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“Rainbow in the Sky”: FM Radio, Technical Superiority, and Regulatory Decision-Making

HUGH RICHARD SLOTTEN

The Commission FM evangelists of yesterday, as today's leaders of the radio industry, seemingly have lost their zeal to bring to the people this utopia of broadcasting and listening potential . . . FM channels in the sky go begging, and this new and superior radio service continues to be just a rainbow in the sky. [Commissioner Robert F. Jones (Federal Communications Commission), January 17, 1950.¹]

When frequency modulation (FM) radio was first developed, during the 1930s, its promoters—especially its inventor, Edwin H. Armstrong—were convinced that the new system's inherent technical superiority would guarantee its success in competition with the established amplitude modulation (AM) system. W. R. G. Baker, an important leader of the radio engineering community, argued that FM was “so much better technically than the present regular broadcast system that it can't fail of acceptance.” Many radio engineers viewed the invention of FM as part of the “march of science which will obsolete the system now in use.” Historical examples, including the triumph of alternating current over direct current electricity, were presented to drive home this point. In 1940, four years after the first public demonstration of his new invention, Armstrong confidently

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¹Robert F. Jones, “Channels in the Sky” (speech before the New York Chapter of the American Marketing Association), January 17, 1950, folder marked “FCC Correspondence, 1950,” box 456, Edwin H. Armstrong Papers, Columbia University Archives, New York City (hereafter cited as Armstrong Papers).

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predicted that FM would supplant the old AM system within five years.²

But nearly four decades passed before FM successfully challenged AM radio's supremacy in the United States. Not until after 1979 did FM's share of the radio listening audience exceed AM's. Historical studies that have examined the failure of FM broadcasting to live up to initial expectations generally repeat the story told by Armstrong and the FM pioneers, who argued that his invention was suppressed by the dominant commercial interests, especially the Radio Corporation of America (RCA) and its subsidiary, the National Broadcasting Company (NBC). FM supporters charged that instead of working for the public interest, these companies were mainly committed to protecting their economic investment in the "inferior" system of network AM radio and in the development of the nascent television industry. Certainly the most serious charge was that the government agency responsible for regulating the broadcast industry, the Federal Communications Commission (FCC), was actively supporting big business's efforts to suppress FM. Armstrong's supporters portrayed him as "an individual warrior struggling against organized evil." The only recent book on Armstrong and FM is subtitled "One Man vs. Big Business and Bureaucracy." Along similar lines, Armstrong's biographer contends that the "vast concentration of economic power" in the broadcast industry "rolled over FM and crushed it to a shape less threatening to the monopolistic pattern of operations."³ Armstrong's suicide in 1954, at the end of the fifth

²Statement of W. R. G. Baker in "Broadcasters Pledge Action on Post-War Allocation Plans," *Broadcasting* 25 (August 9, 1943): 10. C. M. Jansky, "FM—Educational Radio's Second Chance—Will Educators Grasp It," n.d., pp. 8–9, folder marked "Jansky and Bailey," box 124, Armstrong Papers. Armstrong prediction in Edwin H. Armstrong, "Evolution of Frequency Modulation," *Electrical Engineering* 59 (1940): 4. FM commercial operations were suspended during World War II; Armstrong repeated his prediction toward the end of the war. See Edwin H. Armstrong, "The Postwar Future of Broadcasting" (address before the National Association of Broadcasters Executive War Conference), August 31, 1944, folder marked "EHA—NAB Speech, 1944," box 18, Armstrong Papers.

³For a historical comparison of AM and FM listening audiences, see Andrew F. Inglis, *Behind the Tube: A History of Broadcasting Technology and Business* (Boston, 1990), p. 144. "Individual warrior" quotation is from Moore to C. B. Fisher, May 27, 1954, folder marked "Misc. papers from Mrs. Armstrong's Files," box 477, Armstrong Papers. Don V. Erickson, *Armstrong's Fight for FM Broadcasting: One Man vs. Big Business and Bureaucracy* (University, Ala., 1973). Lawrence Lessing, *Man of High Fidelity: Edwin Howard Armstrong* (Philadelphia, 1956), p. 260. A brief account that closely follows Lessing's analysis and fails to use archival sources is Lawrence D. Longley, "The FM Shift in 1945," *Journal of Broadcasting* 12 (1968): 353–64. Also see Christopher H. Sterling, "Second Service: Some Keys to the Development of FM Broadcasting," *Journal of Broadcasting* 15 (1971): 181–94; Harry R. Hyder, "The Rise of Frequency Modulation," *QST* 77 (1993): 42–45; and the articles in "The Legacies of

year of a grueling litigation with RCA over the patent rights to the invention of FM, gives cogency and drama to this standard history.

There is certainly some truth in this view of Armstrong and the development of FM broadcasting, but the focus on a search for conspiracies tends to give a blinkered perspective that ignores complexities and fails to engage broader analytical and contextual themes. This article focuses on a crucial episode in the early history of FM radio: one of the major decisions by the FCC that Armstrong believed was motivated by the desire of both the AM radio and the television industry to severely cripple FM. As part of a new system of allocation for postwar utilization of the electromagnetic spectrum, in June 1945, the commission ordered FM stations to broadcast in the 88–106 MHz frequency spectrum, instead of in the lower 42–50 MHz band, where the industry had been operating since January 1941. This decision made the old FM system obsolete and forced the engineers, manufacturers, and broadcasters who had pioneered the industry to begin again from scratch and compete on an equal basis with RCA and other manufacturers who had not yet invested heavily in FM broadcasting. The FCC's simultaneous decision to place one of the television channels in the old FM band only intensified the suspicions of the FM industry about the "hidden forces" at work "behind the Commission's actions." Armstrong bitterly denounced the new allocation, which the commission justified on purely technical grounds, as "one of the major mistakes in engineering history." He also argued that "in their attempt to preserve and extend the monopoly of broadcasting, the chains [AM networks] . . . enlisted the support from some of the strongest political forces in the country."⁴

A detailed examination of this decision and an exploration of its

Edwin Howard Armstrong," *Proceedings of the Radio Club of America* 64 (1990), especially David L. Morton's essay, which calls for a more sophisticated, contextual analysis of the history of Armstrong and FM. For one of the few examples of an author strikingly critical of the standard history, which generally portrays Armstrong in heroic terms and RCA as the evil corporation, see Inglis, pp. 113–54. Inglis is a retired engineer who was employed by RCA for thirty years.

⁴Armstrong thought the FM shift delayed the "progress of FM broadcasting by more than two years." See Edwin H. Armstrong to the Secretary of the President's Communications Policy Board, February 26, 1951, folder marked "USG—President's Communications Policy Board," box 470, Armstrong Papers. "Hidden forces" quotation is from Edwin H. Armstrong to Charles W. Tobey, Jr., August 28, 1950, box 452, Armstrong Papers. Comment about engineering mistakes is in Edwin H. Armstrong to E. K. Jett, December 5, 1950, folder marked "E. K. Jett," box 124, Armstrong Papers. Edwin H. Armstrong to Charles W. Tobey, January 2, 1946, folder marked "Docket 6651 . . . re Zenith," box 458, Armstrong Papers.

larger implications is especially important for illuminating the historical intersection of technology and public policy, specifically the interplay between technical problem-solving and economic, social, and political decision-making. After briefly discussing the invention of FM radio and the policy decisions of the FCC during the 1930s and early 1940s, the article analyzes the 1945 allocation decision, focusing on the complex negotiations among different institutions and individuals whose involvement helped shape the new technology. The article examines key aspects of the decision-making process, including the attempts by the FCC to legitimate its actions to the public and the response of opponents to the new allocation. A major theme that provides a framework for understanding the particular strategies used by both opponents and proponents of the decision is the tension inherent in regulatory policymaking between technocratic and democratic philosophies. Although a few participants in the debate over the 1945 allocation emphasized that technical evaluation invariably involved social, economic, and political considerations, many participants held strongly technocratic views. They generally wanted to delegate primary responsibilities to engineers and make a clear distinction between policy decisions and technical evaluation. But the resulting controversy involving conflicting engineering evaluation underscored fundamental tensions inherent in this effort to draw sharp boundaries and in the notion of the intrinsic technical superiority of innovations. An analysis of the rhetorical, economic, social, and administrative strategies used by participants in the public policy debates thus helps clarify the complex forces shaping the early history of FM radio and underscores how closely support for FM was connected to the early enthusiasm for television.⁵

The Early History of FM

Armstrong received a patent for wide-band frequency modulation in 1933. His earlier inventions (including the regenerative “feedback” circuit, the superheterodyne circuit, and the superregenerative circuit) had played a crucial role in fostering the radio broadcast boom of the 1920s. Armstrong’s chief motivation for developing FM was to eliminate the problem of natural and man-made static, which had plagued radio since its early development in the late nineteenth century. Because AM radio waves and the electrical signals that pro-

⁵For recent studies that discuss the promotion and regulation by the government of broadcast technologies, see Hugh Richard Slotten, “Radio Engineers, the Federal Radio Commission, and the Social Shaping of Broadcast Technology: Creating ‘Radio Paradise,’” *Technology and Culture* 36 (1995): 951–52.

duce static have similar propagation properties, AM radio receivers are unable to discriminate between the two kinds of signals.

The modulation of broadcast signals refers to the way information is superimposed on a carrier wave of a particular frequency. With AM broadcasting, messages are added by varying the strength or amplitude of the wave. FM encodes information by changing the wave frequency. Armstrong began investigating frequency modulation in 1925. Earlier experimenters believed that static could only be reduced by narrowing the broadcast channel. This had been appropriate for AM, but when researchers treated FM in this way they found it unsuitable for radio broadcasting. In 1932, Armstrong discovered that static could be greatly reduced by widening the band of frequencies used. The key patents Armstrong received in 1933 covered the development of transmitters and receivers for his wide-band FM system.⁶

Beginning late in 1933, Armstrong received support from the Radio Corporation of America (RCA) to improve his system. Armstrong's close connections with RCA dated from 1922, when he sold the patent rights on his superregenerative circuit to the company, became the largest individual shareholder, and promised RCA first option on any new invention. The cordial relationship ended in the spring of 1935, when Armstrong was asked to remove his FM equipment from the NBC station in the Empire State Building so that the company could concentrate on its television experimentation. RCA's decision to invest in the development of television rather than FM left Armstrong suspicious about any decision made by the broadcast industry that did not seem to support FM. Armstrong actually acknowledged that RCA had a right to make this kind of business decision. He was mainly upset with what he believed were illegitimate business practices, including what he called a "talk down campaign" against FM, improper lobbying of government regulators, and a misrepresentation of engineering facts.⁷

Armstrong gave the first public demonstration of FM broadcasting in 1935, soon after his break with RCA, at a meeting of the Institute of Radio Engineers (IRE). Although the IRE members seemed impressed by this demonstration, Armstrong was disappointed that this initial enthusiasm did not lead to overwhelming public and private

⁶On Armstrong's early development of FM, see especially Lessing, pp. 193–223.

⁷Lessing, p. 146. On Armstrong's version of the attempt to block FM, especially the use of a "talk down campaign," see, for example, "Statement by Edwin H. Armstrong on Some Ancient History of Radio Art," n.d., folder marked "EHA—NAB Atlantic City," box 18, Armstrong Papers.

support. Indeed, within a year after this event, Armstrong believed he saw forces working against his invention. The FCC annual report for 1935 (issued in January 1936) contended that stations broadcasting in the higher frequencies where there was room for FM to operate (above 30 MHz) “would serve only a few miles, probably in the order of 2 to 10 miles.” The report made no mention of Armstrong’s tests that demonstrated transmissions over distances of more than eighty miles. Armstrong was especially suspicious when, a few weeks after writing this report, Charles Jolliffe, the chief engineer of the FCC, accepted a position in charge of RCA’s frequency bureau. Armstrong insisted that Jolliffe, despite his denials, must have been aware of these tests.⁸

Jolliffe’s main responsibility at RCA was to obtain the best frequency allocation for television. In the spring of 1936, the FCC requested technical information from the industry to help it decide how to develop the newly available higher frequencies above 30 MHz, where both FM and television would operate. Jolliffe’s representations at this meeting further convinced Armstrong that RCA was actively working to suppress FM. Instead of informing the commission about the extensive FM tests RCA had sponsored, Jolliffe made no mention of FM, although he did discuss in general terms “high frequency broadcasting,” which he later claimed included FM.⁹ Armstrong was especially upset because Jolliffe did not volunteer to admit that his 1935 FCC report was inaccurate.

Armstrong charged that RCA used the “promise of television,” to “create a shortage of channels” for FM. He believed that RCA’s decisions involving the development of television were largely moti-

⁸On Armstrong’s first public demonstration, see Edwin H. Armstrong, “A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation,” *Proceedings of the Institute of Radio Engineers* 24 (1936): 689. *First Annual Report of the Federal Communications Commission to the Congress of the United States for the Fiscal Year 1935* (Washington, D.C., 1936), p. 28. “Memorandum Concerning the Activities of Dr. C. B. Jolliffe,” May 8, 1948, folder marked “Jolliffe, Dr. C. B.,” box 124, Armstrong Papers.

⁹“Statement Concerning Broadcasting Presented by Dr. C. B. Jolliffe on Behalf of the Radio Corporation of America and the National Broadcasting Company, Inc., before the Federal Communications Commission at the Hearing on Frequency Allocation, June 15, 1936,” box 924, vol. 3, Docket No. 3929, Docketed Case Files, Records of the Federal Communications Commission, Record Group 173, National Archives, Washington, D.C. (hereafter cited as Dock/FCC, NA). Also see testimony of Charles Jolliffe in House Committee on Interstate and Foreign Commerce, *Radio Frequency Modulation: Hearings before the Committee on Interstate and Foreign Commerce on H. J. Res. 78 (A Joint Resolution Relating to Assignment of a Section of the 50-Megacycle Band of Radio Frequencies for Frequency Modulation)*, 189th Cong., 2d sess., (February 3 and 4, 1948), p. 248.

vated by a desire to protect its investment in AM network radio (including its control of NBC and key AM radio patents) from the threat of FM competition. In comparison to television, which was years away from extensive commercial use, according to Armstrong, FM was an established technology and was more deserving of support. In May 1936, the FCC assigned FM exclusive use of an approximately one MHz band in the vicinity of 42 MHz, or enough spectrum space for four channels. Experimental television was given exclusive use of more than 50 MHz or enough room for eight channels. Armstrong complained that “the promoters of television” received a “virtual monopoly of the frequency bands.”¹⁰

By the late 1930s, Armstrong believed he had conclusively demonstrated the technical superiority of FM. Most significant was FM’s ability to eliminate naturally produced static and most man-made interference. Further, FM stations broadcasting on the same frequency were much less likely to interfere with one another than AM stations under the same conditions. With Armstrong’s FM system, interference did not occur until the interfering signal was half as strong as the signal from the desired station. An AM signal created interference even when it was one-twentieth the strength of the desired signal. Finally, FM was able to transmit high-fidelity sound reproduction.¹¹

Armstrong’s troubles became potentially more serious late in 1939, when RCA requested that television’s temporary experimental channels be made permanent. If the FCC had granted this request, FM would have been “boxed into” an inadequate band of four channels, without any unused frequencies available in adjacent bands for future growth. By this date, more than one hundred stations had already applied to broadcast in this limited band. Armstrong believed additional spectrum space was needed not only to accommodate these new applications but also to stimulate interest among other potential investors. Two of RCA’s main competitors took an

¹⁰For first quotation, see testimony of Edwin H. Armstrong in House Committee on Interstate and Foreign Commerce, *Radio Frequency Modulation*, p. 7. On the May 1936 allocation, see “Text of New FCC Rules Covering Extra-Broadcast Band Services,” *Broadcasting* 10 (June 1, 1936): 49. For second quotation, see Edwin H. Armstrong to the Secretary of the President’s Communications Policy Board, February 26, 1951 (n. 4 above). During 1936 Armstrong also had difficulty obtaining a license from the FCC to operate his first high-power FM station in Alpine, New Jersey. See Erickson (n. 3 above), pp. 63–64.

¹¹For a complete contemporary statement of FM’s technical superiority, see “Comparative Potentialities of ‘FM’ and ‘AM’ Broadcasting,” n.d. (probably 1944), folder marked “Jansky and Bailey,” box 124, Armstrong Papers. Also see Inglis (n. 3 above), p. 119.

early interest in FM. General Electric Company (GE) and Zenith Radio dominated the early FM equipment market. Both companies also began operating FM stations in 1939, a few months after Armstrong's Alpine, New Jersey, station—the first “full-powered FM station”—went on the air. The first attempt to set up a network of FM stations was also made in 1939 by another Armstrong supporter, the Yankee Network of New England. In 1940, Armstrong and the other FM broadcasters—including a number of newspaper publishers—came together to form an FM trade association, FM Broadcasters Inc. (FMBI).¹²

FCC hearings held in 1940 favored FM, thanks mainly to the support of the new chairman, James Lawrence Fly. A New Deal liberal, Fly believed the commission should not limit itself to evaluating technical issues, but argued for an “integrated and comprehensive regulatory policy” that took into account important social, economic, and political concerns. Fly saw the growth of FM radio as a way to limit monopoly control by dominant elements in the radio industry, especially RCA and NBC. Armstrong's disclosure of confidential RCA engineering reports on FM experimentation that the company did not present to the commission in 1936 helped convince Fly to decide against RCA's allocation request. By transferring television's number one channel to FM (44 to 50 MHz), the final allocation gave FM a total of forty channels in which to expand. The commission also authorized commercial development, which went into effect in January 1941. When the United States entered World War II in December, sixty-seven commercial FM stations had been authorized and forty-three applications were pending. Contemporary sources disagreed on the number of receivers in public use at the beginning of the war, but the generally accepted figure was 500,000. Thus, de-

¹²On FM being boxed in, see Edwin H. Armstrong, (untitled memorandum to the FCC), n.d. (probably 1945), p. 10, folder marked “EAH Quotes and Misc.,” box 18, Armstrong Papers. In December 1939, one of the commissioners wrote Armstrong that he suspected members of the FCC staff of taking “a supercritical attitude” toward FM. See George Henry Payne to Edwin H. Armstrong, December 8, 1939, folder marked “FCC—Correspondence, 1943,” box 456, Armstrong Papers. An internal FCC memorandum gave a favorable evaluation of FM, see “Frequency Modulation vs. Amplitude Modulation—Report on Demonstrations in Schenectady Area,” April 29, 1939, folder marked “April 1, 1939–November 30, 1939,” box 1, Inter-office Information Memorandums (A1/E117), Records of the Federal Communications Commission, Record Group 173, National Archives, Washington, D.C. (hereafter cited as Mem/FCC, NA). For statistic of 150 stations, see Armstrong's testimony in House Committee on Interstate and Foreign Commerce, *Radio Frequency Modulation*, p. 10. On the early history of FM broadcasters and manufacturers, see Erickson, pp. 64–68.

spite FM's early problems, the industry was, according to Armstrong, "going great guns at the time of Pearl Harbor." Although the federal government placed a freeze on the civilian electronics industry at the beginning of the war, FM stations already broadcasting were allowed to continue operations.¹³

Armstrong's charges of conspiracy and dishonest practices by big business and government regulators are an important part of the history of FM. But the purpose of this article is not to evaluate definitively the accusations from this early period. It is clear that all of Armstrong's charges cannot be proved conclusively based on surviving archival material. Jolliffe's personal papers and relevant RCA records have apparently not been preserved. Although there is some convincing evidence to support his position, Armstrong, for his part, tended to present conflicts and disputes in less-than-subtle, black-and-white terms. More important for this study is recognizing how these early debates provided a framework for later developments, especially by predisposing Armstrong to suspect individuals and institutions of working against his new invention.

FM and the Radio Technical Planning Board

To understand the origin of the FCC's 1945 decision to shift FM's frequency allocation we need to look at plans begun during the war

¹³James Lawrence Fly, "Regulation of Radio Broadcasting in the Public Interest," *Annals of the American Academy of Political and Social Science* 213 (1941): 103. On disclosure of RCA engineering reports, see Lessing (n. 3 above), p. 242. On Fly's support of FM radio, also see articles and speeches in folder marked "Articles—FM," box 35, James Lawrence Fly Papers, Columbia University Archives, New York City (hereafter cited as Fly Papers). Also see internal FCC memorandum comparing FM and AM: "General Information Concerning Topics of the Agenda for the Hearing before the Commission en banc in the Matter of Aural Broadcasting on Frequencies Above 25,000 kc Scheduled to Begin March 18, 1940," pp. 4–11, folder marked "December 30, 1939—March 30, 1940," box 1, Mem/FCC, NA. For statistics of the number of FM stations when the United States entered the war, see *Seventh Annual Report of the Federal Communications Commission for the Fiscal Year ended June 30, 1941* (Washington, D.C., 1941), p. 30. This report also related that in November 1941, there were 150,000 FM receivers in use, with 1,500 being produced every day (see p. 30). In 1943, one of the FCC commissioners reported, based on "reliable estimates," the 500,000 figure. See E. K. Jett, "Let's Plan Now for Post-War, Says Jett" *Broadcasting* 25 (April 26, 1943): 30. This was also the prewar number generally accepted by Armstrong and the FM industry. See Armstrong testimony in House Committee on Interstate and Foreign Commerce, *Radio Frequency Modulation*, p. 11. A more recent source states that there were nearly 400,000 FM sets in the hands of the public by the end of 1941. See Inglis, p. 129. For the last quotation, see Edwin H. Armstrong, (untitled address at the Fifth Annual Meeting of FM Broadcasters, Inc.), January 26, 1944, p. 9, folder marked "EHA—FM Broadcasters Address, 1944," box 18, Armstrong Papers.

to establish standards for the postwar civilian electronics industry. As we will see, the FCC was pressured to make a decision in a timely manner to give the industry sufficient time to prepare for postwar expansion and the State Department enough time to prepare for postwar international agreements on the use of the electromagnetic spectrum. Wartime research stimulated new developments in electronics, including new tubes and circuits, which helped open up higher frequencies to commercial exploitation. As early as 1942, it became clear that extensive planning would be needed to develop a new allocation scheme for the use of frequencies above 30 MHz (AM radio operated in the 550 to 1600 kHz band). In November, during a joint meeting of the IRE and the Engineering Department of the Radio Manufacturers Association (RMA), FCC chairman Fly encouraged the radio industry to establish an organization that would work to hasten reconversion to peacetime production and employment by providing the FCC with the necessary engineering advice for developing frequency allocations and system standards. He suggested setting up a new group modeled on the National Television Systems Committee (NTSC), which had been formed in June 1940 to help the industry reach consensus on instituting system standards for television. Fly's proposal resulted in the establishment, in September 1943, of the Radio Technical Planning Board (RTPB). The RTPB was sponsored by at least eighteen "nonprofit associations and societies," including not only professional engineering and trade associations such as the IRE and the RMA but also broadcast groups such as FMBI, the National Association of Broadcasters (NAB), and the Television Broadcasters Association (TBA).¹⁴

The responsibilities of the RTPB were much more extensive than those of the NTSC. During 1944, six hundred RTPB members were doing work divided among thirteen panels. Panel 2 sought to coordinate the use of the entire frequency spectrum and reconcile conflicting frequency allocations recommended by different panels. Panel 5 was responsible for specific recommendations for FM broadcasting, including both frequency allocations and system standards. Other panels studied and developed standards for such services as television, facsimile, standard AM broadcasting, and aeronautical ra-

¹⁴On wartime stimulation of electronics, see W. R. G. Baker, "Planning Tomorrow's Electronic Highways," *General Electric Review*, 47 (1944): 3. On the establishment of the RTPB, see W. R. G. Baker, "Statement of Operations of the Radio Technical Planning Board," September 28, 1944, folder marked "Radio Technical Planning Board," box 422, Armstrong Papers. On Fly's important role, see his 1942 speech in folder marked "IRE Rochester Fall Meeting 11-9-42," box 36, Fly Papers.

dio. The RTPB sought to include the most competent “specialists in radio propagation” as well as “any individual or organization having either a direct or indirect interest in any of the services or problems to be considered by the RTPB.” Significantly, the IRE and RMA engineers who established the RTPB “restricted” the analyses and recommendations of the panel “to engineering considerations.”¹⁵

The RTPB was under significant pressure from the FCC to provide recommendations as soon as possible. The commission was not only concerned about making sure the civilian electronics industry got off to a quick start when the war ended but also needed to provide the State Department with a comprehensive frequency allocation proposal so its Telecommunications Division could be ready for the next International Telecommunications Conference to be held immediately after the war. The FCC was mainly responsible for allocating domestic frequencies used by nongovernmental services. Government use of radio was coordinated by the Interdepartmental Radio Advisory Committee (IRAC), which included representatives from different government agencies using radio.¹⁶

Panel 5 of the RTPB met between December 1943 and June 1944. The chairman, Cyril Jansky, had overseen the construction of the first FM station in Washington, D.C. and had served as president of the IRE. The technical problem that would ultimately play a major role in the FCC’s decision to shift FM’s frequency allocation, the potential for sky wave interference, became a major topic of discussion for members of Panel 5, especially during its second meeting in April 1944. As early as the previous April, an FCC commissioner had expressed concern about the problem of sky wave interference in the vicinity of 40 MHz, the band in which FM operated. Actually, doubts about this location for FM were raised in 1940, when the FCC first authorized commercial operation. Three years earlier, Armstrong himself had admitted that “the indications are that there will be much less trouble at 100 megacycles than on 40 megacycles.”¹⁷

¹⁵On the purpose of Panel 2, see especially *Official Report of Proceedings before the Federal Communications Commission: In the Matter of Allocation of Frequencies to the Various Classes of Non-Governmental Services in the Radio Spectrum from 10 Kilocycles to 30,000,000 Kilocycles*, September 28, 1944, vol. 1, pp. 32–33, box 36, Docket No. 6651, Dock/FCC, NA. Quotations are from W. R. G. Baker, “Statement of Operations of the Radio Technical Planning Board,” pp. 3, 7.

¹⁶On the State Department planning for postwar radio, see “Planners Omit International Shortwave,” *Broadcasting* 27 (August 14, 1944): 66. A joint meeting of the FCC, State Department, and IRAC to prepare for future cooperation was held in November 1943. See “Fly Urges Speed in Allocation Studies for FM and Television,” *Broadcasting* 25 (November 22, 1943): 12.

¹⁷For Jansky involvement with FM, see “Regional FM Allocation Plan Urged,” *Broadcasting* 26 (February 14, 1944): 34. FCC 1940 report quoted by Inglis, p. 128.

FM broadcasters worried about the potential for two kinds of sky wave interference: F2 layer transmission and sporadic E transmission. F2 layer interference occurred when transmitted waves from distant stations (often more than one thousand miles away) were reflected by the upper (F2) layer of the ionosphere and interfered with stations broadcasting on the same frequency. This type of interference was known to decrease with increasing frequency. Under normal conditions, signals above 40 MHz were not reflected by the F2 layer of the ionosphere; for these higher frequencies propagation occurred by direct line-of-sight transmission. During the RTPB and FCC hearings in 1944 and 1945, some engineers warned that F2 layer reflections might occur at higher-than-normal frequencies during maximum sunspot activity. Sporadic E interference was believed to occur when signals were reflected by irregularly distributed areas of ionization in the intermediate (E) layer of the ionosphere. Engineers and broadcasters thought this problem was more prevalent during the summer months.

Interference was also known to occur in the lower regions of the atmosphere. Engineers worried about various tropospheric effects, including long-distance bending and ducting of waves. This form of interference was thought to increase with higher frequencies. Signal shadows were also known to occur behind hills and buildings. This form of interference similarly seemed to become more noticeable at higher frequencies.¹⁸

During the April meeting of Panel 5, William Lodge, director of engineering at the Columbia Broadcasting System (CBS), announced that, despite having voted during the first meeting in favor of keeping FM in its current band, he now believed there was evidence that during the next sunspot maximum sky wave transmission might create intolerable interference in the 40 to 50 MHz band. Three other members also expressed reservations about these lower frequencies and told of specific cases when sky wave interference

Armstrong quotation is from "Remarks on Frequency Modulation by Dr. E. H. Armstrong, at Meeting of Technical Subcommittee of the Interdepartmental Radio Advisory Committee, April 12, 1937," p. 6, box 27, General Records of J. Howard Dellinger, Records of the National Institute of Standards and Technology, Record Group 167, National Archives, Washington, D.C. (hereafter cited as Dellinger Records).

¹⁸For a discussion of the various types of interference, see *Report of Allocations from 25,000 Kilocycles to 30,000,000 Kilocycles: In the Matter of Allocation of Frequencies to the Various Classes of Non-Governmental Services in the Radio Spectrum from 10 Kilocycles to 30,000,000 Kilocycles*, May 25, 1945, pp. 49–72, vol. 31, box 59, General Correspondence, 1927–46, Office of Executive Director, Records of the Federal Communications Commission, Record Group 173, National Archives, Washington, D.C. (hereafter cited as ExDir/FCC, NA).

had been observed. NBC engineer Raymond F. Guy reported that receivers in the United States had picked up European television stations broadcasting on the same frequencies. All members agreed, however, that they lacked the necessary data to make a definitive decision. There had been few stations operating during the last sunspot maximum, and even fewer observations had been made under normal conditions at higher frequencies around 100 MHz. The chairman emphasized the inherent technical uncertainty of the decision, insisting that if they wanted to wait until all the facts were in they would “never make a decision.”¹⁹

Following a suggestion made by Lodge, the panel decided to defer this interference problem to J. Howard Dellinger, chief engineer of the Bureau of Standards and probably the most important engineer in government service. They considered Dellinger one of the foremost authorities on radio propagation and believed his group at the bureau would have the most extensive and reliable set of data. Dellinger responded in general terms that the fear of long-distance, sky wave interference in the 40 to 50 MHz band “is not well founded.” Although he believed there was no good reason to shift FM to higher frequencies, he also emphasized that “no frequencies are free from transmission vagaries.” The panel voted 17 to 3 to keep FM in the lower band after receiving Dellinger’s letter. Lodge voted in favor of the recommendation. Two of the engineers who voted against the proposal felt that more data needed to be collected before a final decision could be made; the third engineer, T. T. Goldsmith of Dumont Television, remained convinced that his data justified moving FM to a higher band. Panel 5’s final report, dated June 1944, recommended that FM stations continue to broadcast in the vicinity of 40 MHz, but in an expanded band—not forty but eighty to one hundred channels, each 200 kHz wide.²⁰

FCC Hearings: Fall 1944

The FCC held official hearings beginning on September 28, 1944, in order to allow public presentation of all available evidence—in-

¹⁹ *Proceedings, Second Meeting of Panel 5 of the Radio Technical Planning Board*, April 11, 1944, pp. 1–57 (quotation on p. 25), folder marked “Panel on FM Broadcasting (1 of 2),” box 1, Records of RTPB—Planning Board Meetings: 1942–48, Office of Chief Engineer, Office of Engineering and Technology, Records of the Federal Communications Commission, Record Group 173, National Archives, Washington, D.C. (hereafter cited as RTPB/FCC, NA).

²⁰ J. Howard Dellinger to C. M. Jansky, May 1, 1944, folder marked “FCC Hearing—Re: FM Broadcasting,” box 40, Dellinger Records. For the voting of the engineers, see Radio Technical Planning Board: Panel 5, *Report on Standards and Frequency*

cluding the recommendations of the RTPB—concerning the allocation of the entire frequency spectrum, from 10 to 30,000,000 kHz. The industry trade publication *Broadcasting* characterized the FCC's plans for postwar allocations as the "most sweeping revision of the radio spectrum since the art began." More than 200 witnesses testified at the FCC hearings, which lasted 25 days; 4,559 pages of testimony were taken and 543 exhibits were received from industry engineers, government engineers, business leaders, and other individuals interested in telecommunications policy. The FCC felt pressured to develop an allocation plan in a timely fashion in order to meet a December 1 deadline established by the State Department. Contemporary observers argued that a "race against time" was apparent in the FCC proceedings.²¹

The FCC first issued orders for the September hearings four days after the State Department held its own conference, on August 11 and 12, to help plan for international allocations. The State Department conference was presided over by Dellinger, the chairman of the Department's technical subcommittee on telecommunications. IRAC (of which Dellinger was also a member) presented a preliminary allocation that reflected the needs of the federal government. The IRAC plan recommended FM be given 60 channels in the 42–54 MHz band but also indicated that a shift to higher frequencies could still be made if justified by technical studies currently in progress. In formulating its own plans, the FCC also needed to consider this proposal, but the State Department emphasized that there was much room for flexibility.²²

Before the start of the FCC hearings, two conflicting proposals for the FM allocation were reconciled through behind-the-scenes nego-

Allocations for Postwar FM Broadcasting, June 1, 1944, pp. 155–64, vol. 22, box 51, Docket No. 6651, Dock/FCC, NA.

²¹"Allocation Conference Opens Friday," *Broadcasting* 27 (August 7, 1944): 16. Description of the FCC Hearings is from Paul A. Porter to Burton K. Wheeler, March 12, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. Last quotation is from "Allocation of '44," *Broadcasting* 27 (September 25, 1944): 40.

²²On State Department conference, see "Allocation Conference Opens Friday," *Broadcasting* 27 (August 7, 1944): 16, and "Allocations Hearings Ordered by FCC," *Broadcasting* 27 (August 21, 1944): 9. For IRAC proposal, see "Proposal of the IRAC for the Revision of Article 7 of the General Radio Regulations (Cairo Revision)," June 15, 1944, folder marked "General Frequency Lists and Proposals—1944 Allocation Hearings," box 18, Fly Papers. On the flexibility of the State Department, see "Planners Omit International Shortwave" (n. 16 above), p. 66. Also see James P. Veatch, "Memorandum to the Chief Engineer," August 18, 1944, folder marked "July 1, 1944 through September 30, 1944," box 6, Mem/FCC, NA.

tiations. The proposal developed by RTPB Panel 5 partly conflicted with the recommendation Panel 6 presented for the placement of television's first channel. A major dispute between FM and television was avoided through the mediation of the chairman of Panel 2, Charles Jolliffe, who met with members from each panel and with the chairman of the RTPB, W. R. G. Baker, an early FM supporter who headed the electronics division at General Electric. After making "full use" of the IRAC proposal and the advice of a government representative, the RTPB made a final recommendation during the FCC hearings in September that FM be given seventy-five channels in the 41–56 MHz band.²³

Despite this recommendation, which was supposed to represent the best advice of the radio engineering community, it became clear during the hearings in early October that the FCC might rule against the RTPB technical experts. The commissioners and the chief engineer began questioning witnesses about moving FM to frequencies in the vicinity of 100 MHz. The main source of support for the move at the FCC hearings came from Oliver Lodge of CBS and T. A. M. Craven, a former commissioner (and one of the few commissioners who had been trained as an engineer), who was now representing Cowles Broadcasting Company. On August 14, about two months after voting in favor of Panel 5's recommendation to keep FM in its lower band, Lodge had published an article in which he again warned of the dangers of sky wave interference. Without presenting many details, he claimed that new tests in July demonstrated the existence of serious E layer interference; Lodge also repeated the old warning of F2 layer interference during the next sunspot maximum—this time without including any new data.²⁴

FM industry representatives responded angrily to Lodge's article and his support of the frequency shift. Armstrong later pointed to Lodge as the main source for the idea of moving FM. FM supporters accused the CBS engineer of using the technical issue of interference as a "smoke screen" to maintain the dominance of AM net-

²³ *Official Report of Proceedings before the Federal Communications Commission* (n. 15 above), pp. 53–55, 162–65. On how some of the television interests, including Dumont Television and the American Television Society, protested the disruption of their 50–108 MHz band, see p. 54 of this report and "RTPB Panel Asks FM, Video Panel," *Broadcasting* 27 (September 11, 1944): 14. Actually, Panel 2 revised its FM recommendation slightly on the last day of the FCC hearing to take into account the needs of amateurs. The final recommendation placed FM in the 43–58 MHz band instead of 41–56 MHz. See "FCC Tackles Conflicting Space Demand," *Broadcasting* 27 (November 6, 1944): 11.

²⁴ On the support for the move at the FCC hearings, see "Rapid Growth in High Band Indicated," *Broadcasting* 27 (October 16, 1944): 1. William B. Lodge, "Keeping FM Free from Interference," *Broadcasting* 27 (August 14, 1944): 13.

work radio. But Lodge's motivations should not simply be analyzed in the context of competition between FM and AM or even between FM and television; his desire to shift FM upward had more to do with internal conflicts within the television industry.²⁵

Both CBS and Cowles Broadcasting wanted to move television broadcasting to much higher frequencies (above 300 MHz instead of in the vicinity of 100 MHz) where the new high-definition, color system the companies were trying to develop would have room for growth. Most of the remainder of the television industry, especially RCA/NBC and Dumont Television, lobbied the FCC to protect its investment in the old television system in the lower frequencies. The proposal from CBS and Cowles to move FM into frequencies being used by television should be seen in terms of their desire to disrupt the established television system and the economic interests supporting that system. As far as CBS and Cowles were concerned, the FM shift was for its own good, since the industry would be given room to grow—from a congested band to a wide-open region where it could, presumably, compete against AM stations (once television also had been moved upward). Testifying for Cowles Broadcasting, Craven proposed that FM be given as many as 400 channels in the vicinity of 100 MHz.²⁶

The commissioners were receptive to the proposals of CBS and Cowles because they were convinced of the advantage of a policy that would result in expanded frequency bands for both television and FM. Although James Fly left the commission in November 1944 before a final decision had been made, his line of questioning during the hearings indicated he supported shifting both FM and television to higher frequencies where both services would have room to grow.²⁷ Fly had been the strongest supporter of FM in 1940, and

²⁵Quotation is from "Damm Replies to Lodge Article," *Broadcasting* 27 (August 28, 1944): 54, 130. On the importance of this kind of competition in the television industry, also see William F. Boddy, "Launching Television: RCA, the FCC and the Battle for Frequency Allocations, 1940–1947," *Historical Journal of Film, Radio and Television* 9 (1989): 45–57.

²⁶For discussion of companies that wanted to protect old television system, see "CBS Asks More FM Space, 300 mc Video," *Broadcasting* 27 (October 9, 1944): 9; "Rapid Growth in High Band Indicated," *Broadcasting* 27 (October 16, 1944): 1; "New FCC Allocations Seen in Fortnight," *Broadcasting* 27 (October 30, 1944): 59; "NAB Panel on FM, Television, and Facsimile," *FM and Television* (1944): 27–28. For Craven testimony, see "Rapid Growth in High Band Indicated," *Broadcasting* 27 (October 16, 1944): 1.

²⁷See "Rapid Growth in High Band Indicated," *Broadcasting* 27 (October 16, 1944): 1; "New FCC Allocations Seen in Fortnight," *Broadcasting* 27 (October 30, 1944): 11; "Fly Urges Video in High Frequencies," *Broadcasting* 27 (September 25, 1944): 13.

there is no reason to conclude he would have favored a policy that might hurt the market position of the new technology. On the contrary, he initially believed the FM shift would help strengthen the industry.

The idea for shifting FM upward gained momentum during the autumn of 1944 because of the generally low-key response from Armstrong and other FM supporters at the FCC hearings. They did not seem to think an all-out lobbying effort was necessary to defeat a technical policy decision that they believed lacked the support of the engineering community. Further, the particular line of questioning pursued by the commission seemed to force representatives of the FM manufacturers—notably Zenith and Stromberg-Carlson—to acknowledge that sky wave interference would be less important in higher frequencies and that the industry would probably be able to survive a frequency shift. Armstrong, for his part, seemed to have been preoccupied fighting a proposal to reduce the channel width of FM broadcasts from 200 to 100 MHz.²⁸

Engineering testimony presented toward the end of the FCC hearings in 1944 gave the commission what it believed was “authoritative” technical evidence to support a decision to shift FM. By far the most important technical evidence—and the most controversial—came from Kenneth Norton, an FCC engineer who had been transferred during the war to the operations and analysis division of the War Department. Norton presented detailed graphs and charts of propagation data from the National Bureau of Standards laboratories near Washington, D.C. and from measuring stations in other parts of the world. The latter data was collected by the Army-Navy Interservice Radio Propagation Laboratory and was subject to war-time restrictions. Norton argued that the available data “demonstrated the necessity for moving FM upwards in the spectrum,” because it indicated serious problems from both sporadic E layer and F2 layer interference for frequencies as high as 80 MHz.²⁹

Despite expert testimony by RTPB engineers against this recommendation, the FCC’s proposed allocation, announced in January 1945, placed FM in the 84 to 102 MHz band. The proposal retained the 200 kHz band width, giving FM ninety channels in which to operate (instead of forty). The FCC also included provisions for FM’s expansion upward into 102–108 MHz and downward into 78–84

²⁸On FCC questioning, see “Rapid Growth in High Band Indicated,” *Broadcasting* 27 (October 16, 1944): 9–10. “Armstrong Defends Wide Band,” *Broadcasting* 27 (October 16, 1944): 14.

²⁹“Interference Data is Revealed for 30–40 mc Band at Hearing,” *Broadcasting* 27 (October 23, 1944): 60.

MHz. Thus, FM might potentially end up with 150 channels. The proposal reduced the number of television channels from eighteen to twelve, placing them in two bands of the remaining frequencies between 44 and 210 MHz. Television's lower band would include FM's old frequencies, but the commission specifically stated that the two television bands should be viewed as temporary allocations that would be used only until television was ready to move into the ultra-high frequencies (UHF) above 480 MHz. The FCC also announced that the proposed allocation would not go into effect until groups and individuals with an interest in the decision had an opportunity to express their views in a series of public hearings.³⁰

The television allocation was a compromise between the CBS and NBC/RCA proposals. Since CBS won a promise from the commission to expedite a shift to the UHF spectrum, the decision to continue television broadcasting in the old frequencies was only a partial victory for NBC and RCA.³¹ Of all the different industry groups, FM supporters were the least satisfied with the proposal. But it is important to recognize that Fly and other members of the FCC initially favored the shift as a way to help the FM industry. As soon as the commission followed through on its promise to shift television "upstairs," FM would have room to expand and grow. Specific technical testimony thus helped legitimate a decision that had originally been formulated to help the FM industry.

Technocratic versus Democratic Decision-making

The exclusive use of technical criteria to legitimate complex policy decisions underscores a fundamental tension in the work of regulatory commissions. The wish to both delegate authority to technical experts to avoid conflict and to stress broad democratic judgment to take into account the controversial socioeconomic factors of tech-

³⁰On the announcement of the proposal, see "Allocation Proposals Announced by FCC," *Broadcasting* 28 (January 16, 1945): 13, 66–67. In September 1944, the engineering staff of the FCC had recommended 150 channels for FM when it proposed shifting FM to the 86–116 MHz band. See "Recommendations on Allocations," September 26, 1944, folder marked "FM—1944 Allocation Hearings—Staff Committee Reports," box 18, Fly Papers. For the official report on the January 1945 proposal, see *Report of Proposed Allocations from 25,000 Kilocycles to 30,000,000 Kilocycles: In the Matter of Allocation of Frequencies to the Various Classes of Non-Governmental Services in the Radio Spectrum from 10 Kilocycles to 30,000,000 Kilocycles*, January 15, 1945, box 31, Docket No. 6651, Dock/FCC, NA.

³¹"Allocation Proposals Announced by FCC," *Broadcasting* 28 (January 16, 1945): 67. On reaction of television industry, also see "Reaction Varies to Allocation Proposal," *Broadcasting* 28 (January 22, 1945): 16, 63; and "Reaction to FCC Spectrum Plan," *Broadcasting* 28 (January 22, 1945): 59.

nical decision-making has been a central dilemma in technology policymaking.³² This tension is especially evident in the way the commission dealt with the FM allocation proposal of January 1945.

In arriving at this proposal, the commission considered the economic impact of the frequency shift and concluded that the cost to manufacturers, station owners, and the public would “not be great.” The official report on the proposal acknowledged that the “determination was not limited to technical considerations but also took into account economic and social factors and considerations of national policy.” However, when FCC commissioners and staff members defended this decision in controversial public forums, for instance before the House Appropriations Committee, they emphasized that the FM shift was demanded purely by technical considerations. The secretary of the FCC responded to public inquiries by bluntly arguing that “the reason behind the Commission’s proposal to move FM higher in the spectrum is that engineering data, some of it available for the first time, shows that FM would be subject to intolerable sky wave interference if it remained at its present assignment and that no such interference would be expected in the higher portion of the spectrum.”³³

In order to understand why the FCC used exclusive technical arguments to legitimate a decision that had also taken into account non-technical considerations, we need to consider the broader political climate of the period. During the three years before the announcement of the allocation proposal, the FCC had been the focus of intense controversy, mainly because of the activist policies of James Fly, who had been appointed chairman in 1939 by President Franklin D. Roosevelt. The journal *Broadcasting*, which tended to reflect the views of the dominant elements in the broadcast industry, complained in 1944 that “probably no Government official in our times,

³² See Slotten (n. 5 above), p. 952.

³³ For first two quotations, see *Report of Proposed Allocations from 25,000 Kilocycles to 30,000,000 Kilocycles*, pp. 18, 75–76. On the FCC taking into account economic factors, see also memorandum from FCC Committee 2 to FCC Steering Committee titled “Transmittal of Report on Economic Considerations Concerning the FM Industry,” September 28, 1944, folder marked “FM—1944 Allocation Hearings—Staff Committee Reports,” box 18, Fly Papers. For an example of technocratic public legitimation of the FCC decision, see testimony of Commissioner E. K. Jett before subcommittee of the Committee of Appropriations, House of Representatives on January 18, 1945, in “Extract from Testimony of FCC Commissioner E. K. Jett,” folder marked “E. K. Jett,” box 124, Armstrong Papers. For comments of FCC Secretary, see T. J. Slowie to Louis Medwin, January 25, 1945, box 32, Docket No. 6651, Dock/FCC, NA.

has used more intemperate or abusive language in dealing with industry.”³⁴

Fly’s most important work on the commission was to complete an investigation, initiated in 1938, of monopoly control by network radio. The resulting *Report on Chain Broadcasting*, issued in 1941, became a blueprint for the partial reform of the radio industry. The Supreme Court upheld Fly’s policies in 1943, and, among the most notable results, NBC was forced to sell one of its two networks, which became the basis for a new entity, the American Broadcasting Company (ABC). Fly’s actions antagonized not only the radio networks but also conservative members of Congress, who launched a series of investigations of the commission beginning in 1941. Their charges ranged from general complaints that the FCC was “acting arbitrarily and exceeding its powers” to specific attacks on employees, who were characterized as “un-American” subversives. Legislative bills were also introduced—albeit unsuccessfully—to revise the 1934 Communications Act. Technocratic advocates of “free radio,” such as the Republican presidential candidate, Thomas E. Dewey, and the influential consulting engineer John V. L. Hogan, called for “unambiguous” legislation that would restrict the FCC to regulating the technical aspects of broadcasting, instead of “debatable” concerns such as programming, business and economic policies, and station and network relations. An important “debatable” concern was the commission’s decision, during the late 1930s, to reserve a number of channels in the FM band for educational broadcasting. Educators had first asked for this special consideration during the late 1920s, when the Federal Radio Commission (FRC) began regulating AM radio. But the exclusive technical criteria used by the FRC had assumed that nonprofit, educational stations were no more valuable than commercial stations. Fly’s rejection of this technocratic position by working to set aside a band of FM frequencies for non-commercial broadcasters brought further criticism from his opponents. Broadcasting complained that “once again the commission ventures into social and economic stratospheres which are questionable.”³⁵

³⁴For an evaluation of Fly’s activities on the FCC, see Erik Barnouw, *A History of Broadcasting in the United States*, vol. 2, *The Golden Web* (New York, 1966), p. 173. “Flyocracy” (editorial), *Broadcasting* 26 (February 14, 1944): 40.

³⁵On congressional investigations of the FCC, see, for example, House Select Committee to Investigate the Federal Communications Commission, *Study and Investigation of the Federal Communications Commission: Hearings on H. R. 21, 78th Cong., 2d sess., (1943)*. Quotations relating charges against the FCC are from “FCC Newspaper

The two chairmen who succeeded Fly and who were responsible for implementing and defending the 1945 allocation had closer ties to the radio industry and were less willing to pursue activist policies. Paul Porter, the attorney who replaced Fly late in 1944, had been employed for a number of years by CBS. Charles Denny, who succeeded Porter in 1946, resigned after one year to become NBC vice president and general counsel. The strategy of technical legitimation pursued by the commission to justify the 1945 allocation should thus be seen as an aspect of a new FCC policy to avoid controversy by retreating from earlier nontechnocratic, activist practices.

The tension between technocratic and nontechnocratic policies had also been an important factor in RTPB decision-making. Although the board's bylaws restricted the activities of the different panels to engineering considerations, some members criticized this position as unrealistic and overidealized. Members of Panel 5 specifically argued that "a question of allocation must, to some extent, give consideration to . . . other policy matters." The chairman of Panel 5, Cyril Jansky, believed that this was especially true for decisions about the number of channels that should be assigned to different services, which he characterized as "not purely an engineering matter but one which in fact is primarily . . . a question of public policy."³⁶

An analysis of the record indicates that in formulating decisions, Panel 5 did take into account social and economic factors. When panel members rejected moving FM to a higher band of frequencies they based their decision not only on the technical evidence but also on "the fact that there is already a substantial public investment in FM equipment and a highly organized public service already being rendered by existing FM stations in this position of the spectrum." Complex, hybrid decision-making was necessary because of the in-

Decision Before Holidays," *Broadcasting* 25 (December 6, 1943): 7. For a general discussion of Fly's troubles during this period, see Barnouw, pp. 168–181. Hogan quoted in "What Radio Wants in a Nutshell—Hogan," *Broadcasting* 25 (December 13, 1943): 49. On Dewey, see "Dewey Demands Free Radio, Revised Law," *Broadcasting* 27 (September 11, 1944): 11. For a general discussion of the government's involvement in educational radio, see U.S. Office of Education, *FM for Education* (pamphlet, n.d. [1944?]), vol. 22, box 51, Docket No. 6651, Dock/FCC, NA. For the first authorization of educational stations, see *Fourth Annual Report of Federal Communications Commission for the Fiscal Year ended June 30, 1938* (Washington, D.C., 1939), pp. iv, 63. Last quotation is from "Last Frontier" (editorial), *Broadcasting* 28 (January 22, 1945): 38.

³⁶First quotation from Radio Technical Planning Board: Panel 5 (n. 20 above), p. 24. Cyril Jansky quoted in *Official Report of Proceedings before the Federal Communications Commission* (n. 15 above), p. 53.

herent technical flexibility and uncertainty of the work. Jansky emphasized that “no panel or no group will know all there is to know about all of the frequencies in the band which we are studying.” At least one RTPB engineer argued further that the organization should include individuals who were not strictly professional engineers, because “the factors before the Committee are not all engineering factors.”³⁷ Like the FCC, the RTPB thus legitimated decisions that involved both technical and nontechnical considerations through exclusive reference to technical criteria. In the case of the RTPB, because of the restrictions imposed by the founders, this tension was inherent in the structure of the organization.

After announcing the proposed allocation in January 1945, the FCC gave individuals and institutions an opportunity to respond during hearings from February 28 through March 1. Opponents of the FM shift mobilized to fight the decision during the month preceding the hearings. The major parties with an interest in the allocation—including engineers, station owners, network executives, manufacturers, and trade associations—responded to the decision in briefs submitted to the commission. Thirty of these representatives also testified as witnesses at the February-March hearings. A “secret hearing” was then held on March 12 and 13, during which the participants discussed the classified military data that had been used to help justify the FCC allocation proposal. Dellinger appeared before the commission for the first time at this proceeding and reiterated the position he had taken in May 1944 against the FM shift.³⁸

After the March hearings the FCC delayed making a final decision until June 27. The State Department had extended the original December deadline it had given the FCC, and by the spring of 1945 it was satisfied with some of the allocation decisions that had already been made for other parts of the frequency spectrum. The delay in the decision on the allocation of FM and television was also made possible because of an announcement in May by the War Production Board that the freeze on the civilian electronics industry would continue until military cutbacks reached 75 percent, which was not expected until at least the first quarter of 1946. The board also assured

³⁷Radio Technical Planning Board: Panel 5, pp. 26, 63, 76.

³⁸For a description of events before and during the February and March hearings, see Paul A. Porter to Burton K. Wheeler, March 12, 1945, folder marked “Docket 6651—Papers and Correspondence,” box 458, Armstrong Papers. On the “secret hearing,” see “Synopsis of Proceedings Involving Preparation and Presentation of Radio Industry’s Recommendations through RTPB to the Federal Communications Commission Regarding Allocations to FM Broadcasting,” folder marked “Radio and Technical Planning Board,” box 422, Armstrong Papers.

the FCC that it would give a ninety-day notice before lifting controls. A major consideration for the FCC had been to develop a new allocation quickly in order to give the industry enough time to prepare for postwar development. Because of the War Production Board's announcement, the FCC now believed it had sufficient time to conduct further engineering measurements. Although the engineers on the commission thought that they already had enough technical evidence to justify moving FM, at least two of the commissioners were convinced more observations were needed. The May 14 issue of *Broadcasting* reported that the FCC was "in a three-way split over FM." An announcement by the FCC in May reflected this disagreement; new engineering tests would help the commission decide between three alternative allocations for FM: 50–68, 68–86, and 84–102 MHz.³⁹

Early in June, the War Production Board reversed its earlier decision and announced that the freeze would be lifted as soon as the Japanese surrendered; it also warned not to expect a ninety-day advance notice. This statement shocked the radio and television industry into pressuring the FCC to make a decision immediately on the allocation of radio and television. The Radio Manufacturers Association (RMA), the Television Broadcasters Association (TBA), and FM Broadcasters Inc. (FMBI) all warned that further delay might result in postwar unemployment since manufacturers needed a significant period of time to design and produce new transmitters and receivers for operation in the new frequencies. The three major trade associations also urged the FCC to adopt the 50–68 MHz allocation for FM. The FM supporters felt confident about pressuring the FCC at this time because they mistakenly believed the commission was ready to choose a lower band. On June 12, the president of Zenith Radio wrote a friend that "it looks as though the Federal Communications Commission are going to compromise on the 50 to 68 megacycle band which is acceptable and will not cripple FM." A hearing was held on June 22 and 23. The FCC took only three days to make its final decision to reject the recommendation of the

³⁹"FM Decision Delayed as FCC Allocates," *Broadcasting* 28 (May 21, 1945): 17. "Allocations Are Unlikely for Fortnight; FCC Said to Favor Wider FM Band," *Broadcasting* 28 (May 14, 1945): 17. FCC News Release dated May 17, 1945, in folder marked "FCC Hearing—Re: FM Broadcasting," box 40, Dellinger Records. A joint committee of industry and FCC engineers was organized to coordinate the observations and analyses. See "FCC Visions FM as Major Radio Service," *Broadcasting* 28 (May 28, 1945): 17. Also see "25 Engineers Asked to Assist in FM Tests," *Broadcasting* 28 (May 21, 1945): 78; FCC News Release dated May 18, 1945, in folder marked "FCC—Correspondence, 1945," box 456, Armstrong Papers.

FM industry and not wait for further engineering measurements but proceed with the original proposal and move FM to the 88–106 MHz band. The long and hostile dispute had helped polarize FCC and RTPB engineers. The final decision reflected the influence of the FCC engineers, who had too much at stake, including pride and professional standing, to agree to a compromise. In August, when facsimile service was moved from a temporary allocation in the 106–108 MHz channel, FM was given its full range of frequencies from 88 to 108 MHz.⁴⁰

The historical contingencies that helped shape the allocation debate only give us a partial understanding of how the final decision was made. We also need to take into account the tension between technocratic and democratic views, which played a central role in the decision-making process. Although the record clearly indicates that the FCC took into account nontechnical factors, the commission continued to justify publicly the FM shift by referring to the technical criteria of engineering testimony. The technocratic legitimation strategy pursued by the commission after January 1945 took three forms. The first continued to emphasize the scientific evidence that guided the commission's decision. Chairman Porter argued in March 1945, for example, that the "rightness of this decision turns upon an evaluation of engineering data," which demonstrated the existence of interference in the lower frequencies. The second form of legitimation emphasized the scientific, disinterested authority of engineers who made the decision. Thus, Porter also insisted that the commission was guided "by the recommendation of our technical staff whom I believe to be competent, disinterested, and without any private axe to grind." The unstated assumption behind this statement was that the engineers on the commission were more reliable because, unlike the RTPB engineers, they did not have a vested interest in any aspect of the broadcast industry. Indeed, the Panel 5 engineers who opposed the FM frequency shift mainly represented FM broadcasters and manufacturers. The final method of legitimation was used in 1948 by the newly appointed chief engineer of the commission, George Sterling, who was responsible for justifying the deci-

⁴⁰On War Production Board announcement, see "WPB to Lift Construction Ban on V-J Day," *Broadcasting* 28 (June 11, 1945): 15, 72. For views of three trade associations, see "TBA, FMBI Demand Quick Allocation," *Broadcasting* 28 (June 4, 1945): 16; "New Hearing on FM Proposals Called," *Broadcasting* 28 (June 18, 1945): 16. For quotation of Zenith president, see Eugene F. McDonald to Howard Vincent O'Brien, June 12, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. On decision following June 22/23 hearing, see "FCC Allocates 88–106 mc Band to FM," *Broadcasting* 29 (July 2, 1945): 13.

sion to Congress, despite not having been involved in its formulation. Rather than primarily emphasize the technical evidence that pointed to the existence of interference, Sterling stressed the legitimacy of the process that the commission had used to evaluate technical criteria and expertise. In testimony before the House Committee on Interstate and Foreign Commerce, Sterling emphasized that he mainly wanted to give “a clear and complete picture of the path the Commission followed in arriving at its decisions; of the opportunity that all parties had to appear; present testimony, and engage in oral argument; and of the full extent to which the significant factors involved in that decision were considered by the Commission.”⁴¹

Despite the public statements of the FCC, however, published and unpublished sources indicate that, during 1945, the evaluation process continued to include both technical and nontechnical considerations. At times, commissioners acknowledged that because “many of the factors involved a judgment upon abstruse technical considerations concerning which there is but little factual information,” nontechnical criteria needed to be taken into account. Most important, the commission tried to predict the economic cost of the FM frequency shift by asking manufacturers to evaluate the relative expense of producing equipment for the higher band as opposed to the lower band. Commissioners also inquired into the amount of time it would take manufacturers to convert to a new production system. The commission wanted to judge the contention of the FM manufacturers that the shift would cost the public millions of dollars in obsolete receivers and contribute to unemployment by delaying the resumption of the civilian electronics industry during a crucial period when returning soldiers would be looking for jobs. Expectations were high that FM radio would take off after the war, replace the AM system, and contribute to a postwar boom in the electronics industry. Even CBS, which had spearheaded the effort to shift FM upward, predicted that FM would soon “supplant” AM radio. Although the FM manufacturers testified that it would take up to two years or more to convert FM receivers and transmitters, the FCC was convinced by the testimony of Philco and other companies—for reasons that remain unclear—that it would take no longer than four months. The commission also emphasized the availability of

⁴¹For first quotation, see Paul A. Porter to Burton K. Wheeler, March 12, 1945, file 66-4a, box 281, Exec/FCC, NA. Also see Paul A. Porter to Edward A. Kelly, May 4, 1945, box 281, Exec/FCC, NA. Second quotation is from Paul A. Porter to Clyde M. Reed, March 28, 1945, file 66-4a, box 281, Exec/FCC, NA. Testimony of George Sterling in House Committee on Interstate and Foreign Commerce, *Radio Frequency Modulation* (n. 9 above), p. 187.

converters that would allow the old FM sets to receive broadcasts in the higher frequencies, thereby preventing complete obsolescence. Further, the commission sought to mitigate the negative effects of the shift by establishing an interim period during which broadcasters could continue using the lower frequencies until they were ready to convert.⁴²

The tension between technocratic and democratic views also provides an important framework for understanding the response of individuals and institutions, especially manufacturers and broadcasters, to the proposed FM shift. The supporters of the new allocation—including the three networks, CBS, ABC, and Cowles Broadcasting Company—emphasized that their evaluations were based on technical, rather than economic or social, considerations. Manufacturers who testified or presented written briefs favoring the move included companies which, in general, had not yet invested heavily in FM: DuMont Television Company, Majestic Radio and Television Corporation, Hallicrafters Company, Philco Corporation, and Crosley Corporation. In most cases, the positions of the companies were presented by their engineers. Two noncorporate groups also supported the shift, amateur radio operators and the International Association of Police Chiefs. Both groups believed the new allocation better served their interests. Under the new allocation, the amateurs, for example, were allowed to use a band of 4 MHz as opposed to the 2 MHz recommended by the RTPB.⁴³

⁴²For first quotation, see Paul A. Porter to E. F. McDonald, February 4, 1946, folder marked “Docket 6651 . . . re Zenith,” box 458, Armstrong Papers. On FCC evaluating economic cost of shift, see “FCC Surveying Effects on Receiver Costs of Moving FM Band Upward,” *Broadcasting* 28 (April 2, 1945): 79. Also see Eugene F. McDonald to Burton K. Wheeler, March 26, 1945, folder marked “Docket 6651—Papers and Correspondence,” box 458, Armstrong Papers. For the CBS prediction, see “CBS Predicts FM Will Supplant AM; Promotes Color Video in ’45 Report,” *Broadcasting* 30 (April 1, 1946): 29. For testimony on conversion, see “Brief of Stromberg-Carlson Company,” vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. Others testified that conversion would take up to five years; see especially Philco testimony in “Military to Confide Secret Data to Radio,” *Broadcasting* 28 (March 13, 1945): 68, 71. On FCC evaluation of this testimony, see untitled FCC Report (probably June 27, 1945, report), folder marked “FCC Hearing—Re: FM Broadcasting,” box 40, Dellinger Records. On the FCC emphasizing availability of converters, see “Shifting of FM Upward in Spectrum Seen,” *Broadcasting* 28 (March 19, 1945): 18.

⁴³On Philco’s position, see “Analysis of the Implications, for Educational Broadcasting, of the Federal Communications Commission’s Report Issued January 16, 1945,” February 21, 1945, p. 15, vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. For ABC’s position, see Frank Marx (director of general engineering), “Statement to the Federal Communications Commission on the Proposed FM and Television Allocations,” February 22, 1945, vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. For CBS’s position, see “Brief of Columbia Broadcasting System, Inc.,” February

Opponents of FCC Policy

Unlike the supporters of the proposed allocation, the opponents who tried to defeat the FM shift used both technocratic and nontechnocratic strategies. The three important licensees of Armstrong's system who manufactured most of the FM receivers and transmitters before the war—Zenith Radio, General Electric Company (GE), and Stromberg-Carlson Company—opposed the new allocation. In addition to the three trade associations—FMBI, TBA, and RMA—the RTPB, especially Panel 5, also lobbied strongly for keeping FM in the lower frequencies. Other opponents included the Yankee Network of FM stations in New England; the Journal Company of Milwaukee, which operated WMFM—one of the first FM stations in the country; educational groups, which had already invested heavily in FM equipment; and supporters of educational radio such as the U.S. Office of Education and state institutions such as the Michigan Commission on Radio Education. Although the FCC proposal set aside twenty FM channels for noncommercial, educational radio, educators worried about some of the technocratic supporters of the new proposal who continued to criticize the use of nontechnical criteria—such as the educational value of station programming—in policy decision-making. Despite Armstrong's claim that the networks were working to defeat FM, NBC and RCA, especially their engineers, also opposed the move. The most vigorous testimony against the allocation during the spring of 1945 came from Armstrong, Panel 5 of the RTPB, and the FMBI. Although he did not testify at the FCC hearings, Eugene F. McDonald, the president of Zenith Radio, also played an important role in the unsuccessful campaign to defeat the proposal.⁴⁴

20, 1945, vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. For Cowles Broadcasting, see "Brief Filed in Behalf of Cowles Broadcasting Company," vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. For Majestic Radio and Television, see "Statement for Federal Communications Commission on 'Receiver Design Considerations for Proposed Frequency Modulation Band' by Majestic Radio and Television Corporation," February 27, 1945, vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. For position of Hallicrafters, see "FM Allocation to Feature FCC Hearing," *Broadcasting* 28 (February 26, 1945): 13. Dumont Television actually wanted to give most of the VHF band to television and move FM even further upward. See "Dumont Would Give 44–216 mc to Television, Eliminating FM," *Broadcasting* 28 (March 5, 1945): 13. For Crosley's position, see Eugene F. McDonald to Paul A. Porter, April 4, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. For position of amateurs and police chiefs, see "RTPB, FMBI Propose Counter-Allocation," *Broadcasting* 28 (February 5, 1945): 66; "FCC Allocates 88–106 mc Band to FM," *Broadcasting* 29 (July 2, 1945): 13.

⁴⁴On the involvement of the U.S. Office of Education, see "FCC Has Open Mind on FM and Television," *Broadcasting* 28 (February 12, 1945): 15. On the Michigan

Opponents of the FM shift who were committed to technocratic policies stressed the authority of the engineers who supported their position. The RTPB engineers were especially upset that the commission seemed to be disregarding the expert testimony of the advisory group it had helped establish. In order to present a united scientific front to the commission, they sought to de-emphasize disagreements among the different panels. Opponents of the shift also argued that the vast majority of engineers disagreed with Norton's testimony. Eugene McDonald contended that of the fifty-eight witnesses who testified at FCC hearings or voted at RTPB meetings, forty-three recommended keeping FM in the lower frequencies while only eleven approved the shift. However, Norton did have a significant group of supporters within the engineering community. A few even insisted that informal polls indicated "the majority of scientists agree that FM allocations should be moved upward." On other occasions, engineers responded to McDonald's efforts to quantify or democratize engineering authority by pointing out that "if majority rule prevailed in the field of science, we wouldn't have many inventions."⁴⁵

Commission, see Joseph E. Maddy to T. S. Slowie, February 15, 1945, box 32, Docket No. 6651, Dock/FCC, NA. For the Journal Company, see "Brief of the Journal Company, Licensee of WMFM, Milwaukee, Wisconsin," vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. On Stromberg-Carlson, see "Brief of Stromberg-Carlson Company." On Panel 5, see "Brief on Behalf of Panel 5 'FM Broadcasting' of the Radio Technical Planning Board," n.d. [February 1945?], vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. On the position of GE and Zenith, see Eugene F. McDonald to Paul A. Porter, April 4, 1945. Panel 7 (panel on facsimile) of the RTPB also actively opposed the shift; see John V. L. Hogan, "Statement on Behalf of Panel 7," vol. 29, box 58, Exec/FCC, NA. For the position of RCA and NBC, see "Brief for Radio Corporation of America, National Broadcasting Company, Inc., RCA Communications, Inc., Radiomarine Corporation of America," vol. 2, box 33, Docket No. 6651, Dock/FCC, NA. Although FM proponents thought RCA executives privately favored the shift as a way to hurt FM, there is no evidence to support this position. See Eugene F. McDonald to T. A. M. Craven, April 16, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. The other FM manufacturers that opposed the shift were Ansley Radio Corporation, Espey Manufacturing Company, Freed Radio Corporation, Garod Radio Corporation, Meissner Manufacturing Company, Pilot Radio Corporation, Radio Engineering Laboratories, and Scott Radio Labs. See "Resolution Prepared at Conference of Pioneer FM Radio Manufacturers, Wednesday, June 6, 1945—Hotel Waldorf Astoria, New York City," box 34, Docket No. 6651, Dock/FCC, NA.

⁴⁵On the effort to construct a unified scientific front, see "RTPB, FMBI Propose Counter-Allocation," *Broadcasting* 28 (February 5, 1945): 15. On McDonald's contention, see Eugene F. McDonald to Paul A. Porter, April 4, 1945. The eleven engineers who McDonald claimed supported shifting FM were K. A. Norton, Frank Marx of ABC, W. B. Lodge of CBS, John D. Reid of Crosley, Cyrus T. Read of Hallicrafters, David B. Smith of Philco, D. E. Noble of Galvin Manufacturing Company, T. A. M.

RTPB engineers acknowledged that since most members were not specialized propagation experts, they were not necessarily the best qualified to evaluate Norton's testimony. The RTPB supplemented the expert testimony they received from J. Howard Dellinger, chief of the Radio Division of the Bureau of Standards, with testimony from a special committee of six engineers who had "extensive experience in the analysis of data on the ionosphere": Dr. Charles H. Burrows, chairman of the Committee on Propagation of the National Defense Research Committee; Dr. Harold H. Beverage, associate director of RCA Laboratories and vice president of RCA Communications; Dr. Harlan T. Stetson, director of the Cosmic Terrestrial Research Laboratory of the Massachusetts Institute of Technology; Stuart L. Bailey, a member of the Committee on Radio Wave Propagation of the Institute of Radio Engineers; Dr. Greenleaf W. Pickard; and Edwin H. Armstrong. The group rejected much of Norton's testimony and recommended leaving FM in the lower frequencies. RTPB engineers acknowledged that Norton was also an expert on propagation matters, but they stressed that their experts were more qualified because they had a higher standing in the profession. Unlike Norton, they pointed out, "both Dellinger and Beverage have been recipients of the Medal of Honor given by the Institute of Radio Engineers for their outstanding contributions to radio science."⁴⁶

Craven of Cowles Broadcasting, T. T. Goldsmith of Dumont Laboratories, E. W. Allen of the FCC, and Archer S. Taylor of Paul Godley Company. Evidence of other engineers who supported Norton, besides the ten listed above, can be found in the following sources: for Lewis M. Clement of Crosley Corporation, see Lewis M. Clement to R. H. Manson, February 10, 1945, box 422, folder marked "Radio Technical Planning Board," box 422, Armstrong Papers; for radar engineer Edward P. Tilton, see "Shifting of FM Upwards in Spectrum Seen," p. 18; for H. W. Wells of the Carnegie Institution Department of Terrestrial Magnetism, see Paul A. Porter to E. F. McDonald, March 28, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers; for chief engineer Morris Pierce of WGAR in Cleveland, see Eugene F. McDonald to T. A. M. Craven, April 19, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. For first quotation, see T. A. M. Craven to Eugene F. McDonald, April 30, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers. On the poll of engineers also see "Military to Confide Secret Data to Radio," *Broadcasting* 28 (March 13, 1945): 70. For second quotation, see T. A. M. Craven to Eugene F. McDonald, April 10, 1945, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers.

⁴⁶For first quotation, see "Statement on Radio Propagation Evidence before the Federal Communications Commission in Docket No. 6651 by C. M. Jansky, Jr., Chairman of Panel 5, FM Broadcasting, of the Radio Technical Planning Board," February 28, 1945, folder marked "FCC Hearing—Re: FM Broadcasting," box 40, Dellinger Records. For second quotation, see "Brief on Behalf of Panel 5 'FM Broadcasting' of the Radio Technical Planning Board."

The second technocratic strategy pursued by opponents of the FM shift was to attack directly the technical evidence and reasoning behind the decision. Armstrong and other engineers shared the FCC's technocratic public position that such technical decisions as the FM and television allocation should be based purely on engineering evaluation. They wanted to draw a sharp boundary between questions of policy and questions of scientific fact. One of Armstrong's major complaints about the FCC was that it "made up the laws of nature to suit itself." Armstrong and other FM supporters believed that the technical evidence was sufficient by itself to justify leaving FM in its original allocation.⁴⁷

In attacking Norton's testimony, they concentrated on identifying errors and mistakes. For example, Norton had argued that in order to determine the strength of F2 layer interference, the condition of the ionosphere at places well outside the United States, for instance over the equator, needed to be taken into account. He contended that transmissions from South America would interfere with stations operating in the United States after being reflected by the ionosphere at the equator. Having made this assumption, Norton argued that the extensive data collected at Washington, D.C., by the Bureau of Standards, which did not indicate the possibility of F2 layer transmission above 40 MHz, had no relevance for this kind of propagation. Using data obtained during the war from observations in Hawaii, he argued that the amount of reflection at places near the equator would be much greater than the amount indicated for Washington, D.C. But Armstrong pointed out that transmissions from South America could not arrive in the United States after only one reflection. The equator was approximately 3,000 miles from the major population centers in the Eastern United States, and the longest single hop that could have occurred would have been 2,200 miles or 1,100 miles on each side of the point of reflection. Thus, transmissions from South America could only arrive in the United States after at least two, and probably more, reflections. Because the last reflection point would be within about 1,000 miles of Washington, the Bureau of Standards data would be approximately accurate for determination of F2 layer transmission for the major cities of the United States.⁴⁸

⁴⁷For Armstrong quotation, see Edwin H. Armstrong, "Memorandum for Senator Charles W. Tobey," March 26, 1948, box 452, Armstrong Papers. For argument that technical evidence was sufficient, also see Eugene McDonald to Congress, April 20, 1943, folder marked "Docket 6651—Papers and Correspondence," box 458, Armstrong Papers.

⁴⁸"Exhibit No. 577, Filed on Behalf of Panel 5, FM Broadcasting, of the Radio Technical Planning Board: Memorandum Concerning the Steps which Must be

Norton admitted his mistake, well before the FCC made its final decision, but he continued to maintain that F2 layer interference would be a problem in the 50 MHz band. This would become clear, he predicted, during the next sunspot maximum. Armstrong attacked Norton by arguing that his evaluation was based on highly questionable theoretical predictions rather than hard scientific evidence. He claimed Norton's prediction of the magnitude of the next sunspot maximum and its effects on the ionosphere was "at variance with the history of sunspot cycles during the past 200 years." At a meeting of the Institute of Radio Engineers in 1945, Armstrong referred to his dispute with Norton and the FCC as an example of the "age-old battle between theory and practice." During the 1920s, a theoretician had claimed that he had proved mathematically that frequency modulation broadcasting would never work. Because of this and similar experiences, Armstrong routinely denounced mathematicians and theoreticians who lacked practical experience. Armstrong preferred Beverage's hard, empirical testimony that the highest observed frequency of F2 layer transmission from Europe or South America had been 45 MHz.⁴⁹

Armstrong also disagreed strongly with Norton about the amount of E layer interference that could be expected in different parts of the 40–100 MHz band. He admitted that this kind of interference would likely occur in the lower part of the band, but he believed its effects would be minor, especially compared to tropospheric interference that he claimed would occur in higher frequencies around 100 MHz. In order to undermine the credibility of Norton's testimony, Armstrong and his supporters also pointed out the large number of unstated assumptions that he had used to reach his conclusions. Although this effort to deconstruct Norton's testimony helped

Taken and the Assumptions which are Involved in any Attempt to Predict Possible Interference with Very High Frequency Services from F2 Layer Transmission during the Coming Sunspot Maximum, and an Analysis of the Assumptions Made in the Preparation of Exhibit 380 for this Type of Interference," folder marked "FCC Hearing—Re: FM Broadcasting," box 40, Dellinger Records.

⁴⁹For first Armstrong quotation, see "Supplemental Brief of Edwin H. Armstrong in Opposition to Proposed FM Assignments," April 18, 1945, p. 16, folder marked "FCC Hearing—Re: FM Broadcasting," box 40, Dellinger Records. Armstrong quotation on theory and practice is in folder marked "EAH Quotes and Misc.," box 18, Armstrong Papers. On Armstrong denouncing theoreticians, see Edwin H. Armstrong, "Mathematical Theory vs. Physical Concept," *FM and Television* (1944): 11–13, 36. Also see Lessing (n. 3 above), pp. 199–200. On Armstrong preferring Beverage's testimony, see "Brief of Edwin H. Armstrong in Opposition to Proposed FM Assignments," February 21, 1945, p. 8, vol. 2, box 33, Docket No. 6651, Dock/FCC, NA.

clarify important points, it also resulted in a counterproductive round of technical nitpicking.⁵⁰

By themselves, the technocratic strategies pursued by engineers like Armstrong only underscored the large degree of observational uncertainty and technical flexibility inherent in the effort to allocate FM radio. The testimony of Panel 5 of the RTPB emphasized “the complexity of the phenomena, the interpretations which must be made and the paucity of reliable data.” Supporters might have been more successful in convincing the commission to leave FM in the lower frequencies if they had supplemented the evaluation of technical considerations with nontechnical judgment. Of course, this tactic might also have jeopardized the long-standing relationship that the engineers had cultivated with the FCC, which emphasized their special role as pure and unbiased technical advisers, but for the specific controversy about the placement of FM some recognition of the complexities of this relationship might have helped supporters convince the commissioners to leave FM in the lower band. In fact, a few FM pioneers did pursue nontechnocratic strategies. The owner of WMFM in Milwaukee conceded that engineering considerations were important but urged “the Commission not to permit them to constitute the sole consideration.” He believed that because the engineers “if nothing else” had demonstrated that there was “grave doubt as to the advisability of making the move, . . . the Commission’s attention should be focused with great emphasis on the non-engineering but otherwise critical factors that are involved.” The chairman of Panel 7 (facsimile) of the RTPB similarly argued that since “no information exists which conclusively demonstrates the superiority of either band,” the FCC should take into account other considerations, such as the fact that the choice of the lower band would allow “the earlier and more economic production of radio transmitters and receivers for the public.” Other supporters of low-band FM insisted that the FCC should take into account the need to protect the pioneers of a new public service. This action was neces-

⁵⁰Armstrong discussed E layer and tropospheric effects in “Brief of Edwin H. Armstrong in Opposition to Proposed FM Assignments,” pp. 15–18. On tropospheric effects, also see “Confidential Brief of Armstrong before FCC,” April 25, 1945, folder marked “FCC Hearing—Re: FM Broadcasting,” box 40, Dellinger Records. On the effort to point out Norton’s assumptions, see “Brief on Behalf of Panel 5 ‘FM Broadcasting’ of the Radio Technical Planning Board,” pp. 9–23. A good example of nitpicking is a letter to the FCC in which Armstrong pursues a lengthy discussion trying to clarify if a question mark should have appeared after a statement in an official transcript. See Edwin H. Armstrong to E. K. Jett, April 23, 1945, folder marked “FCC Correspondence, 1945,” box 456, Armstrong Papers.

sary, they believed, in order to provide entrepreneurs with “an incentive to invest in new industries.”⁵¹

Despite the recognition by a few participants of the hybrid nature of the decision-making process, the response of the most important opponents of the FM shift was highly technocratic. They might have had a greater chance of success if they had acknowledged the essential nontechnocratic nature of policymaking and forced the FCC to take a clear stand on the hybrid relationship. More effort could have been made to pressure the FCC to clearly state, for example, the threshold criteria at which point interference could be considered a problem. Engineering evaluation was important, but it would have been more effective if it had been used to convince the FCC to acknowledge that other considerations also needed to be taken into account. This strategy could have been combined with an effort to point out inconsistencies in the FCC’s technocratic legitimation strategy. Although decisions were justified based on engineering expertise, the public record clearly indicated that the FCC had also considered nontechnical criteria.

If Armstrong and his allies had spent less time pursuing technocratic strategies, they might have done a better job providing the FCC with a clear view of the economic and social effects of the proposed allocation. For example, they could have more effectively testified about the amount of time the industry needed to convert to the higher frequencies, partly by actively refuting alternative testimony. One contemporary observer believed that “one of the . . . factors which prompted the FCC to allocate basically on engineering considerations was understood to have been [the] refusal of manufacturers to state definitely that they would turn out sets with a 2–1 rejection ratio.” The 2–1 rejection ratio referred to FM receivers capable of discriminating between two signals until the weaker signal was half as strong as the main signal, at which point interference would occur. The FCC’s engineers predicted a large amount of sky wave interference, partly because they assumed a 10–1 rejection ratio for receivers.⁵² Had the FM manufacturers done a better job pub-

⁵¹ For first quotation, see “Brief on Behalf of Panel 5 ‘FM Broadcasting’ of the Radio Technical Planning Board,” p. 9. For statement of WMFM, see “Brief of the Journal Company” (n. 44 above). The statement of the chairman of Panel 7 is from John V. L. Hogan, “Statement on Behalf of Panel 7” (n. 44 above). The last quotation is from “Brief of Edwin H. Armstrong in Opposition to Proposed FM Assignments.”

⁵² On 2–1 rejection ratio, see “FCC Allocates 88–106 mc Band to FM,” *Broadcasting* 29 (July 2, 1945): 13. On the assumption of a 10–1 rejection ratio, see the text of the FCC decision to move FM, reproduced in “FCC Allocations Order Text,” *Broadcasting* 29 (July 2, 1945): 64.

licizing the quality of their product, the FCC might have seen sky wave interference as a minor problem.

Conclusion

This study provides a deeper understanding of FM radio's "failure" to live up to the initial expectations of its early enthusiasts. Proponents of FM correctly identified decisions and actions against FM made by some of the large manufacturers and broadcasters, such as the decision to commit limited resources to developing television instead of FM. But the narrative they created tended to collapse the entire complex story of the development of FM radio into a simpler history of the "individual warrior struggling against organized evil."⁵³ Such complexities as the role of the two competing television systems in the 1945 FM allocation decision or the fundamental disagreements among FCC commissioners and staff were played down or ignored. Also, Armstrong's historical narrative failed to acknowledge that the 1945 decision actually seemed to favor FM by authorizing more channels than the FM industry had requested (at least ninety as opposed to seventy-five). Further, although Armstrong's supporters argued that the FCC allocation decisions in the VHF band were motivated by a desire to help the television industry, during the period from the late 1930s to 1946, FM actually gained channels in the VHF band at television's expense. While the number of effective FM channels increased from fewer than thirty-five to ninety, the television assignment decreased from nineteen channels to thirteen. Finally, when discussing the inherent technical superiority of FM, Armstrong tended to ignore the fact that some of the advantages, especially FM's capacity to eliminate static and the ability of hundreds of stations to operate in each channel, partly resulted from the unique propagation properties of the higher frequencies in which FM operated. If AM stations had been allowed to broadcast in the VHF spectrum, they would have enjoyed some—though certainly not all—of the same advantages.⁵⁴

A complete explanation of the "failure" of FM would need to take into account other historical developments, including the rise of the television industry during the 1950s and the impact of other FCC decisions after World War II. But a key point of this study is the importance of avoiding an uncritical, teleological view of technologi-

⁵³ Moore to C. B. Fisher, May 27, 1954, folder marked "Misc. papers from Mrs. Armstrong's Files," box 477, Armstrong Papers.

⁵⁴This point was emphasized by NBC and RCA. See, for example, Niles Trammel, "FM: A Statement of NBC's FM Policy," January 21, 1944, box 104, Dellinger Records.

cal development. Rather than assume unproblematically the inherent “technical superiority” of such inventions as FM radio and look for grand conspiracies to explain their suppression, historians need to take into account the complex nature of regulatory decision-making, the defining role of different institutions and individuals, the contingencies of historical context, and the essential role of non-technocratic—especially rhetorical—strategies in shaping technological development.⁵⁵

⁵⁵On the importance of rhetorical strategies and “boundary work” in science and technology studies, see especially Thomas F. Gieryn, “Boundary Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists,” *American Sociological Review* 48 (1983): 781–95; Sheila S. Jasanoff, “Contested Boundaries in Policy-Relevant Science,” *Social Studies of Science* 17 (1987): 195–230; Hugh Richard Slotten, “The Dilemmas of Science in the United States: Alexander Dallas Bache and the U.S. Coast Survey,” *Isis* 84 (1993): 26–49; Ronald Kline, “Construing ‘Technology’ as ‘Applied Science’: Public Rhetoric of Scientists and Engineers in the United States, 1880–1945,” *Isis* 86 (1995): 194–221.