APPENDICES

APPENDIX A

ALPHABETICAL LIST OF COMMENTS AND REPLIES

Initial Comments

Advanced MobileComm, Inc.

Aeronautical Radio Inc.

Albrecht, Eric K.

Alexander, Paul F.

American Mobile Satellite Corporation

American Petroleum Institute

American Radio Relay League, Inc.

American SMR Network Association, Inc.

American Telephone and Telegraph Company

American Trucking Associations, Inc.

Ameritech Operating Companies

Associated Public-Safety Communications Officers, Inc.

Association of American Railroads

Association of Maximum Service Telecasters, Inc.

Association of Independent Television Stations, Inc.

Bell Atlantic Operating Companies

BellSouth Corporation

BICE & Associates

CBS Inc.

Cellular Telecommunications Industry Association

Center for the Study of Economics

Central Station Alarm Association

Common Ground/U.S.A.

Communications Satellite Corporation

Comsearch

Contel Corporation

Corporation for Public Broadcasting

Digital Microwave Corporation

du Treil, Lundin & Rackley, Inc.

The Ericsson Corporation

Federal Aviation Administration (United States Department of Transportation)

Federal Emergency Management Agency

Forest Industries Telecommunications

Forestry Conservation Communications Association, Inc.

GEC Plessey Telecommunications, Ltd. and Stromberg Carlson Corporation

GTE Service Corporation

Harris Corporation -- Farinon Division

G. M. Howard

Hubbard Broadcasting, Inc.

Institute for Geonomic Transformation

Interactive Technologies, Inc.

International Mobile Machines Corporation

Land Mobile Communications Council

Lichtenstein, Irvin

LiTel Telecommunications Corporation

Manufacturers Radio Frequency Advisory Committee, Inc.

McCaw Cellular Communications, Inc.

Mobile Marine Radio, Inc.

Motorola Inc.

National Academy of Science's Committee on Radio Frequencies

National Aeronautics & Space Administration

National Association of Broadcasters

National Association of Business and Educational Radio, Inc.

National Association of Public Television Stations & The Public Broadcasting Service

National Broadcasting Company, Inc.

National Oceanic and Atmospheric Administration (On behalf of the United States Department of Commerce)

National Public Radio

National Science Foundation

National Spectrum Managers Association

National Telephone Cooperative Association

NYNEX Corporation

Organization for the Protection & Advancement of Small Telephone Companies

Pacific Telesis Group

Personal Radio Steering Group

Radio Technical Commission for Maritime Services

Radio Telecom & Technology, Inc.

Reel, Thomas G.

Southwestern Bell Corporation

Telecommunications Industry Association, Mobile Communications Division

Telocator

Thomson Consumer Electronics, Inc.

Tideman, Nicolaus (Virginia Polytechnic Institute and State University)

U S West, Inc.

United Parcel Service

United States Coast Guard (Department of Transportation)

United States Department of Agriculture

United States Department of Defense (With comments of Air Force, Army, and Navy attached)

United States Department of Health & Human Services

United States Department of Interior

United States Department of Justice (Antitrust Division)

United States Department of Justice (Justice Management Division with attached comments of Federal Bureau of Investigation)

United States Department of Treasury

United States Department of Veterans Affairs

United States Telephone Association

United Telecommunications, Inc.

Utilities Telecommunications Council

Voice of America

Volunteers in Technical Assistance

Waterway Communications System, Inc.

Wertime, Robert, Independent Researcher

WTNN, Knoxville, TN

Zenith Electronics Corporation

Reply Comments

American Telephone and Telegraph Company

Association of American Railroads

Association of Independent Television Stations, Inc.

Association of Maximum Service Telecasters, Inc.

Bell Atlantic Operating Companies

Blackwell, Tom M.

Cohn, Stanley I.

du Treil, Lundin & Rackley, Inc.

Federal Emergency Management Agency

Gaffney, Mason

GEC Plessey Telecommunications, Ltd. and Stromberg Carlson Corporation

GTE Service Corporation

Interactive Technologies, Inc.

Linear Corporation

LiTel Telecommunications Corporation

McCaw Cellular Communications, Inc.

MCI Telecommunications Corporation

National Aeronautics & Space Administration

National Association of Broadcasters

National Public Radio

National Telephone Cooperative Association

Northern Telecom Inc.

NYNEX Corporation

Radio New Jersey

Southwestern Bell Corporation

United States Department of Energy

United States Department of Justice (Antitrust Division)

Utilities Telecommunications Council

APPENDIX B

ALPHABETICAL LIST OF COMMENTER ACRONYMS & ABBREVIATIONS

AAR Association of American Railroads

Ameritech Ameritech Operating Companies

AMI Advanced MobileComm, Inc.

AMSC American Mobile Satellite Corporation

APCO Associated Public-Safety Communications Officers, Inc.

API American Petroleum Institute

ARINC Aeronautical Radio Inc.

ARRL American Radio Relay League, Inc.

ASNA American SMR Network Association, Inc.

AT&T American Telephone and Telegraph Company

ATA American Trucking Associations, Inc.

Bell Atlantic Bell Atlantic Operating Companies

BellSouth BellSouth Corporation

BICE & Assoc. BICE & Associates

CBS CBS Inc.

Coast Guard United States Coast Guard (Department of Transportation)

Common Ground

/U.S.A. Common Ground/U.S.A.

COMSAT Communications Satellite Corporation

Comsearch Comsearch

Contel Contel Corporation

CORF National Academy of Science's Committee on Radio Frequencies

CPB Corporation for Public Broadcasting

CSAA Central Station Alarm Association

CSE Center for the Study of Economics

CTIA Cellular Telecommunications Industry Association

DMI Digital Microwave Corporation

DOD United States Department of Defense (With comments of Air Force,

Army, and Navy attached)

DOE United States Department of Energy

DOJ/Antitrust United States Department of Justice (Anti-Trust Division)

DOJ/JMD United States Department of Justice (Justice Management Division

with attached comments of Federal Bureau of Investigation)

du Treil, Lundin

& Rackley du Treil, Lundin & Rackley, Inc.

DVA United States Department of Veterans Affairs

Eric Albrecht Albrecht, Eric K.

Ericsson The Ericsson Corporation

FAA Federal Aviation Administration (United States Department of

Transportation)

FCCA Forestry Conservation Communications Association, Inc.

FEMA Federal Emergency Management Agency

FIT Forest Industries Telecommunications

G.M. Howard G. M. Howard, Esq.

GPT/Stromberg GEC Plessey Telecommunications, Ltd. and

Stromberg Carlson Corporation

GTE GTE Service Corporation

Harris Harris Corporation -- Farinon Division

HHS United States Department of Health & Human Services

Hubbard Hubbard Broadcasting, Inc.

IGT Institute for Geonomic Transformation

IMM International Mobile Machines Corporation

Interior United States Department of th Interior

INTV Association of Independent Television Stations, Inc.

Irvin Lichtenstein Lichtenstein, Irvin

ITI Interactive Technologies, Inc.

Linear Corporation Linear Corporation

LiTel LiTel Telecommunications Corporation

LMCC Land Mobile Communications Council

Mason Gaffney Gaffney, Mason

McCaw McCaw Cellular Communications, Inc.

MCI MCI Telecommunications Corporation

MMR Mobile Marine Radio, Inc.

Motorola Motorola Inc.

MRFAC Manufacturers Radio Frequency Advisory Committee, Inc.

MST Association of Maximum Service Telecasters, Inc.

NAB National Association of Broadcasters

NABER National Association of Business and Educational Radio, Inc.

NAPTS & PBS National Association of Public Television Stations

and the Public Broadcasting Service

NASA National Aeronautics & Space Administration

NBC National Broadcasting Company, Inc.

Nicolaus Tideman Tideman, Nicolaus (Virginia Polytechnic Institute and State University) **NOAA** National Oceanic and Atmospheric Administration

(On behalf of the United States Department of Commerce)

Northern Telecom Northern Telecom Inc.

NPR National Public Radio

NSF National Science Foundation

NSMA National Spectrum Managers Association

NTCA National Telephone Cooperative Association

NYNEX NYNEX Corporation

OPASTCO Organization for the Protection & Advancement of Small Telephone Companies

Pacific Pacific Telesis Group

Paul Alexander Alexander, Paul F., Arnold, MD

PRSG Personal Radio Steering Group

RNJ Radio New Jersey

Robert Wertime Wertime, Robert

RTMC Radio Technical Commission for Maritime Services

RTT Radio Telecom & Technology, Inc.

Southwestern Bell Southwestern Bell Corporation

Stanley I. Cohn Cohn, Stanley I.

Telocator Telocator

Thomas G. Reel Reel, Thomas G.

Thomson Thomson Consumer Electronics, Inc.

TIA Telecommunications Industry Association, Mobile Communications Division

Tom M. Blackwell Blackwell, Tom M.

Treasury United States Department of Treasury

United United Telecommunications, Inc.

UPS United Parcel Service

USDA United States Department of Agriculture

US West U S West, Inc.

USTA United States Telephone Association

UTC Utilities Telecommunications Council

VITA Volunteers in Technical Assistance

VOA Voice of America

Watercom Waterway Communications System, Inc.

WTTN WTNN, Knoxville, TN

Zenith Zenith Electronics Corporation

APPENDIX C

(seperate document)

APPENDIX D

ESTIMATING THE VALUE OF CELLULAR LICENSES

I. Introduction

This Appendix describes two methodologies that were employed to estimate the current value of a particular portion of spectrum used for a designated purpose -- cellular telephone service. The steps necessary to derive these estimates illustrate the difficulty in estimating spectrum value.

II. Estimating the Current Value of Cellular Licenses in Urban Areas

There are numerous methods of estimating the value that firms place on an operating license, all of which suffer from one weakness or another.[(1)] One of the major problems in estimating the value of cellular licenses is to distinguish between the financial returns attributable to the spectrum input, and those returns attributable to the firm's other production inputs (e.g., capital, management).[(2)]

We employ two methodologies to estimate the current value of the 50 MHz of spectrum devoted to cellular uses in Metropolitan Statistical Areas (MSAs).[(3)] Both methodologies attempt to isolate the value of cellular licenses in MSAs by subtracting the value of other firm assets from the total market value of cellular firms. The first methodology derives total market value from recent sales of cellular franchises in MSAs, while the second derives market value from the stock price of firms that have cellular franchises in MSAs.

A. Methodology Based on Recent Sales Transactions

The first methodology employed to estimate the value of cellular telephone licenses in MSAs involves estimating the aggregate (i.e., total industry) market value of firms providing cellular service in urban areas, based on recent sales transactions, and the aggregate replacement cost of the tangible assets used by those firms. Because the market value should reflect payments made to all inputs (including spectrum) and the replacement cost reflects the cost of replacing all tangible assets, the difference provides an upper bound on the value that cellular providers place on spectrum. In particular, the difference between aggregate market value and aggregate replacement cost provides an estimate of the discounted value of the expected future earnings of the industry.

1. Total Market Value Estimates

We used a multi-step procedure to derive an estimate of total market value of cellular properties in MSAs. First, we obtained recent sales prices for a sample of 24 cellular properties.(4) Then, because of limitations in the available data, including the "skewness" in the distribution of sales prices and populations served, we divided the sample into three market size categories: large markets (population over 500,000), medium markets (population from 162,501 to 500,000), and small markets (population 162,500 or less). For each category, we calculated a weighted average sales price (expressed in terms of price "per pop"), with the weights equalling the percent of the population represented by each property.(5) These values are provided in Table 1.

TABLE 1

Market Size	Average Sales Price (per pop)
Small	$131.46
Medium	$168.62
Large	$250.98

Given the above information, the total market value of cellular properties in MSAs can be calculated by following a three-step procedure. First, we multiplied the average price "per pop" by the total population in each market size category.(6) Second, we summed the resulting products of each multiplication. Third, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the total market value of cellular properties in urban areas is approximately $86,660,800,000.

2. Total Replacement Cost Estimates

Estimates of total replacement cost are based on research conducted by Shew (1990).(7) Shew (1990) followed a three-step procedure to derive an estimate of the total replacement cost of tangible assets of firms in the cellular industry.

First, Shew (1990) obtained from Malarkey-Taylor an engineering estimate of the reproduction cost of plant and equipment for each class of cellular property (i.e., small, medium, and large).[(8)] These estimates, on a "per pop" basis, are shown in Table 2.

TABLE 2

Market Size	Reproduction Cost (per pop)
Small	$ 13.72
Medium	$ 9.48
Large	$ 12.95

Second, to account for the fact that existing plant acquired in a sale is partially depreciated, Shew (1990) adjusted those reproduction costs for depreciation.[(9)] The resulting estimates of the replacement cost of depreciable tangible assets are shown in Table 3.[(10)]

TABLE 3

Market Size	Replacement Cost of Depreciable Tangible Assets (per pop)
Small	$ 11.26
Medium	$ 7.78
Large	$ 10.63

Third, Shew (1990) estimated the value of other, nondepreciable tangible assets, defined as the difference between the total book value of tangible assets and net plant.[(11)] Our estimates of these "other assets" are shown in Table 4.

TABLE 4

Market Size	Replacement Cost of Other Tangible Assets (per pop)
Small	$ 8.41
Medium	$ 5.81
Large	$ 7.94

Finally, we derived an estimate of the total replacement cost of all tangible assets, expressed on a "per pop" basis, by adding the values in Tables 3 and 4. These estimates are provided in Table 5.

TABLE 5

Market Size	Total Replacement Cost of All Tangible Assets (per pop)
Small	$ 19.67
Medium	$ 13.59
Large	$ 18.57

The total replacement cost of the tangible assets of firms providing cellular service in urban areas can be calculated by following a three-step procedure. First, we multiplied the total replacement cost "per pop" times the total population in each market size category. Second, we summed the resulting products of each multiplication. Third, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the total replacement cost of the tangible assets of cellular firms with MSA licenses is approximately $6,724,900,000.[(12)]

3. Value of Cellular Licenses in MSAs

Subtraction of the estimate of total replacement cost from the estimate of total market value is an economically defensible measure of the value that current cellular operators in MSAs place on their licenses (i.e., the spectrum). This calculation is shown in Table 6.

TABLE 6

Estimated Total Market Value	$86,660,800,000
Estimated Total Replacement Cost	$ 6,724,900,000
Estimated Spectrum Value	$79,935,900,000

This estimate of the value of urban cellular licenses represents an "upper bound" to the extent that it also includes other non-depreciable assets (e.g., goodwill). However, based on discussions with financial analysts and our own study of cellular properties, a large majority of the difference represents the value that cellular operators place on the spectrum.

This estimate of spectrum value in urban areas has two important strengths over other methods of estimation. First, we utilized estimates of average replacement cost and sales price "per pop" for three specific classes of cellular properties. This permitted more precise estimates of total market value and total replacement cost than estimates based on more aggregate averages. Second, consistent with economic theory, we adjusted the total market value of cellular properties for the cost of replacing tangible assets. This adjustment eliminates the upward bias associated with equating total market value to license value.

B. Methodology Based on Stock Market Prices

An alternative methodology to estimate the aggregate market value of cellular licenses in urban areas is based on the "public market" value of cellular firms. This benchmark represents the implicit valuation by equity shareholders of a firm's cellular licenses in MSAs.

1. Derivation of Public Market Values

The public market valuation benchmark is derived from the stock trading price of firms with cellular holdings. The methodology used is as follows.(13) First, the total market value of the company is computed by multiplying the number of shares outstanding by the current stock price. Second, the total capitalized value of the enterprise is calculated by adding in long-term debt (what the company owes to others). Third, the value of the firm's other assets (such as working capital, net property, plant and equipment, RSA holdings, and any non-cellular operations) is estimated,(14) which then is subtracted from the total value of the firm; the resulting figure represents the value of the firm's MSA licenses. Fourth, the aggregate value of the firm's licenses is divided by the number of MSA pops attributable to the company to arrive at an "implied value per pop."

2. Recent Estimates of Public Market Values

Based on February 8, l99l stock prices, the implied value of the MSA licenses held by a sample of ten cellular companies ranged from $62 "per pop" for United States Cellular to $199 "per pop" for LIN Broadcasting.(15) The weighted average for these ten companies was $122 "per pop."

Given the above information, the total market value of cellular licenses in MSAs can be calculated by following a two-step procedure. First, we multiplied the weighted average value of $122 "per pop" by the estimated 1989 total urban population of 190 million.(16) Second, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the aggregate market value of cellular licenses in MSAs is approximately $46,360,000,000.

C. Summary of Results

In some sense, each methodology represents a different, but complementary indicator of the economic worth of a firm. Under one methodology, the estimated aggregate value of spectrum used to provide cellular telephone service in urban areas is close to $80 billion; under the other methodology, the estimated aggregate spectrum value is $46 billion.[17]

It is not surprising that the estimate of spectrum value based on stock prices is lower than the estimate based on actual sales transactions: across industries, equity shareholders often place a lower value on firms than does the transaction marketplace. One reason why this may be true is that the purchaser of a cellular property is likely to have better information about the true value of the franchise than do equity shareholders, and is willing to pay more to acquire control of the franchise. Furthermore, the purchaser may be able to make more efficient use of the firm's assets (e.g., through economies of scope and scale or managerial expertise) than the seller can, which enables the purchaser to pay a "premium" above the prevailing per share stock price in order to ensure acquisition of control. In any event, as a practical matter, the average price per share paid in acquisitions of all, or a controlling interest in, the stock of a company generally exceeds the price at which shares were trading prior to the acquisition activity.

APPENDIX E

SPECIFIC REGULATIONS APPLICABLE TO BROADCASTERS

Radio and television broadcasters must comply with a number of specific requirements that are directly relevant to a determination of whether they serve the "public interest, convenience, and necessity" (the "public interest").[18] These requirements are imposed by the Communications Act, (the Act)[19], other provisions of the U.S. Code, or through FCC rules, policies, and decisions. The following is a summary of these requirements.[20]

I. Programming

Radio and television broadcasters have an obligation to provide programming that meets the needs of their communities.[21] "The method to be utilized in meeting this obligation is largely entrusted to the good faith discretion of each licensee."(22) A television licensee "in the exercise of its good faith judgment, will be able to address issues by whatever program mix it believes is appropriate in order to be responsive to the needs of its community."(23)

The FCC requires that applicants for a television broadcasting license provide a "narrative statement of their proposed programming."(24)

II. Local Public Inspection File

Radio and television licensees must maintain a file for inspection by the public,(25) which contains, among other things, a programming content log to be filed every three months, that lists programs that have provided the station's most significant treatment of community issues during the preceding three month period. The list shall include "a brief narrative describing what issues were given significant treatment and the programming that provided this treatment."(26) The licensee should include in its description the time, date, duration, and title of each of the listed programs.(27) The licensee must retain the log for two years. The two year period may be extended if the log involves communications incident to a disaster or an FCC investigation.(28)

In addition, radio and television broadcast licensees are required to retain in their public files copies of applications filed with the FCC;(29) ownership reports;(30) records concerning broadcasts by candidates for public office;(31) annual employment reports;(32) letters from the public;(33) and notices of renewal filings.(34)

III. Ascertainment

Under the old rules, applicants for broadcast licenses were required to follow specific formal ascertainment procedures.(35) Under the current rules, applicants for new and renewal television licenses "may determine the issues in their community that warrant consideration by whatever means they consider appropriate. The FCC will not request "standardized documentation and submission of these efforts."(36)

Applicants for renewal radio licensees are obligated to determine the issues facing their communities by "reasonable means."(37)

IV. License Renewal Forms

In 1981, the FCC instituted a "postcard" renewal application for licensees.[(38)] In 1984, the FCC similarly instituted short form requirements for television licensees.[(39)]

The postcard renewal form, while less lengthy than the previous renewal forms, still contains several questions relevant to the "public interest" obligation. The renewal form requires a licensee to provide: (1) information on the licensee's equal opportunity programs; (2) a description of the licensee's other media interests; (3) a certification of compliance with the Act's alien ownership requirements; (4) information about a licensee's character; and (5) a certification that the licensee included all required materials in its file.[(40)]

V. Personal Attacks

When an attack is made on the character or integrity of an individual or group during a broadcaster's presentation of views on a controversial issue of public importance, the broadcaster must notify the attacked individual or group and allow that party a reasonable opportunity to respond.[(41)] This rule does not apply if the attack is made by a political candidate or parties acting on his or her behalf, during a newscast or news interview, or against a foreign group or foreign public figure.[(42)]

VI. Political Advertising

Broadcasters must provide competing legally qualified political candidates equal access to their stations and broadcasters may not censor candidates' campaign announcements.[(43)] Broadcasters must offer legally qualified political candidates the lowest advertising rates available during the 45 days preceding a primary and the 60 days preceding a general election.[(44)] The FCC may revoke a station's license if the station willfully or repeatedly fails to allow a candidate reasonable access or to purchase air time.[(45)]

VII. Political Editorials

A broadcaster must offer a political candidate "reasonable opportunity" to respond when the station either endorses or opposes another candidate in an editorial.[(46)]

VII. Children's Television

Congress recently enacted the Children's Television Act of 1990[(47)], which institutes commercialization limits and children's programming recommendations for broadcasters. The Act limits commercials on children's television to 10½ minutes per hour on weekends and 12 minutes on weekdays. Additionally, the Act requires the FCC to consider whether a station has provided programming serving the "educational and informational needs of children" when deciding whether to renew the station's license.

The FCC has undertaken a rulemaking proceeding to conform FCC regulations to the new Act.[(48)] The FCC has proposed adopting children's television advertising limitations of 10½ and 12 minutes per hour on weekends and weekdays, respectively, and limiting program-length commercials.[(49)] Under the proposed rule changes, the FCC would require stations to assess children's needs using four criteria: (1) the local community's circumstances; (2) the licensee's other programming; (3) programming by other broadcasters in the community; and (4) other programming, such as cable, available to children in that area. Licensees would have to submit records on their children's programming along with their renewal applications.[(50)]

IX. Emergency Broadcasting

All broadcast stations participating in the Emergency Broadcast System (EBS) may operate during emergency situations for the purpose of providing the President, the federal government or state and local governments a means of communicating to the public.[(51)] Upon activation of the EBS at the national level, all non-participating radio and television stations must broadcast the EBS Attention Signal and the appropriate EBS message and then remove their carriers from the air.[(52)] In addition, for state and local level emergencies, all licensees may, at the discretion of management, discontinue normal programming and transmit emergency announcements.[(53)]

X. Minority Programs

The FCC encourages minority ownership of broadcast media through tax certificates and special distress sales for minority-owned groups.[54] Additionally, in the comparative hearing process the FCC awards priority to license applicants with minority or female ownership.[55] The Supreme Court recently upheld the constitutionality of the distress sale and comparative preference doctrines.[56]

Once the FCC awards a station a broadcast license, the station must comply with the FCC's Equal Opportunity requirements. Under the FCC's rules, "[e]ach broadcast station shall establish, maintain, and carry out a positive continuing program of specific practices designed to ensure equal opportunity in every aspect of station employment policy and practice."[57]

XI. Miscellaneous Provisions

A. Advertiser/Sponsor Identification

For each sponsored broadcast matter, radio and television stations must announce that the matter was paid for in whole or part and the party by whom or for whom the ad was purchased.[58] For commercial products, an announcement stating the sponsor's corporate name or the name of the product must be made.[59]

B. Lotteries

Generally, licensees may not broadcast advertisements or information concerning lotteries or games of chance. However, in certain circumstances a licensee may advertise lotteries run by a state, a charitable organization, or, if a promotional lottery, run by a commercial organization.[60]

C. Obscenity and Indecency

Under 18 U.S.C. § 1464, "[w]hoever utters any obscene, indecent, or profane language by means of radio communication shall be fined not more than $10,000 or imprisoned not more than two years, or both."[(61)] The FCC enforces § 1464 for indecent programming aired before 8 p.m. and for obscene programming aired anytime day or night. The FCC is seeking to enforce a 24-hour ban of indecent programming.[(62)]

D. Public Notice of Broadcast Applications

A radio or television licensee who files for license renewal "must give notice of this filing by broadcasting announcements on applicant's stations."[(63)] Licensees must air specific renewal announcements on the 1st and 16th of each calendar month commencing with the sixth month prior to the renewal. The FCC requires licensees to air as many as five daily announcements.[(64)]

E. Station Identification

Television and radio stations must broadcast station identification announcements hourly, as close to the hour as feasible, and at the beginning and end of each broadcast day.[(65)]

F. Minimum Operating Schedule

Radio stations are required to operate at least two-thirds of the total hours they are authorized to operate between 6 a.m. and midnight.[(66)] After 36 months of operation, television stations are required to operate at least 28 hours per week.[(67)]

G. Cigarette and Smokeless Tobacco Advertisements

Broadcasters may not air cigarette or smokeless tobacco commercials. Since 1971, it has been "unlawful to advertise cigarettes and little cigars on any medium of electronic communication subject to the jurisdiction of the Federal Communications Commission,"[(68)] and a similar law applies for smokeless tobacco.[(69)]

APPENDIX F

EXAMPLES OF SPECTRUM USE QUANTIFICATION

Chapter 5 describes how the quantity of spectrum resources used by radiocommunication systems can be calculated. This Appendix shows how spectrum use can be represented, and describes how it can be calculated, for a single system and for the aggregate of systems in a frequency band.

Figure F-1 shows a surface enclosing the spectrum resources used by a microwave radio-relay transmitter in a three-dimensional spectrum resource space, based on a power density criterion.(70) The horizontal dimensions are spatial (distance east and north of the origin) while the height represents frequency separation. At locations and frequencies inside the surface, the power density exceeds the criterion. In the antenna mainbeam direction, the signal strength is maintained over a greater distance, as shown by the eastward protrusion.(71) A similar volume below the plane is used by the transmitter but is not shown in this figure.

The quantity of spectrum resources used by this transmitter is twice the volume enclosed by the surface shown (since the same quantity is used below the plane). This value would be calculated using approximate (numerical) integration techniques, and could be expressed in units of MHz-km^2.(72)

A second example is the UHF television system in the United States, which consists of a number of broadcast transmitters, regulated by the FCC, and millions of essentially unregulated UHF receivers. The FCC assigns frequencies to new broadcast stations based on a system of required separation distances between stations, commonly called the "UHF taboos".(73) Figure F-2 shows a spectrum use diagram for a UHF transmitter, based on the taboos.(74) Each cylinder shown represents a 6 MHz UHF television channel. The radius of each cylinder is the separation distance required between the transmitter shown and the nearest existing transmitter on that channel.(75) The total spectrum resources used (the volume enclosed) is roughly 2.9 million MHz-km^2. Of that total, the cochannel spectrum use (represented by the broad cylinder in the center) accounts for 1.2 million MHz-km^2 or 41%. In other words, well over half of the spectrum use lies outside the assigned channel.

In both of these examples, the spectrum resource space has dimensions of frequency and space. Portrayal of the time dimension is not necessary, since microwave radio relay and UHF television systems generally operate continuously.(76) For radio services that operate intermittently, however, the time dimension is important. A mobile system, for example, uses a frequency channel over a wide area, but only for short periods. Often several systems will share a channel, each using spectrum resources proportional to the fraction of time it uses the channel.

Spectrum use can also be quantified for the aggregate of communications systems in a frequency band within an area of interest (e.g., the United States, as shown in Figure F-3). In this case, spectrum use is determined at each of a large number of geographic points as the fraction of spectrum resources used at that point. This value is known as the spectrum use factor (SUF). SUF values can be portrayed on a map as shown in the figure.(77)

Averaging the SUF values over the area being studied yields the spectrum use index (SUI), the ratio of the spectrum resources used to the total spectrum resources in the area.(78) The SUI provides a single value describing spectrum use and is valuable for comparing spectrum use in different areas or for assessing the growth of spectrum use in an area.(79)

APPENDIX G

FORECASTING

I. Background of Technological Forecasting

Technological forecasting, which seeks to predict how technologies will evolve over time, has developed over many years. During the 1960s, technological forecasting received much attention, and great effort was applied to developing its capabilities. "In 1965, the President charged the National Commission on Automation and Technological Change to examine, among other things, the use of technological forecasting and its potentials for the federal government. The Commission concluded that technological forecasting was little used."(80) Also in 1965, the twenty-two nation Organization for Economic Cooperation and Development (OECD) assigned Dr. Erich Jantsch to study technological forecasting. He identified one hundred technological forecasting and planning activities(81), and stated that technological forecasting emerged as a recognized management discipline around 1960.(82)

The primary U.S. proponents of technological forecasting have been within the defense community, because of its dependence upon technological advancements. Many of the American leaders in the field have defense backgrounds. The Air Force, Army and Navy all conducted technological forecasting studies during the late 1960s. In 1968, the Navy compiled over six hundred individual forecasts prepared by twenty-three separate R&D activities.(83)

Robert Ayres reported in 1969 that

The forecasting of technological as opposed to economic or demographic change is not yet so universally practiced. In part, this lag is due to a belated recognition of the extent of the impact of technological change on society, and in part it is due to a rather widespread notion that technological change is inherently unpredictable.[(84)]

None of these activities, however, dealt specifically with forecasting the development and use of communications technology for the purpose of spectrum planning.

In 1974, Systems Applications, Inc. (SAI) performed a study for the Office of Telecommunications Policy (OTP), NTIA's predecessor, that considered use of market analyses and demand forecasting to assess more effectively future spectrum requirements.[(85)] It determined that the market analyses then available to OTP were inadequate to produce spectrum demand forecasts. Those market analyses were based primarily upon projected equipment sales and demand for services, with little attempt to discuss their forecasting methods or assumptions. SAI concluded that basing key allocation decisions, solely or primarily, on results, conclusions, on those market reports would be risky. SAI stated that it is unclear whether equipment sales projections represent new spectrum requirements or mere replacement of existing equipment. It also noted that, because other factors, such as system characteristics, usually are not included in market studies, a link to spectrum usage cannot be made. SAI's primary recommendations were to:

1. Establish a program to review market analysis reports and monitor other trade journals for the purpose of extracting forecasting data.

2. Establish a frequency requirements plan supported by annual agency spectrum requirements forecasts. This was to be a statement of federal user frequency needs by band, as a function of time listed for the next 20 years beginning with the present year.

3. Quantify spectrum use for trend analysis.

In a 1976 study for OTP, Sachs/Freeman Associates, Inc. recommended an approach to forecasting that was much more limited than SAI's concept of the federal requirements plan. Sachs/Freeman proposed developing forecasts only for the most congested geographic areas within specific frequency bands.[(86)]

Neither the FCC nor NTIA routinely perform independent forecasts of spectrum requirements, although NTIA has done extensive work on quantifying spectrum use. In specific proceedings, the FCC has used industry-generated forecasts, but it does not have an ongoing program of collecting and reviewing such inputs.

II. Technological Forecasting Methods

As noted in Chapter 6, an understanding of available forecasting techniques, and how and when to apply them, is a major requisite for forecasting.[(87)] Technological forecasts can be based on experience-driven, informed judgments, or on empirical data. In either case, the basis for decisionmaking is structured analysis. Informed judgments, while subject to forecaster error, benefit from the human ability to create or visualize new things. Therefore, they can be applied when no historical data exists, when external factors have an effect much different from previous developments, and when ethical or moral considerations dominate future actions.

Empirically based forecasts apply statistical methods and regressive analysis to quantified data. Such forecasts may result in estimates of the probability of an event's occurrence. These forecasts have their own drawbacks. Since they are based on data from past conditions, they are unable to warn the forecaster of radically changed circumstances. Also, selection of the data on which to base a forecast is extremely important.

There are two approaches to using forecasts, whether derived through informed judgments or empirical methods. These two approaches are known as exploratory and normative forecasting. Exploratory techniques report and analyze anticipated developments. They begin with the current status of, and past developments in, a given technology, and postulate the future of the technology. Normative methods start with a future desired technological state and work backward to the present, determining developments and innovations that are required. We describe below several different techniques for both exploratory and normative forecasting.[(88)]

A. Exploratory Forecasting

1. Genius forecasting

"Genius" forecasting is the type of forecasting with which most people are familiar. The leading expert in a field is consulted to provide a forecast. This method is risky, because the expert's knowledge, though vast for one person, may be limited compared to a group's, and one individual's false concepts or biased viewpoint are unchecked.

In spectrum management, the variety of spectrum uses implies that if "genius" forecasting were to be used in spectrum planning, experts from each of the services would have to be involved. Having one expert provide a single general forecast would not be adequate to support any decision. If, however, individual forecasts were made for each service, the task of querying the experts, and compiling and interpreting responses would be large. Of course, private sector user groups and IRAC members could be queried. The benefits are bound to be moderate because the of the method's reliance on a single expert's judgment for each service. Aside from providing forecasts, experts could evaluate other forecasts. Forecasts for individual services are written from time to time in radiocommunications journals and may be useful.

2. Polls and committees

The use of polls or committees for forecasting can decrease the dangers of genius forecasting, because reliance on several sources can reduce errors. A simple technique would be to poll experts. The results of the poll -- that is, the majority or "average" response, form the basis the overall forecast. Alternatively, forecasting based on the face-to-face interactions of committees attempt to take advantage of small group decision theory, the synergism of group interactions, and the greater risk-taking characteristics of face-to-face groups where responses are often spontaneous, not carefully and cautiously scripted. The committee knowledge combines the individual knowledge, and more factors can be considered. However, face-to-face groups have several disadvantages, including the existence of dominant individuals, idea reinforcement through repetitive discussion, and group pressures that mask the input of a deviant or dissident member with correct data.

For spectrum forecasts, NTIA or the FCC could bring together a group of experts for forecast through polls or committees. There is much expertise within the radiocommunications field from which to obtain such forecasts. As noted above, the IRAC and industry user groups are two ready sources of predictions. A notice of inquiry could also be used for polling, though the quality and quantity of responses would be variable.

One variation of committee forecasting, the "Delphi" technique, was developed at Rand Corporation to overcome difficulties in the dynamics of face-to-face groups. This method combines polling with committee feedback. Questionnaires are submitted to a committee or panel of recognized experts. The results are consolidated, and, together with statistical characterizations of the responses, are submitted to the experts. The panel is then asked to revise their predictions, if desired, in the light of the initial results. Their revised predictions and the reasons for any deviation from those of the group are collected. These responses again are examined and the results are sent to the panel for another round, and so on. Delphi provides the benefits of a committee without the pressures of group interactions. Participants can shift views, based upon other's inputs, without losing face. Delphi provides for anonymity, numerous iterations, controlled feedback, and statistical group response. Success comes once the answers reach stability, not consensus.

Delphi techniques have several difficulties. The social interactions in a small face-to-face group that may have positive effects are missing. Moreover, the questionnaire assumes considerable importance, since questioner bias must be avoided. The proper questions must be asked, and specific quantifiable and unambiguous terms must be used. The selection of the Delphi committee is also important. If people not truly expert in the field are selected, meaningless information will be obtained.

Martino states that, while no study has validated a Delphi forecast, the results of analysis of Delphi methods have shown that when an expert opinion is needed, Delphi is a good way of getting it.(89) In addition, he reports that study results indicate that a panel of 15 members, if truly representative of the "expert community" on some topic, is unlikely to produce forecasts that differ markedly from those of another panel of experts of the same size.(90) Therefore, Delphi appears to produce the most "repeatable" forecasts based on informed judgments. The Delphi approach, if applied separately to each type of spectrum use, would require a significant expenditure of resources to develop, complete, and analyze questionnaires. The initial start-up time and cost, as well as the ongoing support would be higher than for other intuitive methods. However, the greatest difficulty in this approach will be commitment of time by the study team.

3. Growth curves and trend extrapolation

Growth curves and trend extrapolation make use of past developments in a technology or technological area to plot future events. Martino describes these as follows:

Forecasting by growth curves requires fitting a mathematical formula for a growth curve to a set of historical empirical data.(91)

Once the product or service objectives are known, knowledgeable persons should be asked to identify characteristics of the product or service which have been, or can be improved. The characteristics should be as broad as possible so that a minimum number will encompass the objectives, but they must be capable of quantification and measurement.

* * *

When agreement has been reached on the principal parameters that are identified with progress, `demand' factors related to the parameters should be listed for subsequent regression analysis. . . . This should be followed by the selection of a structured set of parameters which contribute to progress in the principal parameters.

*   *   *

Once the present level of capability has been determined, the next step should be the gathering of capability data as far back towards the origins of the selected parameter as possible, but at least as far into the past as the forecast plans to extend into the future.[92]

Several different types of growth curves with associated equations have been applied to technological forecasting, and specific curves can be selected depending on the appropriate variables, the constraints to development, and whether those constraints are physical or technological. Furthermore, since this type of forecast depends upon steady state conditions in the environment within which the technology is developed, one must determine the sensitivity of the variables to changes in the outside world.

Technology use often grows exponentially, followed by an asymptotic approach as the limits of the technology are reached. This results in a sigmoid, or "S" shaped growth curve as shown on the following page in figure 1.

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New technologies often are being developed even as the use of existing technologies grows rapidly. Figure 2 portrays the growth of three successive technologies. Since new capabilities that are developed continue to improve system capabilities, the progression from technology to technology could result in a capability improvement trend that can also be projected, as shown in Figure 3.

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A spectrum-related example of this type of growth might be seen in a band where three successive technologies are introduced that enable the use of narrower and narrower bandwidths. Each technology experiences significant growth as it is implemented. Growth slows as the band fills, but with the introduction of each technology, channel splitting occurs. Therefore, if the capability were measured in channels per MHz, a continuous increase is experienced. Similarly, as bands have become congested with specific types of communications users, new technology has often resulted in increases in information rates, thus greater communications capacity. Through these types of trends, it could be possible to predict future capability levels before the technologies themselves are on the drawing board.

In the past, NTIA has limited its trend analysis to such specific tasks as the straight line extrapolation of assignment counts, thereby determining what the counts would be in five years if past trends continued. However, changes within equipment characteristics may alter the meaning of those counts. For instance, continuous growth in the use of a band could lead to an erroneous conclusion that the band is getting more congested, while technical improvements may have cut system transmission bandwidths, actually resulting in less congestion. Thus, trend analysis must be based upon data that can shed light upon what is occurring in spectrum use.

GTE comments favorably on the use of trends for specific services when forecasters adequately identify relevant parameters. It cites CCIR Interim Working Party (IWP) 8/13 efforts to forecast future public land mobile telecommunications as excellent work.(93) The FAA reports success using historical data on air traffic growth to predict the need for channels in the aeronautical bands.(94) NYNEX supports trend analysis, yet feels that "[i]naccuracies occur when forecasts fail to address macro-environmental components such as the economy, population, natural resources and technology," and "[w]hen applying historical forecasting to spectrum use forecasting, one must... be sensitive to the limitations of this approach."(95)

Growth curves and trends could be applied to diverse aspects of spectrum use. First, however, quantifiable factors must be determined from which trends can be established. Band occupancy or congestion on a geographical basis are two prominent factors. Forecasting when spectrum in a specific location will get congested would help to notify spectrum managers when action needs to be taken to institute spectrum conservation techniques or guidelines. Computer-driven calculations of spectrum use, supplemented by occupancy measurements, would be useful in this approach. Other factors that could be used in decisionmaking are forecasts of technical characteristics such as system bandwidths or data rates. Just as computer capacity has improved, bandwidths have narrowed and data rates increased in some radio communications fields, reducing the need for spectrum.

Many types of trend analysis require a great deal of time and resources, including developing and implementing supporting computer software. If trend analysis were to be applied to spectrum services, many of the services would require different criteria and the data needed to evaluate some types of systems may not be readily available in data files. However, once a trend is developed for each band or service, continuation of the process should not be difficult.

4. Precursor analysis

Precursor analysis theoretically improves upon trend analysis through the forecaster's knowledge of factors that lead or cause trends. Unlike trend analysis, which assumes that what has happened in the past will continue in the future, precursor analysis expressly recognizes that developments in one technology often depend upon preceding developments in another. Clearly, many of the improvements in communications technology have followed related activities in computer technology development. For instance, increased interest in hand-held personal communications systems may be related to the decreases in memory chip size that permit portability.

Precursors probably exist within the different radiocommunications services, but they need to be identified, service by service. Many of the precursor activities may not be related strictly to the technical aspects of a particular development. For example, economic factors can greatly effect users' interest in new technologies.

The basis for precursor analysis -- the identification of related events within the radiocommunications field -- should be a daily ongoing effort by spectrum managers. However, due to continual political, social, and economic changes, precursors themselves may change over time. For example, the importance of developments in defense capabilities, often seen as precursors of civil technology improvements, may decrease in an era of lessened international tensions.

5. Analogies

Through the use of analogies, forecasting conclusions from historical developments of an earlier but similar technology are drawn. Reasoning from comparable situations can aid prediction. For example, one could seek to compare the original growth of broadcast television with the possible future growth of advanced television. In this type of forecasting, only general trends in a developing technology can be predicted. Even so, a similarity to another situation does not necessarily mean that the results will be the same.

Application of analogies to radiocommunications is extremely difficult, both because of the advanced technologies involved and the fact that the social, economic and political factors that affect communications have changed rapidly during the last decades, making reliance on analogies risky. Moreover, analogies can be criticized on analytic grounds because they often rely on informed judgment that can vary among forecasters. For these reasons, within spectrum management in particular, the general conclusions drawn from analogies could be informative, but would probably not be decisive for allocation decisions, and therefore, may not be useful as a predictive tool.

6. Analytical causal models

Analytical causal models take trend extrapolation, growth curves and analogies one step further by including relationships among other factors and other trends, and projecting the resulting interactions.

Causal models have two shortcomings that they share with trend extrapolation, growth curves, and analogies: they are based on observations of behavior, but do not provide essential reasons for explaining the behavior of a technology or technologies; and they are based on data that necessarily will contain errors.

Similar to precursor analysis, analytical causal models place significant demands on forecasters to determine what causal relationships exist. However, such causal relationships must be considered in decision processes if all of the implications of decisions are to be understood. The use of these models in predicting trends would be a long term project that would require substantial additional resources.

7. Technology Tracking[(96)]

Technology tracking is a system of monitoring information on specific areas that affect or lead technology growth and change. New developments and trends can then be examined. The empirically-based techniques discussed previously rely on the rational extension of historical trends. They make no provision for forecasting such events as a technological breakthrough, though precursor analyses depend on such factors. As Martino notes, "Examination of breakthroughs shows that there were many precursor events that would have made it possible to forecast the eventual development of technology."[(97)] Therefore, true early warning signals must be separated from the "noise". A properly designed system will minimize the number of false signals identified and give proper recognition to consequential signals.

COMSAT and others support review of R&D activities within both government and private sectors in order to identify future requirements.[(98)] The Navy recommends R&D monitoring, or tracking, as a source of forecasting data for technology development.[(99)] Foreign research and development also requires coverage. NSF states that R&D monitoring in the field of radio astronomy could provide links to new developments; however, it believes that attempting to link such monitoring to prediction of marketplace demand for radiocommunications in general would be very difficult.[(100)]

A systematic method of monitoring literature in a specific technological area could be established. The information gained would then have to be examined for relevance and significance and catalogued for reference. The 1974 SAI study mentioned earlier recommended tracking of market analyses and trade journals.[(101)] One advantage of this method is that it requires limited resources and can be accomplished by engineers as well as by professional forecasters.[(102)]

Tracking of trade publications for data related to spectrum use should be an ongoing part of spectrum management. At the very least it should be occur through staffwide circulation of journals; a better arrangement would be through designation of a staff member to perform such tracking. Such a staff member would be responsible for ordering trade literature, determining its utility, and preparing reports. This staff member could also maintain contact with relevant research groups within the federal agencies, and the private industry.

8. Cross Impact Matrices

Developments in one technology can directly affect another. For example, as noted above, advances in computer chip design can result in more efficient radio systems. A major issue in technological forecasting involves predicting the interaction of technologies and the effects of such. There are three dimensions of interaction: The "mode" of the interaction - whether the interaction enhances or decreases the likelihood of another event; the "force" of the interaction - whether there is a strong or weak influence; and the time lag of the interaction - the degree of immediacy and duration of the effect.[(103)] The cross impact matrix method takes these dimensions into account. As Twiss states, there are five steps to creating and using a cross impact matrix:

1. Determine technology-related events being forecast.

2. Assign probabilities to and likely dates of the events' occurrence using Delphi, trend extrapolation, or another technique.

3. Determine the interactions between the events, i.e., the mode, the force and the time lag.

4. Generate a future state of the technology by simulations to determine if an event has occurred and then modifying the probability, and expected time of the remaining events in accordance with step 3 above.

5. Perform step 4 many times.[(104)]

If any one or more of the events occur in many of the possible futures developed, one can assume there is a very good likelihood that it will, in fact, occur. The many repetitions necessary imply that a computer is required to best use the cross impact matrix. Although cross impact matrices account for the impact of one technology or another, they often are based on the forecaster's intuition in assigning the degree of interaction among the technologies and are thus open to error.

Since there are many different types of spectrum-based equipment, applications, and services that have fundamental similarities, their impact on one another should be assessed in any approach to spectrum forecasting. However, the development of a computer-aided process like a cross impact matrix approach would require substantial resources.

B. Normative Forecasting

As stated earlier, normative forecasting involves determining what technologies or situations are desirable at a particular time, then backtracking to determine what must occur and when, in order to reach the desired point. Thus, normative forecasting is "needs-" or "goal-" oriented, and results in directive action. Therefore, if spectrum congestion is predicted using one or more of the techniques discussed above, normative forecasting could be used to define a desire outcome and approach to resolving the congestion.

Techniques used in normative forecasting of particular interest in spectrum management are relevance trees; morphological analysis; and mission flow diagrams. These tools are similar in that they each involve determination of some goal or the prediction of a negative situation, such as spectrum congestion. The normative approach is completed by analyzing the technological achievement required to meet the goal or to produce a more desirable situation.

1. Relevance trees

Relevance trees are used for those developments in which levels of complexity or a hierarchy are apparent. For example, the development of pollution-free cars could have several possible solutions (electricity, emission controlled gas, or diesel), each having several functions to be performed and several solutions for each function. The relevance tree is constructed by identifying all conceivable solutions and subsolutions to a given problem. The probability of success associated with each branch of the tree is then determined using exploratory forecasting techniques. The "optimum" solution makes use of these results in the light of organization goals and constraints.

2. Morphological Analysis[(105)]

Morphological analysis is used when a problem can be broken into independent parts. The elements of the system are first listed. Then "solutions" for each element -- that is, the ways each element can be accomplished, are defined. Finally, one selects desirable solutions and evaluates the technology required for each. Some solutions, of course, can be rejected because of conflicts with other solutions. The remaining solutions can then be established as goals for the technologies involved.

Morphological analysis and relevance trees can be used in evaluating similar situations. The elements of the morphological analysis correspond to relevance tree functions, while the most basic "branches" of the relevance tree correspond to components of the elements in the morphological model.

3. Mission Flow Diagrams

Mission flow diagrams were initially developed to analyze certain types of military missions, hence the name. They can be used for the analysis of sequential processes where alternate approaches are possible. All possible routes or sequences to accomplish each task are listed. The significant steps in each route are listed. The difficulties and costs associated with each path and possibly alternative routes can be identified. Once the difficulties have been identified, performance requirements for the technologies involved can be used as normative forecasts.

III. Conclusions

The approaches discussed here are evaluated generally in Chapter 6. A thorough but balanced approach to spectrum forecasting at NTIA and the FCC is recommended. Major parts of such a program would include:

1. Expert input;

2. Trend analysis; and

3. Technology Tracking.

APPENDIX H

SPECTRUM MANAGEMENT TRAINING REQUIREMENTS

Figure 1, shows that since 1980, the number of frequency assignments made at both NTIA and the FCC have increased.[(106)] NTIA authorized 46.1% more stations in 1989 than in 1980; the FCC authorized 52.9% more in 1988 than in 1980. Thus, it is clear that radio systems are more numerous today than they were in 1980. They have also become more complex during this period. Spectrum management decisions involve complex and highly technical applications of radio technology. Successful decisions require detailed analysis of the impact of proposed policy options on the ability of others to use the spectrum, including detailed engineering estimates of new and existing systems to determine the effects of various interference signals, the propagation of electromagnetic waves, and how various interfering signals affect the ability of the user to understand the intended signal. Successful spectrum management decisions balance the technical ramifications of these issues with their inherent social and policy values. Thus, the optimum engineering solution may have to be modified because of economic, legal, and policy considerations.

Moreover, spectrum management problems do not respect national boundaries. Thus, spectrum management decisions also often involve international agreements through diplomatic negotiations in the international forums of the ITU and among neighboring countries. Because of this interchange of technical and policy development requirements, it is unusual to find individuals with the background necessary to perform spectrum management in industry or government.

If the spectrum management community is to respond to increased needs for access to the spectrum in a timely and effective manner, NTIA, the FCC, and users require highly trained spectrum managers.[(107)]

Recognizing this problem as long ago as 1975, the director of the Office of Telecommunications Policy (OTP) established a Government-Wide Career Development Program for Radio Spectrum Management Personnel. The primary objective of this program was to attract, develop, and retain personnel required to meet the present and future staffing requirements in the spectrum management fields. From 1975 to 1983, OTP and then NTIA conducted this program to train entry level interns, mid-level personnel and senior spectrum managers.

The intern program provided a training experience composed of formal seminars and training courses, informal discussion periods, and work assignments. The program involved the selection of nominees by various IRAC member agencies and formalized training requiring complete dedication of the nominee on a full-time basis for a period of one year. An IRAC member agency could also take advantage of some of the training opportunities offered by NTIA for its current employees without committing them to a full-time, year-long program. The Intern Program was primarily designed for high-potential recent college graduates with a degree in the physical sciences or engineering, with particular emphasis in physics and electronics.

OTP and NTIA also conducted programs for more experienced spectrum managers. The mid-level program was for spectrum managers who demonstrated the potential and motivation for successful performance in spectrum management positions at higher grade levels. Each person selected by an IRAC member agency was placed in a development program commensurate with the agency requirements and the individual needs. These learning experiences included both formal training/education programs and rotational assignments. An Individual Development Plan was written yearly for each selectee. The senior program was designed for those persons who demonstrated potential and motivation for higher level responsibilities. Each person selected by an IRAC member agency was placed in a l-year planned program of learning experience including both training/education and developmental on-the-job training (possibly rotational assignments) within the IRAC organization. This program included appropriate managerial training, preparation for and attendance at appropriate international conferences and other training to provide each individual with the maximum of technical broadening and update.

Of the training programs, the intern program was the most effective since new qualified personnel were sought, trained and brought into the spectrum management community. The mid-level program continues to train approximately fifty personnel each year in a one or two week seminar. The senior level program was the least successful because of the difficulty of arranging appropriate courses and on-the-job training in specific organizations for key senior spectrum managers. The intern and the senior level parts of the program were canceled in 1983 due to a lack of funding, which prevented NTIA from offering the programs and made it difficult for the agencies to guarantee the interns positions after a year's training and in developing a suitable curriculum for senior spectrum managers.

The need for the training of personnel is more critical today than it was when the earlier NTIA/OTP training program started, because of the increased complexity of managing the spectrum and the aging of the current agency staffs, with few replacements entering this field.

Thus, NTIA will continue the mid-level program as currently configured, will seek to develop new low-cost training opportunities, such as seminars and work shops for mid-level and senior spectrum managers, and will investigate the practicality of re-establishing, with other Federal agencies and the private sector, the intern/entry-level and senior level training programs.

1. See generally D. Webbink, The Value of the Frequency Spectrum Allocated to Specific Uses, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19 (Aug. l977).

2. According to production theory, the value that a firm places on an input depends upon its contribution to revenues; the greater its contribution to revenues, the more valuable it is to the firm.

3. We have not attempted to estimate the value of cellular licenses in rural service areas (RSAs).

4. Typically, financial analysts express the value of cellular properties as a function of the population potentially served in the franchise area (measured per person, or "pop"). We relied upon the sales price "per pop" figures reported by one leading industry analyst, Paul Kagan Associates, for 24 sales of cellular franchises in MSAs in l990. See Paul Kagan, Cellular Investor, Feb. 22, 1990, at 10; id., Apr. 23, 1990, at 9; id., May 24, 1990, at 10; id., July 27, 1990, at 3, 9; id., Oct. 29, 1990, at 6; id., Nov. 16, 1990, at 3; id., Jan. 31, l991, at 10; Paul Kagan, Cellular Investor News Roundup, Apr. 23, 1990, at 2. According to Paul Kagan Associates, the sales prices reported in its newsletter reflect the price paid for both the cellular license and all other assets of the licenseholder that change hands. For some of these transactions, information is not available on whether the payment terms included non-cash elements such as the transfer of stock or assumption of debt at below market interest rates.

5. We obtained data to construct these weights from Smith Barney, The Cellular Industry: A Reevaluation, Apr. 3, 1990, at 4-8 (relying on 1989 MSA population data obtained from Donnelley Marketing Information Services).

6. In 1989, the MSAs in the small market category had a total population of 11,990,000, the MSAs in the medium market category had a total population of 33,407,500, and the MSAs in the large market category had a total population of 143,920,000. See Smith Barney, supra note 5, at 4-8.

7. Shew, W., Tobin's Q For Cable Television, Media and Telecommunications: A Comparative Assessment, filed as Appendix A, Reply Comments of Time-Warner (filed Apr. 2, 1990) in Competition, Rate Deregulation, and the Commission's Policies Relating to the Provision of Cable Television, MM Docket No. 89-600.

8. Malarkey-Taylor is an engineering consulting firm located in Washington, D. C. that specializes in estimating the value of media and telecommunications properties.

9. Shew (1990) obtained five annual observations on the ratio of net to gross plant. He concluded that the most recent observation -- in which net plant represented .821 of gross plant for Vanguard Cellular Systems Inc. in 1988 -- represented a conservative estimate of the amount of accumulated depreciation in the cellular industry.

10. We derived the values in Table 3 by multiplying the values in Table 2 by .821 for each size class.

11. Using balance sheet data for a sample of four cellular firms, Shew (1990) calculated the weighted average of the ratio of other tangible assets to net plant to be .747. Given this information, we derived the replacement cost of other tangible assets by multiplying .747 times the replacement cost of the tangible assets, as listed in Table 3.

12. This estimate is similar to others developed by industry observers. See AT&T Receives $600 Million Job from GTE, The Wall Street Journal, Dec. 14, 1990, at B9 (total capital invested to date in the cellular industry is about $5.2 billion). This $5.2 billion figure may not take into account depreciation of tangible assets.

13. See, e.g, Bear Stearns, Cellular Mobile Industry, Part XVI, Investment Review and Strategy, Oct. 12, 1990, at 3 (Table I); Donaldson, Lufkin & Jenrette, The Cellular Communications Industry, Winter 1990-91, at 43 (Table 13); Smith Barney, supra note 5 at 11 (Table 7).

14. Financial analysts typically assign a value figure to such assets based on information set forth in the company's financial statements.

15. Material supplied by Donaldson, Lufkin & Jenrette.

16. Smith Barney, supra note 5 at 8.

17. These estimates of spectrum value in urban areas reflect the existing duopoly market structure. If additional competitors were to enter the market, the profits of cellular providers would presumably fall (i.e., the monopoly rents would drop), so that the value of spectrum devoted to cellular uses would likely be lower.

18. See 47 U.S.C. §§ 302a (1988).

19. See, e.g., id. §§ 312(a)(7) (administrative sanctions); 315 (equal opportunity for political broadcasting); 317 (announcements regarding certain broadcasts).

20. Broadcasters, similar to other licensees, are subject to procedural requirements as well. See id. §§ 307(c) (term of licenses); 309 (action upon applications); 311 (application and renewal process); 325 (rebroadcasts).

21. The Revision of Programming and Commercialization Policies, Ascertainment Requirements, and Program Log Requirements for Commercial Television Stations, Report and Order, 98 FCC 2d 1076, 1091 (1984), recon. denied, 104 FCC 2d 358 (1986)("Commercial TV").

22. Deregulation of Radio, Second Report and Order, 96 FCC 2d 930, 931 (1984).

23. Commercial TV, supra note 4, 98 FCC 2d at 1092.

24. 47 C.F.R. § 0.283(a)(7)(i)(A)(1989).

25. Id. § 73.1800.

26. Id. § 73.3526(a)(9).

27. Id.

28. Id. § 73.1840(a).

29. Id. §§ 73.3526 (a)(1), (a)(2).

30. Id. § 73.3526(a)(3).

31. Id. § 73.3526(a)(4).

32. Id. § 73.3526(a)(5).

33. Id. § 73.3526(a)(7).

34. Id. § 73.3526(a)(10).

35. See, e.g., Commercial TV, supra note 4, 98 FCC 2d at 1097-98.

36. Id. at 1098.

37. Deregulation of Radio, Report and Order, 84 FCC 2d 968, 971 (1981).

38. Radio Broadcast Services: Revision of Applications for Renewal of License of Commercial and Noncommercial AM, FM, and Television Licensees, Report and Order, 46 Fed. Reg. 26,236, 49 Rad. Reg.2d (P&F) 740 (1981).

39. Commercial TV, supra note 4, 98 FCC 2d at 1111-1112.

40. See Black Citizens For A Fair Media v. FCC, 719 F.2d 407, 414 (D.C. Cir. 1983) (upholding the streamlined renewal process), cert. denied, 467 U.S. 1255 (1984).

41. 47 C.F.R. § 73.1920(a) (1989).

42. Id. § 73.1920(b).

43. 47 U.S.C. § 315(a) (1988).

44. Id. § 315(b); 47 C.F.R. § 73.1940(b)(1).

45. 47 U.S.C. § 312(a)(7) (1988).

46. 47 C.F.R. § 73.1930(a) (1989).

47. Children's Television Act of 1990, Pub. L. No. 101-437, 104 Stat. 996 (1990).

48. Policies and Rules Concerning Children's Television Programming, Notice of Proposed Rulemaking, 5 FCC Rcd. 7199 (1990) ("Children's TV").

49. See id., 5 FCC Rcd 7199 at para. 2.

50. Id. para. 8.

51. 47 C.F.R. § 73.902 (1989).

52. Id. § 73.918.

53. Id. §§ 73.936(d), 73.937(d). See also id. § 73.1250(b) (station may transmit emergency point-to-point messages at its own discretion if requested by public officials).

54. Statement of Policy on Minority Ownership of Broadcasting Facilities, 68 FCC 2d 979 (1978), clarified, 44 RR 2d 479 (1978).

55. WPIX Inc., New York, 68 FCC 2d 381, 411-12 (1978) (minority enhancement); Mid-Florida Television Corp., 69 FCC 2d 607, 652 (Rev. Bd. 1978), set aside on other grounds, 87 FCC 2d 203 (1981) (female enhancement).

56. See Metro Broadcasting v. FCC, 110 S.Ct. 2997, reh. den., lll S.Ct. l5 (1990).

57. 47 C.F.R. § 73.2080 (1989).

58. See 47 U.S.C. § 317 (1988); 47 C.F.R. § 73.1212(a) (1989).

59. 47 C.F.R. § 73.1212(f) (1989).

60. Id. § 73.121.1 (amended May 7, 1990).

61. 18 U.S.C. § 1464 (1988). See also 47 C.F.R. §§ 73.4165, 73.4170 (1989).

62. See Enforcement of Prohibitions Against Broadcast Indecency in 18 U.S.C. § 1464, 5 FCC Rcd 5279 (1990). The 24-hour ban has been stayed by the Court of Appeals pending judicial review. See Action for Children's Television v FCC, No. 88-1916 (D.C. Cir. Jan. 23, 1989) (stay order).

63. 47 C.F.R. § 73.3580(d)(1) (1989).

64. Id. § 73.3580(d)(4).

65. Id. § 73.1201.

66. Id. § 73.1740(a)(1).

67. Id. § 73.1740(a)(2)(ii).

68. See 15 U.S.C. § 4402(f) (West Supp. 1990).

69. See 15 U.S.C. § 4402(f) (1988).

70. See supra, Chapter 5, for a discussion of the criteria used to evaluate spectrum use.

71. The diagram is simplified in that it uses an envelope antenna pattern and does not include effects such as intermodulation and harmonics.

72. See R.H. Haines, Quantification of Spectrum Use: Spectrum Management Tools for the Twenty-first Century, 1990 International Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 390, 390 1990. (Haines, Quantification). The "spectrum resources used" can be calculated based on denial of a specifically defined reference system or on the emissions of transmitters and the susceptibility of receivers. If the simplified approach were used, eliminating all dimensions other than frequency and

space (see supra Chapter 5), the figure would have a uniform height above the plane.

73. 47 CFR §§ 73.610, 73.698 (1990).

74. The co-channel separation distance shown applies to Zone I, an area encompassing most of the northeastern U.S. and extending westward to Illinois. The separation distances required for Zone II (all U.S. areas not included in Zones I and III) and Zone III (the region of the U.S. bordering the Gulf of Mexico) are somewhat greater. Maps of the zones are found in 47 CFR § 73.699 (1990). The example assumes that all the adjacent channels shown are in the UHF television band.

75. At first glance one might try to maximize band efficiency by packing these "solids" together as tightly as possible without overlapping. Even closer packing is possible, however, because each solid indicates the locations denied to the other transmitters' antennas. In other words, the "solids" may overlap as long as the center of one solid (the antenna location) does not fall within another solid.

76. If the time dimension were included, all cross sections in that dimension would be identical, providing no additional information. The SUF would be unchanged, having been multiplied by one.

77. Haines, Quantification, supra note 3 at 392.

78. R. H. Haines, An Innovative Method for Quantifying Spectrum Use, IEEE 1989 National Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 234, 238 (1989).

79. Haines, Quantification, supra note 3 at 393.

80. 80/ Technological Forecasting for Industry and Government: Methods and Applications, at xii (J.R. Bright ed.1968).

81. Id. at xiii.

82. E. Jantsch, Technological Forecasting in Prospective at 17 (1967).

83. M.J. Cetron, Technological Forecasting: A Practical Approach at 115 (1969).

84. R.U. Ayres, Technological Forecasting and Long-Range Planning at 3 (1969).

85. 85/ M. Drubin, G.P. Mandanis, P. Stanek, The Use of Demand Forecasting in Spectrum Management, (SAI), OTP Contract No. TP3AC001 Wash., D.C. (Sept. 1974).

86. Sachs/Freeman Associates, Inc., Research Study on Spectrum Planning - OTP RFP 76-3, Hyattsville, Md., at 2 (1976).

87. See also Bright, supra note 1, at 151-152.

88. These methods are drawn in general from J. Martino, Technological Forecasting for Decision Making (1983) and B. Twiss, Managing Technological Innovation (1974), but the terms can commonly be found within other references on the subject of technological forecasting.

89. Martino, supra note 9, at 24.

90. Id. at 25-26.

91. Id. at 57.

92. Bright, supra note 1, at 62-63, 64.

93. GTE Comments at 17-18.

94. FAA Comments at 5.

95. NYNEX Comments at 50-51.

96. In technological forecasting literature, this is referred to as "monitoring" but to differentiate between this concept and "monitoring" of spectrum occupancy through measurements, we have selected the term "technology tracking."

97. Martino, supra note 9, at 134.

98. COMSAT Comments at 50-52.

99. U.S. Navy Comments at 4.

100. NSF Comments at 21.

101. SAI, supra note 6, at 108.

102. B. Twiss, supra note 9, at 91.

103. Martino, supra note 9, at 327.

104. Twiss, supra note 9 at 91.

105. "Morphological" means having to do with an organism's structure and form.

106. See R.J. Mayher and F. Wentland, Spectrum Management Structure and Regulations in the U.S. - Do We Need a Change in the Twenty First Century?, Conference Record, IEEE International EMC Symposium, Washington, D.C., Aug. 1990.

107. Several commenters note that the FCC and NTIA have insufficient staff to prevent crisis management and to permit timely and comprehensive responses to the study, planning and oversight of the spectrum. See, e.g., APCO Comments at 2-3 and LMCC Comments at 65.