played. The list should be complete and include all activities related to the nation's economy, society, culture, and security, etc.

(2) Develop quantitative measures of the relative values to the nation, at present and in the future, of each of the identified activities.

(3) Develop quantitative measures of the dependence of each of these activities and their respective rates of growth on telecommunications.

(4) Develop, from the above efforts, relative quantitative values to the nation of each type of telecommunication service and more specifically, the value of each type of service to each activity in which it plays a role.

(5) Develop appropriate methods by which the information and conclusions generated by the above efforts can be disseminated to, and be accepted by the organization's "customers."

(6) Identify the technical opportunities in the future development of telecommunications, determine the degree to which they may be dependent upon the availability of frequencies, and develop measures of their relative importance in enhancing the growth of the nation.

(7) Stimulate and execute or sponsor research and development programs which will supplement already existing programs to the extent needed to bring the nation's total effort on each of the technical opportunities into balance with its measure of importance.

The Panel is very aware of the magnitude of the difficulties and complexities inherent in this program. In fact, there is no implied guarantee of success. Nevertheless, the Panel has the conviction that given a few individuals of sufficient intellectual brilliance, adequately motivated towards making important contributions to the program, the probability of success is sufficiently high to justify making a start on it. The alternative is to accept the fact that at some time in the future, the lack of telecommunications must be a major factor in limiting the rate of growth of the nation.

Some Criteria for Establishing Proposed Organization

The Panel members who, in aggregate, represent a great many years of experience in the establishment and administration of research and development programs of similar complexity believe that a reasonable probability of success can be assured only if certain criteria are satisfied in choosing a "home" for the organization.

(1) The program is of such complexity and difficulty that successful execution requires a single-minded dedication which must not be diluted by day-to-day operating responsibilities, nor by uncertainties as to the degree of loyalty required by the traditions or the other responsibilities of the parent organization within which the program is developed.

(2) The success of the program is critically dependent on the quality of the individuals executing it, on their motivation, and on their dedication to the attainment of its objectives. The attraction, selection, and utilization of such individuals must avoid any limitations which might be imposed by the "image" or traditions of the parent organization.

(3) Success in developing tools for its "customers" is of no value unless the "customers" find the tools acceptable and actually use them. This requires that the organization providing the tools develop an accepted reputation for a high level of competence in its specialized

field and for complete objectivity in that field.

(4) The success of the program will also be dependent on the organization having access to all of the information it needs. This requires that the organization develop an accepted reputation for independence as well as for competence and objectivity.

(5) The organization must be free to work in complete cooperation with all of its "customers."

Reporting Relationship

We well realize that discussion of location for any new organization is always a "touchy" subject. In making the following suggestion, the Panel was torn between its desire to be helpful and a risk of distraction from the basic content of its recommendations.

These thoughts, therefore, are offered on the premise that attention will be given to this reporting relationship matter only after adequate discussion has confirmed the need for the recommended type of work.

After considerable, but not exhaustive discussion, the Panel concluded that if the organization were developed by the Secretary of Commerce and operated at a high level within the Department of Commerce, it could satisfy the above criteria. There are several other factors which give strong support to considering the Department of Commerce as the "home" for the proposed organization.

(1) The main mission of the Department relates to the overall economy of the nation.

(2) Much of the raw economic data and many of the processes for obtaining the new data required by the organization already exist in the Department.

(3) The Department can be objective since it is not primarily a using agency and since it has no direct allocating or regulatory responsibilities with respect to telecommunications.

(4) The nuclei for some of the basic technologies and research activities already exist within the Environmental Science Services Administration and National Bureau of Standards with are parts of the Department of Commerce.

The Organization's Life Cycle

It should be recognized that the proposed organization will have two major phases in its life history. The initial phase, which can be expected to last between five and ten years, will be largely a research effort in which methods of data collection, processing, and analysis will be developed and tested in a dedicated effort to provide some new and badly needed tools. If the organization is successful in developing some useful and accepted tools, its mode of operation will evolve into a second phase in which the information will be collected, analyzed, and disseminated routinely and the further development of the methods will become a slower process of refinement. Obviously, the transition from the initial to second phases will take place slowly.

Nevertheless, it should be recognized from the beginning that the types of management and staff required in these two phases are quite different. For instance, temporary (three to five years) appointments of experienced and recognized leaders in the field could be used initially to fill the key positions in both the management and the staff. Similarly, the Panel concluded that the organization should not attempt, in the beginning, to carry out all of its functions primarily in-house. In addition to its own activities, the staff would take the responsibility for promoting programs in appropriate organizations, for coordinating the results, and for developing supplementary efforts carried out under direct contracts in industry, universities, and in other government agencies. This total approach would guarantee good communications with industry, the government, and with the universities and have the by-product of developing a supply of individuals with training and interest in the field of spectrum utilization. Many of the staff of the proposed organization in its later phase might come from this supply.

Budget

The Panel found it impossible to determine the "correct" budget for the initial operation of the proposed organization. To do this requires the same tools which the organization is being established to develop. This did not disturb the members since it was a familiar problem to many of them. It was recognized that, initially, expenditures would be limited by the difficulties of attracting personnel of appropriately high quality and of establishing a valid program. At this point the magnitude of the intended support is important primarily as an indicator of the importance which the Government attaches to the program. The Panel proposes initial annual investments supporting growth to the $10 million level.

Appropriate growth beyond this initial level will be determined by careful appraisal of the data generated by the early studies. The final level of support (and indeed, the continuation of the activity as proposed) should be determined by demonstrable positive impact on the telecommunication services of the nation. It should be pointed out that, assuming that the organization is successful, an annual budget of $50 million would not necessarily be excessive since that sum is a modest ¼ of one percent of the part of the GNP generated by atmospheric telecommunications.

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APPENDIX 1

CONTRIBUTORS TO TELECOMMUNICATION SCIENCE PANEL MEETINGS

January 26 - 27 Meetings

Subject	Contributor	Organization
Study of Telecommunication Sience and the Federal Government	R. C. Kirby	Department of Commerce
Summary of Federal Communications Commissions Activities and Needs	R. J. Renton	Federal Communications Commission
ITSA and the Telecommunication Science Study	Dr. C. G. Little	Department of Commerce
Descriptive Functions of the Director of Telecommunications Management	F. W. Morris	Office of the Director of Telecommunication Management
Review of the Department of Defense Organization for Telecommunications	Col. E.J. Quashnock	Department of Defense

March 8 - 9 Meetings

Subject	Contributor	Organization
EM Wave Propagation at Frequencies Below 30 MHz	W. F. Utlaut	Department of Commerce
Status of Research in Modulation, Detection, Coding and Noise Below 30 MHz	Dr. E. J. Baghdady	ADCOM, Inc.
Antenna Research for Improved Utilization of the Electromagnetic Spectrum Below 30 MHz	Dr. R. L. Tanner	TRG, Inc.
Character of Present Operations and Trends in Telecommunications at Frequencies Below 30MHz	W. H. Watkins	Federal Communications Commission
New HF Communications Systems and Applications	R. A. Kulinyi	United States Army Electronic Laboratory
Broadcast Services	G. Jacobs	United States Information Agency
HF Radars	A. VanEvery	Department of Defense
Systems at Frequencies Below 500 KHz	A. D. Watt	DECO Electronics, Inc.
Ocean Data Service	J. M. Snodgrass	Scripps Institution of Oceanography
JTAC Committee 65.1 Prospective Uses of the Spectrum	D. Hull	Electronics Industries Association

April 6 - 7 Meetings

Subject	Contributor	Organization
Electromagnetic Wave Propagation and Prediction at Frequencies 30 MHz to 10 GHz	J. W. Herbstreit	Department of Commerce Environmental Science Services Administration, Institute for Telecommunication Sciences and Aeronomy
Information Transmission	W. E. Morrow	Massachusetts Institute of Technology, Lincoln Laboratories
Antennas at Frequencies Above 30 MHz	C. J. Sletten	Air Force Cambridge Research Laboratory
Survey of Telecommunications and Trends at Frequencies Above 30 MHz	W. E. Plummer and R. Cutts	Office of the Director of Telecommunications Management; Federal Communications Commission
Defense Satellite Communications	T. F. Rogers	Department of Defense
Satellite Communications	S. Reiger	Communication Satellite Corporation
Satellite Communication Technology	J. J. Kelleher	National Aeronautics and Space Administration
Radar Systems	R. D. Mitchell	Radio Corporation of America, Missile and Surface Radar Division
Air Navigation and Communications	G. M. Kanen	Federal Aviation Agency
Land Mobile Communications	W. J. Weisz	Motorola, Inc.
Telecommunications Study of the President's Commission on Law Enforcement and the Administration of Justice	R. S. Kirby	Department of Commerce Environmental Science Service Administration, Institute for Telecommunication Sciences and Aeronomy

May 3 - 4 Meetings

Subject	Contributor	Organization
Electromagnetic Wave Propagation at Frequencies from About 10 GHz to Optical	Dr. D. C. Hogg	Bell Telephone Laboratories
Technology Above 10 GHz	W. J. Edwards	Air Force Avionics Laboratory
Cable and Waveguide Technology	L. G. Abraham	Bell Telephone Laboratories
Operations Research; Some Telecommunications Applications	W. H. MacWilliams	Bell Telephone Laboratories
Operations Research; Some Fundamental Aspects and Relation to Spectrum Utilization	Dr. R. S. Machol	University of Illinois
Department of Defense Electromagnetic Compatability Program	J. P. Georgi	Electromagnetic Compatability Analysis Center Naval Experiment Station

APPENDIX 2

RELATED STUDIES

A. JTAC STUDIES

Spectrum Utilization has been the subject of comprehensive publications and continuing studies of The Joint Technical Advisory Committee (JTAC) of the Institute of Electrical and Electronic Engineers (IEEE) and of the Electronic Industries Association (EIA). JTAC has published two books "Radio Spectrum Utilization (1964)" which is a successor to "Radio Spectrum Conservation" (McGraw-Hill Book Co., 1952). These books were prepared to present a current view of our knowledge of the electromagnetic spectrum as a natural resource and to present also the problems which JTAC felt must be solved by the world community in order to attain continued growth and utilization of the spectrum.

General recommendations presented in "Radio Spectrum Utilization" include aspects of: continuous review of usage, research and development, flexibility required, system standards, non-radio communication uses, noise, and technical basis for allocations. Specific recommendations are made in three frequency bands: Below 3 MHz, 3-30 MHz and above 30 MHz. These recommendations deal with relocation of presently allocated services, research and development and allocation objectives.

The Progress Report on "Electromagnetic Compatibility", of the JTAC Subcommittee 63.1, provides a summary of objectives of their work for DTM. The report has the clarifying subtitle "A Challenge in Natural Resource Utilization Requiring Technical Guidance and Direction." The committee was established at the request of Dr. Jerome B. Wiesner and addressed itself to three distinct objectives: to identify EMC problems and existing control techniques; to establish potential technical approaches toward solving compatibility problems and developing greater efficiency of use; to recommend technically-based procedures to increase effective and efficient use of the radio spectrum. The first two of these objectives are now being pursued through group and subgroup activities of the committee. Government agencies represented include: the FAA, GSA, NASA, Treasury Department, Department of Commerce, and the FCC.

With respect to the first objective, identification of EMC, the subcommittee is examining:

- Electromagnetic Compatibility (EMC) in operations of Government Agencies
- EMC in the operations of non-Government users
- Data files for EMC use
- Monitoring and frequency coordination in the field
- New concepts in R&D which will affect the need for spectrum space

Field analyses will be conducted in several specific geographic areas considered representative of large urban areas to obtain an appraisal of electromagnetic compatibility and usage in operating situations. Included will be common-carrier microwave, private microwave, educational microwave, TV, land mobile, special industrial radio, taxicab radio, manufacturers' radio service and public safety services. Radio noise environment studies are to be undertaken.

In the task on Identification of Technical approaches, the objectives are to review and evaluate various procedures that could be developed to:

- Provide for maximum effective use of the spectrum consistent with relative needs for protection from interference
- Meet problems uncovered by the Survey group in developing technical approaches by developing
  - Data File (receiver characteristics and location)
  - System Modeling and Interference Prediction Techniques
  - Optimum Frequency Assignment Model
  - Frequency Band Optimization for service to be rendered
  - Spectrum Utilization efficiency criteria
  - Technical System Optimization
  - Operational System Optimization
  - Equipment Design Specification Standards
  - Monitoring

Another JTAC group (65.1) is currently examining "New Uses of the Radio Spectrum" in conjunction with the JTAC Electromagnetic Study (63.1). The work was undertaken on the basis that knowledge of potential future uses, both as to nature and quantity, would be an important foundation for suggestion on possible technical policy that could guide radio spectrum management.

B. FCC ADVISORY COMMITTEE FOR THE LAND MOBILE RADIO SERVICES

In order to resolve the serious congestion problems confronting the Mobile Services, the FCC, in 1964, established the "Advisory Committee for the Land Mobile Radio Services." This Committee, composed of about 175 people, knowledgeable in two-way radio, has representation from the major user groups in Public Safety, Industrial and Land transportation services, such as Police, Fire, Forest Conservation Petroleum, Public Utilities, Taxicabs, Railroads and many others. Also represented are members of universities, engineering societies, manufacturers, government and FCC staff personnel. Short of reallocation of the spectrum space, the Committee is to explore all possibilities for resolving congestion problems by collecting and analyzing information pertinent to land mobile radio communications and to recommend actions to be taken to alleviate the situation.

Although not limited to the following, some of the prescribed areas of study are:

- Current usage of land mobile service channels
- Service growth predictions
- Extent of harmful interference in land mobile services on various frequencies and various locations
- Technical and operational measures that could reduce harmful interference or increase spectrum utilization efficiency
- Possible use of frequencies above 890 MHZ for land mobile services
- Ways the Commission might improve the administrative and frequency assignment procedures in the land mobile service, both common carrier and private
- Use of computers to assist in frequency assignments

The Committee is composed of three standing committees: Operational Standing Committee, Technical Standing Committee and a Frequency Utilization and Administration Standing Committee, each composed of 8 to 9 working groups. Under each are the following areas of study:

Operational Standing Committee - To study various base-mobile radio systems from an operational point of view and to examine known operating techniques toward more efficient spectrum utilization. Study areas are:

- Operational aspects of multiple access, digital and broadband systems
- Advantages and disadvantages of increased use of channels restricted to low power operation
- Operational aspects of better frequency utilization through one-way, base to mobile systems
- Operational aspects of cooperative use of base stations by more than one licensee
- Operational advantage or disadvantage of increased use of multiplexed transmitting facilities
- Operational aspects of broader use of mobile relay techniques
- Possibilities of improved operational techniques
- Value of land mobile radio service to the overall national economy
- Service growth predictions

Technical Standing Committee - To examine the latest technical developments and recommend those adaptable to land mobile communications and to investigate and recommend possible improvements in present systems. Study areas are:

- Select suitable service frequency bands; study use of frequencies above 890 MHz and examine possibilities of cross-band operation
- Study bandwidth requirements and merits of various modulation systems such as narrow band AM or SSB
- Ambient noise limits
- Feasibility of more precise specification of power, antenna height, location and gain, new signal strength selective devices
- Transmitter power, interference and service limits
- Use of advanced technical developments such as digital systems, compressed information systems, broad-band, etc.
- Use of multiplex channels on FM broadcast stations for land mobile base stations
- Technical standards for reduced channel spacing in the 450 MHz band

<u>Frequency Utilization and Administration Standing Committee</u> - To examine present method of frequency assignment and recommend improvements toward a more practical and efficient spectrum usage. Study areas are:

- FCC techniques, rules, procedures
  - Frequency coordination procedures
  - Examine FCC techniques, rules, procedures (other than frequency coordination and computer techniques)
  - Review application of computer techniques to assignment of frequencies
- Study geographical sharing and allocation
  - Analyze "block" or "service" allocation plans, history and advantage
  - Study alternative allocation plans for land mobile service
  - Analyze EIA card study
  - Compile statements of users about existing land mobile services

To date there has been some useful output in the areas of improved operational techniques and better handling of applications, and licensing procedures, and on the use of multiplex channels on FM broadcast stations for land mobile base stations. However, these and many other areas need more extensive and thorough study.

C. <u>OFFICE OF DIRECTOR OF TELECOMMUNICATIONS MANAGEMENT</u>

(1) <u>Proposal for Long-Range Planning for Allocation and Use of the Radio Spectrum</u>

The DTM has in draft form a proposal for a long-range planning function that will "provide a feasible and continually available guide for the orderly development and exploitation of the radio spectrum." This proposal contains plans for special studies required to support this function. At the time of the convening of this Panel, the material was being reviewed in the Frequency Management Advisory Council.

(2) <u>The Frequency Management Advisory Council</u>

The Frequency Management Advisory Council was formed by the Director of Telecommunications Management to advise on measures to increase the effectiveness of frequency management throughout the Executive Branch of the Government.

The members of the Council are appointed by the Director of Telecommunications Management and represent a cross section of talent and experience from outside the Government to provide objective judgment on frequency management problems and concepts. The present members of the Council are:

Dr. Cullen Crain
Commander T. A. M. Craven
Mr. Richard P. Gifford
Dr. John P. Hagen
Mr. Philip F. Siling
Mr. Ray Vincent
Commodore E. M. Webster

Mr. James D. O'Connell, Director of Telecommunications Management, is Chairman of the Council and Mr. Philip F. Siling serves as Secretary. Mr. Richard C. Kirby, Department of Commerce, is an observer. The Council has been functioning since July 1965.

(3) Study of the Radio Spectrum Requirements for the Space Service Between Now and 1980

A contract was recently made with Jansky & Bailey to determine the frequency needs between now and 1980 for the various space services and how these needs might be met if portions of the required radio spectrum were saturated. The study is to assume the most efficient practicable spectrum utilization to provide a great variety of Government and non-Government satellite services. A report is expected late in 1966.

D. INTERNATIONAL TELECOMMUNICATION UNION

(1) International Radio Consultative Committee (CCIR)

The International Radio Consultative Committee (CCIR) has developed a large number of technical programs relating to spectrum utilization studies. See Appendix 3. Results of studies and recommendations, together with current Questions and Study Programs, have been published in the latest

Documents of the Xth Plenary Assembly of Geneva, 1963.* Subjects covered in five Volumes include:

Volume I.	Emission, Reception
Volume II.	Propagation
Volume III.	Fixed and Mobile Services, Monitoring of Emissions
Volume IV.	Radio Relay Systems, Space Systems, Radioastronomy
Volume V.	Sound Broadcasting, TV

(2) Recommendations of the ITU Panel of Experts

The Panel of Experts was established by the ITU's Administrative Council in 1959 in order to devise ways and means of relieving the pressure on the bands between 4 and 27.5 MHz. After two sessions, held in 1961 and 1963, it adopted 38 recommendations covering the following general matters:

- Discontinuance of double sideband in fixed, maritime mobile and aeronautical mobile services
- Grouping, where practical, of single channel radiotelegraph and radio-telephone circuits into multichannel SSB or ISB circuits
- Siting of stations, choice and maintenance of equipment
- Employment of minimum power and bandwidth
- More stringent tolerances on transmitter stability and spurious emissions
- Use of directional antennas in fixed and broadcast services
- Discontinuance of short-range broadcasting in the HF band
- Use of vertical incidence antennas for broadcasting in tropical zones
- Fixed circuit reductions through groupings on common frequencies
- Reduction in number of frequencies simultaneously used for HF broadcasting
- Need for centralized frequency and telecommunications management
- Use of radio other than HF radio where feasible
- Use of other means of telecommunications where feasible
- Notification of only those frequency assignments which represent actual usage
- Provision of economic and technical assistance to new and developing countries

*Revised at Oslo, Norway, July 1966. To be published in 1967.

- Preparation by IFRB of handbook on recommended techniques for better utilization and reduction of congestion in HF spectrum
- Preparation by CCIR Secretariat of handbook on the performance and application of preferred types of HF directionsl antennas
- Study by CCIR of
  - Arrangements for adoption for SSB systems of the HF maritime mobile service, with suppressed carrier, to control the receiver gain in absence of speech
  - Most suitable methods for automatically controlling output power of HF transmitters
  - Use of HF directional antennas to limit radiation outside of direction necessary for service
- Acceleration of CCIR bandwidth compression studies, taking into account, Panel's recommendations

The DTM has requested each Federal Department and establishment to comply where practical with the actions proposed by IRAC with respect to the Panel's recommendations, particularly in the procurement of new equipment in the bands between 4 and 27.5 MHz, where SSB equipment should be obtained instead of DSB. The impact of the recommendation is expected to become industry-wide.

(3) Conferences

(a) Aeronautical Mobile

An Extraordinary Administrative Radio Conference (EARC) in two sessions revised the allotment plan for the Aeronautical Mobile (R). Service now contained in Appendix 26 to the Radio Regulations. In a first meeting, certain criteria were adopted for the new allocation plan, and members submitted data relating to current HF Aeronautical Mobile (R) Service. The second session (14 March to 6 May 1966) was held to prepare the new allotment plan and to make any necessary amendments to the Radio Regulations.

(b) Maritime Mobile WARC

The Maritime Mobile Service Radio Regulations are to be reviewed and revised in a World Administrative Radio Conference to be held in Geneva in 1967. Objectives include conversion from double to single side band in the medium and high frequency bands, and considerations of accomodating HF requirements for oceanography in the HF maritime and mobile bands.

(c) WARC on Space Radio Communications

The Administrative Council of the ITU reviews annually the progress in space radio communications made by Member Countries of the Union. When appropriate, the Council recommends a WARC to work out further agreements for international regulation of frequency bands allocated for space. However, there is no evidence that the Council sees a need to convene such a conference during 1966.

(d) World Administrative Radio Conference

While no need has yet been expressed for holding an additional world administrative radio conference, a sum has been set aside for an 8 weeks conference to be held within 1968-1971.

(e) XIIth Plenary Assembly of the CCIR

The XIIth Plenary Assembly of the CCIR is expected to be held in 1969 or 1970.

(f) Next ITU Plenipotentiary Conference

The next Plenipotentiary Conference of the ITU is expected to be held in 1971.

APPENDIX 3

SELECTED RELATED QUESTIONS AND STUDY PROGRAMS OF THE CCIR, A RECOMMENDATION OF THE ITU PANEL OF EXPERTS (1963), AND FCC TECHNICAL TOPICS

QUESTION 219(I)

COMPRESSION OF THE RADIOTELEPHONE SIGNAL SPECTRUM IN THE HF BANDS

THE INTERNATIONAL FREQUENCY REGISTRATION BOARD,

IN VIEW OF

the request of the PANEL OF EXPERTS in Section II of Part D of its Interim Report, after considering;

(a) the congestion in the bands between 4 and 27·5 Mc/s;

(b) the need to adopt new methods for the solution of the frequency problems with which Administrations are confronted in the use of those bands;

(c) the work accomplished in the field of Communication Theory;

(d) the need to know what practical experience has been acquired in the matter of compressing the spectrum occupied by HF radiotelephone signals for the Panel's second session;

AND IN VIEW OF

No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES

to submit the following urgent question to the C.C.I.R.:

1. what, in practice, can be done to reduce the spectrum space occupied by HF radiotelephone signals;
2. what experience has been acquired in so doing, for example, what degradation of intelligibility or ability to converse accompanies the use of spectrum reducing techniques?

QUESTION 220(I)

COMPRESSION OF THE RADIOTELEGRAPH SIGNAL SPECTRUM IN THE HF BANDS

THE INTERNATIONAL FREQUENCY REGISTRATION BOARD,

IN VIEW OF

the request of the PANEL OF EXPERTS in Section II of Part D of its Interim Report, after considering;

(a) the congestion in the bands between 4 and 27·5 Mc/s;

(b) the need to adopt new methods for the solution of the frequency problems with which Administrations are confronted in the use of those bands;

(c) the work accomplished in the field of Communication Theory;

(d) the need to know what practical experience has been acquired in the matter of compressing the time-bandwidth product of HF radiotelegraph (or other digital) signals for the Panel's second session;

AND IN VIEW OF

No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES

to submit the following urgent question to the C.C.I.R.:

what are the advantages, limitations and practical experience with:

1. phase-change signalling systems;
2. digital signalling systems which employ three or more states of amplitude, frequency-shift or phase change;
3. coding techniques which provide either message compression or error reduction, or both?

QUESTION 227(I) *

LIMITATION OF RADIATION FROM INDUSTRIAL, SCIENTIFIC AND MEDICAL INSTALLATIONS AND OTHER KINDS OF ELECTRICAL EQUIPMENT

The C.C.I.R., (London, 1953 – Geneva, 1963)

CONSIDERING

(a) that Resolution No. 5, annexed to the International Telecommunication Convention, Buenos Aires, 1952, required the study of the influence of intentional or parasitic oscillations on radio services, especially broadcasting and mobile services, with a view to the possible establishment of standards permitting a harmonious co-existence of radio services with industrial installations producing radio oscillations;

(b) that the harmonious co-existence of radio services with industrial installations, producing radio oscillations, involves close collaboration between organizations representing the manufacturers and users of these installations on the one hand, and the radio services on the other, for which the existing collaboration between the C.C.I.R. and the Special International Committee on Radio Interference (C.I.S.P.R.) provides;

(c) that the C.I.S.P.R. has already studied extensively, and continues to study, the permissible signal-to-interference ratios for sound and television broadcasting, but has not yet made equivalent studies for other radio services;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what is the maximum level of interference, caused by radiations from industrial, scientific and medical installations and other kinds of electrical equipment, that can be tolerated in various frequency ranges by the types of equipment employed by radio services, especially by the mobile services;

2. what are the most appropriate means of determining the level of intentional or parasitic radiations produced by industrial, scientific or medical installations and other kind of electrical equipment;

3. to what levels is it practicable to reduce such radiations?

Note 1. – Some examples of electrical equipment liable to cause disturbance are given in Opinion 2; radio transmitters are excluded.

Note 2. – In this study, the C.C.I.R. should, to avoid duplication of work, keep itself informed of the results of the studies of the C.I.S.P.R. on the same subject.

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* This Question replaces Question 75.

STUDY PROGRAMME 227A(I) *

LIMITATION OF UNWANTED RADIATION FROM INDUSTRIAL INSTALLATIONS

The C.C.I.R., (Warsaw, 1956)

CONSIDERING

(a) that no standard measuring method can yet be recommended for the measurement of unwanted radiation;

(b) that the effect of interference is dependent on the particular type of service and on the waveform of the unwanted radiation;

(c) that, it is desirable to compare measurements made at various test sites and possibly using different methods;

(d) that the effect of interference depends on the transmission coefficient between the source of interference and the receiver affected;

(e) that the C.I.S.P.R. has already studied, and continues to study, extensively the measuring methods for determining the level of interference from industrial, scientific and medical apparatus to sound and television broadcasting;

(f) that due regard should be given to the special requirements of radiocommunication services other than broadcasting;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of which parameters of the interfering field should be measured. The polarization and the relation between the magnetic and electric field should be considered;
2. the effects of the relative positions of the industrial, scientific and medical equipment, or groups of equipments, and the measuring set, the number of measurements at different distances and the number of directions in which measurements should be made;
3. the effect of different open sites on the measured field;
4. the methods that can be used to measure the radiation from industrial, scientific and medical equipment which is situated indoors and the relationship between measurements made indoors and those made on outside sites;
5. the importance of interference due to the presence of radio-frequency voltages in the mains leads of the industrial, scientific and medical equipment and the methods of measurement;
6. the effect of the working conditions of the apparatus to be measured during the measurements;
7. the wave collectors to be used for measurements in the different frequency bands;
8. the characteristics of the equipment to be used for the measurements, particularly its bandwidth;
9. the way in which interference with various radio services depends upon the waveform of the disturbing field;
10. the statistical distribution and the representative values for the transmission coefficient between the interference sources and the receiving antenna in the service concerned.

Note. – In this study the C.C.I.R. should, to avoid duplication of work, keep itself informed of the results of the studies of the C.I.S.P.R. on the same subject.

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* This Study Programme was formerly designated Study Programme 84 (I).

STUDY PROGRAMME 3A(III) *

FACTORS AFFECTING THE QUALITY OF PERFORMANCE OF COMPLETE SYSTEMS OF THE FIXED SERVICES

Signal-to-noise and signal-to-interference protection ratios for fading signals, bandwidth and adjacent channel spacing

The C.C.I.R., (Los Angeles, 1959)

CONSIDERING

(a) that Question 3(III) establishes a permanent study of questions relating to the desired conditions of performance to be fulfilled by the fixed services;

(b) that the conditions for satisfactory performance of a system must take account of the need to receive signals propagated via the ionosphere, which are subject to fading and multipath effects and are accompanied by radio noise and interference;

(c) that studies requiring signal-to-noise and signal-to-interference protection ratios are closely related, and that determination of necessary adjacent channel spacings requires, in addition, consideration of frequency stability and bandwidth of the systems;

(d) that there are a number of different techniques and systems in use in the radiotelegraph and radiotelephone services and, while it is essential to consider the most advanced state of the radio art, it is also necessary to give special study to conventional systems, either affecting integration of land-line and radio services, or of concern to the I.F.R.B.;

UNANIMOUSLY DECIDES to carry out the following studies:

1. Classes of service

The studies concern the following classes of service in regular use in the fixed services, but should also give due regard to new techniques and systems, including those under development, for application to the fixed services:

1.1 *Radiotelephony*

1.1.1 Types of emission: A3, A3A, A3B, F3 **;

1.2 *Radiotelegraphy*

1.2.1 Types of emission: A1, A2, A7, F1;

1.2.2 Telegraph speeds:

- A1, A2, hand speed 8 and 24 bauds, machine speed 50 and 120 bauds;
- A7, multichannel VF telegraphy, 50 to 200 bauds per channel;
- F1, 50 to 600 bauds;

1.2.3 Codes:

- 5-unit start-stop;
- 5-unit synchronous;
- synchronous error-detecting and correcting systems using two-condition signalling codes other than the International Alphabet No. 2;
- other systems using more than two signalling conditions;

1.3 *Facsimile, phototelegraphy; Hellschreiber*

1.3.1 Types of emission: A4, F4.

* This Study Programme, which replaces Study Programmes 44, 45, 49 and 50 and Questions 82, 129 and 131, was previously designated Study Programme 128(III).

** F3 above 30 Mc/s only, with reference to ionospheric-scatter applications.

2. Minimum conditions required for satisfactory service

2.1 Acceptable criteria and values for:

2.1.1 *intelligibility* over radiotelephone circuits *;

2.1.2 *error rate* for characters and elements over radiotelegraph circuits (*efficiency factor* for ARQ circuits);

2.1.3 *legibility* of copy over facsimile (phototelegraphy) and Hellschreiber circuits;

- what is the maximum duration and percentage of the time during which performance inferior to the standard values can be tolerated;

2.2 Performance of the system as a function of:

- signal-to-noise and signal-to-interference (co-channel) ratios;
- required signal-to-noise and signal-to-interference (co-channel) protection ratios for the acceptable standard values of intelligibility, error rate (efficiency factor on ARQ circuits), or legibility, for the various services **, considering:

2.2.1 Signal fading, taking account not only of the amplitude distribution, but also of the autocorrelation function and the distribution of duration of the fades;

2.2.2 Diversity (space, frequency, or time) techniques:

- noise reducers,
- coding including the use of error-correcting; codes or ARQ ***,
- use of more than two signalling conditions, and
- optimum modulation and detection techniques ****,

2.2.3 Multipath effects;

2.2.4 Interference effects of radio noise of various types, such as atmospheric, impulsive, or Gaussian noise, as described by the wave form and amplitude distribution of the instantaneous values of the noise,

- the resulting interference effects on actual reception, taking account of the method of detection, and of filtering prior to and following detection;

2.2.5 Interference effects of co-channel signals representing the various classes of emission, taking account of the spectral and statistical (fading) characteristics of the interfering signal;

2.2.6 Monthly mean signal-to-noise ratios and signal-to-interference ratios, required for circuits of various lengths and directions, for the acceptable standard values of circuit performance (§ 2.1), to be met during the specified percentage of the time, taking into account,

- the distribution within an hour of the mean values of the short-term (fading) distributions of signals and noise,
- the distribution, within a month or season, for a given hour of the hourly mean values of the signal strengths and atmospheric noise levels (Report 322) *****,

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* For the various grades – just usable, operator to operator (order wire);
– marginally commercial;
– good commercial.

** For radiotelephone services, the signal-to-noise ratio required in the audio band must be specified, and from this the signal-to-noise ratio required in the radio-frequency band is established.

*** It would be useful to compare the systems using the various telegraph codes, including those of § 1.2.3, in terms of undetected or uncorrected error rate for a given power and signalling speed, in words per minute, and operating under the same conditions. A 5-unit start-stop system may also be used as the reference system by regarding each mutilated character as an error only. It is provisionally suggested that the ratio of error rates should be expressed for two circuit conditions only, namely, when the system under test is subjected to an average of one undetected or uncorrected error per 1000 characters, and per 10 000 characters.

**** A special study is needed comparing the different systems used for voice-frequency telegraphy on radio circuits; this is dealt with in Study Programme 43A(III).

***** The monthly mean values of atmospheric noise for various time blocks, and information on the distribution of values within the month, is given in Report 322; with regard to monthly mean values of signal strength, and distribution of hourly values within the month, until such time as C.C.I.R. adopts information on this subject, other standard references may be used, such as U.S. National Bureau of Standards Circular No. 462.

this study is intended to lead to revisions or replacement of Recommendations 240, 339 and 340.

2.3 Minimum bandwidth required for satisfactory transmission and reception of the intelligence, in a complete system (this is not the question of " bandwidth necessarily occupied ", involving the capability of the transmitting system to avoid radiation outside the band needed for communication, which is included in Study Programme 181(I)).

3. Determination of adjacent channel signal-to-interference protection ratios, and frequency separations between various classes of service, considering

3.1 the use of effective receiving band-pass filters no wider than necessary for satisfactory reception (§ 2.3 above, and Recommendations 237, 330 and 332);

3.2 the bandwidth occupied by the interfering transmission;

3.3 the frequency tolerance and stability of the wanted and unwanted signals;

3.4 the studies of § 2.2 above relating to co-channel signal-to-interference protection ratios.

Note. – The results of this study should be presented in the form indicated in the Annex. The results are intended to lead to revision of Recommendation 240.

QUESTION 133(III) *

COMMUNICATION THEORY

The C.C.I.R., (Geneva, 1951 – Warsaw, 1956)

CONSIDERING

(a) that for the transmission of a given volume of information through a given telecommunication channel with a given power, either in a given time using a minimum bandwidth, or with a given bandwidth in a minimum time, the theoretical formulae suggest the use of pulse-code modulation;

(b) that the theoretical coding method for improving on this involves a long delay;

(c) that the theoretical coding methods usually do not take into account the presence of a return channel, which in practice has led to efficient transmission systems with a low error rate;

(d) that the U.R.S.I. has suggested further study in Doc. 14 of Warsaw, 1956;

UNANIMOUSLY RECOMMENDS that the following question should be studied:

1. the relation between permissible delay and residual uncertainty and its dependence on bandwidth utilization;

2. the improvement practicably possible in existing systems, with regard to the transmission of information, in particular for those systems where a go and a return channel are available.

* This Study Programme replaces Study Programme 86.

STUDY PROGRAMME 133A(III) **

COMMUNICATION THEORY

The C.C.I.R., (Geneva, 1951 – London, 1953 – Warsaw, 1956 – Geneva, 1963)

CONSIDERING

(a) that, in view of the increasing congestion of the radio spectrum and telecommunication circuits, it would be advantageous to discover technical methods of decreasing the bandwidth, the transmission time of a given quantity of information, or the transmitted power;

(b) that present studies seek mainly to perfect established systems, whereas recent theories seem to show that these systems occupy several times the bandwidths strictly necessary for the transmission of the required information at the required speed;

(c) that, even with existing systems, it is not possible to reduce the bandwidth to that strictly necessary because of unpredictable noise, natural and man-made interference, and complex propagation conditions; a margin of bandwidth is necessary to decrease distortion and the frequency of errors due to these phenomena;

(d) that it is not certain that existing codes, some at least of which were not designed in the light of phenomena peculiar to radio propagation, are making the best use of the occupied bandwidth;

** This Question replaces Question 44.

(e) that, to assess the effectiveness of any error-detecting or error-correcting codes over radio circuits, it is essential that realistic error statistics be known for these radio circuits;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the review of the various codes in use and the study of new codes, leading to an economy of bandwidth or transmission time for a given quantity of information preserving a given quality of transmission, taking into account the phenomena peculiar to radio propagation and the comparison of the various existing systems of modulation from the point of view of the bandwidth occupied in relation to the amount of information transmitted in a given time for a given power; *

2. that experimental determination of error statistics be made for operating radio circuits. On the 3 out of 7 ARQ systems, this can conveniently be done by counting and printing out the errors on " idle alpha " characters, while the system is in full operation. The result of these experiments will be a table, showing the frequency of occurrence of m errors in a sequence of n digits ($m = 0, 1, 2, 3 \ldots$ and $n = 7, 14, 21 \ldots$). Where this is possible, it may be useful to give information on the occurrence of the different types of error);

3. that experimental determination of the relative frequencies of occurrence of m errors be extended to values of n other than multiples of 7. This experiment may require a separate experimental channel. The suggested range of values for n is between about 10 and 100, with particular emphasis put on 15, 31, 63 and 127;

4. the study, in conjunction with the U.R.S.I., of the methods of communication theory that are best suited for practical application.

Note. – The statistical information asked for under § 2 and 3 should, where possible, state the conditions of the channel: signal-to-noise ratio, fading characteristics, special noise or channel disturbances, interference from other stations, etc.

* Relative to this study, it is useful to consider for radiotelephony, the determination of the relationship between intelligibility and the shape and width of the passband of the receiver for signal-to-noise ratios consistent with:

– just usable quality, operator to operator,
– marginally commercial quality,
– good commercial quality,

taking into account that:

– in many cases, the noise power is distributed uniformly over the audio-frequency spectrum, while speech power is distributed unevenly over the spectrum;
– when high noise levels are present in the communication system, and the signal-to-noise ratio is constant, the intelligibility might show a maximum as a function of the bandwidth and the distribution of the power corresponding to the frequencies it contains. This distribution of the power may vary with fading.

QUESTION 233(III)

USE OF COMMON-FREQUENCY SYSTEMS ON INTERNATIONAL RADIOTELEPHONE CIRCUITS

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that relief of the present congestion of the HF (decametric) band is a matter of urgency;

(b) that, in certain cases, the use of the same frequency for both directions of transmission (in combination with the use of VODAS equipment), may result in important economies in spectrum utilization on international radiotelephone circuits;

UNANIMOUSLY DECIDES that the following question should be studied:

1. what are the characteristics to be specified for international radiotelephone systems using the principles of common-frequency operation;

2. what should be the minimum difference in level at the input to the receiver between the received signal from the distant station, and signals from the nearby transmitting station, to avoid interference between the wanted signal and that from the nearby transmitter operating on the same frequency;

3. to what extent will the use of transmitting and receiving antennae, with different transmission characteristics, reduce the possibilities of application of this technique;,

4. to what extent will the possibilities of application of this technique be reduced by the presence of different noise levels at the receiving locations;

5. what other factors should be taken into account when planning such systems, for example:
   - non-linearities in the transmitting and receiving equipment,
   - carrier-filter bandwidth,
   - frequency stability of the equipment?

QUESTION 280(III)

USE OF DIRECTIONAL ANTENNAE IN THE BAND 4 TO 27·5 Mc/s

Limitation of radiation outside the direction necessary for the service

THE INTERNATIONAL FREQUENCY TEGISTRATION BOARD,

IN VIEW OF the request by the Panel of Experts in Recommendation No. 38 of its Final Report, Geneva, 1963, and AFTER CONSIDERING:

(a) that there is serious congestion in the frequency bands between 4 and 27·5 Mc/s;

(b) that there is a need to adopt methods and regulations for the solution of the frequency problems with which Administrations are confronted in the use of these bands;

(c) that occupation of the radio-frequency spectrum is represented, not only in time and bandwidth, but also in the spatial distribution of the radiated power;

(d) that this latter distribution can be effectively controlled by the use of directional antennae;

(e) that the intent of Articles 12 and 14 of the Radio Regulations, Geneva, 1959, would seem to justify further explicit requirements for the use of directional antennae in the bands between 4 and 27·5 Mc/s, as well as for quantitative limitation of the intensity of radiation in directions other than that required for the service;

AND IN VIEW OF No. 180 of the International Telecommunication Convention, Geneva, 1959;

DECIDES to submit the following urgent question to the C.C.I.R.:

what are reasonable standards for the directivity of antennae in the various types of radio services, and for various distances, in the bands between 4 and 27·5 Mc/s, including the width of the main beam and the allowable intensity of radiation (effective radiated power) in directions of azimuth outside the main beam (such standards should reflect due regard for practical considerations of construction and cost)?

STUDY PROGRAMME 235 A (IV) *

FEASIBILITY OF FREQUENCY SHARING BETWEEN COMMUNICATION-SATELLITE SYSTEMS AND TERRESTRIAL RADIO SERVICES

The C.C.I.R., (1961 — Geneva, 1963)

CONSIDERING

(a) that use of communication-satellite systems will require extensive use of the radio-frequency spectrum;

(b) that for communication-satellite systems, the spectrum should be shared with terrestrial services to the extent practicable, in the interest of spectrum conservation; and

(c) that the feasibility of sharing spectrum space with line-of-sight radio-relay systems should be investigated;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. what criteria affect the selection of sites for earth stations in the communication-satellite system, taking into account the various portions of the radio-frequency spectrum;
2. what are the preferred technical characteristics of transmitting and receiving antennae for earth stations at fixed locations, from the standpoint of spectrum sharing with other radio services;
3. what criteria affect the determination of the minimum angle of elevation, which should be employed at the locations of the earth stations;
4. to what degree will physical modification of terminal sites provide electromagnetic shielding between earth stations and stations in other radio services;
5. what criteria affect the selection of satellite power in frequency bands shared with other radio services;
6. what criteria affect the determination of the minimum practicable separation between the transmitting and receiving locations of line-of-sight radio-relay systems and the receiving and transmitting locations of earth stations in the communication-satellite systems?

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* This Study Programme replaces Study Programme 174.

STUDY PROGRAMME 235 B (IV) *

FREQUENCY SHARING BETWEEN COMMUNICATION-SATELLITE SYSTEMS AND TERRESTRIAL RADIO SERVICES

Wanted-to-unwanted signal ratios

The C.C.I.R., (1962 — Geneva, 1963)

CONSIDERING

(a) that methods are described in Report 209 for determining the conditions under which frequency sharing is feasible between communication-satellite systems and terrestrial services;

(b) that a precise determination depends upon the availability of appropriate values for the acceptance ratios between wanted and unwanted signal powers at the receiver input for specified grades of service;

(c) that acceptance ratios are required between each type of wanted signal and each type of unwanted signal, for appropriate modulation and fading conditions, for which a test of the feasibility of sharing is desired;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. theoretical and experimental determinations of the acceptance ratios required for specified grades of service for various types of wanted and unwanted signal, for appropriate modulation conditions and for various kinds of fading;

2. investigation of those techniques of transmission, reception and modulation which will minimize the acceptance ratios required for a specified grade of service.

STUDY PROGRAMME 235 C (IV) **

COMMUNICATION-SATELLITE SYSTEMS

Feasibility of frequency sharing among communication-satellite systems

The C.C.I.R., (Geneva, 1963)

CONSIDERING

(a) that the use of communication-satellite systems will require extensive use of the radio spectrum;

(b) that the feasibility of frequency sharing among communication-satellites operating in the same system or operating in different systems should be investigated;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. what criteria affect interference among communication-satellites in a given system and between communication-satellite systems, taking into account the two directions of transmission, for:

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* This Study Programme replaces Study Programme 179.

** This Study Programme, together with Question 235 (IV), replaces Question 214.

1.1 systems using stationary satellites;

1.2 systems using station-keeping satellites;

1.3 systems using random satellites;

1.4 satellites operating in various orbits in the same system;

1.5 satellites operating in various orbits in different systems;

2. what are the preferred technical characteristics of transmitting and receiving antennae for earth stations, from the standpoint of frequency sharing within the same system and with other communication-satellite systems;

3. what criteria affect the determination of the minimum elevation angle which should be employed at the earth stations, from the standpoint of frequency sharing among communication-satellite systems;

4. is there an optimum range of powers to be employed by satellites and by earth-station transmitters, to facilitate frequency sharing among communication-satellite systems;

5. what are the effects of baseband and modulation characteristics on frequency sharing among communication-satellite systems;

6. would the selection of preferred reference frequencies facilitate frequency sharing among communication-satellite systems?

STUDY PROGRAMME 235 D(IV) *

STUDY OF PREFERRED MODULATION CHARACTERISTICS FOR COMMUNICATION-SATELLITE SYSTEMS

The C.C.I.R., (1961 – Geneva, 1963)

CONSIDERING

(a) that earth satellites are expected to be used extensively for the relay of communication signals of various types;

(b) that substantial use of communication satellites will place substantial demands upon the radio spectrum;

(c) that, in the interest of conservation of the radio-frequency spectrum, effort should be exerted to use the minimum feasible amount of spectrum space to convey the maximum amount of information;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. determination of the preferred characteristics for transmission from earth to satellite to earth in passive communication-satellite systems;

2. determination of the preferred modulation characteristics for transmission from earth to satellite and from satellite to earth in active communication-satellite systems,

3. determination of the extent to which signal compression or signal processing techniques can usefully be employed to conserve radio-frequency bandwidth, and the preferred characteristics which should be employed when such techniques are used for satellite-communication systems.

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* This Study Programme replaces Study Programme 175.

STUDY PROGRAMME 235 E (IV) *

FACTORS AFFECTING FREEDOM OF ACCESS IN COMMUNICATION-SATELLITE SYSTEMS

The C.C.I.R., (1962 — Geneva, 1963)

CONSIDERING

(a) that communication-satellite systems may require simultaneous use by large numbers of earth stations at various locations, this being termed "freedom of access";

(b) that this freedom of access may be affected by the orbital design of the system;

(c) that this freedom of access may be affected by the choice of modulation techniques used;

(d) that this freedom of access may be affected by the interference characteristics of the system or systems used;

(e) that multiple access requirements may dictate a system design, different from that which may be optimum for limited access systems;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. what factors determine the accessibility of a communication-satellite system to a number of earth stations simultaneously or in random order;
2. to what extent does the choice of orbital parameters affect this freedom of access, and are there preferred orbits for such freedom of access;
3. to what extent does the type of modulation and channel arrangement employed affect freedom of access, and are there preferred types of modulation and channel arrangement for such freedom of access;
4. what are the effects of the preferred choices resulting from §§ 2 and 3 on the possibilities of sharing with terrestrial services and with other satellite systems of the same and of different type?

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* This Study Programme replaces Study Programme 178.

QUESTION 236 (IV) **

SHARING OF RADIO-FREQUENCY BANDS BY LINKS BETWEEN EARTH STATIONS AND SPACECRAFT

The C.C.I.R., (1961 — Geneva, 1963)

CONSIDERING

(a) that sharing of the radio spectrum by links between earth stations and spacecraft with all other radio services may be necessary, because of the limited spectrum space available to support the world's communication requirements; and

(b) that factors which determine the ability to share spectrum space are strongly interdependent;

UNANIMOUSLY DECIDES that the following question should be studied:

1. how do the following factors, among others, affect the practicability of sharing:

1.1 location of space and earth stations of a link and the resulting zones of mutual visibility;

1.2 time of use during period of mutual visibility;

1.3 probability of occupancy of the zones of mutual visibility of links between earth stations and spacecraft by other operating stations during the required times of use of the link and the resulting power levels at all earth stations, as a consequence of this combined occupancy;

1.4 other system parameters, such as modulation techniques, antenna directivity, etc.;

1.5 natural (non man-made) interference;

2. to what extent is spectrum sharing feasible for different links between earth stations and spacecraft; between these links and other space systems; and between these links and terrestrial radio services?

QUESTION 237(IV) *

TECHNICAL CHARACTERISTICS OF LINKS BETWEEN EARTH STATIONS AND SPACECRAFT

The C.C.I.R., (1961 — Geneva, 1963)

CONSIDERING

(a) that the value of spacecraft will, in the future, depend almost entirely on the ability to use radio-frequency electromagnetic energy for the transmission of all types of information over links between earth stations and spacecraft;

(b) that available bandwidth in useful regions of the radio-frequency spectrum will be limited;

UNANIMOUSLY DECIDES that the following question should be studied:

what are the preferred technical characteristics and system parameters commensurate with technical feasibility which will insure the maximum practical use of radio-frequency spectrum space for the following types of links between earth stations and spacecraft:

1. maintenance telemetering;
2. tracking;
3. telecommand;
4. communication and data transmission?

Note 1. — This Question relates both to space research and to developmental and operational systems.

Note 2. — The following factors should be taken into account in carrying out this study:

— information rate and duty-cycle as they affect bandwidth requirements;

— required signal-to-noise ratio;

* This Question replaces Question 211.

STUDY PROGRAMME 185 A (V)

PROPAGATION DATA REQUIRED FOR LINE-OF-SIGHT RADIO-RELAY SYSTEMS

(Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that, in planning a communication network, it is necessary to define the overall system performance achieved for given percentages of the time;

(b) that designers of radio systems in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands require to know, from the viewpoint of sustained satisfactory operation, the tropospheric propagation characteristics and the resulting transmission loss (see Recommendation 341), that is not exceeded for a large percentage of the time for each particular frequency band over the working range, which may extend from several tens of kilometres up to more than 200 km for certain links between elevated sites;

(c) that the planning of systems requires a knowledge of the seasonal distribution curves as functions of time, of the transmission loss for the most unfavourable season or month;

(d) that, for interference studies, it is necessary to know the quasi-minimum value of the transmission loss;

(e) that the bandwidth of the system may be limited by the effects of multipath propagation;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. what is the distribution in time of the values, relative to free-space of the received power-level reached, in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands, for each month of the year. The recording should be performed with an instrument having a time constant of less than or equal to one second;

2. what are the levels for given percentages of time corresponding to the most unfavourable month, the most favourable month and those corresponding to the whole year;

3. to what extent do the distributions found depend on the path length, the climate, the nature of the terrain over which the path passes and the clearances of the antennae;

4. to what extent can the distributions found be described by simple statistical laws;

5. what limitations are imposed on transmission by the effects of multipath propagation and how may these be overcome:

6. what limitations on the use of the system are imposed by solar noise and noise from other external sources?

Note. — To meet the needs of Study Group IX, priority should be given to measurements to establish the magnitude of interfering fields at 6 and 11 Gc/s, with antennae representative of practical systems, over representative paths and at longer distances.

STUDY PROGRAMME 185B(V)

PROPAGATION DATA REQUIRED FOR BEYOND-THE-HORIZON RADIO-RELAY SYSTEMS

(Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that in the planning of a communication network it is necessary to define the overall system performance achieved for a given percentage of the time;

(b) that designers of radio systems in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands require to know, from the viewpoint of sustained satisfactory operation, the tropospheric propagation characteristics and the resulting transmission loss, that is not exceeded for a large percentage of the time for each particular frequency band, over the distance corresponding to the service range, which may extend from about 200 km to more than 500 km;

(c) that the planning of systems requires a knowledge of the distribution curves, as functions of time, of the transmission loss for the most unfavourable month of the climatic zone under consideration;

(d) that, for interference studies, it is necessary to know the quasi-minimum value of the transmission loss;

(e) that the bandwidth of the system may be limited by the nature of the mode of propagation employed;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. what is the distribution in time of the basic transmission loss (see Recommendation 341) in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands, for each month of the year (the value of the path antenna gain being specified). The recording should be performed with an instrument having a time constant of one minute * and especial importance should be attached to the quasi-maximum and quasi-minimum values of the transmission loss or field-strength;

2. what are the levels for given percentage of time corresponding to the most unfavourable month, the most favourable month and those corresponding to the whole year;

3. which are the hours of the day for which the greatest transmission loss may usually be expected;

4. what is the distribution in time of the fluctuation of the level of the received signal about its hourly median value **, when the recording is made with a time constant as short as possible;

5. how do the distributions depend on the climatic zone in which the path under consideration is located, and which distinct climatic zones should be taken into consideration ***;

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* Other time constants may be used, should it appear desirable, but in all cases the time constant used should be specified.

** Other periods of time may be used to define the median value, but these periods should be stated.

*** In view of the paucity of data relating to propagation in climates other than temperate, Administrations are urged to give special attention to the collection of data relating to other types of climate.

6. how do the distributions found depend on the frequency, the distance between the stations, the angle of elevation of the antennae at each terminal and on the nature of the terrain over which the path passes;

7. to what extent can these distributions be described by simple statistical laws;

8. what limitations on the bandwidth of the system are imposed by the propagation process employed (diffraction, partial reflection, scattering, etc.);

9. what limitations on the use of the system are imposed by the effects of solar noise, and noise from other external sources?

Note. — The results of these studies should be presented in the form given in Administrative Circular AC/63.

STUDY PROGRAMME 139(V) *

RADIO TRANSMISSION UTILIZING INHOMOGENEITIES IN THE TROPOSPHERE (COMMONLY TERMED "SCATTERING")

(Warsaw, 1956 — Los Angeles, 1959)

The C.C.I.R.,

CONSIDERING

(a) that, in various countries, recent experiments, characterized by the use of transmitting and receiving antennae directed towards the same part of the troposphere, have shown that radio signals in the VHF (metric), UHF (decimetric) and SHF (centimetric) bands can be propagated consistently through the troposphere over unexpectedly great distances, and that, beyond the line of sight, fields are found to be much greater than the diffraction theory for a standard radio atmosphere would predict;

(b) that useful signals can be obtained in this manner at distances greater than was formerly expected;

(c) that tropospheric inhomogeneities play an important role in this phenomenon;

(d) that little is known about geographical and topographical influences;

UNANIMOUSLY DECIDES that the following studies should be carried out:

investigation of this new tropospheric propagation phenomenon, in its widest sense, with a view to the extension of knowledge of:

1. the characterisitcs of the signal, in particular signal strength, signal distortion (time delays, bandwidth), fading rates and fading range and their dependence on frequency, range and geographical situation;

2. the influence of meteorological conditions, including water vapour, rain and snow on signal strength;

3. the efficiency of antennae in relation to size and design;

4. the use of space, frequency and polarization diversity for transmission and reception;

5. the application of such diversity techniques for co-channel transmission and reception.

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* This Study Programme, which replaces Study Programme 91, does not refer to any Question under study.

STUDY PROGRAMME 194 (VI)

IDENTIFICATION OF PRECURSORS INDICATIVE OF SHORT-TERM VARIATIONS OF IONOSPHERIC PROPAGATION CONDITIONS AND METHODS FOR DESCRIBING IONOSPHERIC DISTURBANCES AND THE PERFORMANCE OF RADIO CIRCUITS

(London, 1953 — Warsaw, 1956 — Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that it is desirable to have an index, or indices, suitable for short-term forecasts of ionospheric disturbances;

(b) that long-term indices for ionospheric propagation are not satisfactory for indicating short-term variations in the ionosphere;

(c) that ionospheric propagation disturbances may result from either corpuscular or photon radiation from the sun;

(d) that a correlation has been found between short-term variations of ionospheric propagation conditions and certain indices of magnetic phenomena and solar eruptions;

(e) that it is desirable to have forecasts of ionospheric disturbances, expressed in terms which are at the same time meaningful to operators of ionospheric communications systems, and appropriate for use in the subsequent evaluation of the reliability of the forecasts;

(f) that the application of ionospheric disturbance forecasts varies widely with the type of radio circuit in question;

(g) that it is desirable that the forecasts issued by different agencies should be expressed in a way which facilitate comparison between them;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the possibility of selecting particular kinds of solar observations or observations of other phenomena, such as geomagnetic activity, cosmic rays, whistlers, etc., which can be made objectively, and which may be usefully employed for short-term predictions of ionospheric propagation conditions;
2. the possibility of describing ionospheric disturbances in terms comparable with the forecasts;
3. the possibility of establishing a common method for the description of ionospheric disturbances, for use in forecasting and verification, taking account of such factors of the disturbance as: starting time, areas affected, movement, change of size, duration and magnitude;
4. the possibility of defining indices, which describe the intensity of ionospheric disturbance for each of a series of equal short intervals and which might be combined into an estimate of the importance of the disturbance for the whole period;
5. the relationship between the characteristics of the disturbance, as described by the common method (see § 3), and the expected performance of radio circuits of various kinds;
6. the possibility of defining a more objective scale of the importance of sudden ionospheric disturbances, for example, by studying changes in the mean field-strength of atmospherics in the frequency band 20 to 40 kc/s.

STUDY PROGRAMME 195 (VI)

PROPAGATION BY WAY OF SPORADIC-E AND OTHER ANOMALOUS IONIZATION IN THE E- AND F-REGIONS OF THE IONOSPHERE

(Los Angeles, 1959 — Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that sporadic-E propagation may play an important role in HF communications out to great distances and, frequently, in the lower part of the VHF band, up to distances of about 2300 km;

(b) that sporadic-E data from ionosondes do not provide adequate statistics for the prediction, for oblique paths, of the field strength of the received signal or of the transmission loss;

(c) that data on propagation by sporadic-E and other abnormal ionization obtained from continuous-wave recordings, and from fixed frequency pulse measurements at oblique incidence, provide statistical data of the type needed by engineers;

(d) that with continuous-wave observations, it is frequently very difficult to separate sporadic-E from other anomalous ionization in the E- and F-regions and from tropospheric propagation effects;

(e) that the path configuration plays an important part in those modes of propagation, where reflections from field-aligned ionization seem to occur, as for example, auroral-type phenomena;

(f) that, whilst it may be possible to exploit these anomalous modes, they are also a potential source of interference;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. field-strength or transmission loss of signals propagated by abnormal modes in the E- and F-regions at frequencies in the upper part of the HF band and the lower part of the VHF band. In analyzing the measurements, attention should be paid to:
   - separation of the effects of the different modes of propagation;
   - influence of frequency, distance, time of day, season and solar cycle;
   - the effects of field-aligned ionization;
   - the vertical and azimuthal angles of arrival of the different abnormal modes;
   - characteristics of the terminals, such as antenna gains and directivities, site configuration, receiver characteristics and calibration procedures, transmitter power, and transmission-line losses;

2. comparison, where possible, of the results so obtained with data obtained by means of ionosondes (for example, foEs);

3. preparation of simple world-wide and regional charts of received signal level relative to free-space, or of transmission loss, at suitable frequencies for those abnormal modes which are found to be significant.

STUDY PROGRAMME 198 (VI)

ESTIMATION OF SKY-WAVE FIELD-STRENGTH AND TRANSMISSION LOSS FOR FREQUENCIES BETWEEN THE APPROXIMATE LIMITS OF 1·5 AND 40 Mc/s

(Geneva, 1951 — London, 1953 — Warsaw, 1956 —
Los Angeles, 1959 — Geneva, 1963)

The C.C.I.R.,

CONSIDERING

that present methods of estimating sky-wave field-strength and transmission loss are not always sufficiently accurate;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. detailed theoretical investigations of long distance ionospheric propagation;
2. improvements in methods of estimation, taking into account for example, off great-circle propagation, ground scatter and the influence, not only of the strength of the magnetic field of the earth, but also of its direction relative to the direction of propagation;
3. improvements in the estimation techniques for paths traversing the equatorial or the auroral zone, and for the short paths, up to 800 km, involved in tropical broadcasting;
4. improvements in the estimation of night-time attenuation;
5. statistical comparisons between the calculated and measured values of the field-strength or transmission loss, taking into account the values of the propagation parameters for the period of comparison, as well as the influence of the actual polar diagrams of the antennae;
6. measurements of absorption from both vertical and oblique incidence pulse transmissions on a number of frequencies especially in regions of high absorption;
7. application of the temporal variations of the absorption of extraterrestrial noise and of field strengths of signals received from spacecraft.

STUDY PROGRAMME 200 (VI) **

BASIC PREDICTION INFORMATION FOR IONOSPHERIC PROPAGATION

(London, 1953 — Los Angeles, 1959 — Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that the production of basic predictions for ionospheric propagation involves problems which are not yet fully solved;

(b) that, nevertheless, extensive practical use is made of predictions by radio operating services and Administrations***;

(c) that the application of basic prediction information, as supplied to various Administrations and centres, to specific operational problems, has revealed occasional large discrepancies between predictions and operational results, even though the solar activity may have been correctly forecast. These discrepancies may be attributed to such causes as:

- — different interpretations placed upon the basic ionospheric observations;
- — different methods of converting basic ionospheric observational data into predictions;
- — inadequate understanding and lack of research concerning the role played by the E-, Es-and Fl-layers, for the actual modes of propagation and for the effects of ground and ionospheric scatter;
- — the need for suitable methods of interpolation in the preparation of basic world prediction's especially for regions from which no ionosonde data are available;
- — differences in the statistical significance of the ionospheric and operational data sampled, and in the methods of assessing the circuit performance of the various classes of service;

(d) that the distinction between operational, standard and classical MUF* is not yet familiar to many users.

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the suitability of present methods for predicting oblique-incidence MUF from vertical data for both short and long paths;

2. the ratio of operational MUF to standard MUF so that a correction factor dependent on system parameters such as power, type of service, and information rate could be introduced into predictions wherever it is needed;

3. the extent to which basic prediction data could be improved by different methods of interpolation;

4. the role played by ionization in the layers of the E-region for both short and long paths;

5. practical methods of introducing into predictions such subjects as propagation modes, the related angles of arrival and departure, and the effects of ionospheric-layer tilts;

6. propagation off the great-circle path;

7. a statistical determination in terms of season, solar cycle, location, etc. of the day-to-day variation of both standard and operational MUF so that practical methods may be devised whereby this factor can be introduced into monthly predictions.

STUDY PROGRAMME 153 (VI) *

MEASUREMENT OF MAN-MADE RADIO-NOISE

(Los Angeles, 1959)

The C.C.I.R.,

CONSIDERING

(a) that man-made radio-noise is frequently the limiting factor in the reception of radio signals over a wide frequency range, particularly during daylight hours, when atmospheric noise is low;

(b) that the dynamic characteristics, as well as the geographical, time and frequency dependence of man-made radio-noise are entirely different from those of atmospheric noise;

(c) that information on the relative importance of atmospheric and man-made radio noise is needed for future revisions of Report 322;

(d) that previous measurements of man-made noise have largely been concentrated on the individual sources, the principal objective being the reduction in noise rather than a determination of the composite effect throughout given areas;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. the investigation of the level of composite man-made radio-noise, as a function of geographic location, frequency, and time of day;

2. the investigation of the statistical characteristics of composite man-made radio-noise, as a function of the above variables, during short-time intervals as well as for day-to-day variation;

3. the determination of the correlation of man-made radio-noise levels with population density, industrial activity, electric power consumption, and other factors;

4. the determination of the types of measurement most significant for the evaluation of the interference potential of man-made radio-noise for different types of service, for example, peak, quasi-peak, r.m.s. voltage, average envelope voltage, average logarithm, and probability distribution of the amplitudes.

STUDY PROGRAMME 205 (VI) *

EFFECTS OF RADIO-NOISE IN SPACE ON COMMUNICATIONS WITH SPACECRAFT

(Geneva, 1963)

The C.C.I.R.,

CONSIDERING

(a) that radio noise is an important element in radiocommunications with spacecraft;

(b) that little is known of this noise in the ionosphere and in space;

UNANIMOUSLY DECIDES that the following studies should be carried out:

1. measurement of the noise in the ionosphere and in space from:
   - cosmic sources;
   - lightning discharges and other terrestrial sources;

2. development of methods of prediction of noise in the ionosphere and in space from:
   - cosmic sources
   - lightning discharges and other terrestrial sources.

RECOMMENDATION OF THE PANEL OF EXPERTS
(GENEVA 1963)

REDUCTION OF BANDWIDTH OF RADIO SYSTEMS IN THE 4 - 27.5 Mc/s BAND

The Panel,

considering

a) speech bandwidth compression schemes have been under development for a number of years. Experimental systems have given compression ratios of 6:1 and others proposed may achieve 10 or 20:1. Such systems have not been used in public correspondence networks because they degrade the telephone service and greatly increase the complexity of terminal equipment. Furthermore, the requirement in some systems for full compatibility within the network to transmit signals other than speech also limits the applicability of speech bandwidth compression. On the other hand reasonably simple terminal equipment has been demonstrated which gives 2:1 bandwidth compression with little degradation of transmission quality, and the application of such techniques may offer an increase of channel capacity under conditions of spectrum congestion;

b) multichannel radiotelegraph systems have been developed and placed in operation which make more efficient use of the bandwidth in ISB systems than previously obtained. Combining the advantages of frequency division multiplexing, time-division synchronous multiple-frequency keying, and ARQ such systems have achieved ratios of 1 bit/sec communication rate per 1.7 c/s bandwidth. High capacity data transmission systems have been developed using combined frequency division and time division synchronous multi-level phase keying, and are in operation to communicate 3000 bits/sec. per 3000 c/s bandwidth. Such systems also can accommodate a corresponding number of synchronous teleprinter channels at communication rates of 1 bit/sec. per 1 c/s bandwidth. Error detection coding and ARQ techniques are an important part of the effectiveness of these advanced telegraph systems.

c) recent developments have demonstrated reduced time facsimile transmission.

The Panel recommends

1. As regards radiotelephone systems, the study of the technical and economic feasibility of utilization of speech-bandwidth compression techniques to achieve compression ratios of at least 2:1.

2. As regards radiotelegraph systems,

   a) the study of multichannel teleprinter systems so as to use minimum bandwidth for the composite transmission rate, achieving at least a ratio of 1 bit/sec. communication rate per 2 c/s bandwidth;

   b) the study, for high capacity data transmission (corresponding for example to requirements approaching 3 kc/s bandwidth for several hours per day), of systems especially designed to minimize required bandwidth, rather than to rely entirely on minor adaptations of existing frequency-and-time division multiplexing systems which may be wasteful of bandwidth. It should be expected to achieve a ratio of at least 1 bit/sec. communication rate per 1 c/s bandwidth in such systems.

3. As regards facsimile and phototelegraphy systems, the study of technical development showing promise of reduction of bandwidth or time required for transmission; in particular, for black and white transmission, as for business documents and meteorological charts, the study of systems designed for smaller bandwidth-time product than required for picture transmission.

FCC TECHNICAL TOPICS

The following list consists of items suggested to the Panel on which technical information is desired by the Federal Communications Commission. Work is underway on many of the topics and the FCC is working on some of them. However, the FCC does not have what it considers to be adequate information on these subjects.

LAND MOBILE

What is the optimum channel width?

Merits of low deviation FM vs SSB or other bandwidth reduction technique.

Use of minimum power to cover an area, automatic power reduction or other variable power concept.

How can intermodulation effects be reduced, in receivers, in transmitters, and externally generated?

Can transmitter noise output be reduced by practical means below the presently accepted level of 80 to 100 dB below the carrier level?

Broadband multiple access systems-Are they efficient from a frequency utilization point of view?

Antennas for flutter reduction (especially at the higher radio freqs.) Some sort of diversity necessary?

Noise, measurement, reduction, best methods of combatting?

Merits of multiple low power stations vs single high power stations for base station use.

Different methods of handling information such as teletypewriters, facsimile systems such as hellschreiber, etc.

One way systems.

What is the long range outlook on frequency utilization?

What are the possibilities of frequency usage above 1 Gc/s? Considerable difficulty with flutter in mobile unit expected due to multipath propagation along with vehicle motion.

Methods of designing equipment to make higher frequencies economically attractive to the user.

Complete study of merits of all base stations in a given area being at the same location and with equal power. Assume two frequency operation for each circuit with transmitting and receiving freq. widely spaced and all trans. freq. in one band and receiving in another (a technique for reduction of effects of intermodulation).

Multiplexing of land mobile of FM broadcast stations.

Multiplexing of several land mobile base stations on one station.

Merits of interleaving signals (i.e. bandwidth of emission wider than channel frequency separation).

Information of filtering at VHF and UHF to reduce intermodulation. Crystal filters can be built at 150 Mc/s, can they at 450?

STANDARDS FOR COMMUNICATIONS SYSTEMS

Compile advisory standards for complete systems which can be used for reference in FCC rules as assumed standard for a given service, etc. Includes characteristics of transmitters, receivers, antennas, etc.

CABLE DISTRIBUTION IN LIEU OF RADIO (feasibility and economics of)

Television
Aural program
Land mobile services (e.g. at some submultiple of final frequency and radiated frequently at final freq.)

SSB STUDIES

Freq. stability improvements at low cost
Merits of various amounts of carrier reduction
Use for land mobile, air-ground circuits, etc.
Reduction in equipment size

CONTROL OF VEHICLES BY RADIO

Automatic control of automobiles on highways
Spectrum space requirements

FUTURE GROWTH PREDICTIONS FOR ALL SERVICES

Number of stations seem to be increasing exponentially but reason indicates that there must be a flattening off at some point in time.

RADIO SMOG-RADIO FREQUENCY INTERFERENCE

Man-made noise
- Automobile ignition
  - Transistorized ignition systems likely to be more troublesome than conventional systems.
- Dust precipitators (now becoming available for homes).
- RF cookers (becoming more reasonably priced for home use)
- SCR light dimmers (transient switching pulses may be a problem when SCR's are used for home illumination dimmers, etc.)

NATIONAL AND INTERNATIONAL AGREEMENT ON NOISE STANDARDS AND NOISE MEASUREMENTS

Are differences between ASA and CISPR noise meters necessary?

Is there a more general type of noise measurement that can be applied to new systems without remeasurement of levels?

Is the ITSA - CCIR (Report 322) measurement of atmospheric noise level applicable to man-made or impulsive noise? Over all frequency ranges and for all types of communication systems?

RADIATION MEASUREMENTS

Any correlation possible between 100 foot and 10 foot measurement ranges?

Can screen room measurements be used and correlated with interference effects?

How can meaningful measurements be performed in congested areas (e.g. downtown Manhattan, N.Y.)

RECEIVERS

Performance characteristics of all types of receivers.
- Sensitivity, noise figure, spurious responses, intermodulation effects, desensitization, selectivity, ease of tuning, frequency stability, temperature stability, etc.

RADIO WAVE PROPAGATION

More accurate methods for calculating field strength, esp. VHF and UHF

Propagation over irregular terrain, including effect of trees and buildings on the obstruction.

Comprehensive study of small area prediction techniques.

Depression factor (reduction of signal strength) for cities.

Measurement techniques
- Ht. of receiving antenna
- mobile vs cluster
- road speed
- methods of accounting for type of receiving antenna
- time constant of meter and recorder for mobile meas.

Weather front fades
- methods of combatting fades where diversity does not work
- especially for FM broadcast reception at long distances

Determine field strength levels of distant interfering sources for UHF and microwave

DIRECT BROADCASTING FROM SATELLITES

What frequencies can be used (international) and domestic complications)

Type receiver needed?

Receiving antennas to be used based on various assumptions of service

MEDIUM FREQUENCY PROPAGATION (AM Broadcast band)

Study long distance interference between stations over North-South paths, especially transequatorial, and for various portions of sunspot cycle

Revision of conductivity map

LOUDNESS METER

Method needed for quantitatively measuring loudness as an effect upon the human sensory mechanism. Should take into account the contrast between a preceding sound and the present sound. To be used in determining loudness of commercial announcements, vs adjacent program material.

STEREO TELEVISION - PICTURE AND SOUND

NEW METHODS OF TV TRANSMISSION

Spectrum conserving methods of transmission needed. Needs to be sufficient improvement from a conservation point of view to overcome economic problems with existing investment in equipment.

GROUND CONDUCTIVITY MEASUREMENTS

Would be desirable to be able to directly measure the equivalent ground conductivity for frequencies in the LF and MF range. Present method involves measurement of field strengths along a radial and matching the curve obtained with a theoretical curve.

COMPATIBLE SINGLE SIDEBAND FOR STANDARD BROADCAST STATIONS

Is it worthwhile and under what conditions?

IMPROVED TV RECEPTION FOR THE HOME

Better receivers and antennas

Reduce noise and reduce ghosting

NEW ANTENNA DEVELOPMENTS

Any suitable antenna having low angle radiation properties which is practical for the low frequency end of the standard broadcast band. Franklin antenna becomes unwieldy. A ring type of antenna may be suitable.

MEASUREMENT OF RADIATION FROM ANTENNA AS INSTALLED (VHF AND UHF BROADCASTING)

Method of determining that antenna is performing as designed. Some stations have found that antenna change caused phenomenal change in received signals indicating that original antenna was not connected properly.

ANTENNA DIRECTIVITY AS FUNCTION OF POLARIZATION

If cross polarization is used for broadcast service a detailed study of the actual rejection that can be expected for signals polarized orthogonally to that desired. How stable is the rejection ratio in actual practice? What are the maintenance problems and costs?

DISTORTION OF RADIATED PATTERN OF SIDE MOUNTED FM BROADCAST ANTENNAS

RADIO ASTRONOMY

Where is best compromise between frequencies desired and absolutely necessary?

Degree to which exclusivity is necessary. Can the frequencies be shared?

STUDY USES FOR FREQUENCIES ABOVE 10 GC/S

Have all the windows been found?

Methods for overcoming absorption.

WAVE PROPAGATION PREDICTION FROM WEATHER STATISTICS

If adequate correlation can be found better prediction should be possible since weather data has been taken at more places and for a longer time than radio data.

SITE SCREENING

What amount of site screening can be obtained for space communications sharing with terrestrial services? Best methods?

AUTOMATED MONITORING AND MEASURING

IMPROVED MODULATION MONITORS

Present monitors not adequate for peak measurements. Correlation of frequency of peaks vs interfering effects. Should spec. be changed to quasi-peak that can be read by monitors?

BRANDWIDTH OF EMISSION MEASUREMENTS AND STUDIES

CCIR bandwidth specs. not practical to measure at a distance from the station. CR Spectroscope useful at a distance but does not measure total power to correlate with CCIR specs.

STANDARDIZE TV TESTLINE TRANSMISSION

Testlines transmitted by networks at top of TV picture may be more useful if all stations transmitted same information. Could be used for setting of levels, checking bandwidth of device, color adjustments, etc.

BEST FREQUENCY FOR AIRBORNE EDUCATIONAL TV

Study practicality of frequencies from 2.5 Gc/s and up

INFORMATION RETRIEVAL

Best method of searching for information on devices or ideas that may be useful for telecommunications or cause interferemce. Looking for unknown devices with unknown characteristics. Need to know of the plans for devices prior to existence so guidance can be provided in frequency selection.

COMPUTER APPLICATIONS

Systems engineering computation

Land mobile coordination methods

Modification or adaptation of ECAC methods

AUTOMATIC TERRAIN INFORMATION SYSTEM FROM COMPUTER IMPUT

Need cheap method of obtaining data for or for drawing radials, present studies involve huge amounts of stored data (e.g., several hundred reels of magnetic tape for U.S.)

GENERATION OF FREQUENCY ASSIGNMENT PLANS BY COMPUTERS

Presently being done for broadcast services, is it practical to do for land mobile and microwave?

DATA TRANSMISSION

High speed computers need wide band channels for handling of data from one location to another in a centralized computer operation. What are possible demands on frequencies and where in spectrum?

RADIO MONITORING SURVEILLANCE SATELLITE

Is this a practical method of obtaining the desired information on the higher frequencies?

Can antennas be made directive enough to avoid getting a hodgepodge of signals?

Need storage devices to store signals to be retransmitted on microwave when over receiving location.

Can bandwidth, frequency, signal strength and location of station be determined?

Measurement of noise levels?

RECAPITULATION

Studies or further studies are needed on the following general areas of interest:

(1) Methods for good frequency utilization

(2) Methods to solve the land mobile problem

(3) Methods to solve the intermodulation problem

(4) Methods of reducing undesired emissions (radio smog)

(5) Sharing between the space and terrestrial services

(6) Automated monitoring

(7) Radio astronomy requirements

(8) Uses for frequencies above 10 Gc/s up to and beyond the visible range

(9) Computer applications

* U.S. GOVERNMENT PRINTING OFFICE: 1966—251-021/47

Wednesday 7/2/69

4:15 Mr. A. W. Alexander of the Clearinghouse (in charge of sales and distribution) called to let us know that the staff papers are in the process of printing them. Wanted us to know this in case we had outside inquiries. 321-8503

Suggests discouraging free copies as much as possible as there are 13 volumes in the set, which costs $39.

They will send us our four copies.

COMSAT

COMMUNICATIONS SATELLITE CORPORATION

ROBERT E. BUTTON
The Special Assistant to the Chairman

July 2, 1969

Dear Tom:

In connection with the re-establishing of the Office of Telecommunications Management under some replacement for General O'Connell, I am taking the liberty of sending you the attached extract from a recent hearing of the Subcommittee on National Security Policy and Scientific Developments of the House Committee on Foreign Affairs. The witness is probably already known to you but his views might be helpful in the current situation.

Sincerely,

Bob

Attachment

cc: Darrell M. Trent

Dr. Clay T. Whitehead
Staff Assistant to the President
Room 103
Executive Office Building
Washington, D.C. 20500

SATELLITE BROADCASTING: IMPLICATIONS FOR FOREIGN POLICY

HEARINGS

BEFORE THE

SUBCOMMITTEE ON NATIONAL SECURITY POLICY AND SCIENTIFIC DEVELOPMENTS

OF THE

COMMITTEE ON FOREIGN AFFAIRS

HOUSE OF REPRESENTATIVES

NINETY-FIRST CONGRESS

FIRST SESSION

MAY 13, 14, 15, AND 22, 1969

Printed for the use of the Committee on Foreign Affairs

Summary of Recommendations

I

The scientific progress represented by broadcast satellites contains great potential for increasing international understanding, thus contributing to world peace, and can be a powerful instrument for education and economic, political and social development. In accord with its heritage of freedom of information and its leadership in communications technology, the United States should encourage and support constructive international cooperation in the development of satellite broadcasting within the framework of international law.

II

In order to better coordinate U.S. telecommunications policy, particularly in the field of satellite broadcasting, a centralized authority with responsibility for policy planning and coordination should be established. Consideration should be given to upgrading the Office of Telecommunications Management within the Executive Office of the President to undertake that role.

III

Intelsat should be given the responsibility for establishing and maintaining the satellite portion of a worldwide space broadcasting system.

IV

The United States should support reasonable requests by the Secretary General of the United Nations for free use of Intelsat facilities.

V

A "Center for Developmental Television" should be established within the executive branch, preferably within the Agency for International Development, to plan and implement projects for the use of television and related technologies for educational and developmental purposes in the less developed countries.

mated storage and retrieval of educational materials. We do not have the motivation of industry or the urgency of the military; but education is learning, and will learn, from both. Perhaps there is not yet enough impatience, and, for this reason, Father Culkin's voice is valuable.

Mr. ZABLOCKI. Thank you very much. With the permission of the members, Congressman Fulton, who was unable to be here, has requested that a series of questions be asked that were presented to him from Congressman Brad Morse. If you are so disposed you can answer them for the record. Is there any objection?

(The questions submitted by Mr. Fulton, and the replies thereto, follow:)

Question: Mr. Morris, I understand that you were an advisor to President Johnson's Commission on Telecommunications and were involved in the Report released by the White House. It seems to me that this report raises as many questions as it answers and leaves an enormous burden on this Administration to reconcile some of these problems. How do you view generally the policy statements in the report?

Mr. MORRIS. Yes, I was pleased to serve as Technical Consultant to President Johnson's Task Force on Communications Policy. I should note, however, that my involvement was limited to providing technical and operational telecommunications advice and counsel.

I am in general agreement with the findings and recommendations that are in the areas of direct interest to your committee—i.e., national security policy and scientific developments. The report will undoubtedly serve as a useful addition to the many other studies of telecommunications problems. Now it will be possible for knowledgeable and interested elements of the Congress, the new Administration, industry, and academic and research institutions to further address and attempt reconciliation of policy alternatives discussed and to obtain action. Further dialogue will certainly be necessary.

I am particularly in sympathy with the Task Force's call for and the need to establish and give support and authority to telecommunications policy management in the Executive Branch. It is my view that such authority must be better identified.

As the report points out, an effective office is needed to address, on a continuing basis, the many policy and management problems identified in President Johnson's Message to the Congress of August 1967 and addressed by the Task Force. Ad hoc task forces do not provide the continuity to carry the problems identified through to solution. An effective office of telecommunications management is necessary to determine and optimize policy choices in economic, social, political and technologic areas and to follow through in:

(1) Improving frequency spectrum management and usage;

(2) Policy direction and guidance in the development and operation—and the bringing into being—of a unified National Communications System;

(3) Making more effective the Government's role as stimulator of innovation in management—in organization and economics, as well as social and technological areas;

(4) Removing, to the extent possible, restraints on private initiative in the several fields of telecommunications technology and organization and in the application of considered innovation:

(5) Enlarging the opportunities for new communications business to be developed and exploited which require recognition of interaction in the fields of telecommunications, electronics, graphics, computation, education, etc.;

(6) Insuring that, in enlarging telecommunications systems and services, we adequately protect—through policy and regulatory guidance—the integrity of the systems and networks upon which we rely;

(7) Implementation of the Communications Satellite Act of 1962, including removal of obstacles to progress in bringing early communications satellite service—the quality and economy of such service—to the developing as well

as the developed nations and to allowing the domestic United States to have the benefits of communications satellite service without further delay;

(8) Rationalization of the United States international communications carrier industry structure—as has been repeatedly called for over the years without resultant action;

(9) Insuring emergency preparedness and responsiveness of our national telecommunications resources geared to contingencies of the 1970's; and

(10) Fostering improved federal-state cooperation in governmental telecommunications system planning and funding.

Much work and thought went into the Task Force research with major contributions made by Government agencies, contractors, consultants, the communications carrier and equipment industries and associations. The fact that the Task Force was able to produce such a thorough report is a credit to the dedication of all involved and a reflection to the lack of recognized national policy leadership prior to the Task Force's effort.

Question. Do you feel that there will be far-reaching repercussion from the release of this report? In what way?

Mr. MORRIS. I believe there may be two major areas in which there could be far-reaching repercussions. One is the matter of the domestic satellite system. This could be precluded, however, if the so-called Pilot system were initiated—as was proposed by the Communications Satellite Corporation some three years ago—reserving to a later date the final resolution of questions re ownership of the system, operational responsibility and authorized users.

The other area, and the one most likely to be quite contentious, is that of the establishment of a single U.S. international telecommunications entity. The benefits to the public and to our international relations and negotiating position must be made evident, and be clearly stated, in order to overcome objections.

Question. Mr. Morris, do your current efforts involve the Domestic Satellite issue and what, in your view, is the reason for delaying a decision? Should not this facility proceed? What are the problems in this field?

Mr. MORRIS. I am not currently involved in any work pertaining to the domestic satellite issue, although I am personally strongly in favor of proceeding with an operational demonstration multi-purpose system without delay. I have studied the problems involved in detail.

I fail to see any excuse for further delay except as is necessary to update the plan for implementation in that the FCC docket on this subject was closed, without rendering a finding, more than two years ago. I concede that a wise decision may be difficult to formulate—but it must be formulated. There are only two basic problems in this field—who or what consortium is going to own and operate the system and who will be authorized and desirous of becoming direct authorized users. These questions need not be resolved prior to a go-ahead for the Pilot system.

Question. What role, in your opinion, should the Communications Satellite Corporation play in the Domestic Satellite program?

Mr. MORRIS. I believe the Communications Satellite Corporation should be charged with initiation of the Pilot program working in cooperation with all potential users, as they have proposed to the FCC. With their experience in managing the development and operation of satellites, the development and operation of earth stations, and established close arrangements with NASA for launch services, COMSAT has the capability to establish an operational demonstration system. COMSAT has the charter of Congress in this area regardless of whether or not it is an exclusive charter. COMSAT, by virtue of the fact that it serves as the U.S. entity in the International Telecommunications Satellite Consortium (Intelsat), is in the best position to effect the necessary and early coordination with INTELSAT and with the International Telecommunications Union (ITU) consistent with the position of the United States.

Question. What role, in your opinion, should the Communications Satellite Corporation play in the exchange of information to underdeveloped countries? I believe that in most of the underdeveloped countries they lack the means of distribution of information as well as the input of program data. Does this mean that we will have to supply an internal distribution system?

Mr. MORRIS. Comsat is, in fact, serving in a position of leadership in the exchange of information concerning new communications capabilities for both developed and underdeveloped countries. This they have been doing effectively—and in concert with the Department of State—in promoting interest in Intelsat. Dramatic proof is the fact that there are now sixty-eight member nations of the Intelsat Consortium and forty developing nations now have defined plans or have made commitments for communications satellite earth stations. I understand that plans have been considered to publish an Intelsat periodical which would disseminate on a worldwide basis information concerning the latest developments in satellite communications. This will be a further step forward.

Of course, the services of communications satellites are available to the United States through the international communications carriers and Comsat. Already the United States and the countries with installed earth stations are exchanging vast amounts of information—some for public and some for private consumption. As of December 31, 1968 there were nearly one-thousand full time voice equivalent circuits in use in the Pacific and Atlantic regions and nearly seven-hundred hours of television were exchanged in these regions. This year we will see substantial further increases in such exchange, to more destinations (including more underdeveloped countries) and provision of service in the Indian Ocean region.

Regarding the matter of communications distribution systems internal to the developing countries, you are very correct. Facilities are lacking in many instances. However, tremendous efforts are being made worldwide to overcome these deficiencies. It is becoming more common for the governments of the nations of the World and the international banking institutions to recognize the economic value and viability of improved communications. This means that the United States need not supply internal distribution systems. We must merely encourage action and provide technical assistance in planning. This is an area to which more effort must be applied. I am personally active in this field as I indicated in my testimony. I do feel that U.S. industry must become more aggressive and competitive. The Japanese have moved to the forefront in this area. As an aside, I do believe help could come from an effective executive agency committed to the promulgation of national telecommunications policy in assisting and urging U.S. industry to accelerate the acceptance of recognized international standards of measurement and design.

Question. Mr. Morris, it appears to me that we are losing the opportunity to foster United States' interest in underdeveloped countries by not taking advantage of their media to provide the educational and other information needed by them. This information could be easily disseminated by a Broadcast Satellite. What are the technical and other problems associated with performing their function and why do we not proceed with it? Have we performed the necessary research either in NASA or Comsat to provide the space segment of such a system? Who should finance these equipment developments and programming costs? Have we overlooked other means of communications?

Mr. MORRIS. I could completely agree with the thrust of your comments if you would eliminate the word "Broadcast" and suggest improved dissemination of educational and other information to underdeveloped country governments and to their media through intensified use of satellite distribution capabilities and other communications exchange means.

My views regarding worldwide direct broadcasting via satellite is a matter of record in my testimony as presented to your committee. The critical question concerns the policy acceptability or desirability of direct broadcast on a national or international basis. I find the latter questionable. International broadcasting via satellite poses some profound questions of law, ethics, politics and economics.

I do believe that technical development of the space segment of such a system as would be required for satellite broadcasting should proceed without delay to give us the *capability* if use should be dictated by international developments.

Both Comsat and NASA are concerned with problems and developing the potentials of broadcast and distribution satellites. Comsat has had detailed conversations on this subject with representatives of India, Argentina, Brazil, Chile and Colombia, and in the case of India, the Comsat Laboratories have undertaken preliminary studies in concert with NASA. Technical programs are underway, as I understand the NASA programming, that will contribute to the technology of broadcast satellites. I am, however, unaware as to the degree of funding authorized or the priority established for the efforts. I believe the carrying out of NASA responsibilities under the charter of the Space Act.

I believe Comsat will be constrained in participating or in establishing any broadcast satellte system—save for research and development management. In the light of the Plenipotentiary Conference in progress on the definitizing of arrangements for Intelsat arrangements there is a high degree of sensitivity vis-a-vis specialized services being provided by the Intelsat system or Comsat.

Furthermore, it must be recognized that Comsat is a publicly owned and financially motivated corporation that must work toward providing economically visable service. It is not clear that direct broadcast services via satellite—with the tremendous costs involved—will be a viable venture.

As I noted in my testimony, I do believe we may be overlooking other—and currently available—means of achieving freer flow of information among nations and peoples as a result of fascination with the prospects of satellite provided television transmission.

Question. The Task Force report endorses the idea of a single overseas telecommunications entity. What is your view of this consolidation? Do you feel that a savings can be demonstrated without a loss of efficiency or capability?

Mr. MORRIS. I have previously indicated my support for the establishment of a single United States international telecommunications entity. I am convinced that a savings can be demonstrated without a loss of efficiency or capability. I believe that a rationalization of the industry structure would also offer considerable international political, national security and diplomatic advantage as well as enhance and provide improved balance in the introduction of new modes and means of telecommunications. It would eliminate artificial constraints under which our international telecommunications industry operates today. There is little question but that technical operating efficiency would be improved.

There is no competitive reason for the continuation of a multiplicity of independent U.S. international carriers, separated by mode or service. As regards competition in itself, AT&T has observed in its filing before the FCC in Docket No. 16495, "Comments of American Telephone and Telegraph Company with Respect to Additional Comments of the General Electric Company" (April 9, 1969) that "We believe it is clear that competition in and of itself is not a national policy in the common carrier field. In fact, Congress has specifically limited the applicability of completitive principles in the regulated communications industry . . .".

There is even less technical reason to justify separation of mode of transmission. In the filing cited above, AT&T responded to a contention by General Electric re the feasibility of a split between record and voice communications and replied "The implication of this statement seems to be that there is to be one system for voice communication and another system for record communication. We are firmly convinced that any such proposal to establish separate systems for voice and for record communications is technically unsound, economically wrong and contrary to the interest of communications users in general."

Regardless of the above, as the findings of many prior government and industry studies over the years, the United States—essentially alone in the World—continues to perpetuate an international communications industry structure based upon separation of modes and—with the advent of communications satellites—separated based upon transmission means.

The extent of savings to the public and industry that would accrue from a restructuring of the industry can be demonstrated only after all the facts are laid on the table and analyzed in detailed studies of alternate economic and operational models. This has not, as yet, been done nor is it apparent that it can be done without FCC and/or Congressional support and inquiry to "bring out the basic facts".

Question. In this regard, there is much controversy over the need for satellites as opposed to cables. Do these two methods not complement each other rather than compete and should we not encourage the installation of both methods?

Mr. MORRIS. Cables and satellites are in some instances complementary rather than competitive. However, as the satellite system grows and we take advantages of unique features of satellite service there will be reduced incentive to install cable systems to points served by satellites. It is economically illogical to install many dual path system and the direct interconnection flexibility of satellite service is technically impossible to duplicate by cable. Very likely, long distance submarine cables will tend to be deemphasized other than between traffic locations where extremely high reliability through redundancy of alternate independent modes of transmission justifies their installation and maintenance. More than likely emphasis will tend toward short submarine cable systems such as between islands or land masses separated by bodies of water that cannot be readily spanned by microwave. I do foresee a considerable and increasing market in land cables, particularly where conservation of the frequency spectrum is paramount and frequent "drop offs," switching points, or accesses are desired.

In your considerations you should recognize the unique characteristics of satellites permitting the offering of certain services which are not yet available in present submarine cable technology (e.g. television).

Question. What is your view on Cable Television (CATV) and should we not stop the controversy and get along with the job?

Mr. MORRIS. Here I must state that I cannot pose as an authority in the complicated areas of controversy vis-a-vis community antenna and cable distribution television and over-the-air television broadcasting. I believe that Professor Rostow articulated well his views during his appearance yesterday (May 21, 1969) before the House Subcommittee on Communications and Power of the Committee on Interstate and Foreign Commerce incident to the Subcommittee's hearings on "Regulation of Community Antenna Television Systems". I am pleased to agree with Professor Rostow.

I am concerned that the FCC may have opened Pandora's box with its massive docket announced last December and that progress in the important area of accommodation of CATV and over-the-air television may be delayed unduly and that we may have, as Professor Rostow stated, "a standstill arrangement in the evolution of the (TV) industry" for an extended period of needless restriction.

FUNCTIONS OF THE ODTM

Mr. ZABLOCKI. Mr. Fraser.

Mr. FRASER. Let me come back to this question of fixing responsibility for national policy. I can understand from what we have discussed this morning that educational developmental capabilities in satellite communications as well as in more conventional means could be located somewhere in the Government, and could become, then, a very important evolving resource. But is there a need for some kind of larger overall coordination in the whole field of telecommunications within the Federal Government?

I don't mean in-house communications, but I mean the whole range of policies that the Federal Government ought to be thinking about. In other words, is the ODTM really an adequate operating agency for this purpose?

Mr. ZABLOCKI. Mr. Fraser.

When the question came up last week, we were told, and I don't know how accurately, that that office's principal concern was the in-house communications requirements for the Federal Government, rather than taking a much broader perspective in assuming control overall, in other words, assuming responsibility for the coordination and seeing that the adequate policies were developed.

Mr. MORRIS. Sir, if I might comment on that, it was recognized by President Johnson when—in his message on Communications as transmitted to the Congress in August of 1967, concurrent with his appointment of the Task Force on Communications Policy—he called for a relook at the organizational structure of telecommunications management within Government. President Johnson separated this assignment from that given the task force. He called upon the Director of the Bureau of the Budget to conduct an overall organizational study of telecommunications management. The study results are not being made public as I understand it. The various alternatives, I understand, have been considered and are now being reviewed by the new administration. There is recognition throughout the Government and industry that we need to do more than we are doing now and to organize more appropriately to address the myriad of important problems before us. Concerning the Office of the Director of Telecommunications Management, in the Executive Office of the President, both Dr. Mack and I have testified to the point that the office has performed some good work.

The ODTM is organized with three directorates—one directorate dealing with frequency spectrum utilization, assignment and management for all of Government. This is now the dominating function. It takes the majority of the people.

The second directorate that one might identify is that having to do with the National Communications System. The system having been established on paper, by Memorandum of President Kennedy in August of 1963. The degree to which it has been found possible for the ODTM to provide policy direction and guidance in the development and operation of the National Communications System is questionable. The policy direction, according to the memorandum is to be given to the executive agent for the National Communications System and thence to the manager of the National Communications System. We should note, however, that the executive agent for the National Communications System is also the Secretary of Defense, and that the manager of the National Communications System is also Director of the Defense Communications Agency.

There has been concern expressed—including by congressional committee—that the relative lack of recognition of the Director of Telecommunications management, of recognized authority existent to give policy direction to the Secretary of Defense, is a shortcoming.

The House Government Operations Committee has also noted that possibly the responsibility for the executive action and management of the NCS is incorrectly lodged with the Deparmtent of Defense in that the Department of is the major claimant to the services of the system, and yet with the executive responsibility, is also the adjudicator of the claims of all agencies of government.

The need for policy direction and guidance of the executive agency is obvious.

THE NATIONAL COMMUNICATIONS SYSTEM

Mr. FRASER. When you use the phrase or term "National Communications System" what does that embrace? Is that more than the governmental?

Mr. MORRIS. When the National Communications System was set up—and again, I say, "on paper"—by President Kennedy, it was recognized that we must pull together, strengthen and unify all elements of communications for all major functions in support of government. The objective of the NCS is to provide necessary communications for the Federal Government under all conditions ranging from normal situations to national emergencies and international crises, including nuclear attack.

Mr. FRASER. But still essentially all for governmental use?

Mr. MORRIS. All assets for Government use, yes, sir—total Government use.

Now this is a tremendous job, to pull this complex together. Thus identified is a second major function and element of the Office of Telecommunications Management. This assignment is not an easy one to deal with. It is inappropriate for me to comment on how successfully the function has been perfored. That is for examination.

The third directorate within the Office of the Director of Telecommunications Management—and the one to which both Dr. Mack and I have been most directly exposed—is that charged with considering how the technology is coming along in communications. How is this technology being made use of and managed in the national interest. How is it being integrated into the existing structure, both in Government and outside of Government?

We do have established systems and organizational structures, all working well, in most instances. It is not the easiest thing to bring new technologies into existence, in an already established field. These subjects were addressed by President Johnson's Task Force, particularly with reference to the organization of the domestic common carriers and the organization of our U.S. international carriers. The latter subject has been repeatedly addressed with conclusions reached that a restructuring or "rationalization" of the industry is necessary.

Another subject of importance is that of how we take advantage domestically of communications satellite technology.

MAKING THE ODTM A PROFESSIONAL OFFICE

This subject has been under consideration for several years and now awaits a "go-ahead" by the Federal Communications Commission. The task force recommended early action.

These are some of the potpourri of problems that involve the Director of Telecommunications Management and his office staff in work with the many agencies of Government.

It is not my view that the Office is necessarily understaffed. I am not for big Government. It appears to me, as an outsider, that the Office should be elevated in terms of its position, stature, and support within the executive branch. Perhaps the number of employees could even be reduced by the "farming out" of some support functions required by the Office. The Office could then become a more professional office, perhaps similar to the Office of Science and Technology, where the average grade level is not a subject of major concern. The problem of making the Office wholly professional, hard hitting, and small, is of major importance and must be dealt with.

The opportunity, I believe, exists to make the Office into the kind of an office, that, out of professional respect, can draw upon all elements of Government and industry, in pulling together our Nation's resources in telecommunications and acting in the best interests of the United States.

It is not yet apparent to me that we need to move—as some have recommended—to a Department of Telecommunications. I would hope that the necessary job can be done within the Executive Office of the President. I, however, am not one who believes that this kind of function can be submerged within any department or agency of the Government. I allow, for example, that it would be extremely difficult to have a department or agency of Government allocating frequencies to other elements of the Government, the DOD included. This is executive authority, a very direct responsibility placed with the President by the Communications Act of 1934, as amended.

The Communications Satellite Act of 1962 places very specific responsibilities with the President. The President has been able to pass these along in two ways—as detailed in Executive Order 11191, previously referenced—with the major responsibilities placed with the Director of Telecommunications Management and the Secretary of State.

The present Director of Telecommunications Management, who also serves as Special Assistant to the President for Telecommunications and as Assistant Director of the Office of Emergency Preparedness is the Honorable James D. O'Connell. General O'Connell (U.S. Army, retired) is a dedicated senior citizen who has devoted his life in the service of his country and who has, during the past 5 years, made outstanding progress in improving the quality of leadership and management of national policy in telecommunications.

ENGINEERS VERSUS PROGRAMERS

Dr. MARGOLIN. Mr. Morris makes a point that I would like to highlight. I attended a number of meetings as consultant to the Government, in the area of educational telecommunications.

I must confess, having had just a little bit of engineering background—I am one of these interdisciplinary types that Professor Hanessian says we should produce more of—I found myself in meetings that were largely devoted to discussions of bandwidths and wavelengths, and power resources, and this kind of thing, and when you got down to it, the engineering reasons were the reasons that determined decisions. Not the end products or the characteristics of content or the purpose of the system, that is, education. These were not of great weight or concern in the meetings. This can be a little disturbing, and sometimes it puts off the other professionals, when they find themselves unable to bring their needs and their requirements to bear.

We have had a situation like this, for a number of years, in the computer application to education. It is most graphically told, I think, by one enlightened engineer, who after talking to an educator and scientist who is trying to get him to tell what the computer could do, he finally turned around and says in exasperation, "Doctor, if you will just tell me what you need, we can build the hardware to do that job."

Now I think this is much of our difficulty. With all due regard to the engineers, we are putting the cart before the horse. At this point, I do think we need the programers in the area of education, specifically, the educators, and their associated supporting groups to set the requirements to make some indication of what the needs are, what the needs would be for a country like India, what the needs would be for an American educational satellite system. And then ask the engineering components of this whole system whether they can indeed do the job. I think they can, but if more of those meetings were devoted to what

PRESIDENT'S TASK FORCE ON COMMUNICATIONS POLICY

Staff Reports

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FUTURE OPPORTUNITIES FOR TELEVISION

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THE USE AND MANAGEMENT OF THE ELECTROMAGNETIC SPECTRUM

The Staff Paper
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I - Spectrum Engineering - The Key to Progress (Joint Technical Advisory Committee of the Institute of Electrical and Electronics Engineers and Electronic Industries Association)

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THE ROLES OF THE FEDERAL GOVERNMENT IN TELECOMMUNICATIONS

The Staff Paper

Volume 13: (PB 184424)

BIBLIOGRAPHY

N.B. About the middle of July 1969, these will be available in complete set or separate volumes from:

Clearinghouse for Federal Scientific and Technical Information
Department of Commerce
Springfield, Virginia 22151
(Telephone: 321-8505)

It is understood the established price will be $3.00 per volume.

July 3, 1969

MEMORANDUM FOR HERBERT L. THOMPSON

In reply to your memorandum, I suggest the President not reply personally to the attached letter from Robert D. Ossenberg, Vice President of Telesis Corporation, and that the reply take the form of the attached draft.

Clay T. Whitehead
Staff Assistant

Attachment

cc: Mr. Flanigan
Mr. Whitehead
Central Files

CTWhitehead:ed

July 3, 1969

DRAFT

Dear Mr. Ossenberg:

Thank you for your letter to the President regarding CATV and the problems you face in Jasper-Huntingburg, Indiana.

As you can appreciate, this is an important policy questinn to which the Administration will be giving considerable attention, although primary responsibility at this stage rests with the FCC.

Sincerely,

Mr. Robert D. Ossenberg
Vice President
Telesis Corporation
1253 Diamond Avenue
Evansville, Indiana 47727

July 1, 1969

MEMORANDUM FOR PETER FLANIGAN

Since this refers to a rather deep subject under FCC jurisdiction will you please reply or give us some guidance?

Herbert L. Thompson

attached - incoming

TELESIS CORPORATION
1253 Diamond Avenue
EVANSVILLE, INDIANA 47727

TELEPHONE
812 424-5541

May 22, 1969

The Honorable Richard M. Nixon
President of the United States
Washington, D. C.

Mr. President:

In the past week to ten days, I have been writing letters to most of the congressmen and senators sending them a promotional piece telling of the progress that we are making with local origination for cable TV in Jasper-Huntingburg, Indiana.

These congressmen and senators are from an eight state area, namely: Alabama, Indiana, Kansas, Kentucky, Minnesota, Missouri, Nebraska and Tennessee, in which Telesis Corporation operates CATV systems. There are forty-seven CATV systems under Telesis Corporation. I want these congressmen and senators to know what we are doing with local origination for cities such as Jasper-Huntingburg, Indiana.

Mr. President, this is a complete, new communications field by way of CATV. We feel that there is a need for this type of television by way of localizing the interest of the local viewer. A television station doing the best coverage possible in their particular area cannot provide all the needed services for communities such as Jasper-Huntingburg or others. Cablecasting can cover the local events.

In Jasper-Huntingburg, we have given our viewers programs of strictly local interest which has helped us with our customers. We are giving people employment which is an added plus. We have extended our local origination channel to several colleges in the area and to the two school systems of Jasper-Huntingburg. The schools teach over TV-9, and use the channel for various other functions. Students have earned credit hours over TV-9 origination.

Certainly this is a new mode of communications, and there is still so much more that can be done and will be done by cable. The future is a bright one. We started in our local origination in Jasper-Huntingburg on October 1, 1968. At that time, we had 1,370 customers. Today we are proud to say we have a little better than 1,800 customers.

The enclosed brochure will show you what we have done and are attempting to do in these two fine communities in southern Indiana.

Possibly with a green light, cable TV can be the answer to many of our communication needs for today or tomorrow.

Mr. President - your help is wanted. The industry is a giant and it gets bigger every day. Will you help us?

Thank you, and

Best regards,

Robert D. Ossenberg
Vice President

RDO:ajm

enclosure

Tuesday 7/1/69

12:15 Dr. DuBridge's office advises that Dr. Drew has been involved in the letters, etc. from Kenneth Norton of Boulder.

Apparently there has been a lot of communication. Would youwant to call Dr. Drew?

No

Copy for Mr. Whitehead

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF TELECOMMUNICATIONS MANAGEMENT
WASHINGTON, D.C. 20504

OFFICE OF THE DIRECTOR

July 1, 1969

MEMORANDUM FOR THE DIRECTOR:

In accordance with our current procedure, I am pleased to transmit this report of the significant activities of this office for the period ending June 30, 1969.

J. D. O'Connell

J. D. O'Connell

Encl.

June 30, 1969

WEEKLY ACTIVITY REPORT NO. 72

FREQUENCY MANAGEMENT

1. Institute of Telecommunication Sciences Support

On June 26, OTM personnel met with representatives of the Institute of Telecommunication Sciences, (ITS) Department of Commerce, to determine the support which the Boulder Laboratories might provide OTM on matters of importance in the frequency area. Preliminary investigation indicates that ITS could assist in FY 70 in such areas as (a) survey of radio noise ("electromagnetic smog" caused by devices not built specifically to radiate electromagnetic energy, i. e., car ignition systems, fluorescent lights, arc welders etc.); (b) the definition of what monitoring capability might be necessary to provide a reasonable degree of "overview" of the government's use of communications-electronics; and (c) preparation of a compendium of techniques available within the current state of the radio art to serve as prerequisites to government agencies obtaining radio frequency assignments.

2. Direct Broadcast from Satellites

On June 27, OTM representatives attended an "executive briefing" presented by General Dynamics (under contract to NASA) on the subject of TV broadcasting from satellites. The possible uses foreseen for such application involves provision of a world-wide Armed Forces TV network, instructional television, and educational television for school systems. It was clear to OTM attendees that considerable sums are being spent in studying how satellites might be applied to various areas of the economy, but without clearcut cost-effectiveness analyses in comparison with other communications capabilities (mail, terrestrial radio systems, landlines, etc.). As a result of this briefing and other developments with respect to recent requests by NASA for frequency assignments, a letter is being forwarded to the Associate Director of NASA requesting clarification of their planning with respect to direct broadcast from satellites.

3. RTCM Activities

A member of the OTM staff participated in a meeting of the Radio Technical Commission for Maritime (RTCM) on June 27. This government/industry technical body is preparing a program looking toward marine use of satellites for communications/navigation purposes. A number of deficiencies were noted in economic, technical, and operational areas, and a study effort developed in response to these needs.

TELECOMMUNICATIONS EMERGENCY PREPAREDNESS

*1. Assumptions for Emergency Preparedness Planning

Since the last weekly activity report, representatives of OTM continued to attend OEP meetings of the Working Group on Planning Assumptions. A draft outline of the planning assumptions report has been developed and the OTM will be providing draft items for telecommunications assumptions for those portions of the outline concerning telecommunications in various contingency situations.

*2. Industry Coordination

On June 26, representatives of OTM met with personnel from Advanced Technology Systems, Inc. This meeting was requested by the President of the company and was for the purpose of discussing planning methodology appropriate to the development of improved telecommunication systems in regional, state, and local governments. The information provided by the industry representatives closely followed that methodology already prescribed by the Office of Civil Defense, Department of the Army, and which is contained in Part E of the Federal Civil Defense Guide.

*3. Telecommunications Coordination for Metropolitan Fire Activities

On June 25, representatives of OTM met with Captain Dove of the Los Angeles Fire Department. This meeting was requested by Captain Dove and concerned the role of telecommunications in firefighting activities applicable to metropolitan areas. Considerable discussion centered around the fact that the Federal Government has no major program of assistance or focal point for the coordination of metropolitan firefighting activities. The National Bureau of Standards has the responsibility in accordance with legislation, but funds allotted for the program are so inadequate that funding assistance is not available. Captain Dove is trying to bring attention to the need for funding support comparable to that which law enforcement communications receive.

*4. Office of Intergovernmental Relations Coordination

Since submission of the last report, Mr. Lathey of OTM has conducted continuing liaison and coordination with the Office of Intergovernmental Relations. This has been concerned primarily with actions being taken to disestablish the Federal-State Telecommunications Advisory Committee (also coordinated with OEP staff). During the June 18 briefing by the DTM to Governor Boe, it was agreed that the committee should be abolished as a sponsored activity by OEP and reestablished at a later date under sponsorship of the Office of Intergovernmental Relations.

*5. Communications Warning

On June 25, the DTM forwarded to the Director, OEP, a memorandum on the status of communications warning. Copies of the memorandum were provided to Messrs. Lindjord and Phillips of OEP. The memorandum is informative in nature and covers existing warning systems and home alert systems being considered by the Office of Civil Defense and the Federal Communications Commission.

NATIONAL TELECOMMUNICATIONS

1. Management of Telecommunications Standardization Activities

A meeting was held on June 25 with members of the DCA Standardizations Office and the NCS Manager's Office to discuss approaches to management of telecommunications standardization activities throughout the Federal Government. It is recognized that there is considerable fragmentation of telecommunications standardization activity which can lead to proliferation, duplication and conflicting telecommunications standards. It was appreciated by members at the meeting that potential organizational changes being considered by the new administration could impact on any firm decisions made at this time; therefore, subjects discussed emphasized the extent, the source and potential future actions toward resolving basic problems.

* Items considered of special interest to the Director, OEP

THE WHITE HOUSE

WASHINGTON

December 5, 1969

Return to
Clay T. Whitehead

Memorandum for the Domestic Satellite
Working Group Members

Attached is a summary of the reports of the Economic and Technical Committees. If you have any substantial comments, I would like to have them as soon as possible.

Clay T. Whitehead
Staff Assistant

Attachment

No comments - looks fine
to me.

Tom

AGENDA

DOMESTIC SATELLITE WORKING GROUP MEETING

OCTOBER 17, 1969

1:00 p.m. - Room 401

1. Discuss interactions between Technical and Economic Committee reports. list

2. Consider the structure and content of a final report by the Working Group. ready? timing? issues not appropriate for group

3. Discussion of replies to Mr. Whitehead's letter of August 19, 1969 to industry and other non-government groups.

4. Establish schedule for submission of draft report to the Working Group.

5. Announce date of the next meeting of the Working Group.

W. E. Kriegsman
Executive Secretary

1. Draft implications
Intelsat
Spare spectrum resource
2. Objectives, not
specif. e.g.
p. 3 bottom
Econ report.

THE GENERAL COUNSEL
POST OFFICE DEPARTMENT
WASHINGTON, D. C. 20260

cy sent to Tom Moore

October 28, 1969

Dr. Clay T. Whitehead
Chairman, Domestic Satellite
Working Group
The White House
Washington, D.C. 20500

Dear Dr. Whitehead:

The Postmaster General's representatives to the Domestic Satellite Working Group report that the Economic and Technical subcommittees have their reports in virtually completed form and that the Working Group is about to consolidate these reports into a final report of the Working Group.

The position of the Post Office Department with respect to the future development, use, and control of Domestic Communications-Satellite was set forth in the Postmaster General's communication of May 15, 1969, to the Federal Communications Commission in FCC Docket 16495, copies of which were furnished to you on July 30, 1969.

For the reasons set forth in that communication, the Department has a vital interest in the Working Group's report. The Summary and Conclusions as presently expressed by the Economic subcommittee are sufficiently broad in concept to permit utilization by the Post Office Department of the contemplated type of Domestic Satellite communications systems. However, establishment or use of such systems by the country's largest personal and business communications agency, the United States Post Office Department, is not specifically mentioned.

In our view, the report of the Working Group should explicitly note the following position of the Post Office Department:

> "The Postal Service should not be precluded from acquiring or sharing in the acquisition of a satellite communications system at some future date if it is determined to be in the public interest to operate an electronic postal system. Nor should it, in this event, be restricted to dealing with a sole domestic satellite licensee."

Sincerely,

David A. Nelson

David A. Nelson
General Counsel

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

195 Broadway
New York, N. Y. 10007

August 7, 1969

Dr. C. T. Whitehead
White House
Washington, D. C.

Dear Tom:

Today, August 7, we plan to make a public announcement of a new technological development by the Bell Telephone Laboratories which we believe holds promise of considerable public benefit. It seems to us that a door has been opened to the possibility of tiny computers and communications switching systems for the future.

Such devices will have the increased capabilities and lower costs which will be required by social, health, educational, defense and space programs, and by business operations. The basis of this new technology depends on orthoferrite materials which can be grown as single crystals, then sliced into thin sheets. As a consequence, the results of present research suggest that it may one day be practical to have "almost a computer on a slice."

Bell System scientists have historically pushed forward the boundaries of known technology in seeking improved telecommunications capabilities. One such effort has involved the seeking of new technology to make possible low cost, low power, all-digital data processing and switching. It has resulted in the development of the capability for devices employing new technology which can be made to perform a variety of functions -- logic, memory, switching, counting -- all within one solid magnetic material.

The new technology being explored at Bell Laboratories indicates that minute magnetic "bubbles" may provide these computer and communications processor tasks all within one thin sheet of magnetic material. The present interconnections between the various electronic components now involved in these functions would not be required with this new technique. This may make it possible to provide more compact and inexpensive data storage and processing for tomorrow's computers and telephone switching systems.

The "bubbles," locally magnetized areas that can move about in thin plates of magnetic material, can be created, erased, and moved anywhere in the material. They can interact with one another in a controlled fashion, and their presence or absence can be detected. The energy needed to manipulate the "bubbles" can be applied either by current carrying conductors or picked up from a surrounding magnetic field by microscopic "ferromagnetic antennae" in printed patterns distributed over the surface of the material. The "bubbles" can be controlled either by programming electric currents in an overlaid pattern of conductors or -- with no connecting wires -- by controlling the surrounding magnetic field.

Stepping stones to the new technology are the orthoferrites, magnetic materials composed of rare earth iron oxides. They were grown as crystals first at Bell Laboratories.

When a magnetic field of a critical value is applied to an orthoferrite, "bubbles" (almost perfectly cylindrical magnetic domains) are formed. These "bubbles" can be moved at high speed in the plane of the sheet of orthoferrite material. As the "bubbles" are moved into precisely defined positions, their presence or absence at different positions can represent binary numbers.

"Bubbles" of a size corresponding to only a few wavelengths of light can be manipulated. These lead to memory densities of about one million bits per square inch. The energy required to move, or switch, such a "bubble" is very small -- a fraction of that needed to switch a transistor.

One experimental device, using the "bubble" technology, is a shift register, a component widely used in data transmission equipment and computers for temporary storage of binary digits. Data rates of three million bits per second have been demonstrated with this device.

Only a few processing steps are required to realize its simple structure, and devices of very low cost are anticipated.

Much work remains to be done before these devices can be shown to be practical as parts of communications or computer systems. However, their potential for functional adaptability, physical simplicity, small size, low power, and low cost may open the door to new strategies in systems organization.

The fact that memory and logic now appear almost indistinguishable suggests new approaches to memory organization, and the potential low cost suggests the possibility of new trade-offs between hardware and software.

Technical papers and photographs for this work are being assembled, and we should be happy to provide them and any other additional information you might desire. Give me a call on the phone in this connection if you do.

With warmest regards,

Sincerely yours,

Charles K. McWhorter