THE BUSINESS POTENTIAL OF HD RADIO® AND DIGITAL RADIO MONDIALE:

A COMPARATIVE CASE STUDY OF STAKEHOLDER PERCEPTIONS

by

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A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Capella University

July 2009

Abstract

New broadcasting technologies currently entering the marketplace face both the opportunity to succeed and the potential to fail. This study investigated the possibility of the success or failure of two emerging digital radio modulation technologies by interviewing stakeholders and subject matter experts regarding their concepts of success and failure and the prospects of each for their new technologies, HD Radio and Digital Radio Mondiale (DRM). This study compared and contrasted these two modulation systems and identified the conditions necessary for their success and the avoidance of their failure in relation to various theories of product and technology emergence and analysis of their similarities to and differences from broadcasting technologies that have succeeded or failed in the past. Based on these findings, the researcher provides recommendations to broadcasting technology stakeholders and researchers that aim to assist in ensuring the success of HD Radio and DRM.

Dedication

To my father, Willie H. Barnes, who, due to time and circumstances, was never afforded the opportunity to pursue higher education, yet always realized its value, and to my mother, Lucia E. Barnes, who has supported my musical and radio broadcasting endeavors and adventures throughout my life. To my wife, Jan Holland, who has remained patient, supportive, and encouraging as I have completed the doctoral process. Finally, to all radio broadcasters who, despite their years of association with the industry, are still struck with awe and wonder at the ability of the human voice and music to be carried great distances over the air.

Acknowledgements

I would like to express my deepest gratitude and appreciation for the aid of the following persons, without whose help this dissertation would have been impossible.

The 50 men and women who volunteered to participate in this study are all extremely bright individuals knowledgeable in their respective areas of expertise. They willingly offered the best information possible. Their contributions to this study are greatly appreciated.

Dr. Jelena Vucetic, my mentor, for her interest and encouragement throughout this project and for her willingness to sponsor me as a student member of the Institute of Electrical and Electronics Engineers. Membership in this prestigious organization provided me with access to many valuable references and resources as well as the opportunity to attend its annual conferences.

Drs. Ronald Benson and J. Bruce Francis, the members of the committee from the Capella University faculty, for their advice and counsel.

Dr. H. Donald Messer, for serving as the dissertation committee's visiting scholar and subject matter expert during the proposal phase of this dissertation. He has served as a role model for all in the radio industry through his tireless efforts in analyzing, evaluating, and promoting both HD Radio and DRM while serving on various DRM Consortium committees and fulfilling his responsibilities as a senior engineer for the U.S. International Broadcasting Bureau.

Dr. Rochelle Brooks, for serving as my peer learner during the proposal phase of this dissertation.

Ms. Rose Sales and ACE Transcription Service of Washington, DC, for transcribing many of the interviews that I conducted as part of my data collection.

Mr. Marc Evans at Editors for Students of Minneapolis, MN for conducting the final independent editing prior to publication.

To those who provided assistance with the literature review:

Ms. April Nakamura, Administrator, IEEE Broadcast Technology Society.

Ms. Kimberly Kraus, Librarian, Capella University Virtual Library at Johns Hopkins University.

Mr. Brian Baxter, Librarian, International Research Center, National Association of Broadcasters.

Mr. Michael Henry, Librarian, Library of American Broadcasting, University of Maryland.

Table of Contents

List of Tables

List of Figures

CHAPTER 1. INTRODUCTION

Introduction to the Problem

A groundbreaking form of radio modulation currently emerging into the marketplace holds great promise for broadcasting. According to Paul McLane, managing editor of *Radio World*, *digitally modulated radio* will be the most significant change to radio transmission since the adoption of frequency modulation (FM) (National Association of Broadcasters [NAB], 2002). Digitally modulated radio offers its listeners much improvement in audio reproduction compared to amplitude modulation (AM) and FM transmission, the two primary forms of analog transmission. Specifically, it can provide near-compact disc (CD) quality with none of the interference, anomalies, or artifacts normally heard in the analog forms of radio modulation. In addition to providing enhanced audio capabilities, digitally modulated radio will allow broadcasters to offer new and improved services not normally associated with commercial radio broadcasting, including *multicasting* (providing multiple streams of audio in a single FM radio channel), *datacasting* (transmitting secondary analog audio streams or digital data), and the transmission of multimedia presentations (iBiquity, n.d.).

As with all emerging technologies in all fields, the success or failure of digital radio modulation depends on its acceptance in the marketplace. To assess its potential for success, this study analyzed stakeholders' perceptions of digitally modulated radio and their plans for and actions to date in introducing it into the marketplace.

Background of the Study

History has witnessed the success and failure of a significant number of broadcasting technologies and the dominance of particular forms over others. FM transmission eventually became dominant over AM transmission over the relatively lengthy period of either 46 years, as measured by the number of listeners, or 52 years, as measured by the number of broadcasters (R. Brooks, personal communication, January 9, 2002; Sterling & Kitross, 2002). Moreover, 35 years elapsed before the legal wrangling over patent infringement by various corporate giants and the estate of the inventor of FM technology, Major Edwin H. Armstrong, finally ended (Erickson, 1973).

AM Stereo technology failed in the marketplace primarily due to lack of support from the Federal Communications Commission (FCC) in establishing a national technical standard. Due to much confusion regarding which specific standard to use when transmitting and receiving AM Stereo, less than 11% of commercial AM radio broadcasters ever used AM Stereo technology (Braun, 1994). Digitally modulated radio is now poised to either succeed by following the path taken by FM technology and gaining market dominance or following the path of AM Stereo technology and becoming a mere footnote in the history of radio broadcasting.

Currently, various forms of digitally modulated radio are at different stages of implementation, research, and development. The two forms evaluated in this study are the following:

1. *HD Radio:* The iBiquity Corporation of Columbia, Maryland is currently developing this form of digitally modulated radio. The FCC approved HD Radio on October 10, 2002 for use in the United States in the

mediumwave AM band for daytime transmission only and for FM very high frequency (VHF) commercial radio broadcasting (iBiquity, n.d.).

2. *Digital Radio Mondiale* (DRM): A consortium of broadcasters and broadcast equipment manufacturers called the Digital Radio Mondiale Consortium (DRM Consortium) developed this form of digitally modulated radio. The International Telecommunications Union (ITU) approved DRM for worldwide use at frequencies below 30 megahertz (MHz) in the longwave, mediumwave, and shortwave radio bands. The Consortium is planning the development of another version of this technology for the FM VHF broadcasting band. The first regularly scheduled shortwave broadcasts using DRM technology began service on June 16, 2003 (DRM, n.d.). The BBC English World Service; the BBC Russian Service; Deutsche Welle, the international broadcasting service of the German government; Radio Canada International (RCI); the U.S. International Broadcasting Bureau's Radio Sawa to the Middle East; Radio Sweden; Radio Kuwait; and Vatican Radio, among others, transmit regularly scheduled broadcasts in the shortwave bands using DRM technology (Radio Netherlands, n.d.).

Other new digital technologies are also emerging in direct competition with HD Radio and DRM. These include the Eureka-147 or digital audio broadcasting (DAB), terrestrial digital radio technologies currently used in Europe, the United Kingdom, and Canada that use new spectrums in the GHz range, and the satellite digital radio systems (S-DARS) used by XM Radio, Sirius, and WorldSpace. The new technologies of digital television (DTV), high-definition television (HDTV), iPodcasting, and Internet-streaming audio and video technologies also compete for audience market share with digital and analog radio. Any of these technologies could become the victor by gaining the greatest market share.

Statement of the Problem

This study explored the manner in which stakeholders in the digitally modulated radio industry and subject matter experts in the broadcasting industry define success and failure for this new technology, which factors they consider critical in the success or failure of digitally modulated radio as a viable technology, and which actions they are taking to promote its success. As they explained in their interviews, the success of this new and emerging digital technology depends on three primary factors: *marketing, regulatory support,* and *value to the listening audience*. Specifically, digitally modulated radio must be marketed to three specific groups: to broadcasters to induce them to embrace the new technology and purchase new or modify existing forms of transmission equipment; to transmitter and receiver manufacturers, in particular car radio manufacturers, to produce new digital transmitters for broadcasters and new digital receivers for listeners; and to listeners to educate them regarding the added value of the new digital technology and encourage them to purchase new radio receivers.

Digitally modulated radio must also receive support from regulatory agencies. As witnessed with AM Stereo technology, favorable regulatory guidance that sets specific technical standards for transmission is vital for success (Braun, 1994). This study analyzed how the FCC and the ITU allocated spectrum for digitally modulated radio and how they approved technical standards for digital transmission. Moreover, and perhaps most significantly, this study examined the value of the new technology to the ultimate consumer and end user of the technology: the listener.

Purpose of the Study

The purpose of this study was to acquire important knowledge that will assist in the effective and efficient rollout of two forms of a new radio broadcasting technology within a regulated environment. Specifically, this study compared and contrasted two forms of digital radio modulation to determine which factors contribute to the success or failure of this technology as defined by stakeholders personally involved in digital transition and subject matter experts in the broadcasting industry.

Rationale

In a 2003 article in *Radio* magazine, Mullin argued,

> There is no question that the transition to digital technology will be the biggest change to over-the-air radio broadcasting since its inception. Ultimately, the end-to-end air-chain not only will be capable of delivering higher-quality digital audio within radio's current infrastructure, but it will also enable new services such as datacasting and supplemental audio service over the existing FM channel. (¶1)

In many radio stations, every aspect of the audio air-chain, from the point of the microphone connection to a mixing console to the point of audio connection to a decoder and transmitter, is part of a digital process. The only components currently lacking in the provision of high-quality digital audio and its ancillary services to listeners are digital transmitters and receivers. As Mullin (2003) explained, once broadcasters and consumers are provided with these essential components, the greatest improvement to radio broadcasting throughout its entire history will be poised for takeoff. This study analyzed the evolving process of conversion from analog AM and FM radio to digital radio and the subsequent migration of listening audiences.

Research Questions

This study addressed the following primary research question: How do the stakeholders involved in the emerging technology of digitally modulated radio define success? The study also addressed the following subquestions to examine the marketplace for digitally modulated radio, its means of regulation, and its value to the customer:

1. According to the stakeholders, which factors are critical in the success of digitally modulated radio as a viable technology?

2. What do the stakeholders consider the strengths, weaknesses, opportunities, and threats (SWOTs) of digitally modulated radio?

3. What strategies are being used to market digitally modulated radio to broadcasters, transmitter and receiver manufacturers, and the general public? How effective have these campaigns been?

4. What is the role of the FCC and the ITU in terms of the success or failure of new broadcasting technologies?

5. What additional auditory value does digital modulation radio provide to listeners as compared to AM and FM radio? Why should listeners migrate from one technology to another? How will digitally modulated radio affect radio listening habits?

6. How much time will elapse before HD Radio and DRM succeed or fail in the marketplace?

Significance of the Study

The knowledge gained from this study will assist HD Radio and DRM stakeholders in significantly reducing the cost of introducing their new radio technologies into a regulated environment by identifying more effective strategies for deployment based on stakeholder interests and concerns. By doing so, it will assist in increasing the efficiency of consumer adoption and the value of this new broadcasting technology to listeners.

Definition of Terms

Appendix A provides definitions of the key terms, acronyms, and technical jargon used in this study.

Assumptions and Limitations

Assumptions

1. HD Radio and DRM technologies have been thoroughly tested by their researchers and developers, as well as independent bodies, and are fully capable of providing near-CD quality audio and the ancillary capabilities of datacasting and multimedia presentation.

2. The improved audio quality provided by HD Radio and DRM technologies can be perceived by the bulk of radio listeners among the general public.

3. The experts interviewed in this study provided information that is accurate to the best of their knowledge.

Limitations

1. Only two of the various forms of digital radio modulation was compared and contrasted in this study: HD Radio, produced by iBiquity, and Digital Radio Mondiale. Various other forms exist but were beyond the scope of this study. However, the researcher referenced data pertaining to Eureka-147 terrestrial digital radio and HDTV because more researchers have addressed these technologies than either HD Radio or DRM.

2. The digital modulation of other media (e.g., DTV, HDTV, packet radio, and cell phones) was also beyond the scope of this dissertation.

3. During the data collection phase, the number and method of the interviews that the interviewer conducted was constrained by interviewee time and availability. The researcher conducted some interviews in person and others via telephone or e-mail. The researcher was unable to interview several experts whose participation would have been of value to this study due to time and situational constraints.

4. The researcher acknowledges the possibility of bias due to the researcher's and interviewees' enthusiastic support of digital broadcasting technology. Therefore, the researcher ensured that the data collection and reporting and the recommendations were balanced and that they adequately described the negative aspects of the new technology and its potential for failure.

Nature of the Study

This quantitative case study of HD Radio and DRM compared and contrasted the market potential of two forms of digital radio modulation technology based on data obtained by the researcher's interviews with major stakeholders in their development. Specifically, the researcher identified and analyzed the safeguards in place to help ensure marketplace success for both technologies; their potential for failure; the regulatory processes involved in their approval and operation; the value that they offer to the consumer; and any other factors, as defined by their stakeholders, that require analysis in terms of their ability to impact the success or failure of HD Radio and DRM.

The researcher primarily collected data from conducting face-to-face interviews with subject matter experts and industry leaders, which he recorded on minidisk (MD) before archiving onto CDs. The researcher conducted interviews with the subject matter experts not available for face-to-face interviews via telephone interviews, which were recorded directly to a computer hard drive before archiving onto CDs. He interviewed one expert available for neither in-person nor telephonic interviews via e-mail correspondence. The researcher analyzed the interview responses using Statistical Package for the Social Sciences (SPSS) and Microsoft Excel software.

The interviewees are members of various stakeholder groups, including technology innovators (e.g., iBiquity managers and DRM Consortium committee chairpeople); broadcasters; transmitter and receiver manufacturers; and industry commentators, academics, competitors, and media critics. The researcher sought to identify any commonality of thought within and among the stakeholder groups in their responses to the interview questions regarding the potential for marketplace success and failure.

Organization of the Remainder of the Study

Chapter 2 reviews the literature concerning and discusses the development of HD Radio and DRM, the management of these emerging technologies, lessons learned from the marketplace success of FM and the failure of AM Stereo, and FCC and ITU regulatory processes. Chapter 3 describes the methodology that the researcher employed in this study and the specific procedures that the researcher used to capture, analyze, and store the data collected. Chapter 4 reports the findings from the interviews. Chapter 5 discusses and analyzes the relevance of the various theories of emergence and diffusion introduced in chapter 2 to the actual deployment of HD Radio and DRM and the historical relevance of FM and AM Stereo to digital radio. Based on this analysis, chapter 5 proceeds to provide recommendations for broadcast industry stakeholders to assist them in achieving success with their new digital technologies in the marketplace and for academic researchers to assist them in identifying issues that warrant future research.

CHAPTER 2. LITERATURE REVIEW

In-Band On-Channel/Simulcast Strategy

The researcher selected HD Radio and DRM for analysis in this study due to the similar yet unique way that each deploys a form of digitally modulated radio. Both i*n-band on-channel* (IBOC) transmission, an iBiquity innovation, and *simulcasting*, a DRM Consortium innovation, are radio broadcast technologies that provide both digital and analog modulation using existing broadcasting spectrum, thus transmitting the signal either via digital and AM transmission or digital and FM transmission. Although the analog receivers continue to receive AM or FM radio signals, with all of the anomalies inherent within these forms of broadcasting, listeners can use newer digital receivers that are able to receive and decode the digital data stream to receive crystal-clear CD-quality audio and view ancillary text and video. By using these technologies, broadcasters can remain on their currently authorized frequencies while smoothly transitioning from AM or FM to digital transmission.

Once digital receiver saturation reaches a certain point in the radio listening audience, a period that iBiquity stakeholders refer to as the *digital sunrise*, the analog AM and FM signals can be terminated and the IBOC/simulcast analog-digital signal modified to a digital-only signal. At that point, current conventional AM and FM radio receivers will be rendered useless. After broadcasters transition from IBOC transmission and simulcasting to solely digital transmission, more bandwidth becomes available for digital transmission and the development of enhanced digital features (iBiquity, n.d.). Currently, there is no sunset provision for analog broadcasting by any regulatory body.

Both HD Radio and DRM currently face the classic *the-chicken-or-the-egg* syndrome regarding whether broadcasters or receiver manufacturers must act first: Why should broadcasters invest large amounts of capital in order to transmit in a digital format that currently has few, if any, receivers? Why should manufacturers produce and listeners buy digital receivers if few radio stations are broadcasting digitally modulated signals? However, broadcasters recognize that if they do not begin transmitting in digital formats, listeners will migrate to Internet and satellite radio as well as MP3 players (e.g., iPods; Meyers, Shapiro, & Cohen, 2005), and that the end result of digital migration will be an improved form of radio that allows them to offer additional forms of multicasting and multimedia revenue (Goss, 2001).

Case Study 1: HD Radio and the iBiquity Corporation

The FCC approved HD Radio as the digital system for transmission in the United States. As of February 2009, 1,876 stations are broadcasting their signals using HD Radio technology (examples of HD Radio audio quality in various music formats as well as speech can be heard at http://www.ibiquity.com/hdradio/hdradio_experience.htm; iBiquity, n.d.).

In August 2000, iBiquity Digital Corporation was created from the merger of USA Digital Radio (USADR) and Lucent Digital Radio. At that time, these two companies were operating separately as the two leading developers of IBOC digital broadcasting technology in the United States. iBiquity brought together the technological innovations of both of these companies to produce a combined technology for IBOC AM and IBOC FM radio broadcasting. iBiquity's current focus is commercializing digital radio and assisting radio broadcasters and equipment manufacturers with transitioning from analog AM-FM to digital broadcasting in a cost-effective manner.

Little information is available regarding iBiquity's financial situation because it is not obligated to provide full financial disclosure to the general public as a privately held company. However, its Web site indicates that it has dedicated a sum well in excess of $100 million for research and development. iBiquity has formed alliances with many companies associated with receiver manufacturing, semiconductor production, and radio broadcasting, as well as those involved with providing wireless data content (iBiquity, n.d.). Its partners include leading manufacturers of consumer electronics, electronic components, semiconductors, broadcast transmitters, and broadcast electronics, as well as leading automakers, consumer electronics retailers, radio broadcast station owners, and third-party content providers. As all these companies have agreed to develop coordinated strategies for the market launch of iBiquity's IBOC technology, its partnerships with leading companies is the most important aspect of iBiquity's strategy in bringing digital radio to consumers. These alliances will help ensure commercial broadcast radio's smooth transition to digital transmission.

iBiquity and its investors will achieve a return on investment through iBiquity's licensing of the technology to commercial broadcasters, as explained in an article in *Radio World* (2002b):

> iBiquity is basing its IBOC software license fee on a multiple of a station's FCC regulatory fee. A station would pay a one-time license fee of 15 times its annual FCC regulatory fee for a perpetual license to iBiquity's IBOC software. This software would come pre-installed in exciters manufactured by iBiquity's licensed development partners, including Broadcast Electronics, Harris and Nautel, with

others to follow. iBiquity adopted this tiered pricing model to be equitable to all broadcasters, both large and small, in all markets across the United States. Lower power stations and stations in smaller markets would pay less for software licenses than those stations able to reach more listeners and thereby reap greater reward from the transition to IBOC. Currently, the annual FCC regulatory fees range from $250 to $4,550. This corresponds to a license fee range of $3,750 to $68,250 for a perpetual license. . . . Station licenses also include terms whereby iBiquity would share in the revenue generated through the IBOC auxiliary data capabilities over and above the revenues generated from a station's primary audio programming. iBiquity would receive three percent of additional revenues, if any, generated from new revenue sources that IBOC would enable, such as on-screen or scrolling advertisements; on-demand weather, traffic or news; subscription services; e-commerce applications such as "buy" buttons; and from leasing data capacity to third-party content or applications providers. (¶2–9)

The article continued to describe the cost effectiveness of IBiquity

technology to broadcasters:

iBiquity elected to use a percentage-of-revenue model to ensure that stations only pay a data royalty if the stations increase revenues through exploiting the wireless data opportunities that IBOC affords. . . .To put it in perspective, the yearly software license cost is equivalent to about 1/60th of a share point for a station. Increasing listenership by that amount—or preventing that many listeners from choosing other digital mediums—would offset the cost of licensing. (¶10–12)

Despite its potential to decrease their costs, it remains unclear how HD Radio can initially increase broadcasters' profit or market share. Because of this uncertainty, some commercial broadcasters are fervently embracing this new technology while others continue to view it skeptically. As a whole, the broadcasting industry appears to view the transition to digital as an important step, primarily due to listener demand. According to Scott Stull, iBiquity's director of Broadcast Business Development,

Half of all consumers shopping for a car or home receiver in the next year are interested in buying a digital AM-FM radio. Broadcasters will play a key role in driving iBiquity's HD Radio IBOC technology to eager consumers through the prompt conversion and implementation of HD Radio technology for commercial use within the first year… By meeting the public demand for digital products and services, broadcasters will have the ability to become part of the digital age and provide progressive leading-edge services and sound to their listener base. HD Radio technology will make listeners think twice about abandoning AM-FM radio for other digital infotainment alternatives like MP3, mobile Internet and other digital broadcast services. (as cited in Radio World, 2002a, ¶ 2–5)

However, William Suffa, senior vice president of capital management for Clear Channel Worldwide, takes a different view:

> The whole IBOC thing is one of economics… In a couple of markets, we've taken a look at it because we want to make some assessment of the cost exposure and determine whether and when it's something we want to do. But from a financial basis, it's very difficult to justify going to IBOC at this time… We're talking about return on investment. We're talking about a situation where there are… no receivers out there. Clear Channel is very interested in return to our shareholders. And it's very, very difficult to justify purchase of this kind of equipment where we don't see the clear return. We don't see it, particularly in the short term. You're looking at some substantial money for the equipment, for the license fees or, depending on whether the commission [FCC] were to accept the argument on daytime-only AM, the possible economic dislocation of a part-time digital signal. . . . Really what we're talking about is, is there a direct return on investment from going digital? No. From where I sit, the direct return would be something like an ancillary data service, something using a data channel. The real return is one of a lost opportunity cost—in other words, a loss of what we've got now chipped away by all these other competitors. If we're the only non-digital medium, can somebody else chip away at that? (Stimson, 2002a, ¶8–14)

As these experts indicate, whereas a practical means of providing a return on investment to iBiquity investors (i.e., the licensing of the technology to digital broadcasters) is in place, a system of doing so for broadcasters that transition to the digital technology has yet to emerge. Meyers, Shapiro, and Cohen (2005) explained that HD Radio will initially provide the greatest benefit to AM broadcasters by allowing their broadcast quality to reach the level of FM broadcast quality. However, both AM and FM listeners have a clear desire for digital radio. In a 2005 study, researchers at J.D. Power and Associates (2005) initially found that HD Radio ranked 16th in a field of 22 new automotive features. However, when the researchers revealed that only a one-time investment of $150 is required for a car receiver, compared to $12.95 per month for navigation systems, personal assistance safety services, and satellite radio, or $400 for stability control and premium-surround sound systems, interest in HD Radio greatly increased, rising to a rank of 3. As this study indicated, consumers are more willing to pay a one-time fee for HD Radio than a monthly service charge for satellite radio.

Case Study 2: Digital Radio Mondiale

DRM is a nonproprietary, digital modulation system for shortwave, mediumwave, and longwave AM broadcasting that uses currently allocated frequencies and bandwidth throughout the world. Although DRM is currently only used in the broadcasting bands below 30 MHz, the DRM Consortium has plans to extend it up to 120 MHz, and intends to finish the design, development, and testing phases of DRM by the end of 2009.

At an informal meeting in September 1996 in Paris, international broadcasters and broadcasting equipment manufacturers conceived DRM in reaction to their concern that national and international broadcasting would become completely obsolete unless they made improvements in broadcast quality, particularly in the shortwave radio bands. Those in attendance at this meeting included representatives from Radio France International (RFI), TéléDiffusion de France, Deutsche Welle (German international radio), the Voice of America (VOA), and Thomcast. Later that year, a wider group met that included national and international terrestrial AM broadcasters, network operators, academics, research centers, transmitter and receiver manufacturers, and organizations developing digital AM-band technology. Their objectives were to (a) formulate a market-driven, consumer-oriented digital AM system design that could serve as a single, tested, nonproprietary, evolutionary world standard and (b) facilitate the spread of AM digital technology around the world. On March 5, 1998 in Guangzhou, China, 20 broadcast-related organizations capped their collaborative creation of a universal, digital broadcast system for radio in the shortwave, mediumwave, and longwave bands by signing their first memorandum of understanding.

The DRM Consortium has grown into an international consortium of more than 130 broadcasters, broadcast equipment manufacturers, network operators, research institutions, broadcasting unions, regulatory bodies, and DRM supporters (DRM, n.d.). Major international radio broadcast organizations, including Deutsche Welle, the BBC World Service, Radio Vatican, and the U.S. International Broadcasting Bureau (IBB) have broadcast radio signals using DRM technology. As of February 2009, 48 broadcasters, including local, national and international broadcasters, use DRM technology to transmit 40,823 minutes of programming per week. The DRM Consortium introduced DRM consumer and car radio receivers at the 2005 International Broadcasting Convention in Amsterdam (test transmissions comparing and contrasting DRM digital audio with standard AM audio in the medium- and shortwave bands can be heard at http://www.drm.org/system/audiosamples2.php).

Despite the DRM Consortium's apparent progress, its Web site (n.d.) provides no information regarding which members conducted DRM research and development, nor how the Consortium plans to provide a return on investment to its members and supporters. Perhaps the reality of a worldwide broadcast system that can produce high-quality audio in the shortwave radio bands and below is a sufficient return for Consortium members and supporters.

Past Broadcast Technology Success and Failure

Like any new technology entering the marketplace, digital radio faces both the opportunity of success and the possibility of failure. According to Jolly (1997), the successful commercialization of a new technology progresses as its innovators proceed through five phases of development:

1. They *imagine* the development of an original idea for a new technology and gain awareness of a particular marketing opportunity.

2. They *incubate* the idea in reaction to rivalry among the developers of various forms of a technology, resulting in a description of the application of the technology and the development of specific products to be built that use the technology.

3. They *demonstrate* their technology to colleagues and the general public to show how the technology works, thus creating a link between their conception of a technology and its actual operation.

4. They *promote* their strategy by persuading particular target groups and/or the public to adopt the new technology and building the infrastructure necessary to realize the full potential of the new technology.

5. They *sustain* the new technology by developing the necessary protection to ensure that the newly developed technology enjoys a long life in the marketplace and is not quickly replaced by an even newer and better technology.

Although inventors may have one purpose in mind for their new technologies, the marketplace, as a creative force unto itself, may have other ideas. Consumers determine the success or failure of a technology based on its perceived value to them, not on the inventor's notions of what it may offer. Having proceeded through the first four steps of

Jolly's phases of development, both iBiquity and DRM Consortium face the possibility of success and marketplace dominance, as has FM, or failure, as has AM Stereo. Analysis of the commercialization of these two earlier analog technologies may provide insight into the future of digital radio modulation.

The Success of FM Radio

Initially, marketplace acceptance of FM technology was slow because major broadcasters, almost all of whom used AM transmission, were reluctant to relinquish their lucrative positions on the AM dial (Erickson, 1973). However, FM's inventor, Major Edwin H. Armstrong, pressed on with the development of the new technology and his Yankee Radio Network. His effort was ultimately rewarded; by 1939, 12 new FM radio stations were either on the air or in possession of an FCC construction permit (Broadcasting, 1939; Halper, 1998).

Throughout his development of FM technology, Armstrong attempted to pass his new technology through Jolly's (1997) five phases. In 1933, he conceived the concept of a new interference-free modulation technology, then incubated with a clear application of commercial broadcasting using FM in mind. In 1933 and early 1934, he demonstrated it to engineers and technicians of the largest broadcasting corporations, RCA and NBC, before promoting it to a consortium of radio broadcast engineers (Armstrong, 1936). He attempted to sustain it in the marketplace despite being met with considerable resistance from David Sarnoff, the founder of NBC and leader of RCA, who viewed Armstrong's technology as competition to his new broadcast technology—television (Lewis, 1991; Mortensen, 1997; Ward & Burns, 1991).

Shortly after the end of World War II in 1945, the FCC reallocated spectrum for FM transmission from 42 to 50 MHz to the now familiar 88 to 108 MHz based on Sarnoff's recommendations (Erickson, 1973; Miller, 2002). Shortly thereafter, the approximately 400,0000 early vintage FM radio receivers primarily produced by Armstrong's production company and Zenith Radio became obsolete (Erickson; Radio Adelaide, n.d.). Until the 1960s, when new support for the technology was introduced, the FM band languished commercially. It was only when FCC regulations began requiring separate programming for AM-FM duopolies (geographically co-located AM and FM stations owned by the same broadcasting entity) and radio manufacturers began producing AM-FM receivers, particularly car radio receivers, did the migration from AM to FM begin (Erickson; Morrow & Baudo, 1987).

Arbitron Corporation, which measures radio listenership for major broadcasters, has documented this migration over the years. Figure 1 visually displays the progress of this migration based on data obtained from the researcher's interview with R. Brooks of Arbitron (personal communication, January 9, 2002).

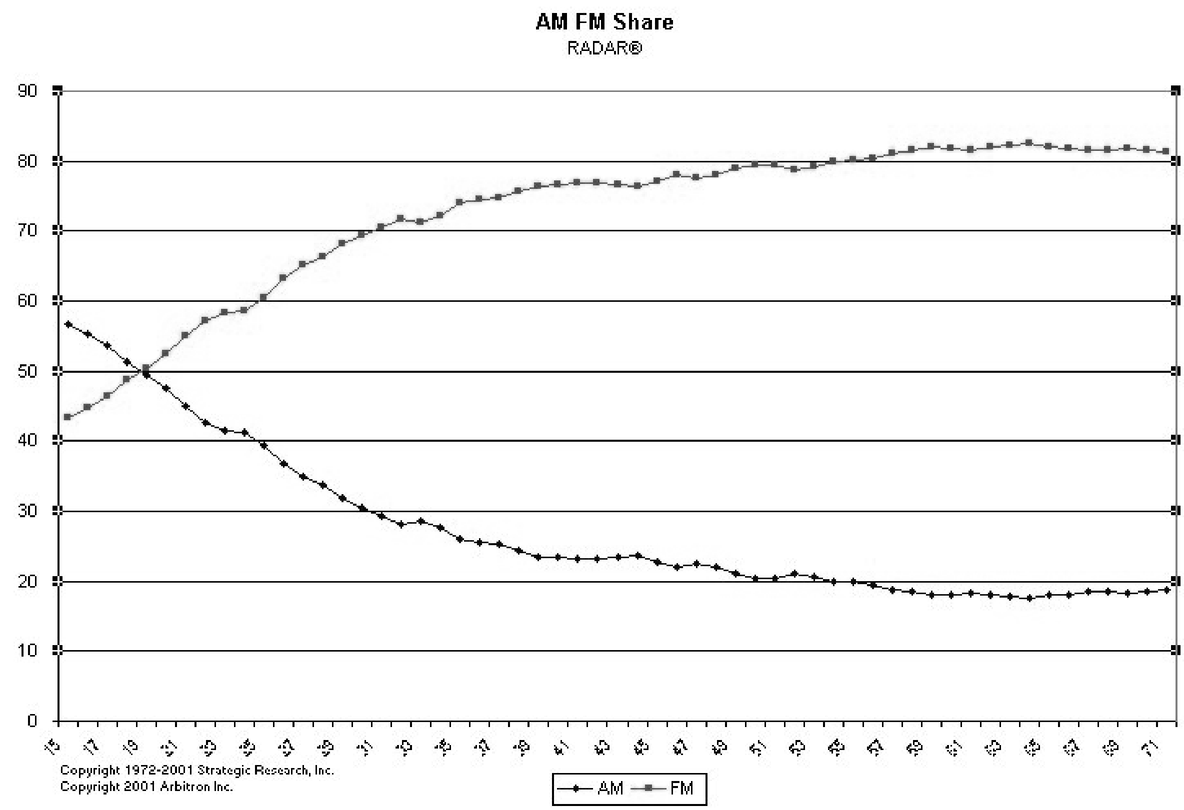

Figure 1. AM-FM audience share. From R. Brooks, personal communication, January 9, 2002.

The figures on the x-axis correspond to the frequency with which Arbitron conducted surveys, which was initially annually, then biannually in the spring and fall, and later quarterly. In the AM-FM radio share chart shown in Appendix B, the second column displays the survey dates, the fourth and fifth columns display nationwide listenership market share in units of 10,000 listeners, and the sixth and seventh columns display the market share for AM and FM in terms of percentage of the market. As indicated by Figure 1 and Appendix B, FM technology began to overtake AM technology in the marketplace after the spring of 1979, the point at which both technologies had the same market share. After that point, FM became increasingly more dominant in the marketplace, consistently maintaining in excess of 80% of the market share of radio listeners, as indicated by surveys from the fall of 1996 to the most recent survey in the fall of 2001 (R. Brooks, personal communication, January 9, 2002).

If the figure used to measure marketplace dominance is the number of broadcasters using the technology rather than the number of listeners, then FM became dominant in the marketplace when the number of FM broadcasters (both educational and commercial) exceeded the number of AM broadcasters. Sterling and Kittross (2002) reported that the number of FM broadcasters exceeded the number of AM broadcasters in 1985, when 4,888 FM radio stations (3,716 commercial and 1,172 educational) and 4,754 AM stations were broadcasting to the public (see Appendix C). From that year forward, the number of FM broadcasters continued to increase, and FM technology maintained its market dominance. Thus, depending on whether the number of listeners or broadcasters serves as the basis of measurement, between 46 and 52 years, respectively, elapsed between Armstrong's invention of FM technology in 1933 and the year at which the technologies held equal market share, either 1979 or 1985, respectively. After this long incubation period, FM has maintained a healthy marketplace dominance as the preeminent technology for commercial radio broadcasting.

It was not only the superior audio quality that eventually made FM the successful technology that it is today. Most importantly, according to broadcasters and academicians alike, it was the enhanced programming provided in the FM radio band (Fortanatle & Mills, 1980; Keith, 1997). During radio's golden age in the 1930s and 1940s, radio broadcasters produced primarily entertainment shows and news programs. With the advent of Sarnoff's television technology shortly after World War II, many radio entertainment artists and news correspondents left the medium of radio entirely to bring their programs to television. This migration of performers and newscasters left radio stations and networks with precious little content for programming material until the 1950s, when a new and exciting genre of music entered the American cultural scene: rock-and-roll. AM radio broadcasters soon found that they could adequately fill their air time by having disc jockeys play music rather than presenting dramatic programming or lengthy newscasts. This new all-music programming seemed to fit in nicely with the needs of listeners, who were now listening to AM radios in their cars while commuting in the morning and working in the office during the day before turning their attention to dramatic programs and newscasts on television when they arrived home in the evening (Mortensen, 1997).

Despite gaining greater market share, FM continued to languish in popularity in the 1950s and 1960s. Whereas many AM stations broadcast popular rock-and-roll or country-western music, most FM stations broadcast classical, jazz, or easy listening music, leading to FM's nickname of "fine music" (Fortanatle & Mills, 1980; Keith, 1997; Morrow & Baudo, 1987). Despite the resonance of the nickname, the commercial appeal of FM's "fine music" was negligible. As sponsors were not interested in advertising to the very small audiences listening to FM, broadcasters of the 1950s and 1960s did not see FM as a profit-making medium. Morris Blum, the owner of WXTC-FM in Annapolis, Maryland and a mentor to the researcher of this study, donated his FM license in the 1960s to a group of religious broadcasters as a gesture of goodwill. In today's market, the license for this 50,000-watt FM radio station, with its ability to blanket the metropolitan areas of Baltimore and Washington, DC with a city-grade signal, would be worth well in excess of $50 million, whereas he sold his AM radio station, WANN, in 1998 for $400,000 (Blum, personal communication, 1998). Likewise, the *Washington Post* newspaper gave away WTOP-FM (now WHUR-FM) to Howard University (Washpostco.com, 2004).

Three factors increased the commercial viability of FM radio in the 1970s and 1980s. The first, as mentioned, was a greater variety of programming. As AM radio stations began playing similar music, their listeners became bored with their uniformity, becoming further disheartened by their increasing airing of commercials from advertisers, who had been attracted by AM's initial success (Fortanatle & Mills, 1980; Keith, 1997). In contrast, FM stations aired fewer commercials and more music than AM radio during any given listening period, and not being bound to a highly structured format, such as Top-40 rock-and-roll or country-western music, developed innovative programming that started to attract new listeners. This programming included extended album-length cuts of rock-and-roll music, "underground" artists who never had any airplay on Top-40 AM radio stations, "modern" country, blues, and news and information from National Public Radio.

The second factor was the development of the AM-FM car-radio receiver in the 1970s. This dual-band receiver, which became standard equipment in newly manufactured cars, gave listeners the choice of listening to either AM or FM radio stations while driving, and, increasingly, more listeners chose FM (R. Brooks, personal communication, January 9, 2002).

The third factor was FCC action that favored FM transmission (Fong-Torres, 1998). During the 1960s and 1970s, the FCC imposed a ban on the granting of any new radio station licenses to AM broadcasters, fearing that too many broadcasters were already on the allocated frequencies for commercial AM transmission in the mediumwave band. Thus, new broadcasters intent on going on air during that time were forced to obtain an FM license. The FCC also stipulated that broadcasters who owned both AM and FM stations in the same market had to provide separate and distinct programming and content for each station. Prior to this stipulation, the owners of "duopolies" would program the same audio content on both radio stations such that listeners with FM receivers received the same programming, albeit with the enhanced audio quality of FM, as did the listeners with AM receivers who received it with the characteristic interference and anomalies of AM transmission. The FCC viewed this duplication of programming by duopoly owners as a waste of radio spectrum and bandwidth and thus began to prohibit it.

A by-product of this prohibition was that many broadcasters sold (or gave away) their FM radio licenses, as producing separate content for FM was not then commercially viable. The newly minted FM broadcasters to whom they sold or gave their licenses then took it upon themselves to develop programming that ultimately enticed listeners away from AM, thus becoming commercially successful at the expense of well-established AM broadcasters.

The Failure of AM Stereo

As FM broadcasters were gaining more market share, radio engineers were attempting to develop another new technology to improve the audio quality of the AM radio signal. Radio engineers thought that if they could produce a stereo signal on AM, a daunting task given the spectral bandwidth constraints of the 10-kHz AM mediumwave channel compared to the 200-kHz VHF FM channel, listeners might migrate back to the AM band (Braun, 1994). Broadcast managers of AM facilities were hopeful that this new technology would revitalize the AM band and help them recapture some of the lost market share.

The engineers developed six separate technologies that all maintained compatibility with existing monaural AM radio receivers for transmitting stereo information and competed with each other to become the nation's standard (Armstrong, 1992; Braun, 1994). The FCC originally selected the Magnavox system for the AM Stereo national standard, most likely because it was relatively simple. However, the Motorola C-QUAM system ultimately gained the most marketplace acceptance, and is still used for AM Stereo broadcasting today. Philco Corporation, RCA, and Leonard Kahn separately proposed AM Stereo technologies to the FCC in 1958 and 1959. On September 27, 1961, the FCC denied all their requests, and denied the appeal of its decision on January 12, 1962. However, when the FM audience share began overtaking that of AM in 1979, the AM Stereo issue arose again. After evaluating the competing systems, FCC engineers determined the Magnavox system to be the superior technology. (see Appendix D for the method and results of their evaluation).

The FCC issued a Further Notice of Proposed Rulemaking (NPRM) on July 31, 1980 seeking more information about the competing systems. After the developers of two of the AM Stereo technologies, Kahn and Hazeltine, filed an appeal requesting the FCC to "let the marketplace decide," the National Association of Broadcasters (NAB) conducted an informal poll of broadcast industry leaders to determine whether they would prefer the FCC to establish one assigned technical standard or to "let the marketplace decide." Table 1 displays the results of this poll.

Table 1
Informal NAB Industry Poll

"Informal" NAB Industry Poll:

ORGANIZATION	*ONE SYSTEM*	*MARKETPLACE*
Kahn/Hazeltine		X
NAB Engineering Advisory Committee	X	
Delco (General Motors)	X	
Electronics Industries Association	X	
Harris Broadcast Products	X	
Panasonic	X	
Pioneer	X	
Magnovox	X	
Motorola	X	
Belar	X	
Ford Motor Company	X	
RCA	X	
Sprague Electric (Integrated Circuits)	X	
National Semiconductor	X	

Note. From *AM Stereo: A Case Study Of A Marketplace Shibboleth*, by M. J. Braun, 1994, Norwood, NJ, Ablex, p.119

Despite the fact that the survey respondents overwhelming indicated that they preferred one standard, the FCC agreed to allow the marketplace decide which AM Stereo system—or systems—it preferred (Braun, 1994). As this decision represented a departure from the FCC's normal rulemaking process, many at the FCC considered this approach a bold new step for the agency.

What followed was a series of lawsuits, mostly between Kahn and Motorola, as all the other systems folded (Braun, 1994). Since neither the broadcasters nor the receiver manufacturers wanted to invest in what could be a losing system, effective implementation of AM Stereo was furthered delayed. By 1989, less than 10% of commercial broadcasters in the mediumwave band were using AM Stereo technology, as indicated in Figure 2.

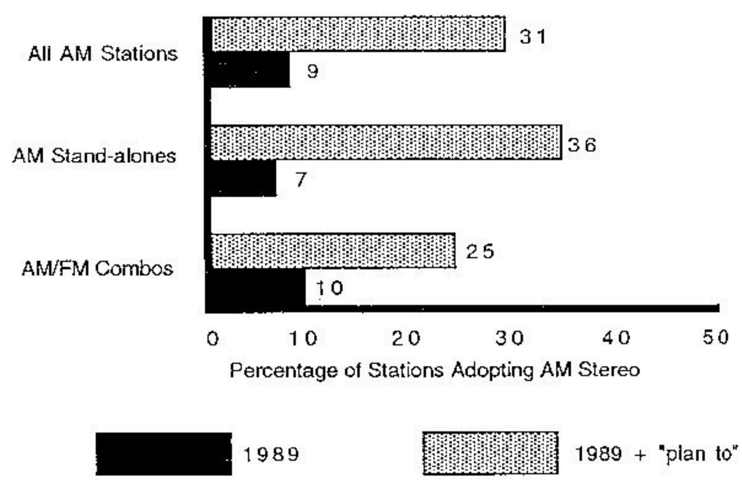

Figure 2. Percentage of stations adopting AM Stereo in 1989. From *AM Stereo: A Case Study Of A Marketplace Shibboleth*, by M. J. Braun, 1994, Norwood, NJ, Ablex, p.138

On October 27, 1992, President Clinton signed the Telecommunications Authorization Act, which required the FCC to adopt a single AM Stereo technology (FCC, 1993). The FCC found that among the stations broadcasting in AM Stereo at that time, 591 used the Motorola C-QUAM system (approximately 11% of all AM broadcasters), 37 used the Harris system (roughly 0.7 %), and less than 20 used the Kahn system (less than 0.4 %). The FCC did not evaluate the Magnavox, Belar, and Hazeltine systems. The FCC found that 26 radio receiver manufacturers incorporated the Motorola C-QUAM system in at least one model of radio, but none used Kahn's system. Based on its findings, the FCC proposed that the Motorola C-QUAM system be recognized as the nation's standard, noting that 24 million receivers using that system had already been sold. The FCC officially adopted the C-QUAM system on November 23, 1993. Many broadcasters criticized this decision, arguing that the FCC did not have sufficient engineering resources to properly test and evaluate the various AM Stereo systems (Braun, 1994).

It is interesting to note that in its historical account of AM Stereo, the FCC makes no mention of its initial acceptance of the Magnavox system as the national standard. It is intriguing that the FCC cites Kahn and Hazeltine as those who recommended that the FCC should "let the marketplace decide," as their systems were two of the least popular, according to FCC analysis (Braun, 1994).

Lessons Learned from the Emergence of FM and AM Stereo Technologies

With both FM and AM Stereo technologies, three factors other than their inventors' belief that their new technologies would "make radio sound better" interacted to result in either their success or failure in the marketplace (Levien, 1997). In both cases, these three factors were the following:

1. The perceived value of the new technology to listeners in the marketplace, which may not be the same value perceived by the inventor.
2. The key role that receiver manufacturers, without whose support a new broadcast technology cannot succeed, play in providing the equipment necessary to create a listening audience in a new broadcast technology.

3. Guidelines from regulatory agencies that include the imposition of transmission standards and the allocation of spectrum.

Of these three factors, perceived value is the most significant because it determines customer acceptance and use of a new product by indicating how customers' lives will be improved by a new technology, product, or service. Therefore, it is important for the developers of new technologies to clearly and accurately describe the value of their new inventions to the consumer. The inventors of both FM and AM Stereo technologies perceived the value of their new forms of modulation as that of providing vast improvements in the audio quality of radio reception. Armstrong believed that listeners would immediately rush to his new audio band after realizing the enhanced qualities of FM reception (Erickson, 1973), whereas all the inventors of the various forms of AM Stereo considered their new technologies a significant improvement in the audio quality of the AM mediumwave and, as such, a way for AM to once again become competitive with FM (Braun, 1994).

However, listeners did not agree with the inventors' assessment. Indeed, many broadcasters and academicians are uncertain whether listeners can even hear the difference between AM and FM transmission or, if they can, whether the difference in audio quality is sufficient, in and of itself, to entice the general listening public to one particular band or another (Barnes, 2003). Most broadcasters and academicians believe that the factor that brought about the migration of American radio audiences from AM to FM was not FM's superior audio quality but rather FM's enhanced programming. Bored with AM radio, audiences became intrigued by the new and different music genres available on FM, which, in conjunction with the fewer commercials aired on FM, led them to change their listening habits.

Any subsequent increase in AM listening (or, perhaps more accurately, a decrease in the rate at which FM listening was increasing) has not been due to AM Stereo technology but rather enhanced programming on the AM band, particularly various forms of talk radio (e.g., news, political, sports, and comedy). When talk radio broadcaster Rush Limbaugh received the Broadcaster of the Year award at the 1998 NAB Radio Luncheon, many credited him with single-handedly saving AM radio.[1] As talk radio became the dominant form of AM programming, few were concerned with its audio quality. Those now in the process of researching and developing HD Radio and DRM must keep this in mind as their technologies evolve. The superior audio quality provided by these technologies is necessary but not sufficient to entice listeners to digitally modulated radio. Like FM, digital modulation needs to serve as a vehicle for enhanced value to the consumer in terms of new and enhanced programming in order for it to become a viable product in the marketplace.

HD Radio and DRM stakeholders must also remain aware that the capabilities of radio receivers were a paramount factor in the ultimate success of FM Stereo. Armstrong, along with his company Zenith Radio, initially reaped great rewards from manufacturing receivers. However, when the FCC reallocated spectrum for FM broadcasting, commercial FM was no longer transmitted on 42 to 50 MHz, rendering his receivers and those produced by Zenith useless, and ultimately leading to the collapse of his company.

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[1] The researcher was in attendance at this event and can still recall the buzz in the room as Limbaugh received his award.

The renaissance of FM only occurred when receiver manufacturers started creating dual-band AM-FM radio receivers, particularly in car radios, which gave listeners a choice.

Herb Squire, former chief engineer of WQXR (FM)/WQEW (AM) in New York City, effectively demonstrated to the FCC, the Society of Broadcast Engineers (SBE), and the NAB that automobile radio manufacturers had degraded the audio quality of the AM section in first-generation AM-FM dual-band receivers such that the AM audio quality was less than that of earlier vintage AM-only radio receivers. This practice increased the difference in audio quality between AM and FM to the average listener switching between the two bands, helping spur the migration of listeners from AM to FM (Barnes, 2003). Whether the receiver manufacturers intentionally manipulated the market is still a point of contention. Nevertheless, the support of the radio receiver manufacturers, particularly car-radio receiver manufacturers, is paramount to the success of a new broadcast technology.

As of this writing, the developers of HD Radio and DRM, as well as the developers of satellite-fed radio programming for XM Radio and Sirius, are aggressively negotiating with car-radio receiver manufacturers to make digitally modulated reception available in new cars in the near future. iBiquity (n.d.) rolled out its HD Radio receivers at the Consumer Electronics Association (CEA) meeting in January 2003 and its transmission equipment for commercial broadcasters at the NAB meeting in April 2002. Only when listeners have the proper receiving equipment can broadcasters using new transmission techniques become successful and capture a share of the market. Digital receivers have been available for car stereo systems since 2007.

Another important lesson learned from AM and FM technology is that the success or failure of a technology is not necessarily tied to the success or failure of the company that developed the technology. Although FM is the current dominant technology for commercial radio broadcasting, as demonstrated by Figure 2, Armstrong's receiver manufacturing company was once in such a terrible predicament during the reallocation of spectrum for the FM band that he committed suicide. Eventually his wife, who was also an electrical engineer, won all of the lawsuits, but Armstrong's company never grew to become a giant in the industry; only the technology that he invented and developed became successful (Erickson, 1973). Moreover, although all forms of AM Stereo technology have failed in the marketplace, the companies that developed many of them—Motorola, Magnavox, Khan, Belar, Harris, and Hazeltime—went on to become industry leaders in broadcast technology by producing various other products.

The lessons learned from this analysis is that iBiquity or DRM could fail financially, even if their technologies gain market share over analog AM and FM, or that they could fail but go on to develop other successful technologies. This dissertation sought to identify the safeguards that iBiquity and DRM have in place to help ensure the success of their technologies and companies.

As they are introduced into the marketplace, HD Radio and DRM will have to contend with other new technologies also competing for market share and listenership. According to Abraham (2002), terrestrial and satellite distributed digital audio services

> are expected to fiercely compete for the hearts and minds of consumers in the United States, with different technology and different programming strategies. However, their challenges in reaching critical mass are very similar:

1. A number of DAB [IBOC] stations in each market.

2. Widespread consumer awareness.

3. Lower-cost receivers.

4. The ability of receivers to pick up programming from multiple DAB (IBOC) and DARS (satellite) services, rather than just one. (¶9)

Although there is general agreement among members of the radio broadcasting community that digitally modulated radio provides a higher-quality audio product than either AM or FM, they are uncertain whether it provides the "value-added" features necessary to entice the migration of the radio-listening audience. At a paper presented at the 2002 Broadcast Engineering Conference, Maxson and Signorelli (2002) discussed a feature of data broadcasting architecture referred to as *datacasting*. In much the same way that FM broadcasters have been able to earn additional revenue through storecasting (transmitting secondary analog audio streams or digital data on their subsidiary communications authorization [SCA] frequencies in addition to the primary signal within an FM channel), HD Radio and DRM broadcasters can transmit additional digital data above and beyond the main audio channel. Maxson and Sigorelli have cited cite 92 examples of possible datacasting.

Sylvie Scolan (n.d.) of Harris Broadcast Europe, a leading manufacturer of broadcast transmission equipment for both radio and television, explained that because the digital broadcast signal is a data stream, other forms of information can be added in addition to the main audio channel information, including instantaneous traffic information for mobile listeners, and other streaming data using Transport Protocol Experts Group (TPEG) formats and technology. Radio receivers could also be equipped with digital data storage units, such as a removable hard drives or disc drives, so that audio could be saved as compressed .mp3 files or other formats. By recording the incoming data, “audio on demand” could be replayed from storage so that listeners could listen to the portions of a broadcast in which they are most interested (e.g., weather or sports).

Recognizing that such features could supply the necessary “value added” to digital radio, the Association of Digital Radio Enhanced Platforms and Technologies (ADEPT) is in the process of developing several features for the Eureka-147 form of DAB in Europe (Scolan, n.d.). ADEPT’s research may have practical applications to HD Radio and DRM. With value provided to the consumer through the new digital service of datacasting and the support of radio transmitter and receiver manufacturers, digital radio modulation in the United States now is poised for success in the marketplace.

The Role of the Regulators

As new broadcast technologies evolve, coordination among them is essential to prevent chaos in the airwaves. The management of this coordination is the responsibility of the ITU on the international level and the FCC on the national level (Codding & Rutkowski, 1982; Hilliard, 1991). These agencies wield the power to either “make or break” a new technology, as witnessed by the FCC’s role in the eventual success of FM and failure of AM Stereo. As the ITU and FCC are responsible for deciding whether to allocate spectrum and develop specific technical standards for HD Radio and DRM, consideration of the role of these two organizations and their rule-making processes is essential when assessing the future of HD Radio and DRM.

The Federal Communications Commission

The management of the airwaves in the United States requires the coordination of two federal agencies. Whereas the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce manages radio-frequency (RF) spectrum for all governmental entities, the FCC manages RF spectrum for and provides regulatory guidance to all nongovernmental forms of communications and entities in the United States. Over the years, as more technologies have been devised that require RF spectrum, and more individuals and corporations have become intent on using it, the decision-making role of the FCC has become increasingly more important in terms of its impact on the success or failure of new RF technologies.

According to the FCC (2002b), its decision-making process begins with the agency's reception of a proposal from a private entity regarding a perceived market for a service. The FCC then requests public comments before deliberating and releasing its decision. During its decision-making process, the FCC considers administrative concerns (e.g., licensing and enforcement) and technical specifications while remaining mindful of international regulations and usage. All of these considerations are covered by the newly adopted rule or regulation.

Regarding this process, Dale N. Hatfield (1993), a senior fellow with the Annenberg Washington Program in Communications Policy Studies of Northwestern University, further explained,

> Although the FCC shares certain regulatory functions with agencies of the individual states, it has exclusive jurisdiction over non-federal-government spectrum management issues. The FCC carries out its responsibilities through procedures set forth in the act [Communications Act of 1934] and in more general

statutes governing the administrative procedures used by federal agencies. These procedures, referred to generically as rulemaking proceedings, require the agency to notify the public of proposed actions; to allow opportunities for public comment; to provide reasoned, written decisions based upon the public record; and to permit appeals of those decisions to the federal court system. (¶1)

The FCC uses a two-step process to properly manage the RF spectrum. First, it sets aside bands of frequencies for use by a specific type of radio service, much like the various broadcast service bands that are allocated in mediumwave and VHF regions, in a procedure similar to that of zoning land for specific purposes in city planning. After setting aside a portion of RF spectrum for a particular use, the FCC will often subdivide it into smaller units referred to as *channels* or *blocks*. An example of a block would be the RF spectrum used in the noncommercial portion of the FM broadcast band in the VHF band (88 to 92 MHz, the “bottom” 4 MHz of this 20 MHz-wide band), where nonprofit college, religious, and public affairs broadcasters can operate without competition from commercial stations. The FCC then assigns channels within these blocks or bands to specific individuals or corporations for broadcasting or transmission through the process of licensing in a process similar to that of leasing land to an individual or a corporation. Although the commission does charge licensing fees, it does not collect “rent” for the use of spectrum.

Over the years, the FCC has used three methods for granting licenses to applicants requesting the use of assigned frequencies: holding hearings to compare the qualifications of the applicants; conducting lotteries whereby the FCC randomly selects “winners” from a group of qualified applicants; and, after receiving congressional approval in 1993, auctioning new commercial licenses via competitive bidding. As a condition of its approval of this last method, Congress requires the FCC to report the results of the competitive bidding process (Kwerel & Williams, 1993).

The FCC is particularly concerned with interference issues among broadcasters in the United States. In order for the broadcast spectrum in the AM and FM bands to be used most effectively, the proper geographical spacing of stations on the same frequency, as well as on the first and second adjacent channel on either side, is essential to ensure that authorized interference-free zones exist. Spectrum management, like many other telecom-related issues in the United States, has become increasingly more complex. As such, debate regarding its management no longer only occurs within bureaucratic agencies such as the FCC but also within congressional hearings. Moreover, as explained by Rudy Baca, vice president and global strategist for the techcom research firm Precursor Group, "The FCC used to be a sleepy little agency that just did routine things. Now, it regulates the companies that are the 'engines of growth' for the economy. Indeed, spectrum management suddenly has the attention of Washington's political elite" (as cited in Jackson, 2000, ¶11-12).

In August 2000, at the direction of the U.S. Congress, the FCC postponed the auction of the 700 MHz spectrum, which led to a loss of $2.6 billion to the U.S. Treasury—an unusual financial decision, even in an era of budget surpluses. The issue was considered so important that President Clinton redirected his focus from the Mideast crisis in order to sign an executive order that outlined a plan to secure spectrum for 3G telecom technology. After President Clinton signed the executive order, FCC Chairman William E. Kennard explained why spectrum management was such an urgent issue:

> As the Internet migrates out of the personal computer and into wireless Web-enabled devices, spectrum management is becoming increasingly important. . . . Indeed, spectrum, or the absence of spectrum in some cases, is emerging as a major factor for the new economy. That's why it’s so important that we elevate spectrum management to a national priority. (as cited in Jackson, 2000, ¶13)

The FCC has played a pivotal role in the development of both FM and AM Stereo. FM got off to a rocky start when the FCC initially allocated it to the 42 to 50 MHz band before later allocating it to the now popular 88 to 108 MHz band. At that time, the public viewed FM technology as “unstable,” and, as such, was not willing to invest in new receivers. Decades later, the FCC provided regulatory guidance in support of FM by requiring AM-FM duopoly owners to provide separate programming and content for FM stations, imposing a freeze on any new license applications for AM, and encouraging receiver manufacturers to construct AM-FM radios.

The FCC did not provide this type of support to AM Stereo technology, instead adopting a “let the marketplace decide” approach to establishing technical standards. As broadcasters were not required to adhere to standards, chaos ensued in the mediumwave spectrum, exacerbated by the development of incompatible forms of technology. As a result of this approach, AM Stereo technology was doomed to failure (Braun, 1994; Erickson, 1973).

However, it appears that the public does not want government to impose its will on the broadcasting marketplace, equating the imposition of technical standards by the FCC with marketplace manipulation by the federal government. Although they cannot be extrapolated to the general public in real terms, the results of a 2002 Worldnetdaily.com survey support certain marketplace trends. The inventors of HDTV view their new technology as a significant improvement over current analog television-broadcasting techniques, much like the inventors of HD Radio view their new technology as a significant improvement over current radio-broadcasting techniques. However, only 5.9% of the 2,819 respondents to the survey indicated that they view HDTV positively, whereas 91.7% view the new technology negatively in terms of marketplace manipulation by the federal government and/or the electronics industry, bad public policy, or as simply not necessary (see Appendix E for complete survey results).

Despite public opinion, if the FCC does not impose technical standards and timelines on HDTV, this new technology, as well as new radio technologies, could also be doomed to failure. As FCC Commissioner James Quello contested,

> One thing that the marketplace doesn't do very well and something government should be prepared to do, it seems to me, is to establish technical standards in the interest of nationwide compatibility. To expect the American public to select a nationally compatible system in a reasonable period of time is sheer folly. (as cited in Braun, 1994, p. 128)

In support of Quello, Ray (1990) argued,

> The justification recited most often for abandoning regulation is that competition in the marketplace will correct whatever deficiencies may exist. . . . However, the commission's reliance on marketplace forces disregards the fact that the laws enacted by Congress to regulate some aspects of broadcasting and other business activities are based on precisely the opposite assumption: that in some areas government regulation is required in order to protect the public. If the FCC's current rationale were carried to its logical conclusion, the Federal Aviation Administration should stop requiring maintenance and inspection of passenger planes. . . . The whole purpose of the Communications Act of 1934 was to make sure that "the free force of the marketplace" did not entirely control radio because broadcasting is affected by public interest. (p. 170)

On October 10, 2002, the FCC unanimously selected iBiquity HD Radio technology as the technology that U.S. stations will use for digital broadcasting. The

Report and Order issued by the FCC allows FM radio stations to transmit with the IBOC form of HD Radio 24 hours a day, and AM radio stations in the mediumwave band to use the IBOC HD Radio transmission between local sunrise and sunset. FCC Chairman Michael Powell described this decision as historic and expressed his delight that radio would join other forms of media that are in the process of "going digital." Also overjoyed were Commissioners Kathleen Abernathy and Michael Copps, who stated that they were eager to purchase the HD Radio receivers that iBiquity had introduced at the 2003 Consumer Electronics Show, as well as the former iBiquity Vice President for Broadcast Engineering, Glynn Walden, who stated, "With this FCC decision, those benefits are now available for broadcasters to bring the benefits of digital radio to the U.S. public" (as cited in Stimson, 2002b, ¶18).

The FCC stated that it will learn much more about HD Radio technology after radio stations start to transmit their digital signals (Stimson, 2002b). If interference occurs from an HD radio station that is transmitting both signals, the FCC hopes that both radio stations can reach a solution together, but is prepared to intercede in situations where broadcasters are unable to come to an agreement on their own. The FCC further stated that although it is uncertain when it would issue final IBOC rules and licensing details, it encourages radio stations interested in starting HD radio transmission to file requests for special temporary authorization and begin digital transmission upon approval.

The International Telecommunications Union

Radio signals do not stop at the geographical borders of countries, regardless of broadcaster intention. Based on the propagation characteristics of the various RF bands, the amount of electrical power of the transmitter, and the efficiency of the antenna system, radio signals may travel through the atmosphere from one country to another. Consequently, countries must agree on international standards of transmission if effective communications are to occur without harmful interference.

The authority of the ITU, the agency that manages the spectrum on a global scale, rests in the agreement of its member nations and its role within the United Nations. However, its reach goes beyond that of its participating member nations; it is also tasked with implementing global standards of telecommunications in developing nations so that these countries, although not full members of the ITU, can effectively communicate with the rest of the world. To do so, the ITU Radiocommunication Sector (ITU-R), the global RF-spectrum coordinator, established the following radio regulations (RRs) for worldwide radio transmission:

1. Establishment of a table of frequency allocations covering the entire RF spectrum.
2. Procedures for the RF spectrum to be used without harmful interference from the radio stations of one country to those located in another.
3. Measures to increase the efficiency of RF spectrum use.
4. Specific rules focusing on the day-to-day operation of maritime and aeronautical mobile radio service.
5. Resolution of conflict among transmitting entities worldwide and recommendations for improvements. (Withers, 1999)

The ITU-R created the RRs as a set of rules to become a binding international treaty governing the use of the radio spectrum by over 40 different types of RF services around the world. Also being the central registrar of international frequency use, the ITU-R records and maintains the Master International Frequency Register (MIFR). The MIFR currently includes over 1,265,000 terrestrial frequency assignments, 325,000 assignments servicing 1,400 satellite networks, and another 4,265 assignments related to satellite earth stations.

As previously discussed, the ITU also divides the RF spectrum into blocks that vary in size according to individual services and their requirements. These blocks are referred to as *frequency bands* allocated to various radio services on either an exclusive or shared basis with other services. As part of the RRs, the ITU's Table of Frequency Allocations (TFA) lists the services and frequency bands allocated in different regions. Changes to the TFA and to the RRs can be made during ITU-sponsored World Radiocommunication Conferences (WRC), during which the ITU balances requests for greater bandwidth with the need to protect existing stations or types of services as part of international negotiations from negotiations among national delegations.

If a country or a group of countries wants to use a frequency or band for purposes other than those specifically listed in the TFA, the ITU (n.d.) can make changes to the TFA during a WRC by the addition of a footnote or it is sanctioned by a RR procedure. The parties involved with the change must also formally seek the agreement of any other nations affected before any new use of the band can begin (ITU, n.d.). In addition to managing the TFA and RRs, at the WRC conferences the ITU approves allotment plans for services where use is not restricted to a particular country or territory. With assignment plans, frequencies are allocated for each station within a given service of each country. Allotment plans assign frequencies to be used by a given service, which the national authorities can then assign to stations within that service in that country. The ITU-R prepares a WRC for continuing the decision-making process by developing regulatory procedures and examining specific technical issues to calculate the risk of harmful interference (Codding & Rutkowski, 1982).

In 2000, the ITU (2000) approved the use of DRM technology in all bands worldwide at frequencies below 30 MHz (ITU, 2000). By this action, the ITU made DRM a legally usable modulation method for worldwide use in the longwave, mediumwave, and shortwave radio broadcasting bands (see Appendix F).

Managing Emerging Broadcast Technologies

Like other emerging technologies in a variety of fields, HD Radio and DRM have the potential to either succeed or fail. If they do succeed, their success will not take place overnight. Many researchers have sought to identify the factors that impact the success or failure of innovative technologies. Freeman and Soete (1997) hypothesized that the following characteristics of successful innovating firms form the groundwork for successful technical innovation:

1. *Strong in-house professional research and development.* Both HD Radio and DRM have strong research and development programs. The radio broadcasting industry, which privately funds iBiquity, underwrites research for HD Radio and iBiquity. DRM Consortium member organizations conduct DRM research at their own expense.

2. *Collaborative research or close connections with those conducting such research.* The National Radio Systems Committee (NRSC) conducted HD

Radio research in conjunction with the CEA before presenting its findings to the FCC. As such, close connections are maintained between iBiquity, the NAB, the NRSC, the CEA, and the FCC. Likewise, the DRM Consortium maintains close connections with the ITU.

3. *The use of patents to gain protection from and bargain with competitors.* iBiquity holds several patents on its technology for its CODEC (digital coding and decoding algorithms), data compression system, IBOC analog-digital scheme, and use of spectrum. As the DRM system is an open-source technology, the DRM Consortium does not rely so heavily on patents.

4. *Sufficient size to finance considerable research and development over long periods.* Both innovating organizations enjoy strong backing from industry leaders. iBiquity is backed by a large number of investors, including the leading broadcasters ABC, Beasley, Bonneville, Citadel, Clear Channel, Cox Radio, Cumulus, Emmis, Entercom, Gannett, Radio One, Regent, Saga, Susquehanna, Univision, and Viacom; the leading manufacturers Ford Motor Company, Harris Corporation, Texas Instruments, and Visteon Corporation; and the leading financial institutions Grotech Capital Group, Intel Capital, J.P. Morgan Partners, New Venture Partners, and Pequot Capital (iBiquity.com, n.d.). The DRM Consortium is currently comprised of 48 broadcasting and manufacturing organizations (DRM.org, n.d.).

5. *Shorter lead times than competitors.* One interviewee in this study strongly stressed that lead time is an area of great danger. HD Radio and DRM are both late entrants to the marketplace relative to satellite radio (e.g., XM and Sirius), Internet radio broadcasting, and podcasting. As such, both technologies are in an inferior position relative to these competing technologies.

6. *A readiness to take high risks.* The backers of both technologies have taken enormous risks in developing their new technologies, including the risk of broadcasters not migrating to the new technology and listeners not purchasing new receivers to migrate to the new technology.

7. *Early and imaginative identification of a potential market.* Although the developers of both technologies have identified potential markets, they have not implemented their technologies in a timely manner. As previously described, their potential markets may be captured by satellite radio broadcasters, Internet radio broadcasters, and podcasters by the time they aggressively introduce HD Radio and DRM into the marketplace.

8. *Careful attention to the potential market and substantial efforts to involve, educate, and assist users.* HD Radio has clearly outperformed DRM in this area. With its development of commercials for HD Radio broadcasters and its training program for retail electronics sales associates, the HD Radio Alliance has started the formidable task of educating the public about HD Radio. The DRM Consortium currently has no similar programs in development.

9. *Entrepreneurship sufficiently strong to coordinate research and development, production, and marketing.* The strong and independent entrepreneurship of the iBiquity Corp, which appears to have a centralized and direct decision-making process, has been instrumental in the development of HD Radio. The DRM Consortium's loose confederation of broadcasters and manufacturers uses a more decentralized decision-making process that appears to have been adequate during the initial research and development stage but less effective during the production and marketing stages.

10. *Good communications with the outside scientific world as well as customers.* The backers of both technologies have presented themselves well at broadcasting conferences and conventions and have built core constituencies among prospective broadcasters. In contrast, they have not done so well with receiver manufacturers.

Like the developers of other emerging technologies, those of HD Radio and DRM will face a period of adoption by the marketplace. iBiquity has planned on experiencing what it refers to as a *digital sunrise* in the adoption of IBOC technology in the U.S. This term refers to the period over which more radio broadcasters transition from analog AM and FM transmission to digital transmission and more listeners purchase and use digital receivers until there is a point of marketplace saturation at which the analog portion of the IBOC signal can be "turned off" nationwide, leaving commercial radio broadcasting in a digital-only environment. iBiquity's conception of the digital sunrise is consistent with Day and Schoemaker's (2000) conception of the rate of adoption of new and emerging technologies. The researchers posited that five different types of individuals embrace new and emerging technologies at five different rates, as indicated in Day and Schoemaker's adoption curve in Figure 3. This framework is useful for defining the characteristics of broadcasters purchasing new digital transmission equipment and the behaviors of radio listeners purchasing new digital receivers.

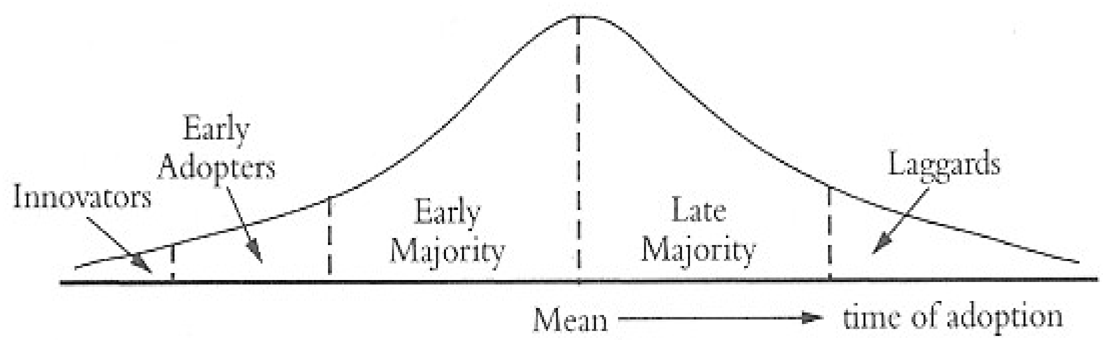

Figure 3. Day and Schoemaker's adoption curve. From *Wharton on Managing Emerging Technologies*, by G. S. Day and P. J. H. Schoemaker, (Eds.), 2000, New York, John Wiley, p. 135

Day and Schoemaker's (2000) framework encompasses the following five groups:

1. *Innovators or technology enthusiasts*. Innovators are committed to the possibility that any new technology in their area of interest has promise and are willing to take the time to master it. They are often "lead users" who have needs in advance of the rest of the market. They not only prove the new product but their endorsement is key to acceptance by other segments.

2. *Early adopters or visionaries*. Early adopters see the opportunity presented by the new technology to change the rules of competition in their market. They help publicize the new technology, but are costly to support because they require special adaptation to their requirements. Often, these visionaries are in specialized niches.

3. *Pragmatists or the early majority*. Pragmatists decide to adopt a technology only when the benefits of the technology have been well proven and its risks are tolerable. They typically buy from leading firms because these vendors usually have the most reliable configuration to attract the largest number of third-party companies into the aftermarket .

4. *Conservatives or the late majority*. Conservatives adopt an innovation only after the majority has tried it. They tend to be price sensitive, skeptical of their ability to derive any value from the innovation, and very demanding. They have high needs for service support and assurance, but will invest little to have their demands met, which reinforces their doubts about the new innovation.

5. *Laggards or traditionalists*. Laggards are suspicious of changes and likely to adopt an innovation only when they have no choice or it begins to become a measure of tradition itself.

However, as previously discussed, radio migration depends on more than simply audio quality; new programming and other value-added features such as digital datacasting are significant, as well as the quirks of the marketplace. Moreover, Day and Schoemaker (2000) argued that decision-making often takes place amid great uncertainty when one is dealing with emerging technologies:

> Managers are forced to make decisions about pursuing new technologies with highly imperfect information. The reality is that some technologies succeed and some fail and managers can never know for sure whether a technology will be a dud or the next killer application. . . . As managers seek to assess the potential of new technologies, they also should do so with humility. It is easy to make mistakes. (pp. 17–18)

The researchers argued that because the management of a new and emerging technology is fraught with ambiguity, managers need to become familiar with high levels of complexity and paradox. They explained that because "simple, absolute answers are few and far between . . . the ability to live with these ambiguities and to continually identify them and think through them is one of the most important skills of managing emerging technologies" (pp. 19–23).

Having been embraced by innovators and early adopters, both HD Radio and DRM are at the early stages of Day's and Schoemaker's adoption curve of new and emerging technologies shown in Figure 3. According to iBiquity's Web site (n.d.), 1,822 or approximately 15% of the 12,000 to13,000 radio stations in the United States are broadcasting with HD Radio technology as of November 2008. Likewise, the DRM Consortium Web site (n.d.) indicated that 43 international broadcasters are using their new technology in the shortwave and mediumwave to broadcast 105 programs, mostly on a daily basis as of November 2008. Even at this early stage in their development, either technology could experience failure. As indicated in a modified version of Day and Shoemaker's adoption curve in Figure 4, either could follow the "A" line to success or the "B" line to failure.

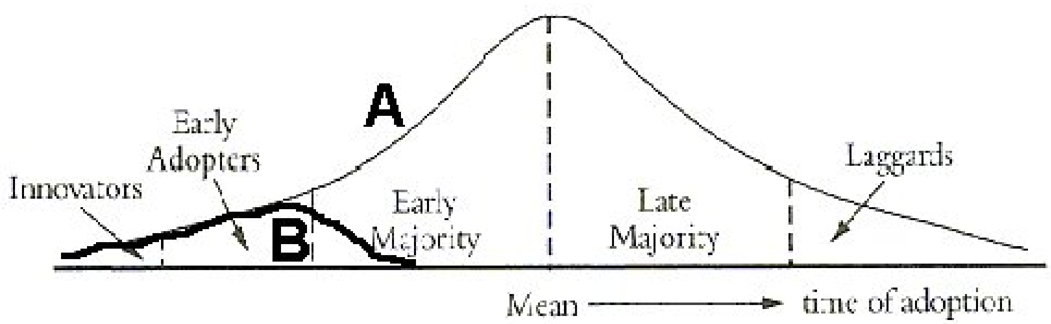

Figure 4. Day and Schoemaker's adoption curve as modified by the researcher. From *Wharton on Managing Emerging Technologies*, by G. S. Day and P. J. H. Schoemaker, (Eds.), 2000, New York, John Wiley, p. 135

Rather than conceiving of the rate of adoption of new media as a bell curve, Fidler (1997) conceived it as an "S" curve. As shown in Figure 5, a new form of technology experiences slow adoption during the initial phase of its evolution as only early adopters embrace it, then experiences rapid adoption and diffusion until the bulk of users (the early and late majority of Day and Schoemaker's adoption curve) migrate to the new technology at its midlife, then little to no growth as later adopters finally accept the new technology.

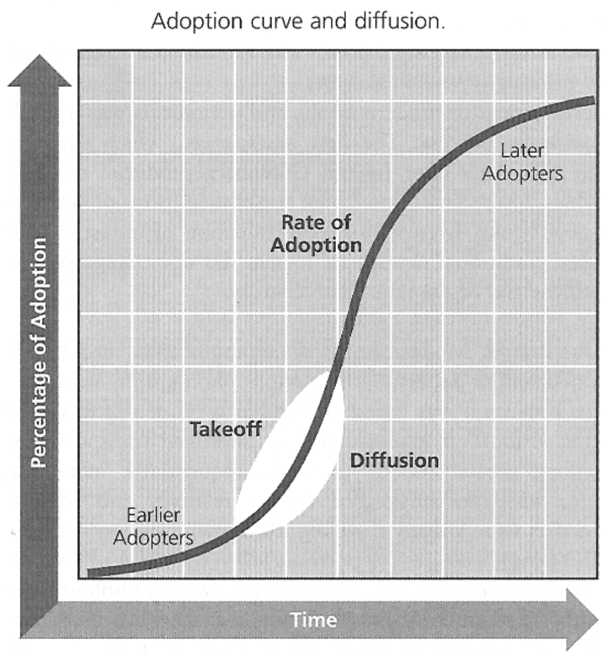

Figure 5. Fidler's S curve of adoption and diffusion. From *Mediamorphosis: Understanding New Media*, by R. Fidler, 1997, Thousand Oaks, CA, Pine Forge Press, p. 15.

In relation to his S curve, Fidler (1997) referenced Saffo's 30-year rule regarding change and the adoption of new media. According to Saffo, it takes a little more than a human generation for a new form of media to be adopted. The emergence and eventual marketplace dominance of FM radio generally fits this rule (46 to 52 years, depending on whether listeners or broadcasters are measured) despite its rocky beginnings. Using this timetable, the marketplace dominance of digital radio would not occur until sometime between the 2030s and 2040s. Fidler's S curve provides another means of considering the potential success or failure of HD radio and DRM. Even before either version of digitally modulated radio achieves what Fidler refers to as takeoff and diffusion, either could experience failure. The modified version of his graph shown in Figure 6 shows the path to success in the "A" line and the early path to failure in the "B" line.

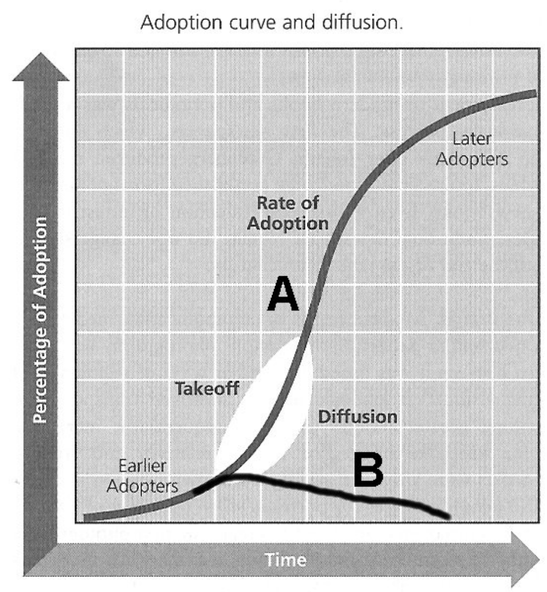

Figure 6. Fidler's S curve of adoption and diffusion as modified by the researcher. From *Mediamorphosis: Understanding New Media*, by R. Fidler, 1997, Thousand Oaks, CA, Pine Forge Press, p. 15.

Fidler (1997) described the phenomenon of multimedia operation as *convergence*. Nicholas Negroponte of the MIT Media Lab had first used this term in 1979 to describe the coming together of various forms of media until they become almost indistinguishable from each other. Figure 7 shows the MIT Media Lab's construct of the convergence of broadcast, print, and computer technologies.

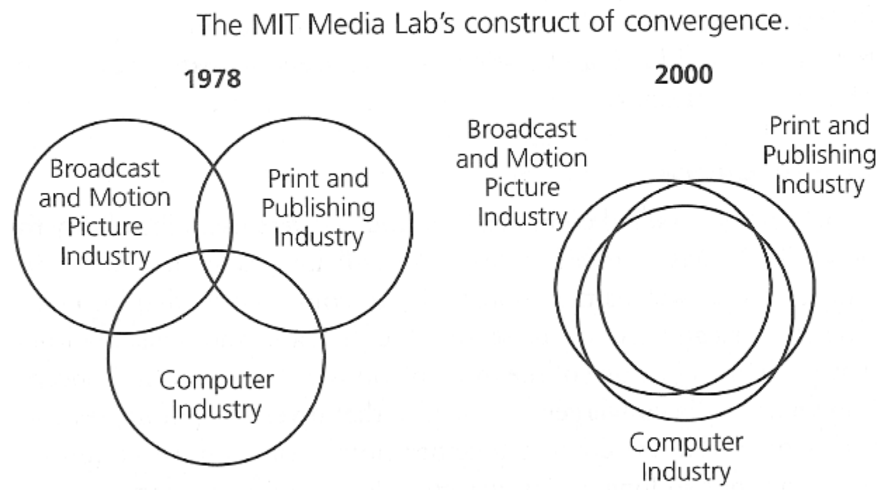

Figure 7. The MIT Media Lab's construct of convergence. From *Mediamorphosis: Understanding New Media*, by R. Fidler, 1997, Thousand Oaks, CA, Pine Forge Press, p. 26.

Figure 7 could also apply to the convergence of audio technologies (radio, CD-MP3 audio, and Internet-streaming audio); video technologies (television, DVDs, and Internet-streaming video; and text technologies (newspaper, magazines, and Internet graphics and text). The convergence of these forms of media may, over time, lead them to become indistinguishable from each other.

Fidler's (1997) reference to Negroponte's theory of convergence has direct application to the current media market for HD Radio and DRM. The multiple platforms of radio available to listeners could converge, making the same or similar content available to all with listeners, who move seamlessly from one technology to the other, as indicated in the modified MIT model of convergence in Figure 8. An example of this convergence is *Radio Margaritaville*, a radio station that primarily plays the music of Jimmy Buffet. Beginning as an Internet radio station, its content can now also be heard on Sirius and XM satellite radio. In the future, it also could be heard as an HD-2 or HD-3 stream from a terrestrial HD Radio station or worldwide on a DRM shortwave station. An HD Radio receiver manufacturer indirectly discussed this convergence during his interview when he stated, "Clear Channel is probably the leader in that they are involved in getting their content out on XM, on Internet radio, traffic data. They're really trying to diversify to get away from FM radio ad sales as being their one and only revenue source."

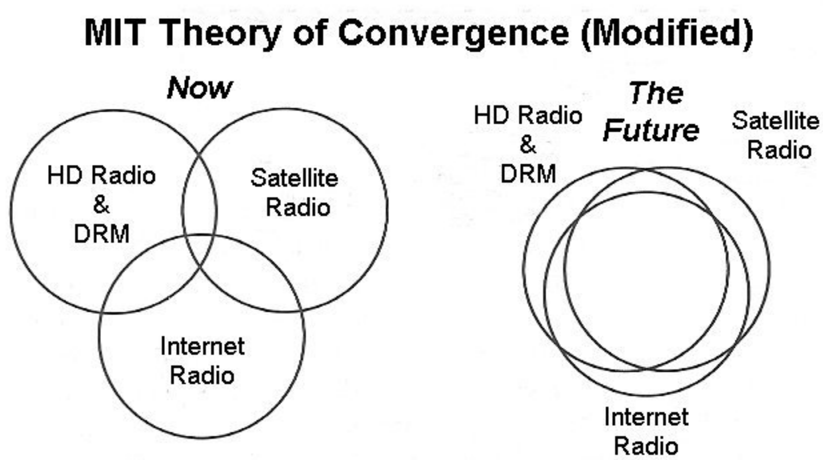

Figure 8. The MIT Media Lab's construct of convergence as modified by the researcher. From *Mediamorphosis: Understanding New Media*, by R. Fidler, 1997, Thousand Oaks, CA, Pine Forge Press, p. 26.

Fidler (1997) described his hypothesis of *mediamorphosis*, the morphing of one media form into another, such as analog commercial radio broadcasting transmission and reception morphing into digital transmission and reception, in terms of six fundamental principles:

1. *Coevolution and coexistence.* "All forms of communication media coexist and coevolve within an expanding, complex adaptive system. As each new form emerges and develops, it influences, over time and to varying degrees, the development of every other existing form" (p. 29). Other digital media, including Internet-streaming audio and video, HDTV, and CDs, have inspired the development of digital radio. Listeners have come

to expect digital-quality audio from other media (e.g., MP3 players, CDs, and the Internet). Radio now must "catch up" with them in terms of quality.

2. *Metamorphosis.* "New media do not arise spontaneously and independently—they emerge gradually from the metamorphosis of older media. When new forms emerge, the older forms tend to adapt and continue to evolve rather than die" (p. 29). Digital radio is evolving from analog AM and FM radio in much the same way that FM evolved from AM. As HD Radio and DRM are evolving, so are Eureka-147 DAB, SDARS XM, Sirius radio, and Internet-streaming audio. Even though there is no mandated sunset provision for analog radio broadcasting, eventually all AM and FM stations will migrate to digital transmission or become obsolete.

3. *Propagation.* "Emerging forms of communication media propagate dominant traits from earlier forms. These traits are passed on and spread through communicatory codes called languages" (p. 29). As radio broadcasting migrates from analog to digital, many of the currently successful programming forms will also migrate.

4. *Survival.* "All forms of communication media, as well as media enterprises, are compelled to adapt and evolve for survival in a changing environment. Their only other option is to die" (p. 29). Again, current AM and FM stations will, over time, be compelled to convert to digital transmission once digital receivers reach a certain point of marketplace saturation.

5. *Opportunity and need.* "New media are not widely adopted on the merits of a technology alone. There must always be an opportunity, as well as a motivating social political and/or economic reason for a new media technology to be developed" (p. 29). There are many in radio broadcasting who feel that digital radio will "breathe new life" into the industry. The opportunity lies in how this new digital media is programmed (i.e., how the secondary audio streams and multimedia capabilities are used) and presented to the consumers to satisfy a "need."

6. *Delayed adoption.* "New media technologies always take longer than expected to become commercial successes" (p. 29). Saffo, whose 30-year rule of new technology diffusion has been referenced over the past 5 decades, coined the term *technomyopia* to describe the "tendency of established enterprises to overestimate the short-term potential of a new technology and, when it fails to meet their expectations, underestimate its long-term potential" (p. 29). According to the 30-year rule, HD Radio and

DRM will become fully accepted and a commercial success by 2035, by which time, as many of the futurists in this study have predicted, HD Radio and DRM may be overtaken by ubiquitous, wireless, mobile Wi-Fi /Wi-Max or 3-G technologies.

Rogers (1995) formulated a theory of diffusion that posits that a new technology's rate of adoption depends on its *relative advantage, compatability, complexibility, trialability,* and *observability*. Rogers' definition of these terms and their application to the diffusion of HD Radio and DRM are as follows:

1. "*Relative advantage* is the degree to which an innovation is perceived as being better than the idea it supercedes." (p. 212) Although the initial relative advantage of digital radio over conventional analog AM and FM radio was its CD-quality audio, the marketplace may consider its provision of secondary and tertiary audio streams, multimedia products, programming enhancements, and shorter commercials to be its the relative advantages. HD Radio and DRM may not have a relative advantage over satellite radio, Internet radio, and podcasting due to their late entries into the marketplace.

2. "*Compatibility* is the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters." (p. 224) Because HD Radio and DRM operate on the same radio channels as conventional AM, FM, and shortwave radio, they are fully compatible with analog radio in terms of spectrum usage. Both analog and digital receivers can receive IBOC and simulcast technologies. However, digitally modulated radio is not compatible with analog receivers currently in the marketplace. The marketplace needs to be supplied and replenished with digital receivers.

3. "*Complexibility* is the degree to which an innovation is perceived as relatively difficult to understand or use." (p. 242) Because digital receivers are not currently in wide distribution, their complexity has yet to be determined. It is hoped that consumers will find these new receivers no more difficult to operate than conventional AM and FM radio receivers.

4. "*Trialability* (referred to as *reliability* in Fidler, 1997) is the degree to which an innovation may be experimented with on a limited basis." (p. 243) Again, this is yet to be determined for digital radio. Although a number of tests have been conducted regarding the reliability of HD Radio

(most notably by Messer [2001, 2002] for the NRSC and the CEA) and DRM transmission and reception, their trialability will not be known until the majority of stations broadcast their signals digitally and HD Radio and DRM receivers are in wide use.

5. "*Observability* is the degree to which the results of an innovation are observable to others." (p. 244) Currently, two competing technologies, digital satellite radio and Eureka-147 DAB, are at this phase of diffusion. Over two million subscribers have XM or Sirius radio receivers, and many are buying DAB receivers in Europe and the United Kingdom, exposing others to them in the process. HD Radio and DRM may be at this same point of observability in one or two years.

Winston (1995) argued that the diffusion of new media can be considered from two perspectives, that of *technological determinism* and *cultural determinism* (p. 55). Regarding the success of FM radio, one may ask whether it gained marketplace dominance over AM radio because of its superior technology (i.e., higher-quality audio technology) or because of "cultural" factors (i.e., the provision of fewer commercials and greater programming variety). Likewise, one may ask whether digital radio will gain market dominance over analog AM and FM because of its superior technology (i.e., higher-quality audio technology) or because of "cultural" factors (i.e., the provision of shorter commercials, secondary and tertiary audio streams, additional multimedia products and programming not offered by analog AM and FM radio).

Winston, as cited in Fidler (1997), theorized that there are technological *accelerators* or *pushes* and *brakes* or *pulls* that, in accordance with three important principles, affect the diffusion of a new technology as it emerges into the marketplace:

1. Social, political, and economic forces play powerful roles in the development of new technologies.

2. Inventions and innovations are not widely adopted on the merits of the technology alone.

2. There must always be an opportunity as well as a social, political, or economic reason for a new technology to be developed. (p.19)

Winston (1995) described the accelerators for the diffusion of a new technology as "supervening social necessities," (p. 68) whereas he described a brake on a new technology as the "suppression of radical potential." (p. 69) Both are based on the needs of companies, requirements of other technologies, regulatory and legal actions, and general market and social forces.

Regarding the success or failure of HD Radio and DRM from a technological perspective, both have demonstrated that they are functional as digital data streams that provide superior audio quality compared to analog transmission and have the ability to provide ancillary text and graphics not available with analog radio. However, their cultural advantages or disadvantages have yet to be determined. Will they deliver content that the public desires, or will satellite and/or Internet radio better cater to public demand? This question cannot be answered until HD Radio and DRM have fully entered the marketplace.

The accelerators of HD Radio and DRM are the efforts expended by their innovators and supporters, including the HD Radio Alliance and DRM Consortium, whereas the primary brake appears to be the reluctance of receiver manufacturers and broadcasters to fully embrace these technologies. The social factors include the belief that digital radio can provide more diverse content than is available today. The political factors are the results of negotiations between the innovators and the regulatory bodies (the FCC and ITU), as well as the results of the negotiations currently underway between the NAB on behalf of American broadcasters and the FCC to include HD Radio as a standard item in car radios along with satellite radio as part of the XM Radio and Sirius merger. The most evident economic implication is that broadcasters could triple their income by using the additional streams provided by digital radio (i.e., HD-2 and HD-3). Economic factors also include the need to price the receivers at a level affordable to listeners.

The findings of this study support Winston's argument that "innovations are not widely adopted on the merits of the technology alone." (Fidler, 1997 p. 19) As later discussed in chapter 4, many of the participants in this study believe that content will drive the success or failure of HD Radio and DRM, not the technology itself. HD Radio and DRM offer the opportunity for radio broadcasters to "catch up" with the rest of the world by offering the public a digital medium providing multiple streams of content as well as multimedia and interactive products in addition to higher-quality audio—services that they could never have anticipated receiving from analog radio.

All of these theories of emerging technologies have direct applications to the development and diffusion of HD Radio and DRM digital radio technology. As the practical application of each of these theories has demonstrated, both versions of digital radio under study in this paper are at a very early stage of emergence—a point at which each sits on the precipice of success or failure.

Conclusion

The literature indicates that the marketplace of radio listeners and radio equipment manufacturers, as well as the regulatory decisions of the FCC, were all dominant factors in the eventual success of FM radio and the subsequent failure of AM Stereo technology. As HD Radio and DRM digital radio technologies emerge onto the airwaves, either technology is poised to experience either of these two scenarios—success or failure.

Analysis of the success of FM and the failure of AM Stereo also indicates that new modulation technologies for broadcasting do not become successful solely based on their ability to provide higher-quality audio technology. Success also depends on their developers' ability to market the technology to manufacturers, broadcasters, and the public; receive the support and approval of the relevant regulatory bodies; and provide "value-added" to the listener in the form of new and innovative content and programming. Regardless of their degree of technical innovation, ability to improve the audio quality of radio, capacity to transform commercial and international radio broadcasting into an entirely new medium with enhanced multimedia capabilities, or obtain regulatory support, either technology could fail to gain marketplace acceptance. Moreover, they face the possibility of becoming embroiled in a fierce battle with each other that could lead both to lose significant market share to other emerging technologies.

The available literature indicates that iBiquity and the DRM Consortium have begun marketing their technologies, have attained regulatory support, and have defined value to the listener much more effectively than had the developers of FM or AM radio. However, radio today faces competition for listenership from technologies, such as MP3 players and satellite and Internet radio, that were not in existence when FM and AM Stereo were emerging.

The aim of this dissertation was to support or disprove the findings of the literature based on the data obtained from interviews with those intimately involved in the development of digitally modulated radio. In the process of doing so, this study described the HD Radio and DRM stakeholders' definitions of success and failure for their technologies and provided insight into their marketing strategies, their negotiations with regulatory bodies, and their ability to provide new and innovative programming and digital media products (i.e., value) to consumers as they strive for success with their new broadcast technologies.

CHAPTER 3. METHODOLOGY

This nonexperimental, descriptive, multiple case study compared and contrasted HD Radio and Digital Radio Mondiale, two forms of digital radio technology. The researcher collected data by interviewing subject matter experts and business leaders involved in various facets of digital radio technology strategy, marketing, regulation, and implementation. The researcher classified the interviewees into one of five groups for each technology according to their role in digital radio development: innovators (iBiquity senior managers and DRM members); regulators; transmitter and receiver manufacturers; broadcasters; and "other" stakeholders (media critics, competitors, academics, and the "innovative user"). There were five groups of interviewees for the HD Radio case and another five groups for DRM.

The researcher analyzed the data using SPSS and Microsoft Excel software and triangulated the data gleaned from these groups to uncover more specific information regarding HD Radio and DRM strategies, regulatory actions, and value to the listener. This analysis allowed the researcher to identify procedures currently in place that support the successful emergence of these digital technologies as well as factors that may contribute to their failure.

The researcher selected the case-study method for this study because it focuses on digital radio modulation as a whole system or entity in terms of its description and explanation. Specifically, the researcher compared and contrasted multiple specific case studies of HD Radio and DRM as a method of extrapolating broad truths regarding the overall phenomenon (Winegardner, n.d.). The researcher considered each form of digital modulation a separate case to capture as much data as possible about each in terms of its marketplace potential, regulatory consideration, and value to the listener from individuals involved with those aspects of these two forms of digital radio technology.

Sources of Data and Participants

The researcher collected data by interviewing subject matter experts and business leaders at iBiquity and the DRM Consortium involved in various facets of digital radio technology strategy, marketing, regulation, and implementation; FCC officials concerned with spectrum management, interference issues, and technological regulation; manufacturers of commercial radio transmitters and receivers; broadcasters currently using or intending to use these new digital modulation technologies; noted industry commentators who have expressed views, both pro and con, regarding the advent of digital radio modulation; a competitor from the satellite radio industry; academics; and an "innovative user."

Instrumentation

The researcher used the qualitative interview as the primary research instrument. The researcher asked only open-ended questions during the interviewing process based on Aberbach and Rockman's (2002) contention that highly educated people, such as the managers in this study, "do not like being put in the straightjacket of close-ended questions. They prefer to articulate their views, explaining why they think what they think" (¶8). The researcher asked all the participants the same initial seven questions before proceeding to ask them specific questions based upon their specific area of expertise (e.g., strategy, marketing, regulation, manufacturing, or broadcasting; see

Appendix G for a complete list of the interview questions), asking no interviewee more than 20 questions. Each interview lasted approximately one hour.

Data Collection

Although the researcher was able to conduct several interviews in person, time and circumstances led him to conduct most via telephone and one via e-mail. The researcher recorded the in-person interviews using a professional broadcast-quality MD recorder and a studio-quality lavaliere microphone and subsequently archived the audio onto two CDs. The researcher recorded the telephonic recordings directly onto a computer hard drive and subsequently archived the audio onto two CDs.

Ethical Considerations

Each interviewee was presented a *Research Participant Informed Consent Form* attached to a cover letter asking for their participation in this study. At the beginning of each interview, each interviewee was asked if he or she had read the informed consent form and if they were in agreement with it. Only after a positive response was attained and recorded did any interview begin. All data regarding participants' identification has been securely archived along with the CD recordings of the interviews.

Data Processing and Storage

The researcher processed the data collected from the individual interviews using direct-to-hard-drive audio software. The archived audio files on CDs and transcripts of the interviewees' answers provide a sufficient audit trail and resources for future researchers interested in replicating or improving on this study.

Data Analysis

The researcher analyzed the raw data using SPSS and Microsoft Excel software. The researcher cataloged the interview questions to separate the HD Radio data from the DRM data in a manner that allowed him to either analyze the two cases separately or to combine the data for an overall analysis of digitally modulated radio. By placing subject matter experts in various population groups, the researcher could cross-index their responses by group using SPSS or Excel software to identify variances and commonalities in thought among the groups. Using this methodology, the researcher found that the definitions of success and failure often varied from group to group, and the true definitions appear somewhere in the middle where there is agreement among the groups.

The literature and personal communication defines success for a new radio broadcasting technology as the act of capturing a majority of the listening audience and broadcasters. R. Brooks (personal communication, January 9, 2002) reported more than 50% of radio listeners have been listening to FM radio since 1979 and that 80% of listeners have been listening to FM radio over the last few years. Sterling and Kitross (2002) reported that since 1985, more than 50% of broadcasters have been transmitting their signals using FM technology. Thus, FM technology has achieved success by capturing a majority of the listening audience and broadcasters. This literature defines failure as a lack of listeners and broadcasters using a particular technology. As only approximately 10% of stations use AM radio technology (2% of all AM and FM stations over the last few years), it can be deemed a failure.

These definitions do not suffice for application to digital radio technology for the individuals interviewed in this study, each of whom had his or her own perspective on success and failure that varies along a long continuum. The researcher equally weighted and cross-indexed the responses to the core questions (SPSS Q2 to Q10) that he had asked all the groups to determine whether there was any agreement regarding their definitions.

Each group had its own specific area of specialization. As such, the innovators had much to say about strategy and marketing whereas the regulators expressed many thoughts and concerns regarding spectrum use and interference. Therefore, the researcher did not cross-index responses to questions concerning specialized areas of knowledge. The researcher also analyzed the responses of each group to several questions and then cross-indexed the responses only with other groups that shared the same interest. For example, the researcher cross-indexed the responses of the innovators and regulators because both are interested in the fairness of the regulatory process.

Through this analysis, the researcher gained a greater understanding of digitally modulated radio's potential for success or failure based on the participants' individual and collective definitions of these terms based on their personal experiences.

Pilot Study

The researcher conducted a pilot study prior to execution of the actual study using 9 subject matter experts selected from 3 of the groups. The researcher's intention was to determine whether the interviews would capture the needed data, whether the number of questions proposed for the interviews could reasonably be asked and answered within the span of an hour, whether commonality or differences existed among the groups, and whether face-to-face and telephonic interviewing (the methods used in the pilot study) would be effective methods for the actual study.

Validity and Reliability

Trochim (1999) described *credibility, transferability, dependability,* and *confirmability* as the four factors that determine the validity and reliability of qualitative inquiry. The researcher determined that this study was credible due to the credible nature of the information gleaned from the interviews with subject matter experts in digital radio technology, whose comments provided an accurate picture of the condition of HD Radio and DRM at the time of the interviews from the perspective of the interviewees.

Regarding *transferability,* the data obtained from this study could be applicable to the emergence of other new media technologies (such as HDTV, satellite radio, and iPodcasting) in much the same way as the lessons learned and mediamorphosis of the successful emergence of FM radio and the failure AM Stereo could be applied to digitally modulated radio. However, future researchers must determine how practical it is for this study to be generalized and applied to their work.

Dependability emphasizes the need to consider the ever-changing environment within which research occurs. New technologies are constantly evolving, even before their implementation and presentation to the mass market. If this study were conducted a year later (or even a year earlier), different results should be expected due to the constant technical evolution of HD Radio and DRM. If other researchers were to interview these same subject matter experts at a later date, they would be able to confirm the current state of the digital radio technologies at that particular time.

Confirmability describes the way in which others can corroborate the results of a research project. Confirmability in this study was derived from the various sources of data gleaned during the interviews. Each person's individual point of view offered a certain perspective on the development of the marketing, regulation, and capabilities of the new and diverse programming offered by these two technologies. Points of agreement from these multiple sources, as well as points of agreement with the literature, confirmed specific activities in the development of HD Radio and DRM.

In an effort to arrive at valid conclusions, the researcher triangulated the responses to specific answers from the various groups to determine and establish validity. Triangulation strengthened the validity of this study by allowing the researcher to corroborate one set of findings with another and examine the phenomenon of digitally modulated radio from a variety of vantage points (Banning, n.d.; Massey, n.d.)

Bias

The interviewees in this study expressed bias in the form of excessive optimism regarding the future success of digital radio, which may be due to the fact that most are stakeholders in this new technology and, with the exception of the interviewees in the "other" category, their personal success hinges on its success. Of the 50 research subjects in this study, only one consistently described the potential for failure of HD Radio and DRM technologies throughout his entire interview.

Capturing data from individuals who are members of the “other” groups that are not direct stakeholders in these digital modulation technologies yet involved in the radio broadcast industry offset this bias for success. These “other” groups included media critics, academics, an “innovative user,” and those involved with competing technologies, such as satellite digital radio. One individual in the HD Radio “other” category contemplated the failure of the radio broadcasting industry, with or without the emergence of digital radio. Those from the competing technology of satellite radio did not express a bias in favor of failure for HD Radio or DRM, and one operations manager of a satellite radio company even offered encouraging comments regarding HD Radio.

The researcher ensured that balance and uniformity existed between responses from direct stakeholders and those not direct stakeholders. In all likelihood, the truth regarding the reasons for the possible success or failure of digital radio technology is somewhere in the middle. By striving for this middle ground, this report has produced results that are closer to being bias free.

As they must demonstrate that personal interest will not bias their studies (Marshall & Rossman, 1999), Douglass and Moustakas (1984) urged researchers to examine their potential for bias and their preconceived notions of what they may find before beginning their research. Much like the stakeholders in digital modulation, this researcher is highly enthusiastic about HD Radio and DRM and hopes that they will become successful in the marketplace. Much like the engineers who developed the various form of radio modulation systems discussed in this study (AM, FM, and digitally modulated radio), this researcher greatly enjoys the benefits of the superior audio quality provided by these technologies. Prior to the beginning this research, the researcher presented papers and lectures to amateur radio associations regarding the technical characteristics of digital modulation and its potential for improved communication. The researcher also compared and contrasted AM and DRM in the mediumwave and shortwave bands in discussions with journalists and international broadcasters, to whom he presented audio samples.[2]

The researcher also provided these audio samples in CD format to activists who periodically speak with congressional staffers in an effort to gain added political support for digital radio transmission from U.S. governmental international broadcasting entities. Before beginning this study, the researcher was keenly aware of digital radio's potential to revitalize radio broadcasting, particularly shortwave radio, at a time when major international broadcasters are curtailing transmissions in shortwave radio due to its poor analog AM audio quality and increasing loss of audience share (Cuff, 2001; Heil, Whitworth, & Jury, 2004). DRM, in the opinion of the researcher, has the potential to reverse this trend.

The researcher has similar beliefs regarding HD Radio in the United States. The researcher became aware of the enhanced audio qualities of this new invention while attending an iBiquity (then USADR) meeting in May 1998 as part of a field trip by the Baltimore chapter of the Society of Broadcast Engineers to the iBiquity facilities in Columbia, Maryland.[3] The comparisons of AM, FM, and IBOC radio conducted at this

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[2] Audio samples comparing and contrasting AM and DRM IBOC audio quality in the mediumwave and shortwave are available at http://www.drm.org/system/centraudio2.htm.

meeting left a deep impression on the researcher in support of the new technology. Based on his involvement in these activities, the researcher took into account his potential for bias regarding the success of digitally modulated radio before beginning the data-collection process.

Conclusion

The researcher's use of multiple case-study methodology to capture data from principal individuals involved in the radio broadcasting industry allowed him to gain a clearer understanding of the status and progress of HD Radio and DRM at the time of the interviews (September 2006 to June 2007). The information provided by industry leaders personally involved in the digital radio modulation process allowed for the collection of a body of data that the researcher analyzed using SPSS and Excel software before triangulating to gain greater understanding of the marketability, regulation, programming capabilities, and potential for success or failure of HD Radio and DRM technologies. By doing so, the researcher gained greater understanding of the marketplace factors, stakeholder and regulatory actions, and listener values that impact digital radio's development and dissemination.

[3] Audio samples comparing and contrasting AM, FM, and HD Radio IBOC audio quality are available at http://www.ibiquity.com/hdradio/hdradio_experience.htm.

CHAPTER 4. RESULTS

Introduction

This chapter describes the data collection and data analysis procedures that the researcher employed to identify the current status and marketplace potential of HD Radio and DRM technologies. Based on analysis of the participants' responses to each research question, the researcher describes trends in the radio broadcasting and technology industries and their implications for HD Radio and DRM stakeholders.

Data Collection

The researcher interviewed 50 stakeholders involved in digitally modulated radio regarding their perceptions of the potential for the success or failure of their new and emerging technologies. These stakeholders came from five specific population groups or areas of interest: subject matter experts and business leaders at iBiquity and the DRM Consortium involved in various facets of digital radio technology strategy, marketing, regulation, and implementation; FCC officials concerned with spectrum management, interference issues, and technological regulation; manufacturers of commercial radio transmitters and receivers; broadcasters currently using or intending to use these new digital modulation technologies; noted industry commentators who have expressed views, both pro and con, regarding the advent of digital radio modulation; a competitor from the satellite radio industry; academics; and an "innovative user."

Of the 65 individuals whom the researcher invited to participate in this study, 7 declined to participate and 8 expressed interest in participating but could not do so due to time constraints. The remaining 50 individuals initially contacted comprise the study participants. The researcher conducted the interviews between September 15, 2006 and June 29, 2007. The researcher conducted 40 interviews via telephone using a broadcast-quality hybrid and digitally saved the audio onto a computer hard drive before archiving it onto 2 CDs. The researcher conducted 8 interviews in person and recorded the audio on a broadcast-quality digital MD player drive before archiving it onto 2 CDs. The researcher completed one in-person interview that had been interrupted due to a personal matter with the interviewee the following day as a telephone interview. The researcher conducted one interview via e-mail, with the interviewee supplying his answers to his copy of the "read ahead" document that the researcher had sent to all interviewees in order to prepare them for their interviews.

In general, the interviewees responded with a great deal of candor. Several indicated that they were expressing their own views and not necessarily those of the organizations for which they work, and many stated they do not want their employer's name mentioned in the final report. The researcher promised anonymity in the final report as a condition of their participation.

The original study design called for 25 interviews with HD Radio stakeholders and 25 interviews with DRM stakeholders, with 5 interviews with each of the 5 population groups comprising the two technologies for a total of 50 participants, as shown in Table 2.

Table 2
Proposed Number of Interviewees per Group

Group	HD Radio	DRM

Innovators	5	5		
Regulators	5	5		
Manufacturers	5	5		
Broadcasters	5	5		
Others	5	5		
Total	25	25	50	100 %

However, the researcher was unable to obtain the exact number of interviewees in each group called for in the proposed study design, but rather the numbers shown in Table 3.

Table 3
Actual Number of Interviewees per Group

Group	HD Radio	DRM		
Innovators	5	7		
Regulators	5	0		
Manufacturers	5.5	5.5		
Broadcasters	4	5		
Others	8	5		
Total	27.5	22.5	50	100 %

One interviewee, a senior manager of a transmitter-manufacturing corporation that produces both HD Radio and DRM transmitters, provided answers relative to both technologies. Consequently, the researcher considered him a partial interviewee for each.

Pilot Study

The researcher conducted the pilot study interviews from September 15, 2006 to October 25, 2006. The researcher's original plan for the pilot project was to capture data from interviews with 9 stakeholders representing the 3 population groups involved with HD Radio, as indicated in Table 4.

Table 4
Proposed Number of Pilot Interviewees per Group

Group	HD Radio	
Innovators	3	
Regulators		
Manufacturers	3	
Broadcasters	3	
Others		
Total	9	100%

However, as later occurred with the main study, the researcher was unable to obtain the exact number of interviewees in each group called for in the proposed pilot study design, but rather the numbers shown in Table 5.

Table 5
Actual Number of Pilot Interviewees per Group

Group	HD Radio	
Innovators	4	
Regulators		
Manufacturers	3	
Broadcasters	2	
Others		
TOTALS	9	100%

The results of the pilot study indicated that all the interview questions addressed the research questions, that the interviewer could ask and the interviewees could respond to the additional interview questions relative to each interviewee's particular area of expertise within one hour, and that each of the interviewees could provide substantive answers to all the interview questions. Analysis of the pilot study data indicated that SPSS software would not be an adequate analysis tool for the responses to all of the interview questions by all of the interviewees since SPSS only provided one cell for an answer to each particular question from each interviewee. Many interviewees provided multiple answers—some which were contradictory—to a single question during the pilot study.

Consequently, the researcher determined that another analysis tool was needed to analyze multiple responses to one question. Therefore, the researcher analyzed the interview questions for which all the interviewees provided only one answer using SPSS software as the statistical tool but analyzed the interview questions for which they provided multiple answers using Microsoft Excel. The researcher used one Excel worksheet page for each interview question and entered every response in a cell of a particular column. The researcher used 10 additional columns to indicate the 10 stakeholder population groups and entered "1" in the cell for the row representing the response and the column representing the interviewee's population group to determine within which groups answers were being derived. This method allowed the researcher to tally all the HD Radio and DRM group columns to determine differences in trends among their stakeholders and add all the HD Radio and the DRM totals together to determine trends among all interviewees.

Data Collection Limitations

The researcher experienced three limitations during the data-collection process:

1. The loss of some data during the interviewing process.
2. Difficulty in obtaining interviews with regulators.
3. The inability to conduct interviews with the management and leadership of the HD Radio Alliance.

Loss of Some Data in the Interviewing Process

At the beginning of each face-to-face interview, the researcher conducted a test recording to ensure that the portable MD machine was recording properly. Once the interview started, during several interviews, the recorder momentarily stopped in the middle of the interview before resuming recording again on its own. Although the researcher lost some data, he lost none of the data pertaining to the interview questions concerning the basic research questions listed in chapter 1.

Difficulty in Obtaining Interviews With Regulators

The researcher was unable to interview any of the ITU regulators involved in the DRM approval process. As a consequence, the researcher could not obtain statistical data or profound commentary regarding their perspective on the regulatory process or the eventual success or failure of DRM. Although one retired FCC regulator who had been involved in the HD Radio approval process was extremely enthusiastic about discussing HD Radio’s potential and the regulatory process, several other FCC regulators personally involved in the HD Radio approval process seemed quite aloof. Per one regulator's suggestion, the researcher directly contacted the FCC chairman with a request for interviews, which allowed the researcher to conduct interviews with 5 FCC regulators who participated in the HD Radio approval process.

Due to the lack of participation by ITU employees involved in the DRM approval process and the minimal amount of data provided by some FCC employees involved in the HD Radio approval process, the researcher could not gain a full understanding of the regulators' perspectives on not only the approval processes and procedures but also on the potential for the success or failure of these emerging technologies. This situation leads to the question: Do regulators feel any ownership concerning the success or failure of the technologies that they are tasked to regulate? From their lack of interest in participating in this study, the initial indication is that they do not.

No Interviews With the HD Radio Alliance

The HD Radio Alliance is an ad-hoc organization of radio broadcasters whose primary goal is to market HD Radio to the general public. The researcher sent e-mail messages to the two individuals listed on its Web site as points of contact requesting their participation. Although both responded, the researcher could not schedule an interview with one in a timely manner and the other did not want to participate in this study. Consequently, this study lacks valuable information and data regarding the HD Radio Alliance's effort to market HD Radio to the listening audience in the United States and the perspective of that organization's leadership.

Data Analysis

With the exception of one interview analyzed during the pilot project, the researcher analyzed all the interviews after completing the data-collection process between July 2007 and August 2008. During this process, the researcher found that many interviewees went well beyond merely answering the questions; they provided a rich text of profound statements. As a consequence, the researcher prepared a qualitative transcript of their in-depth answers, which provided a wealth of direct quotations that could be used in the final report. Due to the slow and arduous task of transcribing these responses, the researcher contracted a professional transcriber in January 2008 to complete the last 50% of the interview transcripts.

Anomalies in the Data Analysis

Although the responses from most interviews fell into general patterns, the responses from 2 participants significantly differed from those of the other participants. Neither is a major stakeholder in HD Radio or DRM, although both are intimately involved with radio. The researcher placed both in the "other" category, and referred to the participant involved with HD Radio as the "contrarian" and the participant involved with DRM as the "innovative user."

The Contrarian's Data

Although most interviewees believe there is some attainable benchmark of success for HD Radio and DRM, the contrarian expressed his belief that digitally modulated radio (and the radio broadcasting industry in general) is already a failure. A member of the HD Radio "other" category, former major market radio programmer, founding editor of a major trade publication, and professor at a major West Coast university, the contrarian is convinced that the radio broadcasting industry is already dead and that HD Radio and DRM will not revive it.

He stated that iBiquity is, in his opinion, "a fraud," and that broadcasters and programmers are misguided. He also feels that the inordinate amount of time already spent on wrangling over transmission standards and completing the regulatory approval process has made HD Radio a late entry into the marketplace in relation to satellite radio, iPodcasting, Internet radio, and the Apple iPhone, which will lead to its failure.

The contrarian expressed a similar negative view of the radio broadcasting industry in all his responses to all of the interview questions, in which he also issued an impassioned plea for broadcasters to consider using delivery systems other than traditional over-the-air radio (analog or digital) and to significantly improve the quality of their content. He based his comments, in part, on his experience as a former commercial radio programmer and, in part, on his knowledge of the media use of the next generation, of which he has knowledge from his work as a university professor and his personal observation of the next generation's specific lack of interest in radio.

The Innovative User's Data

Unlike all the other interviewees in this study, who are involved with the commercial or international radio broadcasting business in some manner, the innovative user is a scientist and an experimenter with radio who appears interested in its use for purposes other than commercial broadcasting. As a consequence, he had an "outside-of-the-box" approach to the use of DRM. He could see DRM become a successful technology not necessarily as a direct broadcasting service but rather as a data pipe in the shortwave. Much of his discussion involved using DRM in the shortwave as a networking tool over large geographical areas, which he explained is significantly cheaper than using satellite services. He also discussed his experiments with using DRM in the shortwave for transporting ship-to-shore (and shore-to-ship) e-mail, which, again, he cited as being significantly cheaper than using satellite, Wi-Fi, or Wi-Max technologies.

Responses to the Research Questions

Research Question 1: What Is Success and Failure?

What is success? To the question "How do you define 'success' for the HD Radio (or DRM) technology?" 49 of the 50 interviewees provided 90 responses, 43 for HD Radio and 47 for DRM, that yielded 72 separate definitions of success. One interviewee, the contrarian, could not define success, but provided five descriptions of failure for HD Radio. The interviewees' responses to the question that asked them to describe a definition or benchmark of success for HD Radio or DRM exist on a spectrum that stretches from "it is already a success" to "it has already failed." Most of the stakeholders defined success for HD Radio and for DRM technology as some level of marketplace penetration of digital receivers in the radio listening audience, ranging from 5% to 100% of the market. Appendix H provides a listing of all of their responses to this question.

Many of the interviewees believe that success hinges on the penetration of digital receivers into the marketplace. A senior manager at iBiquity contested, "The measure of success is definitely receiver sales," and a DRM transmitter manufacturer confirmed, "I think a lot of good work has been done throughout the years. But without what I call commercial receivers that are mass produced, then we cannot be successful." An HD Radio competitor from the satellite radio industry described success as a technology becoming very ordinary and the "usual" technology. Drawing an analogy to the television industry, he stated, "As far as I know, it is very difficult to buy a black-and-white television anymore. At one time, color was the new thing, but eventually, it has become commonplace, until, eventually, the other technology just goes away."

Others, however, believe that there are two major factors that measure success: broadcasters adopting the new technology and receiver diffusion. An HD Radio transmitter manufacturer supported the view that receiver penetration must be preceded by broadcaster adoption, stating, "I really think there are two avenues. One vector is the adoption or the implementation of transmission [and] the other vector is receiver penetration." Several participants set an extremely high bar for defining success, arguing that success would not occur until all radio receivers in the marketplace are digitally capable. A stakeholder from the HD Radio innovator group echoed the HD Radio competitor when he argued that HD Radio

> will be on every radio station and in every radio. . . . This is very much like the transition from black-and-white to color television. . . . It's the upgraded service, and you don't ask for a color TV when you go into a store any more. You ask for a TV.

A regulator also set a high bar when she stated that she would consider HD Radio a success only after the transition from the hybrid IBOC mode with both analog and digital signals to the all-digital mode had occurred.

Capturing all of the market is a lofty goal. FM radio, which has never captured more than roughly 80% of the market, was considered a successful technology when it had captured more than 50% of listenership and broadcasters, as discussed in chapter 2. It was at this point in time that broadcasters started adding commercial advertisements to their programming, and FM became a commercial success in the marketplace. The same holds true for HD Radio and DRM; the point of success is when they become commercially viable.

Several DRM stakeholders had a completely different conception of success. They believe that DRM is already a success simply because it works. A DRM broadcaster explained, "DRM technology will be successful if users find it helpful to get data of some sort from point 'A' to point 'B.'" The innovative user argued that HD Radio and DRM are not new technologies but rather newer versions of digitally modulated radio, which has been in use for years for purposes other than broadcasting. From a technical perspective, he stated, "We've had a lot of experience with it. So we think that success with this is just a 'no brainer.' It's going to happen." Many of the DRM stakeholders had an almost an amateur, "ham-radio" approach to success for DRM and did not seem to take market forces into consideration. In general, the HD Radio stakeholders used a more market-based approach in their definitions of success.

What is failure? The contrarian spoke at length about the fact that HD Radio is late to market in relation to other new and emerging media, such as satellite radio and podcasting. He believes that over the last few decades, broadcasters have done an extremely poor job in producing new and innovative content, which he believes accounts for the departure of large segments of the listening audience. The radio broadcasting industry is in trouble, in his opinion, and HD Radio does not have the wherewithal to save it. He stated the next generation is finding more of the content that they want on media other than radio. He argued that the iPhone, which had been launched the day of his interview, is more relevant to the needs of the public than HD Radio, and urged radio broadcasters to see their collective future in the iPhone (see Appendix I for a transcript of many of his extended comments about the failure of HD Radio and the entire radio broadcasting industry).

Although there is a great deal of truth in the contrarian's commentary, relinquishing hope in domestic commercial mediumwave and VHF and international shortwave over-the-air terrestrial radio broadcasting (AM, FM, and digital) in favor of other emerging media is too drastic a move, as analog radio still retains a formidable segment of the market. Although this market is shifting, radio still has the opportunity to compete for listeners, and digital radio, as the other stakeholders affirmed, can assist terrestrial radio in remaining a valuable medium for consumers.

Research Question 2: Critical Factors in Success and Failure

The researcher asked all the interviewees to describe the most important factors for success or failure for HD Radio or DRM. Regarding success, 49 of the 50 interviewees provided 119 responses (68 from HD Radio stakeholders and 51 from DRM stakeholders), providing 63 unique answers to this question. The contrarian stated that there were no factors for success. Regarding failure, the interviewees provided 130 responses (68 for HD Radio stakeholders and 62 for DRM stakeholders), with 62 separate critical factors for failure. Appendixes J and K display the ranking of the factors for success and failure, respectively.

Critical factors in success. Receiver issues appeared to be the most significant concern among the participants, as they provided 50 responses (30 HD Radio and 20 DRM), which included 9 answers that cited receiver issues. An HD Radio transmitter manufacturer asserted, "It has to have a cost to the consumer, which is reasonable. Receivers have to be inside of a certain price range, under $100." A chief engineer for a large consolidated group of radio stations affirmed, "We need the receivers to be installed just like AM-FM radios are installed now in cars. We need to have it as not an option." A DRM broadcaster who also expressed concern with the distribution of receivers in the marketplace argued that the most pressing issue is marketing: "The receivers have been promised by the manufacturers for a couple of years now and a lot of buying has come and gone, and so people are becoming a bit anxious to see what happens." The innovative user agreed, "Receivers are going to be the key. . . . Maybe this is where the government steps in and begins to seed the market to get people to listen to it and then after that it'll take off."

A former FCC regulator and coauthor of a major college textbook on broadcasting cited the portability of digitally modulated radio receivers as a factor for success when he mentioned that many potential listeners always carry iPods with them. He surmised, "If they can listen to HD Radio with iPod technology and those little tiny earbud headphones, then I think it is far more likely to be adopted quickly and, obviously, be more convenient for listeners."

Yet others feel that providing unique and compelling content to the listening audience from digital radio is the most critical factor for success. Although many broadcasters, innovators, and transmitter manufacturers cited the importance of introducing and promoting receivers in the marketplace, one receiver manufacturer stated, "The absolute most important critical success factor is that you be able to get content on the new technology that you cannot get anywhere else…'Content is king' is an overused phrase [but it is true]." A DRM broadcaster with an international perspective agreed that the most critical factor is the transmission of new and compelling content when he observed that "all the recently launched radio systems have shown that content really is what motivates people to go and buy the radios." The participants thus highlighted two possible avenues for success: transmission and reception. The critical factor for success in transmission is the broadcasting of compelling content only available from digital radio, which entices listeners to embrace digital radio and helps stave off the erosion of the radio listening audience, whereas the critical factor in reception is introducing affordable receivers into the marketplace.

An HD Radio stakeholder stated that because the FCC primarily examines technical issues and interference within the spectrum as measures of success, "our definition of success would be that the technology would be implemented by a majority of our radio stations without an undue number of interference cases that we couldn't resolve." The amount of interference to co-channel and adjacent-channel analog stations caused by the digital component of the HD Radio IBOC signal will not be fully known until all stations are on the air with IBOC composite signals. However, Mr. Robert Savage, the general manager of the 20,000-watt WYSL (AM) station outside Rochester, New York, has already filed an interference complaint with the FCC concerning the IBOC signal emanating from the 50,000-watt WBZ (AM and HD) station in Boston on his adjacent channel (Stimson, 2007). Another interviewee, the contrarian, a former major-market radio station programmer and founding editor of a major trade publication, believes that there is no one factor for success. When asked how digitally modulated radio could succeed, he responded, "It can't succeed by taking something that nobody wants, which is radio. Radio really started its decline, from a content point of view, in the late 80s in my view."

Clearly, the most critical factors for success are introducing receivers into the marketplace, making them available to consumers (particularly in their cars), educating consumers regarding the value of digitally modulated radio in order to encourage them to buy the receivers, and encouraging radio stations to provide compelling content to give listeners a reason to purchase the new receivers. An excellent example of providing compelling content available only on the new technology as an enticement for the public to buy new digital receivers is in the programming provided by WAMU HD-2 in the Washington, DC market. For many years, WAMU was known for its bluegrass music programming, and developed a loyal audience base of bluegrass fans. As an NPR affiliate, however, its programming took a drastic shift when its FM and HD-1 stream became all NPR-developed news and information programming including the nationally syndicated *Diane Rehm Show,* which emanates from the WAMU studios.

WAMU now programs bluegrass music 24 hours a day on its HD-2 stream. Therefore, its established and highly dedicated bluegrass audience members can continue listening to their favorite music on WAMU, but must buy new HD Radio receivers to do so, and these new receivers must be available to be in the marketplace for them to buy. Four participants in this study argued that a critical factor for success in introducing the receivers into the market is the alignment of all interested parties and industries. This coordination, they feel, is difficult but another critical for success.

Critical factors in failure. Again, 52% of the participants cited the most critical factor is introducing receivers into the marketplace at a reasonable price. Many stakeholders believe that if affordable receivers remain unavailable for consumer purchase, HD Radio and DRM will fail. As a DRM broadcaster stated, "The big problem is getting those receivers out." A DRM transmitter manufacturer expressed similar thoughts when he stated, "The key to all of the success is an inexpensive receiver available in the market very quickly." An HD Radio competitor, the broadcast operations manager of a satellite radio company, spoke of the importance of combining HD Radio with other electronic products and installing HD Radio receivers in cars without manufacturers expecting some form of royalty payment: "The trick is going to be how does the broadcast business or the receiver manufacturer or the transmitter—whoever it is—start getting the product designers to include it without expecting a payment?"

Eight interviewees expressed concern with digital radio's ability to provide new content, without which the new technologies could fail. A faculty member of a major university in Washington, DC who once served in the FCC drew an analogy between AM Stereo and digital radio technology in this respect:

> AM Stereo never offered anything new, never really had a chance. . . . What you really want to do is give people a real reason to hunger for HD Radio—to really want to listen to it . . . and history tells us that technology alone is not enough.

The innovative user contested that the technology was sound but that the marketplace factors of transmission and reception, which he feels are connected, could lead to failure. When asked about the possible causes for the failure of DRM, he responded, “If nobody is listening to it, for whatever reason, it’s going to fail. If there isn’t a large enough population to keep it viable, it will fail. It will not fail because of technical reasons.” The contrarian believes that digital radio has already failed. While describing the critical factors in the failure of HD Radio, he stated, “I think it’s too late, too little. . . .This [HD Radio] is a loser. And they’d better get off of it and get into the mobile space.”

HD Radio and DRM will undoubtedly fail if new receivers are not available, if digital radio does not provide innovative and interesting content available that cannot be received elsewhere, and if the listening audience is not informed of the availability of this unique content.

Research Question 3: SWOT Analysis

Based on their area of expertise, the interviewees responded to questions regarding the strengths, weaknesses, opportunities, and threats to HD Radio and DRM.

Strengths. Forty-nine of the 50 interviewees provided 134 responses (62 from HD Radio stakeholders and 72 DRM stakeholders) identifying 63 strengths of HD Radio and DRM. One interviewee, the contrarian, believes that there are none. Appendix L lists the strengths in rank order.

Multiple participants from every population group (62% overall) described improved audio quality as one of the major strengths of HD Radio and DRM. As one

DRM broadcaster explained, “Obviously, it’s quality because the big problem with shortwave has always been the audio quality—the static, fading, the interference—compared to standard local AM transmission, or certainly FM transmission.” A regulator agreed, “For AM, it’s a dramatic improvement in audio quality, stereo as opposed to mono, a tremendous improvement in noise immunity, and an elimination of the static and other noise that has plagued AM radio for years.” A college professor in the “other” category who had been closely following the HD Radio rollout stated, “It is digital. Everything else in the world is digital or becoming so and, therefore, the potential strength is that it could be—and this sounds a little overstated—the savior of radio.”

The improvement in audio quality of HD Radio and DRM is indeed dramatic, particularly when compared to AM in the shortwave and mediumwave. It was the improved audio quality of HD Radio that caught the attention of the researcher during the playing of audio from experimental IBOC transmissions at a 1998 SBE meeting at iBiquity’s headquarters and of audio samples of DRM’s Field Test 2-A at Dr. Messer’s desk at the U.S. International Broadcasting Bureau, which served as the impetus for this paper. In the researcher’ opinion, the vast improvement in audio quality brought by digitally modulated audio, as perceived by one with the well-developed ear of a classically trained musician, puts these two forms of broadcasting on par with the audio quality of CDs, and perhaps even better than that of digitally compressed MP3 files. The ability to transmit and receive audio of this quality, particularly in the AM bands, is a milestone toward success in and of itself.

As many participants in this study stated, improved audio quality by itself will not make a new broadcasting technology successful. Twenty percent of the participants cited the provision of new services, including multimedia and data services, as a strength of HD Radio and DRM technologies, which offers a new perspective on what "radio" truly is; that is, radio is no longer "just audio." Interestingly, participants of every population group cited these services, with the exception of HD Radio broadcasters and HD Radio "others," indicating that they continue to consider "radio" as an "audio-only" medium.

An international media analyst interested in this new facet of radio stated, "It will be able to send text along with the audio and it will even be able to send pictures—slow-scanned pictures—along with it turning old-fashioned radio into a multimedia experience." A DRM broadcaster argued that its multimedia strength "could be value-added services, which could bring revenue to the broadcaster." HD Radio and DRM broadcasters may consider their added digital transmission capabilities as simply data pipes in a manner similar to how WRNR (FM) in Annapolis, Maryland leases its subsidiary SCA capability to transmit digital telemetric data on behalf of the local electrical power company to lower the power usage during peak periods.

Another strength cited by 14% of the participants was that HD Radio and DRM work in existing spectrum allocated for broadcast purposes. An HD Radio transmitter manufacturer explained, "There is no additional spectrum required from governments, so this could either be in the United States or globally." As a consequence, radio stations can stay on their currently authorized frequencies, maintaining the status quo in terms of station ownership, locations on the radio dial, and the relative worth of radio properties.

One strong point the participants cited regarding terrestrial radio, particularly with HD Radio in the United States, is that of localism; unlike satellite radio, terrestrial radio does not become homogenized nationally but retains its ability to serve a specific city or a local area, thus preserving its local flavor. Two interviewees addressed this aspect of HD Radio, including one HD Radio transmitter manufacturer who stated, “Satellite and Internet-based [radio] and some of these others certainly have the ability to offer a very wide area of distribution via the satellite footprint, but it is pretty hard to tailor that to a local market.” Indeed, localism is an important feature in the promotion of HD Radio in the United States. Even a small one-kilowatt AM station in a rural community could provide the high-quality audio and ancillary services of HD Radio to its listeners while delivering local content, such as reports from live high-school sporting events and discussions of local politics by well-known community members.

Four of the DRM stakeholders believe that cost savings to broadcasters are important strengths of their new technology. Because digital transmission requires less power than analog transmission, it allows for significant savings for broadcasters in terms of electricity costs. A committee chairman of the DRM Consortium specified,

> The digital transmitter only uses 40 to 50% of the electricity [used by an analog AM-FM transmitter]. So your electricity bill, which is pretty high with the high-powered transmitters of 200 to 500, or even 1,000 kilowatts, is reduced by 40, 50, 60%.

Although applicable to both forms of digital radio modulation, the cost savings for broadcasters in terms of power requirements for transmission is a particularly important strength for international shortwave broadcasters using DRM. Despite a cap on the output of domestic radio stations of 50,000 watts in the AM band and 100,000 watts effective radiated power (ERP) in the FM band, international shortwave stations of 250 and 500,000 watts are not uncommon. The cost of the electricity needed to operate one of these facilities is exorbitant, and was a contributing factor in the closing of the VOA shortwave transmitting facility in Kavala, Greece (Elliott, 2006). DRM technology can help these high-powered broadcasters transmit their signals in a cost-effective manner. Another cost-saving aspect for broadcasters is that they can transition to the new technology without purchasing an entirely new transmitter. They can merely exchange the exciter stage of their transmitter and keep their old high-power amplifier stages of their existing transmitter.

Weaknesses. Forty-nine of the 50 interviewees provided 92 responses (47 from HD Radio stakeholders and 42 from DRM stakeholders) to list a total of 65 separate weaknesses of digitally modulated radio. One DRM broadcaster could think of none. Appendix M provides a rank-order listing of all the responses.

Sixteen percent of the interviewees expressed concern with the current high prices of HD Radio and DRM receivers. A writer for a major trade publication who is also a college professor at a Midwestern university best expressed this concern: "The biggest weakness is receiver cost. We've got to see a lower cost receiver. And the other weakness is availability of the receivers as OEM [original equipment manufacturer] product in new vehicles."

The price of receivers will inevitably decrease over time, but will it decrease sufficiently rapidly in relation to the emergence of other digital technologies, such as the iPod and the iPhone? Should investors or the government subsidize HD Radio and DRM receivers? There is an increase in construction cost to put a digital chip in a radio receiver, but this cost must be offset in some way to make the receiver affordable to the average consumer. In this way receivers can proliferate in the marketplace and the technology become successful.

Ten percent of the interviewees expressed concern that the success of these new technologies would render existing radio receivers useless (when HD Radio and DRM are in the all-digital mode), forcing consumers to purchase new radio receivers. A DRM broadcaster described this situation on a worldwide scale: "There are hundreds of millions of these analog shortwave receivers out there now that all the world can use, and people will have to buy a new DRM capable radio to pick up these transmissions."

As stated earlier by a regulator, the eventual goal of iBiquity and the DRM Consortium is that radio becomes an all-digital mode of transmission. As such, the HD Radio IBOC or DRM simulcast mode of transmitting in both analog and digital is only a hybrid transition as new digital receivers enter the market. In order for the final goal to occur, all analog receivers must be replaced, requiring consumers to take action by replacing all their analog radio receivers with digital receivers, which could require much time. Indeed, there could be an extended "analog sunset" unless governments intervene in much the way that the U.S. government mandated transition to digital television in 2009.

Four DRM stakeholders expressed concern that there is no "graceful degradation" of the audio signal as a listener travels away from the transmitter or as conditions change, but rather a "sharp knee" or "cliff effect" in the radio receiver's response to the DRM signal. If the signal level at the receiver is above a threshold point, the listener receives near-CD quality audio, but when the signal dips beneath the threshold point, the signal disappears completely. A writer for a shortwave listening magazine described, "If reception is not possible via DRM, reception still might be usable in an analog sense. So the fact that DRM is indeed digital is a weakness of it in that it either works or it does not." An international media analyst corroborated, "It doesn't have the robustness of analog shortwave. And the real strength of shortwave is that it can get into far-away places under adverse conditions, including jamming and interference and poor propagation."

Although this issue was not cited as a weakness by any of the HD Radio participants in this study, it is nonetheless a concern with HD Radio, as evidenced by the researcher's practical experience in listening to HD Radio in a mobile environment. For 2 years, from March 2007 until the time of this writing in February 2009, the researcher has been listening to an HD Radio aftermarket car radio receiver while driving primarily in the Washington, DC and Baltimore, Maryland market areas. The researcher found the "sharp knee" or "cliff effect" of the HD-2 and HD-3 stations, by which the audio completely disappears when the signal level unexpectedly dips beneath the threshold point, extremely frustrating, whether listening to music or speech. The researcher found the "blend" back to analog FM from the HD-1 stream not to be so disturbing unless the timing between the station's digital signal and analog signal is not properly synchronized.[4] However, he found the "blend" from digital HD Radio to analog AM at the threshold point extremely disturbing due to the severe disparity between the HD Radio signal and the analog AM signal in terms of equalization, timbre, volume, and quality of signal (crystal-clear in digital but with noticeable amounts of man-made and atmospheric interference and anomalies in analog).

To date, only one radio station, the Clear Channel Communications-owned WCAO (AM) in Baltimore, broadcasts music (in this case gospel) programming with HD Radio on the AM band in the entire Washington, DC and Baltimore markets. While listening to this station in a mobile environment and driving outside of the Baltimore beltway area or in the extreme downtown area of Baltimore, where large buildings can interfere with the RF signal, the constant flutter from digital to analog and back as the signal level constantly drifts above and below the threshold point makes the music on this radio station entirely unlistenable on an HD Radio receiver. The "blend," in this instance, is not a benefit, but rather a detractor. Even though the audio quality of analog AM radio is relatively poor, the music on WCAO (AM) would, undoubtedly, sound better on an analog-only AM radio receiver, because then it would at least remain at a constant volume, timbre, equalization, and quality.

As these four DRM stakeholders have described and as the researcher has personally discovered, the "sharp-knee" or "cliff" effect is a definite weakness for both forms of digitally modulated radio under study in this paper, particularly in a mobile environment. Another writer for another shortwave listening magazine echoed this

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[4] The researcher listened to the initial unsynchronized signals of WAMU and WCSP in Washington, DC and WYPR and WEAA in Baltimore as each of these stations transitioned from analog FM to HD Radio. In each instance, the stations made a correction within the first few weeks of IBOC transmission.

sentiment when he stated, "It is not portable. Radio—I'll say it a million times—a radio has to be portable."

An HD Radio broadcaster concerned with the time and rate to market described "a relatively limited window of opportunity. It's not terribly narrow, but there is one. And I think if the receivers are not there in quality and at quantity at attractive prices in that window, that's a potential problem as well." A DRM transmitter manufacturer concerned with poor marketing to consumers lamented, "It's hard to convince somebody that there's something new out there and they should spend money to use it without some good way to convince them of that." As these stakeholders contested and which they affirmed in their response to a later research question addressing marketing, the lack of marketing to consumers at this juncture is a weakness.

One developer expressed concern regarding the difficulty in coordinating the movement of multiple industries to facilitate a smooth transition to the new technology. He clarified, "Those industries have very divergent viewpoints and different things that drive them. So our challenge is a little bit like the United Nations trying to move all those guys together at the same time. It's just hard." As Clausewitz described the actions of armies on the battlefield, the coordination of diverse forces (e.g., infantry, cavalry, and artillery) is a major challenge and a key to victory; so too is bringing a new technology to market. Transmitter development, production, and sales; receiver development, production and sales; chip development and production; content development and production; and advertising and promotion all must be coordinated in an effective manner in order to gain market share and achieve success.

As they did in their responses to other questions, the interviewees mentioned a lack of compelling content as a weakness of digitally modulated terrestrial radio. As a strength of terrestrial radio is localism, one apprehensive HD Radio broadcaster mentioned the added expense of producing additional content for the new HD-2 and HD-3 streams required on a station-by-station basis nationwide. As previously discussed, the local flavor of terrestrial radio is a key ingredient in the potential success of HD Radio, but that success is tied to the quality of the content that it carries. Local small-town broadcasters need to maintain high-quality production standards if digital radio is to achieve success. Otherwise, listeners will continue to migrate from radio toward other emerging digital technologies that have a more professional presentation.

Finally, one innovator expressed concern about the name of the technology itself, *Digital Radio Mondiale,* explaining, "A big weakness is DRM stands for 'digital rights management,' which in the media industry is a horrible thing. People run away from it." iBiquity's technology was initially described to the industry during its rollout to broadcasters as *IBOC*, but because this term has no particular meaning to the general public, iBiquity developed a new trademark for the technology—*HD Radio*—which many believe stands for *high definition.* A senior manager at iBiquity stated that although *HD* does not stand for anything at all—it is merely a trademark—it creates the impression that HD Radio is a higher-quality product than analog radio in much the same way that consumers perceive HDTV as a higher-quality technology than analog television. By not making a similar connotation, the *DRM* trademark could be a weakness.

Opportunities. When asked about opportunities, 49 of the 50 interviewees provided 113 responses (57 for HD Radio and 56 for DRM stakeholder) that yielded 68 separate answers. One interviewee only cited the lost opportunity of providing niche programming, as satellite and Internet radio currently do, on account of HD Radio's late entry into the marketplace. Appendix N provides a complete listing of the interviewees' answers.

Surprisingly, only 3 interviewees—one HD Radio innovator and one interviewee from each of the HD Radio and DRM "other" categories—cited the improved audio quality of digital radio as an opportunity. Multiple interviewees in every population group involved with HD Radio (44% of all HD Radio participants in this study) and one DRM transmitter manufacturer believe that the greatest opportunity for digitally modulated radio lies in the multicasting capability of HD Radio in the FM band. More specifically, the HD-2 and HD-3 streams have the potential to become additional revenue streams for broadcasters once a critical mass of the public becomes listeners. An HD Radio broadcaster involved with the Digital Radio Broadcasting subcommittee of the National Radio Systems Committee (NRSC) described this opportunity when he stated, "We've effectively been handed a second, and possibly, as we go down the road, a third program channel for the cost of the equipment to put it on the air. That's an amazing opportunity!"

A regulator claimed that the multicasting feature of HD Radio in the FM band would open up new opportunities for broadcasters to provide public service programming to niche communities in their locale, whether they are "language communities or cultural communities or religious communities or the blind and print handicapped." An HD transmitter manufacturer who agreed that multicasting is an opportunity believes that datacasting is another untapped prospect for broadcasters:

> People are putting these GPS navigation systems in their cars, so we could have real-time data about traffic and that sort of thing. There are probably a lot of data opportunities that need to be found. Traffic information is just one.

Three participants believe that these new technologies provide an opportunity to offer new content to rural areas. Regarding driving through Alaska, the "innovative user" described, "I've driven for hours and hours up there and there are no radio stations. It's the only place I've been where you put 'search' on the radio and it just keeps going around and around and doesn't find anything." DRM, he feels, has the capacity to provide coverage for large geographical areas, such as the state of Alaska.

Another 3 interviewees believe that niche programming to small communities could be viable on the HD-2 and HD-3 streams. A manufacturer of both HD Radio and DRM transmitters described a scenario based on his overseas experience: "If you did a secondary program channel, jazz would appeal to a very high end of the demographic in India. The people who are jazz aficionados would run out and buy the receivers without a problem." Stakeholders in both HD Radio and DRM feel that these new technologies could breathe new life into the radio broadcasting industry as they bring it into the digital age alongside other audio products. As one DRM transmitter manufacturer stated, "It will be a resurrection of HF broadcasting all over the world." Describing opportunities for local shortwave broadcasting on 26 MHz, he explained, "You can cover the whole states of Mississippi and Arkansas with a 100-kilowatt shortwave transmitter." A writer for a shortwave listening magazine agreed, "The biggest opportunity to DRM is that it could make the shortwave band viable again."

Two regulators and a college professor in Washington, DC believe that the most significant opportunity lies in the improved audio quality for radio stations broadcasting in the AM mediumwave band. No longer would these stations be limited to talk, news, information, and sports formats; with full-spectrum audio and stereo capabilities, they could return to a musical format. One regulator described, "The increase in audio quality is dramatic in AM in contrast to the FM situation. I think it could keep that creaky old service alive longer than people expected."

Once again, the contrarian argued that opportunity for HD Radio to succeed had already come and gone, and it is now arriving too late to the marketplace in relation to other emerging technologies: "The opportunities that are not there now but would've been there would be to do niche programming before the Internet, before satellite. Now it's irrelevant."

As defined by the interviewees, the opportunity for HD Radio broadcasters in the FM band lies in multicasting, which has the potential to triple their revenue stream and help them retain listeners with new, diverse, and niche content—if that content is appealing. AM broadcasters also have new opportunities for more diverse programming with HD Radio. Shortwave broadcasters using DRM can provide improved audio to listeners thousands of miles away by providing low-cost networking over large geographical areas. With DRM technology in the 26-MHz segment of the shortwave band, broadcasters can start local programming on an entirely new band that is already allocated for broadcast purposes.

Threats. Among the significant number of threats looming on the horizon for HD Radio and DRM, the participants were able to identify 49. Forty-eight of the 50 interviewees provided 110 responses (55 from HD Radio and DRM stakeholders each) illustrating the threats to these new technologies. One HD Radio broadcaster and one DRM manufacturer believe that there are none. Appendix O displays a rank-order listing of all the threats identified by the interviewees.

The interviewees overwhelmingly described the greatest threat to HD Radio and DRM technologies as the other emerging media technologies currently capturing market share from terrestrial radio, such as MP3 players, satellite radio, and Internet radio. Fifty-eight percent of the interviewees (62% of HD Radio and 53% of DRM stakeholders) described other emerging technologies as the greatest threat. Although all the HD Radio innovators and broadcasters and all the DRM manufacturers provided this answer, only one DRM innovator, one DRM broadcaster, and one HD Radio regulator from the FCC did so.

A broadcast operations manager at a satellite radio company attributed the threat from these other media technologies in part to HD Radio's late arrival to the marketplace, explaining, "HD Radio has been signed for a long time, but it has not been available for a long time. Satellite radio has been coming up on 6 or 7 years, and for many of those, it has been integrated into the dashboard." An HD Radio broadcaster stated, "I think the proliferation of MP3 players and devices is certainly a threat. They're probably not listening to radio."

A transmitter manufacturer who constructs both HD Radio and DRM high-powered commercial transmitters voiced concerns about Internet radio stations taking over the international broadcasting function once assumed by shortwave radio: "The two major strengths that shortwave has, which are broadcasting to expats overseas and broadcasting political messages, may be being taken over by Webcasting as Internet listenership and Internet capability continues to advance around the world."

A DRM receiver manufacturer who discussed the decision-making process that consumers must use when deciding whether to purchase a DRM receiver or an Internet radio receiver asked, "Why buy a radio when you can have any channel you want via the Internet?" An innovator expressed his concerns regarding the listening habits and media choices of the next generation:

> A lot of people are growing up in a world without radio for the most part. When I went to college, there were a lot of Hi-Fis and CD players were just coming out, but everyone had a radio. Now, I doubt if when you go into dorm rooms there's a radio anywhere unless you're streaming off the Internet.

Almost every emerging technology eventually loses ground or is eventually rendered obsolete by an even better technology with continued innovation and improvement. A good example of such evolution is audio storage, which in the last 100 years has gone from Thomas Edison's wax-and-wire cylinders to vinyl records to magnetic tape to CDs to .wav digital audio files for computers to the current standard—compressed MP3 audio files for computers and MP3 players.

Even before HD Radio and DRM are established in the marketplace, some stakeholders can already visualize digitally modulated radio being overtaken by an even newer and better technology. For these visionaries, the "killer application" is worldwide, ubiquitous, high-speed Internet access in a mobile environment, often referred to as *Wi-Fi* or *Wi-Max*. Futurists in the interviewee population predict that when scientists and engineers can fully develop and launch ubiquitous DSL-quality wireless Internet access (Wi-Fi, Wi-Max, or 3G technology), radio broadcasting as we know it—AM and FM as well as terrestrial digital and satellite—will cease to exist. One HD Radio stakeholder stated, "If you believe Wi-Fi/Wi-Max will be out there ubiquitously mobile [and] free, that's probably not a good thing for radio broadcasters and, therefore, the overall size of our opportunity could be threatened." Similarly, a writer for a major trade publication stated, "Wi-Max is not a threat yet but it could be in the long term. Once people get Internet capability that's reliable in the car . . . that is a real threat to all kinds of audio entertainment." Regarding the rollout of HD Radio, her boss, the managing editor for the same publication, stated, "These kinds of competing media [Wi-Fi and Wi-Max] may make this discussion [about HD Radio and DRM] somewhat moot."

Regarding new and improved systems of the future that may possibly overtake HD Radio, a regulator who had been involved in the HD Radio approval process asked, "When analog broadcasting has all gone away and this digital is sitting by itself, will we then come up with a better digital system? If you want to call that a threat, I don't know, you can call it progress."

When ubiquitous worldwide Wi-Fi or Wi-Max exists, the box that is now in the car known as a "radio" will have become a small computer with a sound card, amplifier, and speakers. Instead of tuning in to a radio station, whether terrestrial or satellite, on a particular frequency or channel, the listeners of the future will input a URL into their mobile minicomputer to listen to anything from anywhere in the world on the Internet. These futurists predict that ubiquitous worldwide wireless Internet access is about 40 to 50 years away. In the meantime, they believe that digital modulation can serve listeners' needs.

The interviewees identified lack of receivers in the marketplace, broadcaster's apathy, and the slowness of the rollout in the marketplace as major threats to the rollout of HD Radio and DRM among the seven threats that they mentioned. A DRM transmitter manufacturer believes that DRM success depends in large part on large receiver manufacturing companies; if they do not take an interest in it, DRM could fall by the wayside in a manner similar to AM Stereo. He explained, "Until the big guys get in there and say, 'We're going to be part of this market,' it's going to be slow in rolling out the receivers." An editor of one of the major trade magazines stated that one major threat to HD Radio is "apathy from stations that aren't adopting it or are kind of focused on the fact that 'I'm a radio station. I don't have to change.'"

Apathy, as described by these interviewees, is inversely proportional to the excitement generated by these new technologies. If HD Radio and DRM developers do not generate the "wow" factor (as a major market FM station general manager stated in his closing comment) among broadcasters, manufacturers, and the listening public, then apathy will set in, and both versions of digitally modulated radio could be doomed to failure.

The contrarian in this study brought the SWOT analysis to a close by asserting that HD Radio is not sufficiently developed to face threats. Radio in general, he believes, is threatened by other emerging media technologies, but HD Radio has not sufficiently developed to even warrant facing threats. When asked to identify threats, he responded, “When you can get your Internet on the fly, everything else is over. HD has never made it yet and radio has made it, but it is on the decline. Radio is over, increasingly, as people turn to the Internet.”

Research Question 4: Marketing

The researcher did not ask all the participants questions regarding the marketing of DRM and HD Radio because many, such as the FCC regulators, do not have any involvement in marketing or a working knowledge of the marketing currently being conducted. In interviews with other participants, such as those with iBiquity and DRM Consortium innovators, lengthy discussion of other facets left little or no time for discussion of marketing. The researcher approached the topic of marketing on various levels, as there is marketing from iBiquity and the DRM Consortium to manufacturers, marketing from manufacturers and innovators to broadcasters, and marketing from broadcasters to the general public.

Marketing to manufacturers. Six interviewees—2 iBiquity senior vice presidents, the iBiquity CEO, the director of engineering of a major broadcasting group who sits on the iBiquity board, 2 DRM Consortium committee chairmen, and a DRM broadcaster—

discussed marketing to transmitter manufacturers. One senior manager expressed his belief that iBiquity's marketing to transmitter manufacturers was going extremely well and another other executive described iBiquity's marketing to five licensed manufacturers as going well. The third innovator and the director of engineering were both skeptical.

All the DRM stakeholders stated that they have not observed any direct marketing to transmitter manufacturers. The DRM broadcaster stated, "To be honest, I did not perceive any direct marketing from the Consortium aimed at transmitter manufacturers. It seemed like many of the manufacturers were already part of the consortium as we were." Both the HD Radio and DRM stakeholders explained that marketing to transmitter manufacturers occurs by direct contact. Marketing to transmitter manufacturers appears be a one-on-one process. iBiquity and the DRM Consortium have both maintained booths at venues such as the annual NAB show in Las Vegas, where they have had the opportunity to discuss their new technologies with transmitter manufacturers. Most of the major transmitter manufacturers are producing HD Radio and DRM transmitters, as evidenced by their advertisements to broadcasters in trade publications. An HD Radio transmitter manufacturer stated, "I think that one of the things that iBiquity has been very good at is establishing a core relationship with broadcast manufacturers. While I would say there is not marketing per se, it tends to be personal selling." A DRM Consortium committee chairman describing the involvement of transmitter manufacturers in the Consortium stated, "The overall DRM project has been driven by the transmission manufacturers because they were rightfully concerned that their business might become obsolete when nobody wants to hear shortwave anymore."

Three iBiquity managers described the issue of marketing to receiver manufacturers as "nonstop," "cautiously," and "slower than we hoped for." A DRM Consortium chairman also stated "cautiously." A senior manager stated, "We have 40 to 50 licensees now—people that already have a product in the marketplace or are building product or are getting ready to build product. But there are still other guys out there we need to lasso." He then described iBiquity's business development team and its mission of developing relationships with receiver manufacturers. Of the 2 interviewees who described the marketing process to receiver manufacturers as "cautious," an innovator asserted that aftermarket manufacturers were more likely to build receivers than OEM manufacturers: "There are the aftermarket [manufacturers] who are usually a little more willing to adopt at a shorter period of time because they can come to market more quickly and their overall risk is less." A DRM transmission service provider, stated, "I don't see broadcasters producing compelling content, and it's a difficult balancing act. Sony or Blaupunkt aren't going to suddenly mass produce millions of receivers if no one is rushing out to buy them."

Marketing to receiver manufacturers does not appear to have been as successful as marketing to transmitter manufacturers. Many of the major manufacturers, such as Pioneer and Panasonic, have not yet ventured into producing HD Radio or DRM receivers. Receiver manufacturers do not feel that they have as large a stake in the success of HD Radio or DRM as do transmitter manufacturers. The process of marketing to receiver manufacturers, however, seems to be the same as that of marketing to transmitter manufacturers, with one-on-one contacts from the innovators' business development teams.

Marketing to broadcasters. The interviewees provided 57 responses regarding marketing to broadcasters (33 from HD Radio stakeholders and 24 from DRM stakeholders), yielding 52 separate answers. Appendix P displays a rank-order listing of their responses.

The interviewees rated marketing to broadcasters from "very good" to "poor." Although 3 interviewees believe that iBiquity performs the majority of HD Radio marketing to broadcasters, 3 believe that transmitter manufacturers do so. When describing iBiquity's marketing efforts, a vice president stated, "The marketing we're doing to the broadcasters has primarily to do with awareness building, with promotion opportunities, with, really, assistance." A senior manager of a transmitter manufacturing company believes that neither HD Radio nor DRM innovators have sufficient resources to effectively market to broadcasters: "That's a unique position because that puts the manufacturer in a situation where he is not only selling a product but he's going to sell the concept first, and that's a little bit more complicated." A troubling response came from two HD Radio manufacturers, one of whom stated, "I don't believe I'd call it marketing so much as fear mongering and trepidation." They believe that because the major broadcast groups have such a large stake in HD Radio and wield so much influence, they are pushing this technology on the rest of the industry.

Three HD Radio participants believe that marketing to broadcasters is only taking place at the major-market level, one believes that the marketing to small-town broadcasters is poor, and all believe that second- and third-tier broadcasters are being ignored. However, a general manager of a small-town radio station understands the necessity of this approach, explaining, "They're going to go where the money is too. So I think they spend their time having conversations, largely, with group ownership and with others, and they spend their time pushing this at shows."

A similar situation holds true for DRM. Because most transmitter manufacturers and many of the big international broadcasters are members of the DRM Consortium, there is a considerable amount of buy-in at that level. However, as one DRM transmitter manufacturer stated, "The small local stations might not be aware of that technology. And again, they may think that DRM is 'digital rights management.' So I think that the smaller broadcasters need to be informed of the DRM."

Marketing to the general public. Three senior managers from iBiquity and one academic who is also a writer for a major trade publication discussed marketing HD Radio to the general public. The editor of an international trade publication, a senior manager of a shortwave transmitter manufacturing company, and 3 DRM Consortium committee chairmen discussed marketing DRM technology to the public. Appendix Q displays their responses.

The stakeholders in both technologies believe that marketing to the public must be done by someone other than the innovators. When asked about marketing HD Radio to the general public, a senior manager stated, "It's primarily being driven by the broadcasters. . . . [iBiquity] had what I would call a very minor role in encouraging them to do that, but it was pretty much done by the broadcasters themselves." A DRM Consortium committee chairman stated, "We really view the marketing pieces to the general public as being outside of our control, currently, and it really needs to be in the hands of people who do this thing for a living, i.e., manufacturers and retailers."

Two HD Radio stakeholders spoke about HD Radio Alliance's marketing to the general public. Another senior manager at iBiquity describing the goals of the HD Radio Alliance stated, "This is a stand-alone entity which uses pledged assets from the broadcasters to run awareness advertisements, to run call-to-action to retail distribution education." The HD Radio Alliance has developed radio advertisements and a six-course program of study for retail sales associates outlining HD Radio's history and features, as well as various sales strategies.

The strategies for marketing DRM to the general public appear much less defined. A European member of the DRM Consortium stated, "I don't think there's something directly analogous from DRM itself to consumers as the HD Radio Alliance in the States." As he was describing DRM marketing to the general public, a transmitter manufacturer stated, "It needs to be much more focused. Not only does there need to be focus in terms of shortwave but there needs to be focus in terms of mediumwave, and that's going to be a much more difficult scenario."

Although the marketing of HD Radio and DRM to transmitter manufacturers and first-tier broadcasters has been successful, it has been less successful to receiver manufacturers, local broadcasters, and the general public. Receiver manufacturers do not have the same incentive to invest in HD Radio or DRM as do transmitter manufacturers and the major broadcasters. However, even the marketing to these manufacturers does not seem to have yielded considerable results. Although receiver manufacturers are stakeholders in HD Radio and DRM, their success or failure is not tied as closely to these technologies as is the success of transmitter manufacturers and broadcasters.

Because the researcher was unable to conduct interviews with members of the HD Radio Alliance, he could not obtain data on its specific efforts. The researcher's observations indicate that the HD Radio Alliance had been instrumental in developing radio advertising for HD Radio, which radio stations with HD streams appear to air only during periods of unsold time.[5] However, there has been precious little cross-media advertising for HD Radio. Despite observing on-air radio advertisements for HD Radio, the researcher has observed no newspaper, television, or Internet pop-up advertisements; no advertising on mass-market Web sites (such as the Drudge Report, Washingtonpost.com, or Google); or any billboard signage in the Baltimore-Washington, DC metropolitan area, with the exception of one billboard at a Washington, DC Metro subway station.

Marketing at all levels appears to be a painstakingly slow process, but HD Radio seems to be promoting its technology more successfully than did AM Stereo during its rollout. Because commercial radio is an advertising-driven media, it appears that HD Radio could be introduced much more effectively to the general public by using

[5] Unsold time refers to airtime on a radio station that has been allocated for commercials but has not been sold. Therefore, an HD Radio commercial run during unsold time has no detrimental impact on the radio station because it does not run at a time when a profit-bearing commercial could have run.

resources readily available in the industry that currently sells other products and services to the mass market.

Research Question 5: The Role of the Regulators

Almost all the interviewees agreed that the primary causes of the failure of AM Stereo technology were lack of FCC regulatory support and lack of a single technological standard in the marketplace. Because the researcher was unable to conduct any interviews with ITU regulators involved with the DRM-approval process, this discussion of regulatory issues primarily focuses on HD Radio in the United States and the role of the FCC.

When the researcher asked 12 HD Radio stakeholders if they thought that the FCC had treated HD Radio fairly, unfairly, or preferentially in the regulatory-approval process, 9 responded fairly, 1 responded fairly and rapidly, 1 responded cautiously and critically, and 1 responded that HD Radio had been given "preferential treatment" due to experimental licensing. When the researcher asked 5 of these same HD Radio participants if they believed that standard FCC processes and procedures had been followed in the HD Radio approval process, they all responded in the affirmative. When the researcher asked 9 DRM participants the same question regarding the ITU, 4 stated, "Fairly," 4 stated, "I don't know," and one stated, "I have not heard of any problems."

The researcher asked all 5 FCC regulators, 1 iBiquity manager, and 1 participant from the HD Radio "other" category if the concepts of public interest, convenience, and necessity (PICAN) had entered into the FCC's decision-making process. Their eight answers to this question cited seven specific ways in which HD Radio serves the public's interest in terms of convenience and necessity by improving audio quality, adding additional content within the current allocation scheme, revitalizing the AM band, by redressing "a disastrous several decades of AM technical regulation that resulted in a much more stringent rule" following the FCC trend toward deregulation, and providing advantages to the consumer by responding to consumer desires. Regarding broadcaster necessity, they cited that radio broadcasters feel that they will become obsolete even more rapidly if they do not go digital. Appendix R displays a rank-order listing of their responses .

The researcher asked all the regulators and a representative from iBiquity's general counsel why they do not believe that any digital technology other than HD Radio has the potential to become the U.S. broadcasting standard. Why did the "standards war" of AM Stereo not exist with the relatively swift approval of HD Radio technology as the U.S. standard? Two regulators and an innovator stated that there has been no competition from other technologies, 2 regulators stated that Eureka-147 DAB would not work in the existing spectrum, and 1 regulator stated that CAM-D has been late to the market and has never demonstrated evidence of working in the presence of analog signals.

A concern among many of the interviewees in this study was the way in which the testing and evaluation of IBOC technology had been conducted. Unlike the various AM Stereo technologies, all of whose testing and evaluation had been conducted by FCC labs, the NRSC in conjunction with the Consumer Electronics Association (CEA) had sponsored the testing and evaluation of IBOC technology in the AM and FM bands. After they had reported their findings to the FCC, the FCC had conducted no corroborative testing of its own. When asked if the FCC should have independent engineering capability of its own or if the FCC commissioners should have engineers on their individual staffs, 10 of the 22 HD Radio stakeholders answered affirmatively, as indicated in Figure 9.

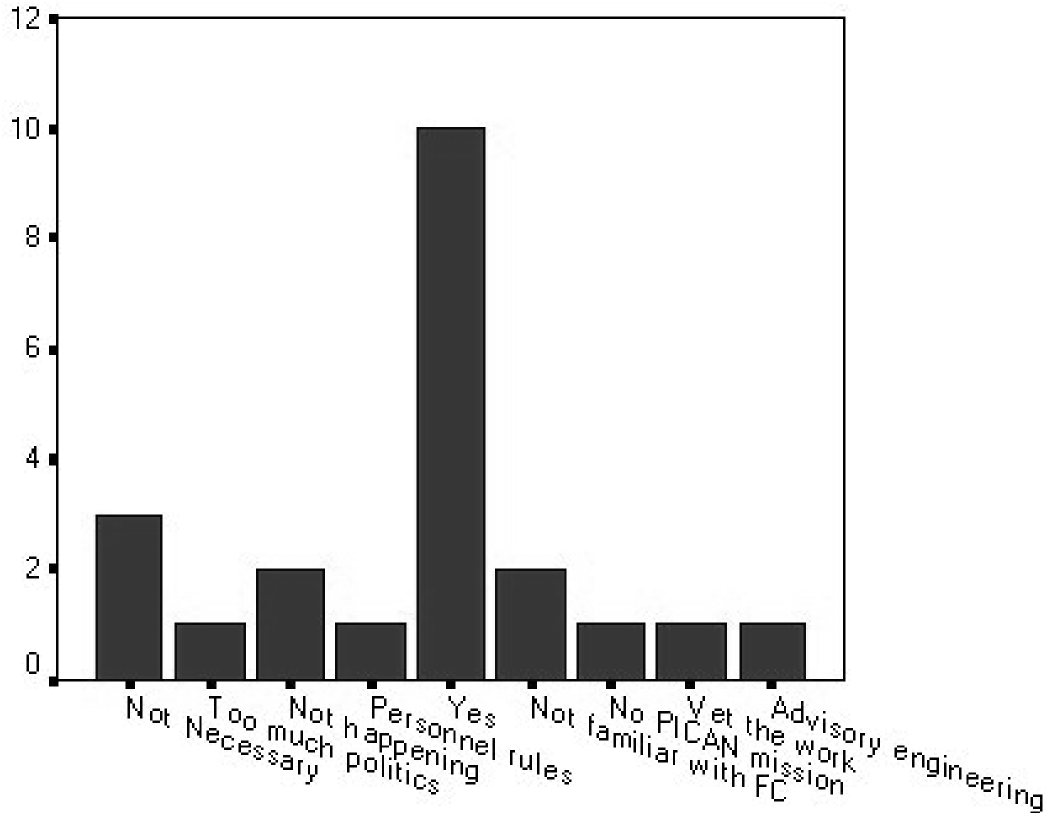

Figure 9. Participant responses regarding independent testing by the FCC.

Another concern was how and why the FCC had never approved the out-of-channel design of IBOC technology: Why is out-of-channel digital sideband transmission not considered "spurious radiation,"[6] and what is its impact on adjacent and co-channel analog stations? Figure 10 provides a graphic representation of the approved AM IBOC design.

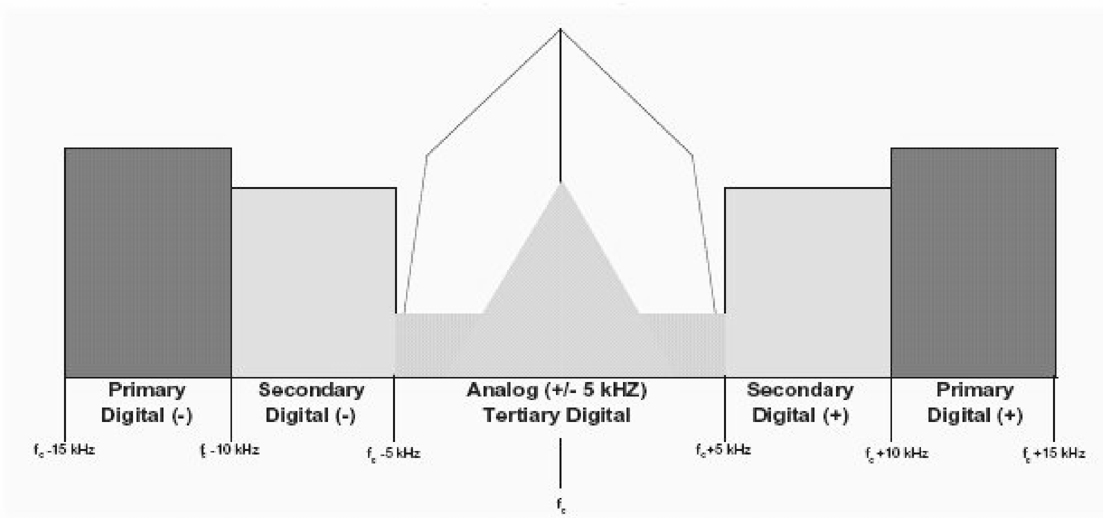

Figure 10. IBOC composite signal. From AM620_KMKI. Retrieved August 11, 2009, from http://www.hfunderground.com/wiki/images/b/b2/AM_IBOC_Mask10.gif

As indicated in Figure 10 (hfunderground.com, n.d.), the primary and secondary digital sidebands extend outside of the allocated AM channel and into the secondary and tertiary adjacent channels. A noted international media analyst described this problem with an interesting analogy: "It's like parking your car in a supermarket parking lot full of Hummers. Everybody can park there but you can't open your doors. So it's a real problem."

[6] The researcher vividly recalls receiving an FCC cease-and-desist order as a junior high school student for operating a poorly engineered novice-class 75-watt amateur radio station that produced "spurious radiation" that could be heard on out-of-channel frequencies.

One innovator responded to this analogy by adding, “Except they’d be really small doors. That would be the key to the whole thing because our digital signals are really low power, so they squeeze in under the interference requirement.”

When the researcher asked 6 stakeholders about the out-of-channel IBOC design, all responded that the FCC had accepted it because the out-of-channel digital sidebands fall below the FCC interference mask, as shown in Figure 11.

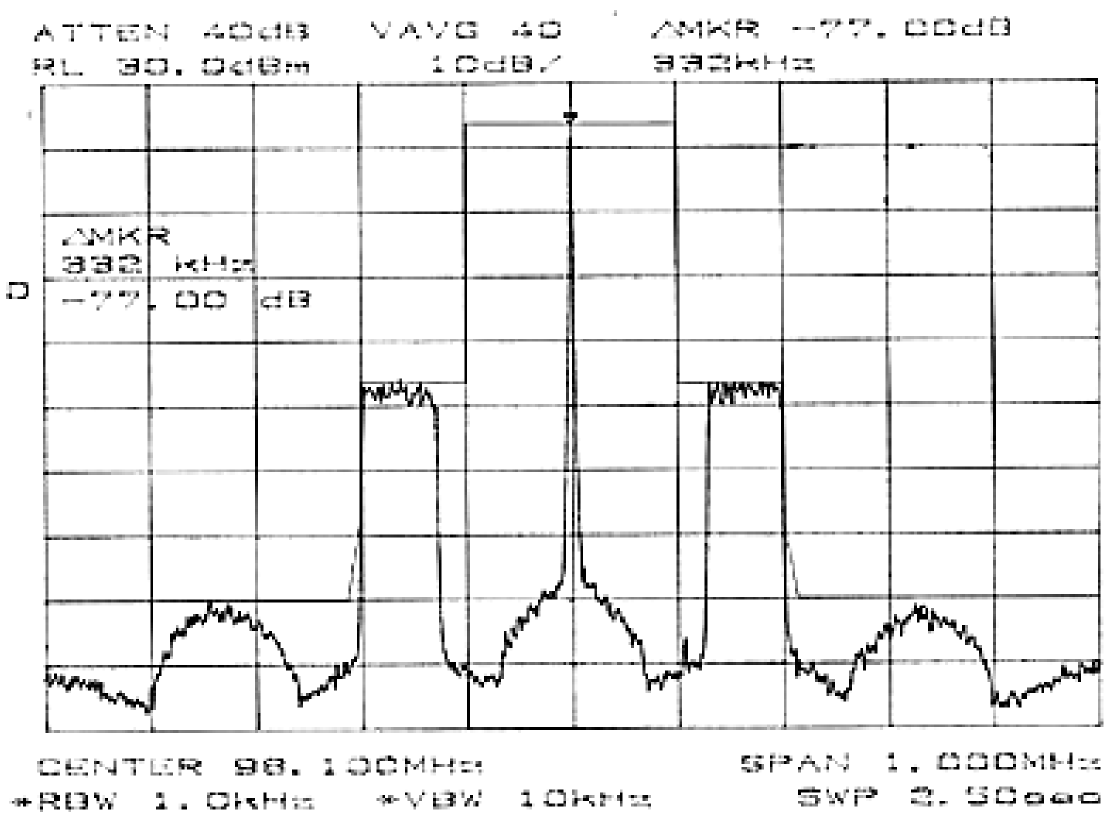

Figure 11. IBOC signal with FCC interference mask. From Continental Electronics, retrieved September 23, 2008, from http://www.contelec.com/images%5CSpectral-plot.jpg

When asked how the FCC should address interference issues, 1 regulator suggested reducing power in the digital sidebands, whereas another regulator argued that interference issues should be taken on a case-by-case basis.

The role of the regulators is extremely important during the approval process, as they can determine the success or failure of an emerging technology by either accepting or rejecting it. Beyond the approval process, their role appears almost negligible. HD Radio became the U.S. national standard primarily because there was a lack of competition from other digital technologies. As one regulator stated, “This was a one-horse race, and it’s not hard to pick the winner.” After approving the HD Radio technology, the FCC seems to have taken a laissez-faire attitude in terms of its eventual success or failure. Its only concern and involvement at this juncture appears to be with the resolution of any possible digital interference complaints from existing analog stations.

Unlike for HDTV, for which the FCC mandated conversion from analog to digital by June 2009, the FCC has proposed no action to accelerate the analog sunset for HD Radio. Without further regulatory support for the entrance of HD Radio receivers into a marketplace rife with technological competition, FCC inaction may be a prescription for failure.

Research Question 6: Value to the Listener

The interviewees in this study described 18 ways that HD Radio and DRM provide value to the radio listener. Appendix T provides a rank-order listing of their 42 responses (25 from HD Radio stakeholders and 17 from DRM stakeholders). Nineteen percent indicated that digital radio's greatest value to the consumer is better audio, which creates a more pleasurable listening experience. An international shortwave broadcaster in the United States affirmed, "The biggest value is the increased audio quality. Listeners are used to all of the bad things about shortwave reception—static—and this will give them the ability to hear far-off stations with the same type of quality [as local stations]."

Sixteen percent believe that the new multicasting capability of HD Radio in the FM band brings the greatest value to the consumer. A regulator stated, "WAMU here in Washington is a great example of that. They have a couple of multicast channels . . . so there's an increase in programming diversity. I see a lot of opportunities for niche programming."

When the interviewer then asked what new programming they envisioned that digital radio would provide for radio audiences in the 21st century, the interviewees provided 52 responses (27 for HD Radio stakeholders and 25 for DRM stakeholders) that yielded 39 separate answers, which are shown in Appendix U. Five interviewees—4 HD Radio stakeholders and 1 DRM stakeholder—stated that, as in the example of the success of FM, content is the route to success. An editor of a major trade publications stated, "The short answer is the technology alone [will not make it succeed]. Content is the key. Content is the king over and over and over." An author of several books on the radio broadcasting industry stated, "If the stations provide a greater diversity or variety of programming using those multiple digital streams and not simply more of the same stuff then, I think, HD can make a heck of a difference." The interviewees discussed “narrowcasting” on the HD-2 and HD-3 streams, citing several examples of diversity and new programming, including local, jazz, classical, and holiday programming; the broadcasting of local bands and entire CDs; the introduction of new formats such as “edgy” country music; and the coverage of NASCAR with pit-to-crew communications. A trade paper editor suggested,

> Let’s think like “microcasters.” Let’s be clever. Let’s use those outlets in clever ways and, if three of them don’t work, the fourth one might be really, really hot. You might start the new “thing” that’s actually going to cause a 17-year-old to want to consume it rather than chase them away.

Two DRM stakeholders from the “other” category did not agree with the premise that the introduction of new content on FM had been a factor in its success. The innovative user stated, “No, I don’t think that content has anything to do with it. I think the content on FM and AM is the same. I think the audio quality on FM is clearly superior.” He defended DRM technology by arguing, “Shortwave radio has clearly not been superior in sound in the past, with the fades and the multipath distortion. Now it will be.” Two HD Radio participants believe that FM’s success was due to a combination of better audio quality and new and diverse content.

Ten percent of the interviewees believe that value would come from new services and datacasting. Others cited specific digital improvements, such as Program Associated Data, Electronic Program Guides, time shifting of content similar to TiVo for television, subscription services, and the direct purchase of songs heard on digital radio from iTunes. A regulator stated, “I think it’s a necessary step. It’ll allow them to offer the features that people are coming to expect and that only a digital signal can do it.”

In general, the interviewees asserted that the value of digital radio to the consumer relates to three specific areas: higher-quality audio, greater diversity of content, and new digital services. Higher-quality audio is particularly significant in the AM mediumwave and the shortwave bands. Diversity of content can be achieved through the multicast capabilities of HD Radio in the FM band; by the potential of an entirely new digital DRM band for local programming in the 26-MHz range of the shortwave; and by the improved clarity of signal of extremely distant stations in the lower- and mid-shortwave band regions, which allows their diverse content to be audible with high quality at greater distances. The data-pipe capacity of digital radio appears to have so much potential that the breadth of services it can offer is yet uncharted. These three areas constitute the primary value provided to the customer by bringing HD Radio and DRM into the marketplace.

Research Question 7: Length of the Digital Sunrise

The interviewees' answers to this question were based on 2 variables: their personal definition of success and the length of time that they believe is necessary for a technology to achieve a particular benchmark for success. Figure 12 shows the responses of 19 HD Radio interviewees. Comparing the digital radio transition with that of HDTV, an innovator stated, "The analog sunset is a critical issue [with HDTV]. That's because there is spectrum to be reclaimed, which is hugely valuable and people want it. That's not the case in radio, so it will be a more market-based transition." Considering the sunrise to success for HD Radio, another senior leader and innovator stated, Look at the natural lifecycle of radios. Portable products are on a 5- to 7-year lifecycle. But a car radio might have a 10- to 12-year lifecycle. And so you have to protect those products for that period of time.

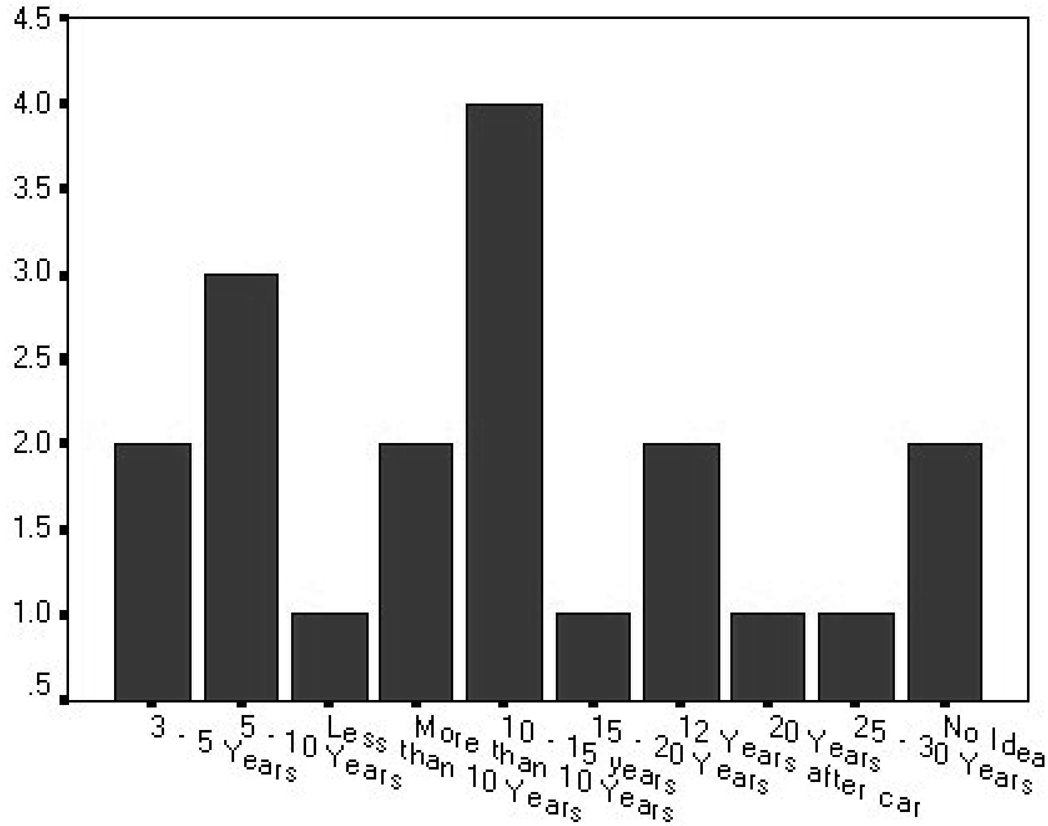

Figure 12. Participant estimation of the length of the HD Radio digital sunrise.

Figure 13 shows the responses that 18 DRM stakeholders provided regarding the length of the digital sunrise for their technology. Some feel that DRM should already be in the marketplace and that the process has been too slow. One DRM broadcaster stated, “Some people are disappointed that they’ve been in the dark too long and the sun should have risen a couple of years ago. I think it’s got to be soon or not at all.” He argued that the sunrise must begin within the next 12 months (at the time of the interview, by the end of 2008), with the sale of over one million DRM receivers. He explained, “If we’re not on track on that kind of time line, I think DRM is going to regress or will have just lost its opportunity." A DRM Consortium committee chairman also concerned with the timing of DRM stated, "If in 5 years [2012] no indication of a real market penetration is visible then, I think, it might even fail."

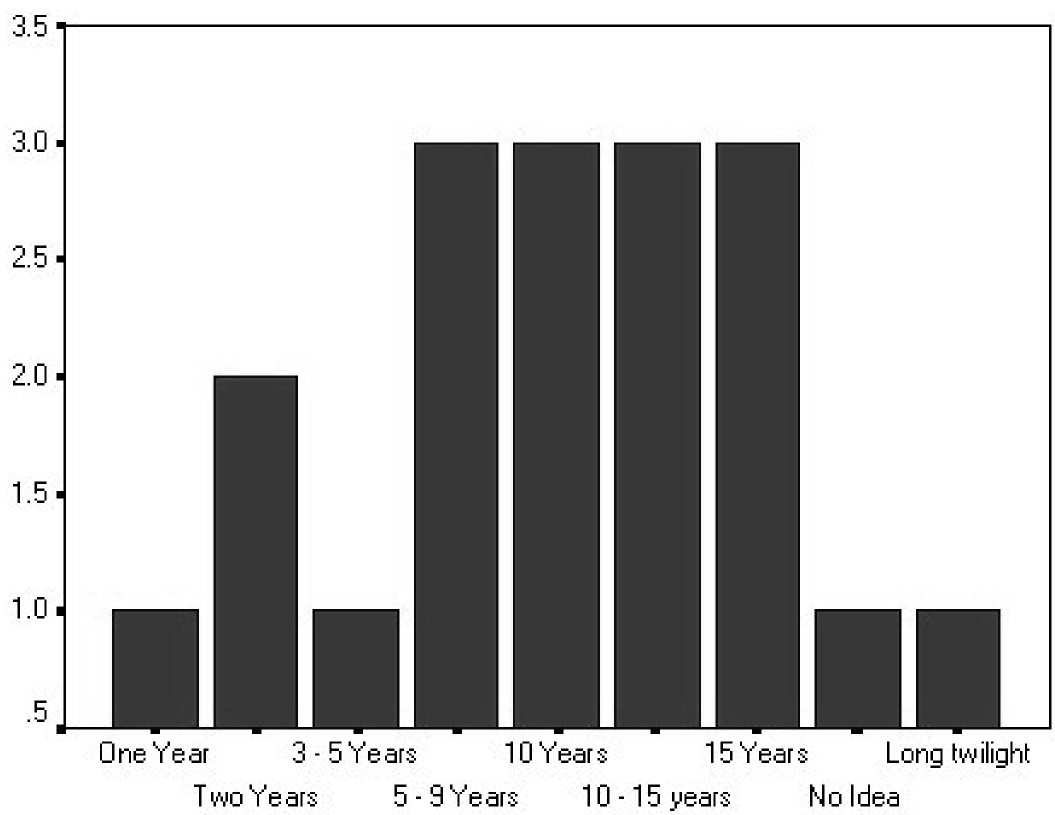

Figure 13. Participant estimation of the length of the DRM digital sunrise.

As many of the interviewees have stated, the lifecycle of analog radio receivers must be taken into consideration when determining the digital sunrise for HD Radio and DRM. As analog receivers are replaced with digital receivers, digital radio stakeholders hope that audiences will migrate to the new digital content and that broadcasters using both technologies will dispense with concurrent analog and digital IBOC and simulcast transmission and convert to all-digital modes. The next 5 to 15 years appear to be the critical window of opportunity for both technologies, as it is likely that both technologies will have reached the threshold of success or failure somewhere between 2011 and 2022.

Additional Factors in Success

When time permitted, the researcher asked 26 of the interviewees if they agreed or disagreed with the conclusion forwarded at the end of the literature review: the new broadcasting modulation technologies will not succeed solely due to their ability to improve radio audio quality but also on account of their stakeholders' ability to market their technologies, receive the support and approval of the relevant regulatory bodies, and provide additional value to the listener. As shown in Figure 14, 13 agreed with the statement, 12 expressed that something should be added to or emphasized within it, and 1 disagreed with it.

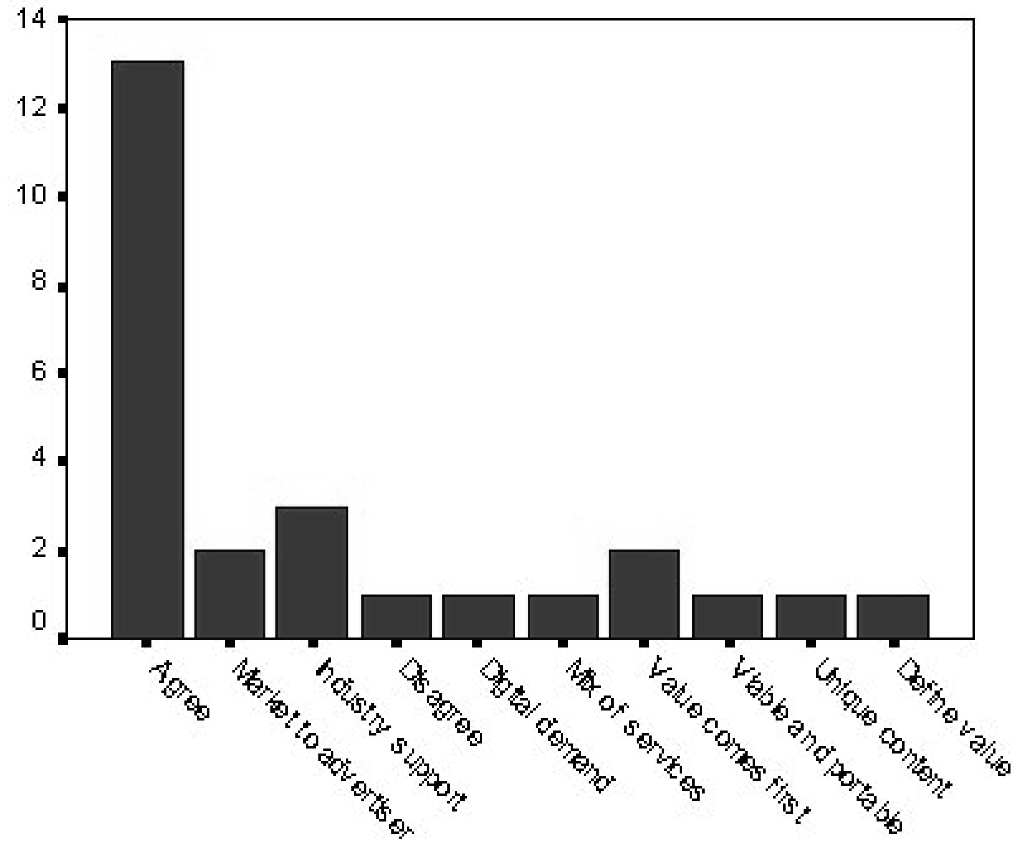

Figure 14. Additional factors in success.

Three stakeholders believe that a fourth factor—industry support—is necessary for a new and emerging technology to become successful. A former FCC employee turned academic explained, “FM shows that [there should also be industry support] because it took Armstrong and a few others a long time to get the industry, or at least parts of it, behind FM.” A trade magazine editor added, “Our current regulatory environment has certainly shown that if the industry wants it, it’ll probably get it or vice versa." When asked if there should there be a fourth critical factor of industry support, a manager at a trade association stated,

> Absolutely. And certainly IBOC digital radio has had that support, and I think the proof is in the pudding. It's been adopted by the FCC, it's being rolled out by industry, receivers are being made, and NAB has been at the forefront of that effort.

Several interviewees believe that value to the customer is the most important factor. An HD Radio receiver manufacturer stated, "I would prioritize them and say that the consumer value is the most important. And the element of that which makes sense in this context is content, unique content." A manager at a satellite radio company agreed and provided an interesting analogy:

> I think that it is true. I think I would put the customer—I know they are not in a 1-2-3 order—but that is probably the highest one and the most unpredictable. . . . You know the story of the guy who opens this dog food factory and he uses only the finest ingredients and has a fantastic television commercial but when you open the can, the dog will not eat it? So the customer thing probably comes first.

An HD Radio transmitter manufacturer added, "I would agree with that but it would be tough to rank them 1-2-3. They all have to converge into a perfect storm."

Once again, 1 interviewee—the contrarian—disagreed with the others:

> There's an elephant in the room here for this conversation. And that elephant is our digital, mobile, online world. And we keep forgetting it. It's almost like discussing Civil War military tactics. You might learn something if you were to fight a similar type of a war. But in the day and the age we're in right now, you couldn't really do that. The way the world is today is that mobile, online, with a market that's attention-deficit prone, with a record industry providing you with 90% of your content [that is] in turmoil as to what it is. And we're here talking about HD Radio?

Industry support should be included among the factors for success discussed in chapter 2. Armstrong was garnering industry support for his invention of FM in 1933 and

1934 when he demonstrated its capabilities to RCA engineers. Likewise, the DRM Consortium and iBiquity have been attempting to garner industry support by presenting their technologies to manufacturers and broadcasters. Lack of industry support, in addition to lack of regulatory support, is one of the critical factors in the demise of AM Stereo technology, as it contributed to a lack of broadcasting industry (as well as FCC) agreement on a single technological standard.

Closing Comments

When time permitted, the researcher asked several participants whether they had any additional comments to add to the discussion or if they believed that a particular point had not been fully addressed. An iBiquity vice president closed his interview by commenting on how much the marketplace had changed from the rollout of FM radio and how rapidly modern technologies evolve: “FM was allowed to evolve. It took 20 years. We don’t have that luxury.” Many of the participants expressed great optimism about the future of digitally modulated radio at the conclusion of their interviews. A senior manager of an HD Radio transmitter manufacturing company stated, “We are very excited about our participation. We believe that the conversion to digital is a huge opportunity for any broadcaster, domestic or global, that is looking to go through it.” At the end of his interview, an international DRM broadcaster from Canada stated, “I think that the sun will rise eventually. . . . People can carry around some of their favorite music on iPods and the same, but I think there’s still a need for live broadcasting.” Another DRM broadcaster from Great Britain stated, “I think there’s a lot of obvious opportunities in the revitalization of shortwave, of AM, and of the increased quality.” An enthusiastic retired FCC regulator who had been involved in the HD Radio approval process stated, "I'm a little concerned with some of these 'come late Charlies,' whether it be DRM, Digital Express, or Leonard Khan's system. But overall, the marketplace is going to be the one at this particular point that will have to embrace it."

The managing editor of an international trade publication expressed concern with the slow pace of digitally modulated radio's entry into the market despite the research that had been invested in it. He clarified, "DRM now maybe isn't as far as I would really like it to be just on the technology introductions rollout curve. But I think it's doing better than some others." An iBiquity vice president concluded his interview by arguing that despite the unwieldy process of establishing regulatory standards, the NRSC process was "very effective at building industry consensus and vetting and answering industry concerns in an environment that is more free flowing and has more of an exchange of information than you have in a typical FCC public-comment process."

A member of the DRM Consortium expressed concern with not only getting his new technology into the marketplace but also educating consumers about the new and advanced features that it offers. He explained, "People aren't familiar with the ability to 'time shift' radio in a way that they have with television. It's interesting that the simpler medium has lagged behind the more complicated medium in that sense." With regard to the new features of HD Radio, an FCC regulator indicated that there are still some issues that need to be resolved. He asked, "Could they also have a stream that's a pay stream, and should there be limits on the amount of that they can do and what kind of public service obligation should apply to pay streams to the extent they do them?"

At the close of their interviews, 5 participants expressed concern regarding the entry of HD Radio and DRM receivers into the marketplace. The innovative user is concerned not only regarding getting receivers into the marketplace but also acquiring federal support for the process. As he finished his interview, he spoke of DRM's ability to cover a wide area and provide emergency information in a disaster. Referencing Hurricane Katrina, he stated, "If you had this [DRM in the shortwave] working, you could have at least got some information out to the people. The U.S. government needs to weigh in and needs to do something with this."

A writer for a shortwave listening magazine is so concerned about the lack of availability of digital receivers and the proliferation of other emerging media that he questioned the likelihood of DRM becoming successful: "Since nothing has been available and, at the same time, Wi-Fi and Wi-Max have become increasingly available—in the past year we have seen these new Wi-Fi radios—I am increasingly concerned over the viability of DRM going forward." Another shortwave listening magazine writer expressed similar thoughts: "I'm waiting for a radio. The Morphy Richards radio was not approved by the FCC for use here [in the U.S.]. . . . They need to have receivers in peoples' hands." The senior manager of a company that manufactures both HD Radio and DRM transmitters who asked, "Can't we all just get along?" explained that all stakeholders need to cooperate, especially in identifying those areas of the world where DRM and HD Radio are likely to find success as centers for the manufacture of cooperative receivers.

In their closing comments, 4 participants addressed the important issue of radio broadcasters developing compelling content as HD Radio and DRM emerge into the marketplace. The coauthor of a major college textbook on communications offered three words for the success of digitally modulated radio and its ability to reach listeners: ”Programming, programming, and programming.” He clarified, “It’s all about content. All of the rest follows. Regulation isn’t going to make it happen. Even marketing isn’t going to make it happen. It’s going to be programming that gives people a reason to listen.”

A DRM broadcaster involved with the redistribution of international radio is specifically concerned with the programming coming from the U.S. International Broadcasting Bureau. Specifically, he questioned the U.S. Broadcasting Board of Governors’ decision-making process and strategy for VOA content: “I feel the VOA is making a big mistake by moving away from English programming because the BBC is, without making a big fuss about it, they’re introducing English programming into China because programming Chinese is jammed.”

As he ended his interview, the general manager of a small-market HD Radio station in rural Virginia expressed concern about the possibility of broadcasters using digital radio only as a data pipe for enhanced revenue rather than as another source of innovative content for the listening public. He is concerned that HD-2 and HD-3 streams will not be used as programming channels “but as bandwidth, to be managed as bandwidth. And I don’t think we’re in that business. I hope not. I hope we’re smarter than that and better than that.”

Finally, the managing editor of a major U.S. national trade publication for commercial radio broadcasters ended his interview by sharing his overall philosophy:

> I think we need to be realists. And HD Radio is a realism format. As I stated, it’s defensive to a certain extent, it’s strategic, and the industry has to be realistic about what it can accomplish with it. It does represent a revenue opportunity. It does represent protection of our assets, so it’s important. But if we don’t invest in quality

programming at the core of all of these discussions, they become irrelevant. That's my thesis.

Conclusion

It is clear that most stakeholders feel some modicum of success is inevitable for HD Radio and DRM, although some define that level of success as merely capturing a small portion of the listening population; slowing the current erosion of radio audiences; or keeping radio broadcasting alive until another technology, such as ubiquitous wireless Internet access using Wi-Fi or Wi-Max, emerges. HD Radio and DRM may also achieve success through the repurposing.

Most participants believe that digital radio will acquire market share but will do so slowly, perhaps over a span of 10 to 20 years. As an iBiquity vice president stated, the marketplace has significantly changed since the emergence of FM and AM Stereo, and both technologies faced stiff competition from other emerging digital technologies. As a consequence, technological competition for "earshare" has become much more fierce.

As the interviews during this snapshot in time indicate, the greatest concern among the majority of stakeholders between September 2006 and June 2007 was the availability and distribution of HD Radio and DRM receivers to the general public. However, the ultimate success or failure of these new technologies rests squarely on the success or failure of another factor—the content that they deliver.

CHAPTER 5. DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

This chapter describes the conclusions that the researcher drew from the findings presented in chapter 4 and relates them to the lessons learned from the emergence of FM and AM Stereo technologies described in chapter 2. Based on his findings from his interviews with HD Radio and DRM stakeholders, particularly those regarding the factors most vital in the success of these technologies, the researcher provides recommendations that may assist in the successful emergence of HD Radio and DRM in the marketplace. These recommendations include specific recommendations to the broadcasting industry regarding technical considerations for implementing and deploying HD Radio and DRM (see Appendix V) and to academics assisting in the emergence of these digital radio technologies (see Appendix W). The latter set of recommendations include both areas addressed by this study that require more in-depth analysis as well as topics raised by the stakeholders during their interviews that were beyond the scope of this paper.

Responses to the Core Research Questions

This study addressed the following primary research question: How do the stakeholders involved in the emerging technology of digitally modulated radio define success? The study also addressed the following sub-questions to examine the marketplace for digitally modulated radio, its means of regulation, and its value to the listener:

1. According to the stakeholders, which factors are critical in the success of digitally modulated radio as a viable technology?

3. What do the stakeholders consider the strengths, weaknesses, opportunities, and threats (SWOTs) of digitally modulated radio?

4. What strategies are being used to market digitally modulated radio to broadcasters, transmitter and receiver manufacturers, and the general public? How effective have these campaigns been?

5. What is the role of the FCC and the ITU in terms of the success or failure of new broadcasting technologies?

6. What additional auditory value does digital modulation radio provide to listeners as compared to AM and FM radio? Why should listeners migrate from one technology to another? How will digitally modulated radio affect radio listening habits?

6. How much time will elapse before HD Radio and DRM succeed or fail in the marketplace?

Definitions of Success

With the exception of one stakeholder, all the stakeholders in this study believe that Radio and DRM will achieve some measurable level of success. They defined success along a spectrum ranging, from capturing merely 5% to more than 50% of the listening audience using these technologies. Several believe that success would be achieved when the new technology becomes the "normal" or default standard, citing how color television and FM radio technologies have become accepted standards.

Several believe that HD Radio and DRM could achieve success as methods of keeping terrestrial radio broadcasting viable until it is overtaken by another technology, such as universal wireless Internet technology. Others believe that repurposing digitally modulated radio technology might also lead it to achieve a certain level of success.

Critical Factors in Success

The interviewees overwhelmingly described the most critical factors for success as providing the marketplace with HD Radio and DRM digital radio receivers for consumer purchase and filling the spectrum with digital content. Many interviewees, however, believe that the success or failure of the new technologies rests solely on their ability to deliver new and high-quality, compelling content to listeners.

Marketing Strategies

The stakeholders described the marketing of HD Radio and DRM to major-market broadcasters and manufacturers as generally progressing smoothly and being received with enthusiasm. However, they described marketing to small-market broadcasters and the general public as minimal. Although the HD Radio Alliance has taken some positive steps, its results have been negligible, whereas no member of the DRM Consortium appears to have assumed responsibility for this important activity. Some DRM stakeholders believe marketing to consumers is the responsibility of the broadcasters or the manufacturers, and not a function of the Consortium.

Role of the Regulators

The interviewees believe that the regulatory agencies have a crucial role in the rollout of these new technologies and that their approval or disapproval of an emerging technology can define success or failure in and of itself. Many pointed to the historical failure of AM Stereo technology as a prime example of the consequences of a lack of regulatory support. The interviewees generally agreed that HD Radio had been treated fairly by the FCC and that DRM had been treated fairly by the ITU. Although there were no ITU data available describing the DRM approval process, the FCC regulators interviewed indicated that after the technology had been approved, their only concern has been refereeing interference issues.

Some stakeholders feel more regulatory support is necessary from the FCC or that government subsidies and involvement are required in order to get HD Radio receivers into the marketplace. Others believe that the FCC should reestablish its engineering capabilities.

Value to the Listener

During the development phase, the innovators of HD Radio and DRM defined the technologies' value to the customer as their superior audio quality over analog radio. This is still true regarding DRM, as there is a drastic difference in audio quality between DRM and analog AM shortwave. However, HD Radio stakeholders now see more value to the customer in their technology's ability to provide listeners with additional programming content through the HD-2 and HD-3 streams in the FM band. They believe that this additional content will spark more interest in radio listening within the general public, possibly creating new audiences and encouraging some listeners to migrate back to terrestrial radio from XM Radio, Sirius, Internet radio, or iPodcasting. The stakeholders also feel there is potential value to the customer in HD Radio and DRM through multimedia transmission and datacasting, but these capabilities are currently not available.

Length of the Digital Sunrise

Opinions regarding the length of the digital sunrise varied widely, from 1 to 15 years, as the stakeholders simply gave a rough figure based on their personal experience.

From these answers, their various definitions of success could be realized as early as 2008 (which did not happen) or as late as 2022.

Lessons Learned from the Emergence of FM and AM Stereo Technologies

Although the interviewees generally agreed that valuable lessons could be learned from analysis of the success of FM and the failure of AM Stereo technologies, they suggested that the industry not bind itself too closely to these historical events. If it does so, innovators may do what the military is sometimes accused of doing—fighting the current war with the strategies and tactics of the last war. Just as it is not feasible to fight a war in the sands of the Middle East using the strategies and tactics employed in the jungles of Vietnam, merely copying successful FM strategies and avoiding AM pitfalls will not guarantee success for HD Radio or DRM technology.

The current marketplace is entirely different from the marketplace in which FM and AM Stereo emerged. Listeners today have many more choices than simply over-the-air radio, television, or LP and 45 rpm records. Strategies and tactics consistent with this new marketplace must be employed, but only after refining the definitions of success and failure. In the modern diverse marketplace, capturing 80% of the listening audience using one particular technology, as did FM, is no longer feasible. Likewise, capturing only 2% of the listenership may not be such a devastating failure as it was for AM Stereo.[7] There are, however, lessons to be learned from the rollout of FM and AM Stereo technologies.

Although there is some controversy among the interviewees as to whether the reason for FM's success was based solely on its superior audio quality over AM or on its

[7] Eleven percent of AM radio stations were using AM Stereo of the remaining 20% of listeners tuned to AM, which equates to roughly 2% of the radio listening market.

superior audio quality coupled with its delivery of new and innovative content, it is the latter that must be considered for the rollout of HD Radio and DRM. Although a new technology must offer higher-quality audio than its predecessor to encourage migration, it also needs to provide fresh and dynamic content unavailable on current receivers to motivate listeners to purchase a new receiver with newer capabilities. Clearly, in today's media marketplace, new technology will succeed or fail by the content it delivers.

HD Radio in the United States appears to have overcome the major obstacle that led to the downfall of AM Stereo, as governmental support of a single transmission standard seems to have already been achieved. However, some interviewees questioned whether AM Stereo ever provided any particular value to listeners. Because most AM radio formats had evolved into some form of talk radio by the time AM Stereo was codified into law as part of the Telecommunications Act of 1996, a stereo signal was superfluous since very little music recorded in stereo was being played on AM radio stations at that time. Therein lies another lesson learned from AM Stereo: A new technology must have a perceived value to listeners in order for them to migrate to its use.

Financial Viability

None of the interviewees participating in this study described a specific plan for maintaining the financial viability of HD Radio or DRM via specific price points, although some interviewees stated they would not become successful until consumers could purchase receivers for less than $100. The researcher could not determine whether this lack of data was due to security concerns regarding iBiquity and the DRM

Consortium strategies or because they simply have no specific plans. However, the interviewees, particularly the HD Radio stakeholders, implied that they believed that their technologies were financially viable for commercial radio.

Most of the U.S. broadcasters involved with HD Radio stated that they are looking at this new technology in primarily a defensive mode. One broadcaster explained, "Everything in electronics is going digital, so we must do the same thing in order to stave off further erosion of our audiences to satellite radio, Internet radio, and iPods." Many of these broadcasters look at HD Radio as a possible solution to help stop the "bleeding" of their audiences. With larger audiences come higher ratings; with higher ratings come higher price points per advertising spot announcement rate; and with higher spot rates comes increased financial viability for commercial radio stations.

Many of the HD Radio broadcasters and innovators described the financial return from HD Radio to broadcasters as increased revenue from the new HD-2 and HD-3 audio content streams for FM stations, as every FM station now has the potential to function as three separate radio stations with HD Radio technology. From these three separate audio streams there is also the potential for three separate revenue streams. However, this has yet to occur. Almost all the interviewees in all the categories agreed that there is no immediate return on investment for broadcasters investing in HD Radio or DRM infrastructure upgrades because there is no immediate associated revenue stream. Thus, many broadcasters who are now using HD Radio technology consider it an investment in the future.

As described in chapter 2, iBiquity has a specific plan for maintaining financial viability based on licensing its software and acquiring the four following revenue streams to recoup capital for its investors:

1. Charging a royalty fee to transmitter manufacturers for using its software (which gets passed on to the broadcasters purchasing the new transmitters and exciters).

2. Charging a royalty fee to receiver manufacturers for using its software (which gets passed on to listeners purchasing the new HD Radio receivers).

3. Charging a royalty fee to broadcasters for using its new technology on the air. This is a one-time fee based on a percentage of the regulatory license fee a station must pay the FCC annually to remain on the air (larger fees for large-market stations and smaller fees for small-market and noncommercial stations). Broadcasters can pay this as a lump-sum payment or structure it as multiyear payments.

4. Charging a small fee to broadcasters who realize any profit from the increased transmission capability in the HD-2 and HD-3 streams afforded by HD Radio technology.

The FCC regulators interviewed do not appear to have any interest in financial viability, which they believe is a consideration best left to others. Their only concern at this juncture, now that the technology has been approved for on-air use, is addressing possible interference issues among radio stations using the new technology. Interestingly, many of—and only—the FCC regulators spoke of using the HD-2 and HD-3 streams as a venue for providing reading services to the blind. Clearly, this use appeared to have been a "selling point" for HD Radio to the FCC; that is, using the additional audio streams for noncommercial public service purposes rather than as sources of additional commercial revenue for broadcasters.

The FCC regulators also expressed less of an interest in converting analog AM and FM radio to HD Radio than in converting analog ATSC TV to HDTV. This disparity may be attributable to the fact that HD Radio lies in the same spectrum as analog radio broadcasting, whereas with HDTV, the U.S. government can recoup the spectrum that currently exists for lower television channels to auction and privatize it, thereby helping drive down the national debt. The companies that buy that spectrum from the U.S. government will, no doubt, eventually use it for developing and providing ubiquitous Wi-Fi, DSL-quality wireless Internet access, which, according to the futurists interviewed, will lead to the demise of digitally modulated radio—if it ever does become successful and commercially viable. That, according to these futurists, will be the point in time when car radios will turn into car minicomputers and ubiquitous, mobile Internet radio will reign supreme, and terrestrial radio technology as we know it today—AM, FM, and digital—will cease to exist. Therefore, even if HD Radio does become successful and attains commercial viability, it will have a limited shelf life.

From the perspective of financial viability, DRM technology is entirely different from HD Radio. DRM has its greatest potential in the shortwave spectrum, most of whose broadcasters are not commercial broadcasters but rather either religious broadcasters or governmental broadcasters. Their intention goal is not achieving commercial or financial service but rather propagating faith or ideology and public diplomacy through their broadcasts. They do not seek a return on investment or additional revenue streams for additional financial viability; they seek an increase in audio quality in order to make their broadcasts more appealing to listeners to propagate their messages more effectively. Therefore, there is not a direct correlation between success and financial viability with DRM in the shortwave bands worldwide as there is with HD Radio and commercial broadcasting in the United States.

Nevertheless, the data collected in this study indicate that there are some avenues for increased commercial activity in the shortwave bands. This is important due to the inherent physical properties of the shortwave spectrum. Shortwave is the only portion of the electromagnetic spectrum that can transmit a low-angle signal to the ionosphere, where it is reflected back to the earth to leave a footprint two continents away, as explained in detail in Appendix V. As the innovative user and others so aptly described during their interviews, DRM can be repurposed to function in the shortwave as a networking tool, which differs from its intended purpose—broadcasting directly to listeners. DRM in the shortwave can be used as an effective digital technique to network other AM and FM transmitters worldwide at great distances from the original source of the broadcasts. Whereas many costs are associated with maintaining a satellite in synchronous orbit with the rotation of the earth to transmit radio signals (as XM Radio and Sirius are discovering), few costs are associated with a DRM shortwave network.

Networking in the shortwave is not a new concept; it was what the VOA did prior to using the VOA/NASA-JPL satellite network that it currently uses. The difference now is that the digital quality of the DRM signal is far superior to the scratchy, distorted AM signal in the shortwave of the past, and thus comparable to the high-quality digital satellite networks currently in use. In addition to the long-range networking of DRM in the shortwave using a low angle of radiation and vertical antennas, this technology can also be used for near-field networking by using *near vertical incidence skywave* (NVIS) transmission techniques with horizontal antennas, as described in Appendix V. Digital networking in the shortwave, whether long distance or in the near field, may increase the financial viability of DRM, although none of the interviewees overtly stated or described it in commercial terms.

Another potential source of financial viability for DRM is in the development of another commercial broadcasting band in the high end of the shortwave band at 26 MHz for local commercial broadcasting purposes, as described in Appendix V. This portion of the shortwave, which functions more like VHF (where the FM broadcasting band is located at 88 to 108 MHz) with line-of-sight transmission to the horizon (and slightly beyond), could be used for local or regional broadcasting. This 26-MHz band could provide the spectrum needed for use by micro-broadcasters or community broadcasters, which the FCC attempted to facilitate with a low-powered FM (LPFM) program that, unfortunately, gained little traction. The 26-MHz band is already allocated for broadcast purposes, and future DRM broadcasters could monetize it to increase the financial viability of broadcasters, but, again, none of the interviewees framed it in that context.

The shortwave bands in the United States are outside of domestic commercial broadcasting due, in part, to the commercial radio industry's heavy lobbying of Congress in the 1940s and, in part, because of what the researcher found to be an FCC misinterpretation of the legislation concerning the VOA. There are no shortwave bands on car radio receivers in the United States because the shortwave bands were never commercialized, and this is because internal broadcasting within the continental United

States on the shortwave bands is precluded by law. As discussed in Appendixes V and W, there have been calls since 1948 to lift the prohibition on internal commercial shortwave broadcasting within the United States, which could monetize this spectrum for broadcasters. Although some of the interviewees discussed internal broadcasting in the United States by shortwave broadcasters and the importance of U.S. citizens being allowed to have the opportunity to hear VOA content, none discussed it in specifically financial terms.

Unlike the iBiquity employees, the DRM Consortium members themselves paid all the costs associated with the initial research and development of their technology. The Consortium itself has very few expenses of its own, as its administrative costs are paid by membership dues. For these reasons, there are no royalties for DRM use; DRM is an open-architecture system and there is no financial remuneration to the Consortium for using it. Consideration of the financial viability of the DRM Consortium, therefore, is moot.

The members of the Consortium appear to feel successful simply because they can broadcast signals using their technology. As one member expressed, "We have proven that you can send a digital signal a great distance away and hear it with great quality. Therefore, it is a success." Winston (1995) described such an attitude as reflective of the difference between the *technological success* and the *cultural success* of a new technology. In a commercial environment, cultural success and financial viability are closely interconnected, and may be construed as the same concept. Whereas the DRM stakeholders appear to be focusing on achieving technological success, the HD Radio stakeholders appear to be focusing on cultural success and financial viability through a market-based approach.

Such a difference also applies to the history of FM and AM Stereo technologies. FM radio has been culturally successful as well as financially and commercially viable, allowing many to earn much revenue broadcasting and operating FM radio stations, but such was not always the case. The current status HD Radio and DRM is similar to that of FM radio in the early 1960s: little content, few receivers, small audiences, and little financial viability. However, FM radio eventually grew into the giant success that it is today.

On the other hand, even though AM Stereo was "technologically successful" in Winston's terms, it never became culturally successful or financially viable. Few commercial AM radio transmitter manufacturers made much money, and those who did only did so for a short period of time. The FM and AM Stereo scenarios are analogous to the "A" and "B" lines, respectively, on Day and Schoemaker's (2000) adoption curve in Figure 4 and Fidler's (1997) S curve in Figure 6.

As many interviewees stated, compelling content is the most important factor in attracting and retaining listeners, and with more listeners come higher ratings, with higher ratings come higher price points per advertising spot, and with higher price points come increased financial viability for commercial radio stations. Therefore, the financial viability and cultural success of a new and emerging broadcast technology are tied to the compelling content it provides. HD Radio and DRM must provide compelling content that inspires people to buy HD Radio and DRM receivers and migrate to the new technologies if they are to become commercially viable. This argument is shared by the stakeholders interviewed and it is the conclusion of the researcher.

Recommendations for the Radio Broadcasting Industry

The researcher developed this set of recommendations based on several issues brought forward by the interviewees in this study. As these recommendations represent the greatest concerns for HD Radio and DRM as they enter the marketplace, they offer the possibility of more rapid and certain success for HD Radio and DRM if adopted.

End the Chicken-or-Egg Syndrome

The most pervasive problem facing the successful emergence of HD Radio and DRM technologies is what many of the interviewees referred to as the chicken-or-egg syndrome. Broadcasters do not want to provide content on the HD-2 and HD-3 channels or simulcast with DRM until the marketplace offers digital receivers at prices acceptable to consumers. On the other hand, receiver manufacturers do not want to invest in the production of digital receivers until broadcasters offer content that appeals to listeners. Because of this chicken-or-egg syndrome, the forward upward motion in Day and Schoemaker's (2000) adoption curve (see Figure 4) and in Fidler's (1997) S curve (see Figure 6) has become stymied or is progressing at a much slower rate than anticipated.

In order for HD Radio and DRM to become successful, both broadcasters and receiver manufacturers must take a leap of faith. Broadcasters need to start producing and transmitting content on the new digital platforms, even if there are no (or few) receivers in the marketplace, and receiver manufacturers need to start producing digital receivers and promoting them to consumers, even without a full array of offerings available on the air.

As several interviewees stated, a great challenge to the successful emergence of technologies such as HD Radio or DRM is the coordination of effort among several industries with disparate interests. But which should come first, the “chicken” or the “egg?” Broadcasters, almost to a person, stated that the problem at this point in time is the lack of availability and dissemination of digital receivers in the marketplace. Receiver manufacturers, however, contend that the problem is a severe shortage of digital content in the broadcasting bands. Who needs to move forward first?

Radio broadcasting is, by and large, a form of entertainment. As such, an analogy can be drawn between radio broadcasting and an amusement park. Would investors want to build the transportation infrastructure and attract customers to an amusement park before all of the rides are built? Of course not; the sensible plan would be to ensure that all rides are operational before the first customer arrives. The same holds true for HD Radio and DRM. The spectrum needs to be rife with new and diverse content unavailable on AM, FM, or shortwave analog radios in order to make listeners, as one major-market general manager stated in his closing comments, “drop their glass and go, ‘Wow!’” during their initial experience.

As shown in Table 6, there are more than 78 AM and FM radio stations in the Baltimore-Washington metropolitan area.[8] As stations in the FM spectrum can transmit

[8] The researcher determined that there were 78 radio stations in these overlapping markets by adding the number of Arbitron-rated stations (Arbitron.com, n.d.) in each market (minus the overlap of stations rated in both markets) and adding the number of nonrated public and educational FM stations and other known AM stations in the Annapolis-Laurel area that were also nonrated.

three streams of content using HD Radio, terrestrial radio broadcasting stations have the capacity to deliver at least 190 separate streams of content in these overlapping markets, which should provide sufficiently diverse content to rival the 206 channels currently offered by XM satellite radio (XM.com, n.d.). Surely, that amount of free content should be sufficient to induce HD Radio listeners say “Wow!” during their first encounter with the technology.

Table 6

Number of Radio Stations in the Baltimore-Washington Market

Location	Band	Analog total	HD total
Baltimore, MD	AM	8	8
Baltimore, MD	FM	23	69
Washington, DC	AM	10	10
Washington, DC	FM	32	96
Annapolis and Laurel, MD	AM	4	4
Annapolis and Laurel, MD	FM	1	3
Total		78	190

However, while driving through the Baltimore-Washington market for the past 2 years, the researcher found that the amount and diversity of content currently available on the HD-1, HD-2, and HD-3 streams in this area is nowhere near as awe inspiring as that of XM Radio. Drawing on the analogy of the amusement park, the rides must be ready before the customers arrive, which is not the case with HD Radio. Likewise, international broadcasters are delivering some content in the shortwave DRM band, but, again, it is not sufficiently compelling to induce listeners to buy DRM-capable receivers. The shortwave bands need to be teeming with digital content not available in any other form in order to inspire listeners to tune in with new digital receivers.

In order to end the chicken-or-egg syndrome, both broadcasters and receiver manufacturers must aggressively move forward, but broadcasters should assume the responsibility of making a more concerted effort to ensure that digital content is available when the listeners arrive.

Provide Compelling Content

Echoing the phrase "content is king," many interviewees stated that content needs to be "compelling," and bemoaned the standard content currently offered. They shared the sentiment expressed by a character in the movie *A Prairie Home Companion* when he lamented that contemporary commercial radio programming is nothing more than "people yelling at each other and computers playing music" (Nayman, 2006). The development, production, and delivery of high-quality digital content that listeners truly want is equally as critical as ending the chicken-or-egg syndrome to allow for the successful emergence of HD Radio and DRM. In the current highly competitive marketplace, if listeners cannot find what they seek on terrestrial radio, whether analog or digital, they will turn to satellite radio, Internet radio, or iPodcasts in order to find the content that interests them.

Broadcasters need to improve the quantity and diversity as well as the quality of their content. As one interviewee stated, with the ability to broadcast multiple streams, HD Radio broadcasters should think of themselves as "microcasters" and produce content that appeals to a small niche market of listeners. An example of a microcaster is WAMU HD-2, which offers bluegrass music to its small community of listeners in the Washington, DC area 24 hours a day.

Of the 78 radio stations in the Baltimore-Washington market, Clear Channel owns 8 (7 FM stations and one AM station) and Radio One also owns 8 (4 AM and 4 FM stations; Arbitron.com, n.d.). Between them, they have the capability of providing the area with 48 of the possible 190 streams of digital radio content, approximately 25% of the region's HD Radio signals. Major group owners such as these have the resources to produce highly innovative and appealing programs with a local flavor for narrowly targeted audiences, such as the 48 available to Clear Channel and Radio One in the Baltimore-Washington area. They need to make that investment now in order for HD Radio to become successful.

With DRM, particularly in the shortwave, broadcasters must produce high-quality programming available on multiple frequencies that appeals to foreign audiences. Only when listeners have multiple choices will this technology become successful.

Seed the Marketplace With Digital Receivers

A clear majority of the interviewees stated that their biggest concern with the rollout for HD Radio and DRM is getting receivers into the marketplace at a more rapid pace, a task that could benefit from broadcaster assistance. Almost every U.S. commercial radio station holds contests as a method of retaining audience interest, the prizes for which can be as small as a free tank of gas to as large as a new car. Stations broadcasting with HD Radio technology should also include a new HD Radio receiver as part of the prize to encourage their most loyal fans to listen to their new HD-2 and HD-3 streams. These fans and contest winners could then become what Day and Schoemaker (2000) described as early adopters who could demonstrate the merits and features of HD

Radio to others. In the future, HD Radio stations could hold contests for which the contestants must supply answers after being given several clues, one of each coming from each of the station's HD Radio streams. In other words, the only way to win would be to become an HD Radio listener.

For DRM in the shortwave bands, governmental international broadcasters are often interested in supplying news and information to areas of the world with political unrest that may experience media blackouts imposed by tyrannical regimes. In the words of the father of broadcast journalism and former director of the U.S. Information Agency, Edward R. Murrow, "The really crucial link in the international communications chain is the last three feet" (as cited in Snow, 2004, p. 99). Although Murrow was referring to the importance of face-to-face interaction in the exercise of public diplomacy, the same rule applies to DRM and international broadcasting. Putting digital radio receivers in the hands of listeners two or three continents away is "the really critical link." The same rule also applies to HD Radio and local broadcasting: Putting digital radio receivers in the hands of listeners in the same city as the transmitter operator is also "the really critical link."

In order to do just that, governmental international broadcasters—particularly those transmitting to the same areas of the world in the same languages with similar messages such as the VOA, the BBC, Deutsche Welle, RCI, and RFI—could form a strategic alliance to purchase DRM-capable receivers at a reduced rate per unit by purchasing them in mass quantities. These digital receivers would require no electrical infrastructure, being either solar-powered radio receivers or wind-up generator receivers, and thus be easily operable in even the war-torn regions in which broadcasters distribute them (or smuggle them, if necessary). In the case of U.S. and U.K. international broadcasting, distribution in areas of conflict and disorder could occur with the assistance of the CIA and the MI-6. In this way, the peoples of strife-ridden countries and areas, such as Zimbabwe, Rwanda, and the Darfur region of the Sudan in Africa, would have a constant source of credible news and information transmitted with CD-quality signals, while governmental international broadcasters could build a digital audience of disenfranchised listeners.

Likewise, religious international broadcasters could help seed the marketplace with DRM-capable receivers in parts of the world where they are intent on propagating their faith. The purchase and distribution of digital receivers would be a means of closing in on the "last three feet": the distance from the radio receivers' speakers to the listeners' ears.

Develop a More Aggressive Marketing Strategy

Many of the interviewees credited the formation of the HD Radio Alliance as a good start in the marketing of HD Radio; but it is only that—a good start. Although the Alliance has developed advertisements for HD Radio that radio stations have played during unsold commercial airtime (at no expense or loss of revenue to the station), it has engaged in no cross-media advertising of HD Radio. The HD Radio Alliance needs to develop television, newspaper, billboard, and Internet advertisements to educate and attract potential HD Radio listeners from multiple platforms.

While conducting this study throughout 2006, 2007, and 2008, the researcher observed no Christmas sales or advertisements of HD Radio receivers at Circuit City, Radio Shack, Best Buy, Target, Wal-Mart, or any other electronics or "big-box" store. During the Christmas 2008 buying season, Circuit City displayed advertisements for car radios that were XM Radio capable with iPod interfaces, but no in-store advertisements for HD Radio car receivers; it was as if this new technology did not exist. These outlets need to promote HD Radio if it is to succeed.

To date, there is no collaborative marketing plan for DRM, with several interviewees explaining that marketing is outside of the parameters of the DRM Consortium. However, if no one assumes responsibility for marketing DRM, it too will fail. The Consortium must develop a worldwide marketing plan that includes advertising targeted to countries intent upon using DRM technology. All the suggestions previously described for HD Radio also apply for DRM. If their stakeholders do not develop aggressive marketing plans directed toward the general public, both technologies are in jeopardy of failure.

Rebrand DRM

Most people, including technically savvy individuals, do not know that the acronym *DRM* refers to *Digital Radio Mondiale* as well as *digital rights management*, the latter of which has negative connotations due to its ability to impose limitations on access to new media by users. Just as iBiquity rebranded *IBOC* as *HD Radio*, the DRM Consortium needs to rebrand DRM technology to make it more appealing to consumers.

Recommendations for Researchers

The researcher developed the following set of recommendations for academics to consider when planning further research based on the participants' indications that several of their prime concerns remain unanswered.

Define Compelling Content

Many participants repeatedly affirmed that all radio content, not only HD Radio and DRM content, must become more "compelling" for not only the survival of HD Radio and DRM but the entire radio industry. However, none was able to provide a definition of compelling content. What is it that makes a listener want to listen to a particular broadcast? What is it, for example, that makes fans of Howard Stern's radio show want to expend the extra time, effort, and money in order to subscribe and migrate to Sirius satellite radio in order to continue listening to his programs? Codifying the factors that make both radio and television content compelling, regardless of genre, would greatly benefit the broadcasting industry.

Determine the Effectiveness of Marketing Programs

Although marketing is a prime factor in the success of an emerging technology, a statistical measurement of its effectiveness was beyond the scope of this study. A detailed analysis of the marketing efforts of iBiquity and the DRM Consortium and a measurement of their effectiveness would be of value to both organizations.

Identify Additional Factors in the Success of an Emerging Technology

Chapter 2 discussed three factors particularly significant in the success or failure of a new and emerging radio broadcasting technology: marketing, regulatory support, and the ability to provide value to the listener. As discussed in chapter 4, the interviewees provided three additional factors: industry interest, support, and approval. Are these all the factors necessary for the success for a new and emerging radio broadcasting technology? Or are they necessary but not sufficient; that is, are there additional factors? A more detailed study into the factors of success and failure would assist the broadcast industry and could create a template for other emerging technologies to follow.

Conclusion

At this point in their evolution, HD Radio and DRM are poised for either success or failure. However, if their stakeholders do not take strong action now, failure is the more likely result. The recommendations in this chapter and Appendixes V and W suggest actions that, if taken, may lead these two technologies to thrive in an increasingly competitive marketplace. Terrestrial radio broadcasting assisted by digital modulation, as described by the interviewees in this study, has the potential to remain viable for a number of decades, but only if its stakeholders redouble their efforts and remain keenly focused on the marketplace factors necessary for success.

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APPENDIX A

Definition of Terms

AM	Amplitude modulation. AM is an analog change of the amplitude of an electrical voltage superimposed on an RF carrier wave. It contains the audio information of a radio transmission. At the receiver, the carrier is stripped away leaving only the audio signal for human hearing.
AM Stereo	A system of audio transmission/reception that provides two separate audio signals for listeners to hear in separate left and right speakers. Transmission of this signal is contained in the bandwidth and spectrum of standard 10-kHz wide mediumwave AM channels using a modification of AM.
Analog	Electronic transmission conducted by adding signals of varying frequency or amplitude to the carrier waves of a given carrier frequency of alternating electromagnetic current, usually represented as a series of sine waves. The term indicates that the modulation of the carrier wave is analogous to the changes of the audio wave containing voice or music. Broadcasting and telecommunications have used analog technology since their origin.
ATSC	Advanced Television Systems Committee. "The ATSC is a standards organization that was created in 1982 as part of the Advanced Television Committee (ATV) to promote the establishment of technical standards for all aspects of advanced television systems." (whatis.com)
BBC	British Broadcasting Corporation. The government-owned and operated international radio, television, and Internet-broadcasting organization of the United Kingdom.
CAM-D	Compatible amplitude modulation-digital. A digital radio modulation technology developed by Leonard Kahn.
Case study	The quantitative or qualitative study of one particular instance of a subject or phenomenon.
CD	Compact disc.
CEA	Consumer Electronics Association.

C-QUAM — Compatible quadrature amplitude modulation. The Motorola version of AM Stereo technology that transmits two signals (L+R and L–R) on the same frequency 90° out of phase with each other.

DAB — Digital audio broadcasting. Sometimes referring to all forms of digitally modulated radio and sometimes synonymous with Eureka-147.

DARS — Digital audio radio service. Often synonymous with Satellite-DARS (S-DARS), used by XM Radio, Sirius, and WorldSpace.

Datacasting — Data services that can be transmitted and received on digitally modulated radio independently from the main audio program.

DRM — Digital radio modulation. DRM also refers to Digital Radio Mondiale, the organization representing digital radio in the HF spectrum.

DTV — Digital television.

Duopoly — A broadcasting entity that owns an AM station and an FM station in the same commercial market. Until the FCC changed the rules, duopolies in the 1950s and 1960s would often broadcast the same programming on AM and FM Stereo. Duopolies were some of the first broadcasters to experiment with stereophonic transmission.

ETSI — European Telecommunications Standards Institute.

EU — European Union.

Eureka-147 — A consortium of European broadcasters tasked with developing a digital radio modulation process. The process that it developed, also referred to as Eureka-147, is currently operational in Europe, the United Kingdom, and Canada.

FCC — Federal Communications Commission. An independent U.S. government agency directly responsible to Congress established by the Communications Act of 1934 that is charged with regulating interstate and international communications by radio, television, wire, and satellite broadcasting in the continental United States and in U.S. possessions.

FM — Frequency modulation. A process of altering the frequency of a radio carrier wave while keeping the amplitude constant. The form of radio transmission authorized by the FCC for use in the commercial VHF band is from 88 to 108 MHz.

Frequency	The number of times an alternating current changes direction, usually measured in Hertz or cycles per second.
GHz	Gigahertz. One GHz equals 1,000,000,000 cycles per second.
HD Radio	The brand name for iBiquity's IBOC digital radio system.
HDTV	High-definition television. A new and evolving technology that uses a digital data stream to provide enhanced picture quality in television transmission and reception.
Hz	Hertz. One Hertz equals one alternating current cycle per second.
iBiquity	The U.S. company developing digitally modulated radio in the U.S.
IBOC	In-band on-channel. The digital modulation process developed by USA Digital Radio and Lucent Digital Radio (now merged as iBiquity) by which both digital and analog transmission occur simultaneously on the same radio broadcast channel.
IEEE	Institute of Electrical and Electronics Engineers.
iPod	An "iPod is a combination digital audio player and portable hard drive from Apple Computer" (Whatis.com, n.d.).
iPodcasting	Broadcasting digital audio files via the Internet for listeners to download to their portable iPod devices for "time-shifted" listening.
ITU	International Telecommunications Union.
kHz	Kilohertz. One kHz equals 1,000 cycles per second.
L-Band	"An RF band of 390 to 1550 MHz (.39 to 1.55 GHz) and corresponding wavelengths of 77 to 19 cm" (Graf, 1973, p. 316).
Mediumwave radio	Radio waves between 300 kHz and 3.0 MHz.
MHz	Megahertz. One MHz equals 1,000,000 cycles per second.
Modulation	The addition of information or another signal to a carrier signal.
Modulator	A section of a radio transmitter where the modulation is applied to the carrier wave.

MP3 — "MP3 (MPEG-1 Audio Layer-3) is a standard technology and format for compression of a sound sequence into a very small file (about one-twelfth the size of the original file) while preserving the original level of sound quality when it is played" (whatis.com, n.d.).

Multimedia — "More than one concurrent presentation medium. Multimedia is typically used to mean the combination of text, sound, and/or motion video" (Whatis.com, n.d.).

Multiplexing — A system of transmitting several radio signals simultaneously on the same circuit or channel. Used in FM Stereo modulation to simultaneously transmit the left channel, the right channel, and the SCA channels.

NAB — National Association of Broadcasters. The NAB is a trade association representing the interests of over-the-air radio and television broadcasters.

NBC — National Broadcasting Company. The radio network, television network, and symphony orchestra founded by David Sarnoff.

NCE — Non-commercial educational. FM radio stations located in the lower portion of the FM VHF spectrum (88 to 92 MHz), for which noncommercial broadcasting is allocated.

NPR — National Public Radio.

NPRM — Notice of Proposed Rule Making. The first step in the FCC's regulatory process, an announcement to the public that the FCC is starting to consider initiating a new regulation.

NRSC — National Radio Systems Committee.

NVIS — Near Vertical Incidence Skywave. Shortwave propagation to the near field by the use of a horizontally polarized antenna.

Ofcom — Office of Communications. An independent organization that regulates British broadcasting, telecommunications, and wireless communications sectors and sets and enforces rules on fair competition among companies in these industries. In essence, the British nongovernmental equivalent of the U.S. FCC.

Packet radio — Data routing between an origin and a destination on a packet-switched radio network.

Qualitative inquiry — "Inquiry that is grounded in the assumption that individuals construct social reality in the form of meanings and interpretations and that these constructions tend to be transitory and situational. The dominant methodology is to discover these meanings and interpretations by studying cases intensively in natural settings and by subjecting the resulting data to analytic induction" (Gall, Borg, & Gall, 1996, p.767).

Quantitative inquiry — "Inquiry that is grounded in the assumption that features of the social environment constitute an objective reality that is relatively constant across time and settings. The dominant methodology is to describe and explain features of this reality by collecting numerical data on observable behaviors of samples and by subjecting these data to statistical analysis" (Gall, Borg, & Gall, 1996, p. 767).

RCA — Radio Corporation of America. Established by David Sarnoff.

Reliability — The ability of an academic study to be replicated. A study has a high level of reliability when similar studies produce the same or similar results.

RF — Radio frequency. "Refers to alternating current (AC) having characteristics such that, if the current is input to an antenna, an electromagnetic (EM) field is generated suitable for wireless broadcasting and/or communications. These frequencies cover a significant portion of the electromagnetic radiation spectrum, extending from nine kilohertz (9 kHz), the lowest allocated wireless communications frequency (within the range of human hearing), to thousands of gigahertz (GHz)" (whatis.com, n.d.).

RRs — Radio Regulations. Rules adopted by the ITU for radio spectrum use on an international scale.

SCA — Subsidiary Communication Authorization. An FM broadcast signal at 67 kHz or 92 kHz above the bottom of a standard VHF FM broadcast channel used for a secondary or tertiary broadcast transmission.

SBE — Society of Broadcast Engineers.

SDARS — Or S-DARS. Satellite Digital Audio Radio Service.

SFN	Single frequency network. "A type of radio network that operates several transmitters on a single frequency. To avoid interference, each station is usually run synchronously with the others, using GPS or a signal from the main station or network as a reference clock. Both FM and AM radio stations can operate in this manner, as can other non-broadcast operations, but television has proven to be more difficult. When this technology is used in a simplified form, a secondary transmitter may be known as a booster or on-channel repeater" (Wikipedia, n.d.).
Shortwave	Radio waves between 3.0 MHz and 30 MHz with wavelengths of 100 to 10 meters. Synonymous with HF.
Sirius	Satellite-fed digital broadcasting offering commercial-free programming to consumers on a subscription basis.
Stereo	Audio replication involving the use of at least two separated microphones, two separate transmission channels, two separate receiver amplifiers, and two separated speakers or headphones in order to achieve the spatial separation of a live hearing.
Storecasting	The SCA provision of instrumental music with no commercials or announcements to businesses on a subscription basis as an ancillary form of income for FM radio stations.
SWOT	Strengths, weaknesses, opportunities, and threats.
Techno-myopia	The "tendency of established enterprises to overestimate the short-term potential of a new technology and, when it fails to meet their expectations, underestimate its long-term potential." (Fidler, 1997, p. 29)
TFA	Table of Frequency Allocation. An ITU document that assigns various radio services to specific frequencies or spectrum on an international scale.
TPEG	Transport Protocol Experts Group. "This Group developed within the EBU (European Broadcasting Union in Geneva, Switzerland) since 1997 a new standard for the transmission of traffic and travel information within digital broadcast systems such as DAB (Digital Audio Broadcasting, DVB (Digital Video Broadcasting) and the Internet" (Navigadget.com, n.d.).
Triangulation	The use of multiple processes or multiple data sources within a research project to provide added support to the project's overall findings.

Validity variable fact,	The ability of a research study to accurately describe the results of factors within the study (i.e., the variables within a study are, in measuring what they are supposed to measure).
VHF	Very high frequency. “The VHF (very high frequency) range of the radio spectrum is the band extending from 30 MHz to 300 MHz. The wavelengths corresponding to these limit frequencies are 10 meters and 1 meter” (whatis.com, n.d.).
WorldSpace	Satellite-fed digital broadcasting offering programming to listeners in targeted areas of the world.
WRC	World Radiocommunication Conference. An ITU-sponsored meeting at which changes are made to the TFA and RRs.
XM	Satellite-fed digital broadcasting offering commercial-free programming to consumers on a subscription basis.

APPENDIX B

AM and FM Radio Share of the Marketplace

			AM	FM	AM	FM
Radar VIII	1972	April	-	-	75	25
IX	1973	March	16568	6463	72	28
X	1974	March	15359	7610	67	33
XII	1975	September	15124	9090	62	38
13	1976	Spring	14594	9573	60	40
14		Fall	13679	9719	58	42
15	1977	Spring	13462	10279	57	43
16		Fall	13687	11041	55	45
17	1978	Spring	13760	11907	54	46
18		Fall	12778	12152	51	49
19	1979	Spring	12320	12547	50	50
20		Fall	12145	13362	48	52
21	1980	Spring	11331	13847	45	55
22		Fall	10768	14447	43	57
23	1981	Spring	10440	14694	42	58
24		Fall	10328	14654	41	59
25	1982	Spring	10085	15474	39	61
26		Fall	9759	16744	37	63
27	1983	Spring	8972	16724	35	65
28		Fall	8542	16835	34	66
29	1984	Spring	8001	17125	32	68
30		Fall	7703	17496	31	69
31	1985	Spring	7472	17936	29	71
32		Fall	7100	18101	28	72
33	1986	Spring	7136	17751	29	71
34		Fall	6715	17472	28	72
35	1987	Spring	6115	17432	26	74
36		Fall	5987	17478	26	74
37	1988	Spring	5968	17588	25	75
38		Fall	5837	18190	24	76
39	1989	Spring	5657	18398	24	76
40		Fall	5618	18380	23	77
41	1990	Spring	5548	18338	23	77
42		Fall	5502	18328	23	77
43	1991	Spring	5547	18181	23	77
44		Fall	5569	18071	24	76
45	1992	Spring	5470	18487	23	77
46		Fall	5375	19133	22	78

47	1993	Spring	5385	18658	22	78
48		Fall	5137	18139	22	78
49	1994	Spring	4969	18681	21	79
50		Fall	4904	19050	20	80
51	1995	Spring	4826	18725	20	80
52		Fall	5063	18878	21	79
53	1996	Spring	4979	19083	21	79
54		Fall	4838	19327	20	80
55	1997	Spring	4820	19405	20	80
56		Fall	4735	19467	20	80
57	1998	Spring	4508	19414	19	81
58		Summer	4363	19288	18	82
59		Fall	4280	19454	18	82
60	1999	Winter	4289	19417	18	82
61		Spring	4363	19408	18	82
62		Summer	4366	19899	18	82
63		Fall	4347	20023	18	82
64	2000	Winter	4362	20424	18	82
65		Spring	4462	20334	18	82
66		Summer	4496	20352	18	82
67		Fall	4648	20476	19	81
68	2001	Winter	4737	20832	19	81
69		Spring	4641	20879	18	82
70		Summer	4689	20692	18	82
71		Fall	4833	20921	19	81

From R. Brooks, personal communication, January 9, 2002.

APPENDIX C

Number of AM and FM U.S. Broadcasting Stations, 1941 to 2000

Broadcasting Stations since 1941

Year	AM Radio	FM Radio Commercial	FM Radio Educational
1941	831	18	2
1942	887	36	7
1943	910	41	8
1944	910	44	8
1945	919	46	8
1946	948	48	9
1947	1,062	140	10
1948	1,621	458	15
1949	1,912	700	27
1950	2,086	733	48
1951	2,232	676	73
1952	2,331	637	85
1953	2,391	580	98
1954	2,521	560	112
1955	2,669	552	122
1956	2,824	540	123
1957	3,008	530	125
1958	3,196	537	141
1959	3,326	578	151
1960	3,456	688	162
1961	3,547	815	175
1962	3,618	960	194
1963	3,760	1,081	209
1964	3,854	1,146	237
1965	4,044	1,270	255
1966	4,065	1,446	268
1967	4,121	1,643	296
1968	4,190	1,753	326
1969	4,265	1,938	362
1970	4,292	2,184	413
1971	4,343	2,196	472
1972	4,374	2,304	511
1973	4.395	2,411	573
1974	4,407	2,502	652
1975	4,432	2,636	717
1976	4,463	2,767	804
1977	4,497	2,873	870
1978	4,513	3,001	926
1979	4,549	3,107	982
1980	4,558	3,155	1.038
1981	4,589	3,282	1,092
1982	4.634	3.349	1,118
1983	4,685	3,421	1,090
1984	4,733	3,527	1,122
1985	4.754	3,716	1,172
1986	4,718	3,875	1.231
1987	4,863	3,944	1,261
1988	4.902	4,041	1,301
1989	4,948	4,174	1,383
1990	4,978	4,357	1,435
1991	4.987	4,392	1,440
1992	4,985	4,570	1,507
1993	4,961	4,785	1,588
1994	4,944	4.971	1,662
1995	4,913	5.109	1.733
1996	4,909	5,296	1,815
1997	4.857	5,419	1,864
1998	4,762	5,542	1,923
1999	4,793	5,662	2,017
2000	4,783	5,766	2,066

Note. From *Stayed Tuned: A History of American Broadcasting,* by C. H. Sterling and J. M. Kittross, 2002, Mahwah, NJ, Lawrence Erlbaum, pp. 827-828

APPENDIX D

FCC AM Stereo Matrix

EVALUATION CATEGORY: Numbers in parenthesis ( ) indicate the maximum possible scores in the various categories or sub-categories.	MAGNAVOX	MOTOROLA	HARRIS	BELAR	KAHN
I. MONOPHONIC COMPATIBILITY:					
(1) Average Harmonic Distortion (15)	15	9	6	9	12
(2) Mistuning Effects (5)	5	5	5	5	5
II. INTERFERENCE CHARACTERISTICS:					
(1) Occupied bandwidth (10)	3	4	10	5	6
(2) Protection Ratios (10)	7	7	8	1	9
III. COVERAGE (Relative to Mono):					
(1) Stereo to mono receiver (5)	5	5	5	5	5
(2) Stereo to stereo receiver (5)	*	*	*	*	*
IV. TRANSMITTER STEREO PERFORMANCE:					
(1) Distortion (10)	8	8	6	6	4
(2) Frequency Response (10)	8	5	5	6	8
(3) Separation (10)	10	10	10	8	3
(4) Noise (10)	6	10	8	6	8
V. RECEIVER STEREO PERFORMANCE: Degradation in stereo performance over that measured at the transmitter, including consideration of directional antenna and propagation degradation (10)	9	8	9	5	5
TOTAL SCORES:	76	71	72	58	65

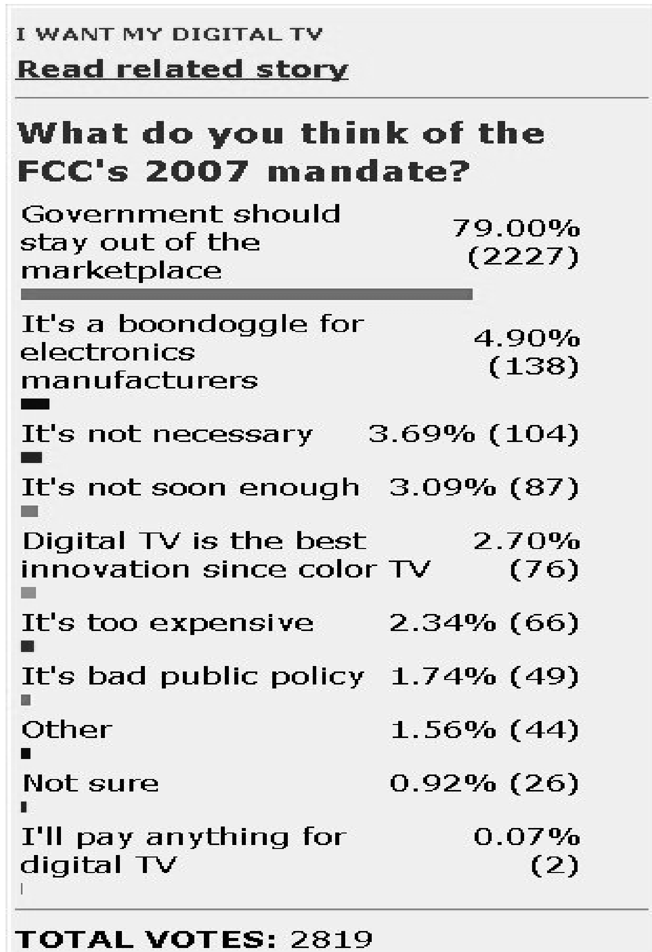
Note: The entries in the table which are underscored are the ones which we have either completed or modified based upon data submitted in response to the *Further Notice* of September 11, 1980.

Source: FCC 82-111 *Report and Order (Proceeding Terminated): In the Matter of AM Stereophonic B/casting,* FCC docket file 21313 document, adopted 4 March, 1982, released 18 March, 1982: 13.

Note. From *AM Stereo: A Case Study Of A Marketplace Shibboleth*, by M. J. Braun, 1994, Norwood, NJ, Ablex, p. 130

APPENDIX E

HDTV Poll Results


I WANT MY DIGITAL TV

Read related story

What do you think of the FCC's 2007 mandate?

Government should stay out of the marketplace	79.00% (2227)
It's a boondoggle for electronics manufacturers	4.90% (138)
It's not necessary	3.69% (104)
It's not soon enough	3.09% (87)
Digital TV is the best innovation since color TV	2.70% (76)
It's too expensive	2.34% (66)
It's bad public policy	1.74% (49)
Other	1.56% (44)
Not sure	0.92% (26)
I'll pay anything for digital TV	0.07% (2)

TOTAL VOTES: 2819

Note. From *What Do You Think of the FCC's 2007 Mandate?* by Worldnetdaily.com, 2002, retrieved July 20, 2003, from http://www.worldnetdaily.com/polls/former_poll.asp?POLL_ID=557

APPENDIX F

Broadcast Radio Bands

Broadcast Radio Bands	
Meter Band	**Frequency (MHz)**
LW	.150 - .285
MW	.530 - 1.710
120	2.30 - 2.50
90	3.20 - 3.40
75	3.90 - 4.00
60	4.75 - 5.20
49	5.85 - 6.20
40	7.10 - 7.50
31	9.35 - 9.90
25	11.55 - 12.05
22	13.60 - 13.90
19	15.10 - 15.70
16	17.55 - 17.90
15	18.90 - 19.30
13	21.45 - 21.85
11	25.67 - 26.10

Note. From *Shortwave Radio Bands*, by the National Aeronautics and Space Agency, 2002, retrieved September 24, 2004, from http://www.grc.nasa.gov/WWW/MAEL/ag/swbands.htm

APPENDIX G

Interview Questions

1. (SPSS Q1) Of which group are you a member?

   a. Innovators (iBiquity Corp. or the DRM Consortium)
   b Regulators (the FCC or the ITU)
   c. Manufacturers (of transmitters, receivers, or chips)
   d. Broadcasters
   e. Other (academics, competitors [satellite radio, iPodcasting, or CAM-D], or media critics)

Innovators

iBiquity HD Radio

A. General questions to all iBiquity stakeholders:

   1. (SPSS Q2) How do you define success for HD Radio technology?

   2. (SPSS Q3) How will HD Radio affect radio listening habits?

   3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

   4. (SPSS Q5) What factors will cause it to fail?

   5. (SPSS Q6-9) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio?

   6. (SPSS Q10) How do you see the development and success (or failure) of HD Radio progressing over analog transmission in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

   7. (SPSS Q11) What safeguards are in place to help prevent the failure of HD Radio so that it does not follow a path similar to that of AM Stereo technology?

B. Are you involved with iBiquity's HD Radio rollout strategy? If yes:

   1. (SPSS Q12) How does iBiquity intend to achieve a return on investment for its research and development?

2. (SPSS Q13) What competition do you envision between DRM and HD Radio technologies?

3. (SPSS Q14) What strategy is in place to help ensure the success of HD Radio over other emerging broadcast technologies (e.g., satellite radio [XM Radio, Sirius, and WorldSpace], HDTV/DTV, Internet-streaming audio, and iPodcasting)?

4. (SPSS Q15) How long do you expect the "digital sunrise" (i.e., the transition from IBOC with analog AM-FM to fully-digital HD Radio) to last?

5. (SPSS Q16) Once HD Radio is in the fully digital mode, what plans are in place for broadcasters to initiate single frequency networks (SFNs)?

6. (SPSS Q17) Should more spectrum be available for terrestrial radio broadcasting?

    a. (SPSS Q18) If so, should it be allocated in the longwave, mediumwave, shortwave, VHF, UHF, or satellite bands?

    b. (SPSS Q19) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30 American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the United States?

    c. (SPSS Q20) How would digital radio technologies affect such a decision?

C. Are you involved with iBiquity's HD Radio marketing? If yes:

1. (SPSS Q21) What is the current status of the marketing of HD Radio to broadcasters? How is it being received?

    a. (SPSS Q22) Why should broadcasters transition to digital modulation?

    b. (SPSS Q23) What benefits does HD Radio offer to radio broadcasters?

    c. (SPSS Q24) What is the cost to the broadcaster for the transition from AM or FM to IBOC HD Radio transmission?

d. (SPSS Q25) How do commercial radio broadcasters earn revenue using digital modulation technology?

e. (SPSS Q26) How do broadcasters receive a return on their investment in their purchase or modification of the transmission equipment necessary to transition from AM or FM to IBOC HD Radio?

2. (SPSS Q27) What is the current status of the marketing of HD Radio to transmitter manufacturers? How is it being received?

3. (SPSS Q28) What is the current status of the marketing of HD Radio to receiver manufacturers and auto manufacturers? How is it being received?

   a. (SPSS Q29) When do you expect to see the first generation of HD car radios?

   b. (SPSS Q30) What is the anticipated cost to consumers for an HD Radio receiver compared to that of an analog AM-FM receiver?

   c. (SPSS Q31) When will HD Radio receivers become available for consumers?

4. (SPSS Q32) What is the current status of the marketing of HD Radio to the general public (i.e., listeners)? How is it being received?

D. Are you involved with HD Radio regulation? If yes:

1. (SPSS Q33) How has the FCC treated HD Radio? Has it been treated fairly or unfairly, or do you feel that it has been given preferential treatment over other evolving technologies?

2. (SPSS Q34) Were the normal processes and procedures for developing new regulatory guidelines followed?

3. (SPSS Q35) Why do you feel that Eureka-147 DAB, DRM, and CAM-D technologies were rejected by the FCC in favor of HD Radio as the U.S. standard for digitally modulated radio?

4. (SPSS Q36) How/why did the FCC approve this out-of-channel design and configuration?

a. (SPSS Q37) Why is this out-of-channel operation not considered "spurious radiation"?

b. (SPSS Q38) What services could be offered if the HD Radio IBOC signal is limited to the constraints of the currently allocated channels?

5. (SPSS Q39) Why did the FCC authorize daytime-only transmission of IBOC HD Radio in the AM mediumwave band?

   a. (SPSS Q40) What is the current status of study regarding the use of HD Radio for nighttime mediumwave operations?

   b. (SPSS Q41) How will this limitation on transmission time affect HD Radio's success in the AM mediumwave band?

E. To all at iBiquity stakeholders. Value to the consumer:

1. (SPSS Q42) What value does digitally modulated radio provide to the consumer?

2. (SPSS Q43) Many media critics and academics have cited the fact that the success of FM over AM was not due to FM's superior audio quality but rather FM's ability to provide new and diverse program content in the 1970s and early 1980s. What new content will HD Radio provide to 21st-century listeners?

3. (SPSS Q44) What is the current status of HD Radio's ability to transmit multimedia products?

   a. (SPSS Q45) What ancillary services will be available in first-generation receivers?

   b. (SPSS Q46) What improvements do you envision in second- and third-generation receivers over first-generation receivers?

F. To all iBiquity stakeholders:

1. (SPSS Q47) What other comments do you have regarding the marketing, regulation, research and development, and implementation of HD Radio technology?

Digital Radio Mondiale

A. General questions to all DRM stakeholders:

1. (SPSS Q48) How do you define “success” for DRM technology?

2. (SPSS Q49) How will DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of DRM?

6. (SPSS Q54) How do you see the development and success (or failure) of DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q55) What safeguards are in place to help prevent the failure of DRM so that it does not follow a path similar to that of AM Stereo technology?

B. Are you involved with DRM’s rollout strategy? If yes:

1. (SPSS Q56) How does the DRM Consortium intend to achieve a return on investment for its research and development?

2. (SPSS Q57) What strategy is in place to help insure the success of DRM over other emerging broadcast technologies (e.g., satellite radio [XM Radio, Sirius, and WorldSpace], HDTV/DTV, Internet-streaming audio, and iPodcasting)?

3. (SPSS Q58) How long do you expect the digital sunrise (i.e., the transition from simulcasting with analog AM-FM to fully digital) to last?

4. (SPSS Q59) Does DRM have the potential of revitalizing shortwave and/or longwave radio broadcasting?

5. (SPSS Q60) Once DRM is in the fully digital mode (after the digital sunrise), what plans are in place for broadcasters to initiate single frequency networks (SFNs)?

a. (SPSS Q61) Using DRM technology, can SFNs operate on a global scale in the shortwave bands?

6. (SPSS Q62) How does the DRM Consortium plan to pay for the research and development and implementation of the new modulation technology?

   a. (SPSS Q63) How will DRM Consortium investors realize a return on their investment?

7. (SPSS Q13) What competition do you envision between DRM and HD Radio technologies?

8. (SPSS Q64) What strategy is in place to help ensure the success of DRM over other emerging broadcast technologies (e.g., Eureka-147 DAB, satellite radio [XM Radio, Sirius, and WorldSpace], HDTV/DTV, and Internet-streaming audio)?

9. (SPSS Q15) Should more spectrum be available for terrestrial radio broadcasting?

   a. (SPSS Q17) If so, should it be allocated in the longwave, mediumwave, shortwave, VHF, UHF, or satellite bands?

   b. (SPSS Q18) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30 American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the U.S.?

   c. (SPSS Q19) How would digital radio technologies affect such a decision?

   d. (SPSS Q65) Are there plans for a VHF/UHF version of DRM technology?

B. Are you involved with the marketing of DRM? If yes:

1. (SPSS Q66) What is the current status of the marketing of DRM to broadcasters? How is it being received?

   a. (SPSS Q22) Why should broadcasters transition to digital modulation?

b. (SPSS Q67) What benefits does DRM offer to radio broadcasters?

c. (SPSS Q68) What is the cost to the broadcaster for the transition from AM or FM to DRM transmission?

d. (SPSS Q25) How do commercial radio broadcasters earn revenue using digital modulation technology?

e. (SPSS Q69) How do broadcasters receive a return on their investment in their purchase or modification of the transmission equipment necessary to transition from AM or FM to DRM?

3. (SPSS Q70) What is the current status of the marketing of DRM to receiver manufacturers and auto manufacturers? How is it being received?

a. (SPSS Q71) When do you expect to see the first generation of DRM car radios?

b. (SPSS Q72) What is the anticipated cost to consumers for an DRM radio receiver compared to that of an analog AM-FM receiver?

c. (SPSS Q73) When will DRM receivers become available for consumers?

4. (SPSS Q74) What is the current status of the marketing of DRM to the general public (i.e., listeners)? How is it being received?

B. Are you involved with DRM regulation? If yes:

1. (SPSS Q75) How has the ITU treated DRM? Has it been treated fairly or unfairly, or do you feel it has been given preferential treatment over other evolving technologies?

2. (SPSS Q76) Were the normal processes and procedures for developing new regulatory guidelines followed?

3. (SPSS Q77) Why do you feel that Eureka-147 DAB, HD Radio, and CAM-D technologies were rejected by the ITU in favor of DRM as the world's standard for digitally modulated radio below 30 MHz?

D. To all at DRM stakeholders. Value to the consumer:

1. (SPSS Q40) What value does digitally modulated radio provide to the consumer?

2. (SPSS Q78) Many media critics and academics have cited the fact that the success of FM over AM was not due to FM's superior audio quality but rather FM's ability to provide new and diverse program content in the 1970s and early 1980s. What new content will DRM provide to 21st-century listeners?

3. (SPSS Q79) What is the current status of DRM's ability to transmit multimedia products?

   a. (SPSS Q80) What ancillary services will be available in first-generation receivers?

   b. (SPSS Q81) What improvements do you envision in second- and third-generation receivers over first-generation receivers?

E. To all DRM stakeholders:

   1. (SPSS Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of DRM technology?

Regulators

FCC Regulators

1. (SPSS Q2) How do you define "success" for HD Radio technology?

2. (SPSS Q3) How will HD Radio affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio?

6. (SPSS Q10) How do you see the development and success (or failure) of HD Radio progressing over analog transmission in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11) What safeguards are in place to help prevent the failure of HD Radio so that it does not follow a path similar to that of AM Stereo technology?

8. (SPSS Q33) How has the FCC treated HD Radio? Has it been treated fairly or unfairly, or do you feel it has been given preferential treatment over other evolving technologies?

9. (SPSS Q34) Were the normal processes and procedures for developing new regulatory guidelines followed?

10. (SPSS Q35) Why do you feel that Eureka-147 DAB, DRM, and CAM-D technologies were rejected by the FCC in favor of HD Radio as the U.S. standard for terrestrial digitally modulated radio?

11. (SPSS Q36) How/why did the FCC approve the out-of-channel design and configuration of HD Radio?

    a. (SPSS Q37) Why is this out-of-channel operation not considered "spurious radiation"?

    b. (SPSS Q38) What services could be offered if the HD Radio IBOC signal is limited to the constraints of the currently allocated channels?

12. (SPSS Q39) Why did the FCC authorize daytime-only transmission of IBOC HD Radio in the AM mediumwave band?

    a. (SPSS Q40) What is the current status of study regarding the use of HD Radio for nighttime mediumwave operations?

    b. (SPSS Q41) How will this limitation on transmission time affect HD Radio's success in the AM mediumwave band?

13. (SPSS Q42) What value does digitally modulated radio provide to the consumer?

14. (SPSS Q83) How does the approval of digital radio modulation benefit the public interest, convenience, or necessity (PICON)?

    a. (SPSS Q82) Is PICON a consideration in the regulatory process?

15. (SPSS Q16) Should more spectrum be available for terrestrial radio broadcasting?

    a. (SPSS Q17) If so, should it be allocated in the longwave, mediumwave, shortwave, VHF, UHF, or satellite bands?

    b. (SPSS Q18) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30

American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the United States?

c. (SPSS Q19) How would digital radio technologies affect such a decision?

16. (SPSS 83) In terms of digital radio modulation, most of the world is considering DRM technology below 30 MHz and Eureka 147 DAB for terrestrial use in the satellite L-Band. What affect will this have on American broadcasting, which has adopted HD Radio as its technological standard?

17. (SPSS 84) If interference issues exist between analog and digital cochannel or adjacent channel broadcasters, how do you expect to resolve them?

18. (SPSS Q47) What other comments do you have regarding the marketing, regulation, research and development, and implementation of HD Radio technology?

ITU Regulators

1. (SPSS Q48) How do you define "success" for DRM technology?

2. (SPSS Q49) How will DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of DRM?

6. (SPSS Q54) How do you see the development and success (or failure) of DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q55) What safeguards are in place to help prevent the failure of DRM so that it does not follow a path similar to that of AM Stereo technology?

8. (SPSS Q75) How has the ITU treated DRM? Has it been treated fairly or unfairly, or do you feel it has been given preferential treatment over other evolving technologies?

9. (SPSS Q76) Were the normal processes and procedures for developing new regulatory guidance followed?

10. (SPSS Q77) Why do you feel that Eureka-147 DAB, HD Radio, and CAM-D technologies were rejected by the ITU in favor of DRM as the world's standard for digitally modulated radio below 30 MHz?

11. (SPSS 86) If interference issues exist between analog and digital cochannel or adjacent channel broadcasters, how do you expect to resolve them?

12. (SPSS Q17) Should more spectrum be available for terrestrial radio broadcasting?

    a. (SPSS Q18) If so, should it be allocated in the longwave, mediumwave, shortwave, VHF, UHF, or satellite bands?

    b. (SPSS Q19) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30 American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the United States?

    c. (SPSS Q20) How would digital radio technologies affect such a decision?

13. (SPSS Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of DRM technology?

Manufacturers

Transmitter Manufacturers

1. (SPSS Q2 or Q48) How do you define "success" for digitally modulated radio (HD Radio or DRM)?

2. (SPSS Q3 or Q49) How will HD Radio or DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9 or Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio or DRM?

6. (SPSS Q10 or Q54) How do you see the development and success (or failure) of HD Radio or DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11 or Q55) What safeguards are in place to help prevent the failure of HD Radio and DRM so that they do not follow the path similar to that of AM Stereo technology?

8. (SPSS Q87) What is the current status of development and implementation of digital transmission equipment?

9. (SPSS Q88) What other factors are necessary, in addition to purchasing a new transmitter or exciter, for a broadcaster to transition to HD Radio or DRM from AM or FM?

10. (SPSS Q21 or Q66) What is the current status of the marketing of HD Radio or DRM to broadcasters? How is it being received?

    a. (SPSS Q22) Why should broadcasters transition to digital modulation?

    b. (SPSS Q23 and/or Q67) What benefits does HD Radio and/or DRM offer to radio broadcasters?

    c. (SPSS Q 24 or Q68) What is the cost to the broadcaster for the transition from AM or FM to HD Radio or DRM transmission?

    d. (SPSS Q25) Where is the profitability for commercial radio broadcasters in digital modulation?

    e. (SPSS Q26 or Q69) How do broadcasters receive an return on investment for their investment in purchasing or modifying their transmission equipment in order to transition from AM or FM to HD Radio or DRM?

11. (SPSS Q89) How rapid is the actual rate of purchase of new digital broadcast transmission equipment in relation to projections?

12. (SPSS Q47 or Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of HD Radio and DRM technologies?

Receiver Manufacturers

1. (SPSS Q2 or Q48) How do you define “success” for digitally modulated radio (HD Radio or DRM)?

2. (SPSS Q3 or Q49) How will HD Radio or DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9 or Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio or DRM?

6. (SPSS Q10 or Q54) How do you see the development and success (or failure) of HD Radio or DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11 or Q55) What safeguards are in place to help prevent the failure of HD Radio and DRM so that they do not follow a path similar to that of AM Stereo technology?

8. (SPSS Q90) How is development and sales for HD Radio and DRM receivers progressing in relation to that of Eureka-147 DAB and satellite radio (XM, Sirius, and WorldSpace) technologies?

9. (SPSS Q91) How rapid is the actual rate of purchase of new digital broadcast receivers in relation to projections?

10. (SPSS Q92) Has any consideration been given to the development of digital receivers that include tuning of the shortwave bands as standard equipment?

11. (SPSS Q93) Has any consideration been given to the development of a "universal" receiver capable of decoding HD Radio, DRM, Eureka-147 DAB, and, with the use of an electronic lock and key (opened after verification of subscription), satellite radio technology (XM Radio, Sirius, and/or WorldSpace)? What is the projected cost for a "universal" receiver compared to that of an HD Radio- or DRM-only chip?

12. (SPSS Q47 or Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of the HD Radio and DRM technologies?

Chip Manufacturers

1. (SPSS Q2 or Q48) How do you define "success" for digitally modulated radio (HD Radio or DRM)?

2. (SPSS Q3 or Q49) How will HD Radio or DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9 or Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio or DRM?

6. (SPSS Q10 or Q54) How do you see the development and success (or failure) of HD Radio or DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11 or Q55) What safeguards are in place to help prevent the failure of HD Radio and DRM so that they do not follow a path similar to that of AM Stereo technology?

8. (SPSS Q94) What is the current state of development of digital chips for radio receivers necessary to decode HD Radio or DRM modulation?

    a. (SPSS Q95) How much do they cost?

    b. (SPSS Q96) What is the added cost to a typical analog AM-FM receiver?

9. (SPSS Q97) How are chip development and sales for IBOC HD Radio and DRM receivers progressing in relation to that of Eureka-147 DAB and satellite radio (XM, Sirius, and WorldSpace) technologies?

10. (SPSS Q93) Has any consideration been given to the development of a "universal" chip capable of decoding HD Radio, DRM, Eureka-147 DAB, and, with the use of an electronic lock and key (opened after verification of subscription), satellite radio technology? What is the projected cost for a "universal" chip compared to that of an HD Radio- or DRM-only chip?

11. (SPSS Q47 or Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of the HD Radio DRM technologies?

Broadcasters

1. (SPSS Q2 or Q48) How do you define "success" for digitally modulated radio (HD Radio or DRM)?

2. (SPSS Q3 or Q49) How will HD Radio or DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9 or Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio or DRM?

6. (SPSS Q10 or Q54) How do you see the development and success (or failure) of HD Radio or DRM progressing over analog AM transmission below 30 MHz in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11 or Q55) What safeguards are in place to help prevent the failure of HD Radio and DRM so that they do not follow a path similar to that of AM Stereo technology?

8. (SPSS Q21 or Q66) What is the current status of the marketing of HD Radio or DRM to broadcasters? How is it being received?

    a. (SPSS Q22) Why should broadcasters transition to digital modulation?

    b. (SPSS Q23 or Q67) What benefits does HD Radio or DRM offer to radio broadcasters?

    c. (SPSS Q24 or Q68) What is the cost to the broadcaster for the transition from AM or FM to HD Radio or DRM transmission?

    d. (SPSS Q25) Where is the profitability for commercial radio broadcasters in digital modulation?

    e. (SPSS Q26 or Q69) How do broadcasters receive an return on investment for their investment in purchasing or modifying their transmission equipment in order to transition from AM or FM to HD Radio or DRM?

9. (SPSS Q17) Should more spectrum be available for terrestrial radio broadcasting?

    a. (SPSS Q18) If so, should it be allocated in the long-, medium-, shortwave, VHF, UHF, or satellite band?

    b. (SPSS Q19) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30

American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the U.S.?

c. (SPSS Q20) How would digital radio technologies affect such a decision?

10. (SPSS Q47 or Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of HD Radio DRM technologies?

Academics, Competitors, and Media Critics

1. (SPSS Q2 or Q48) How do you define "success" for digitally modulated radio (HD Radio or DRM)?

2. (SPSS Q3 or Q49) How will HD Radio or DRM affect radio listening habits?

3. (SPSS Q4) What critical factors are necessary for digitally modulated radio to succeed as a viable technology?

4. (SPSS Q5) What factors will cause it to fail?

5. (SPSS Q6-9 or Q50-53) What do you view as the SWOTs (strengths, weaknesses, opportunities, and threats) of HD Radio or DRM?

6. (SPSS Q10 or Q54) How do you see the development and success (or failure) of HD Radio and DRM progressing over analog transmission in relation to the progressive dominance of FM over AM in the 1970s and 1980s?

7. (SPSS Q11 or Q55) What safeguards are in place to help prevent the failure of HD Radio and DRM so that they does not follow a path similar to that of AM Stereo technology?

8. (SPSS Q12 or Q56) How does iBiquity or the DRM Consortium intend to achieve a return on investment for its research and development?

9. (SPSS Q13) What competition do you envision between DRM and HD Radio technologies?

10. (SPSS Q33 or Q75) Have the digital radio technologies (HD Radio and DRM) been treated fairly or unfairly by the regulatory bodies (the FCC and the ITU), or have they been given preferential treatment?

11. (SPSS Q85) In terms of digital radio modulation, most of the world appears to be considering DRM technology below 30 MHz and Eureka-147 DAB for terrestrial use in the satellite L-Band. What affect will this have on American broadcasting, which has adopted HD Radio as its technological standard?

12. (SPSS Q43 and/or78) Many media critics and academics have cited the fact that the success of FM over AM was not due to FM's superior audio quality but rather from FM's ability to provide new and diverse program content in the 1970s and early 1980s. Can a new radio broadcast technology become successful solely due to its ability to "sound better?" What new content will HD Radio and/or DRM provide to 21st-century radio listeners?

13. (SPSS Q26 or 69) How do broadcasters receive an return on investment in the purchase or modification of the transmission equipment necessary to transition from AM or FM to IBOC HD Radio or DRM?

14. (SPSS Q57) What strategy is in place to help ensure the success of DRM over other emerging broadcast technologies (e.g., satellite radio [XM Radio, Sirius, and WorldSpace], HDTV/DTV, Internet streaming, MP3 iPodcasting, etc.)?

15. (SPSS Q58) How long do you expect the "digital sunrise" (i.e., the transition from simulcasting with analog AM-FM to fully-digital) to last?

16. (SPSS Q59) Does DRM have the potential to revitalize shortwave and/or longwave radio broadcasting?

17. (SPSS Q17) Should more spectrum be available for terrestrial radio broadcasting?

    a. (SPSS Q18) If so, should it be allocated in the long-, medium-, shortwave, VHF, UHF or satellite band?

    b. (SPSS Q19) Currently, a great deal of spectrum is allocated for U.S. broadcast purposes in the shortwave bands, yet there are fewer than 30 American stations licensed to use this entire spectrum. Should the FCC's citing of the Smith-Mundt Act of 1948 be amended or eliminated to allow more commercial shortwave broadcasting in the United States?

    c. (SPSS Q20) How would digital radio technologies affect such a decision?

18. (SPSS Q47 or Q82) What other comments do you have regarding the marketing, regulation, research and development, and implementation of HD Radio and DRM technologies?

APPENDIX H

Critical Factors in Success, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	When more than 50% of listeners (a majority) use HD Radio or DRM compared to analog radio.	5	4	1
2.	When adopted by consumers.	4	4	0
3.	When there is 10% to 20% receiver penetration/audience listening of digital radio.	4	2	2
4	When digital radio becomes the default (normal) form of radio. When it is universally accepted and ubiquitous.	3	3	0
5	When 50% of households outside of top-100 markets purchase digital receivers.	2	2	0
6.	When HD Radio or DRM achieve sufficient "earshare" to sell space to advertisers.	2	2	0
7.	When HD Radio or DRM achieve 30% to 50% receiver penetration.	2	2	0
8.	When HD Radio or DRM achieve technological success (i.e., they "work"). The buildup and achievement of the system.	2	1	1
9.	When millions of radio receivers are in use in the Marketplace.	2	1	1
10.	When HD Radio or DRM achieve 50% of listenership within 10 years (2017)	2	1	1
11.	When there is a reasonable return on investment	1	1	0
12.	When HD Radio or DRM are adopted by broadcasters.	1	1	0
13.	Produce receivers.	1	1	0
14.	When HD Radio or DRM produce compelling content.	1	1	0

15.	When HD Radio or DRM achieves 5% percent receiver penetration over the next 5 years.	1	1	0
16.	When HD Radio or DRM is on every radio station and in every radio.	1	1	0
17.	When 33% of the audience can hear HD signals.	1	1	0
18.	When 85% percent of the audience is listening on a digital signal	1	1	0
19.	A measure of uptake for the U.S. commercial and noncommercial market.	1	1	0
20.	When the average consumer knows about it, is familiar with it, is comfortable using it, and can afford it.	1	1	0
21.	When HD Radio is monetized so that broadcasters can get a return on investment for their multicast streams.	1	1	0
22.	When HD Radio or DRM is implemented by a majority of radio stations without interference cases that the FCC cannot resolve.	1	1	0
23.	When HD Radio or DRM work as advertised and provide high-quality signals without degradation of analog broadcasting or intersystem interference.	1	1	0
24.	When radio stations convert to all digital. The IBOC system is not the objective. It is just a way to get started.	1	1	0
25.	Number of stations starting to use HD Radio relative to the iBiquity 10-year adoption cycle report.	1	1	0
26.	Receiver penetration is secondary because 80% of people seeking to adopt are likely to look for receiver availability.	1	1	0
27.	Two metrics: the number of stations that have installed digital transmission technologies and receiver penetration.	1	1	0
28.	When we get requests from broadcasters to operate in an all-digital mode, which has many extra benefits.	1	1	0

29.	When HD Radio or DRM is commonly included in most receivers sold.	1	1	0
30.	When there is sufficient consumer demand that the leader take the increased price points for inclusion in radio receivers.	1	1	0
31.	When it becomes technologically feasible to include HD Radio or DRM in radio receivers at a lower cost or at no additional cost.	1	1	0
32.	When 50% of middle- and small-market owners have made the conversion to HD Radio.	1	1	0
33.	When the earshare does not deteriorate.	1	1	0
34.	When HD Radio or DRM is standard in car stereos and in reasonably priced consumer electronics gear.	1	1	0
35.	When DRM is an international success.	1	0	1
36.	When receivers are available under $100.	1	0	1
37.	Quantity of receivers sold.	1	0	1
38.	DRM content on the air needs to precede receiver sales.	1	0	1
39.	Marketing to the public about DRM needs to precede receiver sales.	1	0	1
40.	When there is a growing listener base.	1	0	1
41.	To bring high-quality audio to listeners on the AM bands.	1	0	1
42.	When digital radio has been used for years for non-broadcast purposes.	1	0	1
43.	By DRM's use of superior digital coding.	1	0	1
44.	When DRM stations are reaching the FM level.	1	0	1
45.	When there is 25% market penetration within 10 years in countries where HD Radio or DRM has already been launched.	1	0	1

46.	When several millions of DRM receivers are sold worldwide within 10 years.	1	0	1
47.	When HD Radio or DRM survive for 4 or 5 years.	1	0	1
48.	When DRM replaces AM radio.	1	0	1
49.	When DRM technology is used around the world.	1	0	1
50.	When all receivers have DRM capability so that all listeners can receive DRM as well as analog radio.	1	0	1
51.	When 80% of users (broadcasters and listeners) have HD Radio or DRM technology worldwide.	1	0	1
52.	When DRM is used in all parts of the world (unlike HD Radio, which has only the U.S. as a target).	1	0	1
53.	When about 60% of broadcasters use DRM in about 2 or 3 years.	1	0	1
54.	When a company that gets the technology to market recoups its money with receivers in the marketplace.	1	0	1
55.	When DRM can provide an increased level of service for minority groups around the U.K.	1	0	1
56.	When 250,000 additional listeners tune in to DRM-based radio services in the U.K.	1	0	1
57.	It would probably be defined in terms of the cost of a radio set, the lowest price. That definition was previously used by DAB.	1	0	1
58.	When a developed standard, compliant transmitters, and the radio receivers are in the market.	1	0	1
59.	When HD Radio or DRM can stand on its own.	1	0	1
60.	When broadcasters start shutting off their analog transmitters without believing that they will experience a decrease in listenership.	1	0	1

61.	When receivers become ubiquitous and inexpensive so it is easy for consumers to buy them.	1	0	1
62.	When all analog radios are replaced with ones that receive digital signals.	1	0	1
63.	With DRM the business model is not necessarily purely economic. There are policy goals.	1	0	1
64.	When foreign service broadcasters can use DRM to reach deeper into countries with a more stable signal.	1	0	1
65.	DRM is keeping shortwave relevant.	1	0	1
66.	When HD Radio or DRM is a widely accepted platform by which people can receive content, whether audio or data.	1	0	1
67.	This is more about DRM finding its place within the multiple platforms that exist in which people can receive and consume content.	1	0	1
68.	When users can use DRM technology to get data of some sort from point "A" to point "B."	1	0	1
69.	When widely available radios as well as regularly available broadcasts are easily heard in one or more geographic locations.	1	0	1
70.	When HD Radio or DRM include applications outside of traditional broadcasting, such as utility broadcasts.	1	0	1
71.	When it is possible to broadcast a signal from a regional transmission facility to remote villages for local retransmission on FM or AM radios.	1	0	1
72.	When listeners can continue to receive HD Radio or DRM service while traveling from city to city.	1	0	1

APPENDIX I

The Contrarian's Comments on Failure

Increasingly, radio listening is down and radio sales, advertising, is off, and the projections for the next year is that it will be off again. This is happening to traditional media because interactive media is coming along. And our lives are changing, technology is changing, people are changing. So, if you came to me and said, "I'm going to go to Wal-Mart, Best Buy, and Radio Shack, and I'm going to do deals with them so they could sell HD Radios," which is what the industry has done, it has had zero impact because the stores don't want to sell it. In many cases they don't have them in stock when they say they're going to sell it. The radios are too expensive. I know, I know, I know, they'll be less expensive later. But they offer nothing that you want. Apple, on the other hand, has a telephone [the iPhone] that you want because it's a minicomputer, it's an entertainment center, and it's being used on a technology that you don't want [the Cingular/AT&T wireless network]. So what you have with HD is nothing that the audience wants. The people who are listening to radio, who are baby boomers, are happy to listen to the same signals. And if you said, "Hey, we're going to put some other subchannels," well, radio didn't do that. It would be as if Apple decided to come out with their phone today and stated, "Here, you can buy our phone and it's got the ability to do movies and to play your music and to show you who calls on the telephone so you can return the phone call instead of listening to the message, you can get your Internet, but we're not even going to invest in that yet. You're going to get it later." And if you can see where I'm going with this, the radio industry is a "yawner." They went out and they offered something that nobody wants, gave them no reason to be tempted, not investing any of their money in content, and I can't understand for the life of me how so many smart people can be so dumb. You've got the wrong guy if you think I'm going to compliment HD Radio because it's awful. . . .

It's sad. And I just can't get anybody's attention to tell them that, you know, we love this thing. It [commercial radio broadcasting] was great while it lasted. We helped kill it off with consolidation, but even before consolidation we were killing it off because we got lazy and we weren't developing new formats and we were losing the next generation. Now, the next generation found something and they don't need us. And we have to decide. Can we do this better now? Can we do niche programming? Can we do content? Can we have many opinions? Can we have 1,000 different Top-40 radio stations? And are these radio stations 24 hours a day, or are some of them 30 minutes long and they're so good we want more? Whatever the future brings, we have to learn our lesson. Technology does not drive it. Content does. And when content fights technology you have what you had when HD came out originally. You have battles over which system [is best] and all the regulatory crap and you're late to the market until it doesn't matter anymore. You bastardized the advantage of HD by adding sub-channels instead of saying, "We're going to improve the fidelity while you improve the content." There's a lot of mistakes that have been made here, and I want to wake as many people up as possible and say, “Get to the Apple store and look at your future.” And that’s primitive [the new Apple iPhone]. . . .

Here's a good idea. Take all that money you're wasting [on digitally modulated radio] and go and start developing new programs. And then, get a bunch of people together and figure out how to deliver it using the latest technology. So maybe you’re the one that delivers the morning show that isn't on the air on your radio station but it is delivered via, let’s say, the Internet or via the cell phone. And you [the listener] can purchase it through an account. And you can consume it as you want to consume it. Why can’t the radio industry realize that they’re in the content business?

I always tell my students that the railroad barons of the 1900s always saw themselves as “railroad men.” You know, it was a big business. Everything moved by the railroad. They made a mistake because when air travel came along, they were “railroad men” and airline companies were “flyers.” The railroad barons should have thought of themselves as being in the transportation business. And this is where radio has got a problem. They think of themselves as being in radio with transmitters and FM, AM. and, ooooh, look at this HD. It's going to save us. In reality, they've got to get into the content business—not the broadcasting business. . . .

My projection is—and you can’t research the future but you can predict it and I’m about to do that—is that your morning show won’t even be on the radio. It’ll be a podcast that's delivered for delayed use probably whatever the average commute time is in your city—40, 45 minutes. And you’ll go in and you’ll buy it when you buy your coffee at Starbucks or buy your breakfast at McDonalds, pay an extra 50 cents and instead of “supersizing” your meal you’ll “supersize” your iPod, and you’ll walk away with the kind of content that you want. Therefore, the delivery system changes and we become content deliverers instead of radio broadcasters. Therefore, the technology [of HD Radio] is out of sync with where we’re headed.

I’m suggesting to you that programming will be delivered and you’ll take it on your iPod and you’ll bring it and use it and consume it and throw it away and decide to buy more based on your ability to use it [when] and where you want to use it.

The only reason you have morning shows [on the radio] that start at 5:00 a.m. and end at 10:00 a.m. is because that’s what broadcasting was. You wake up, and at 7:20 we have the most listeners, and we’ll do our contest promo at 7:20. Well that’s not the way it is anymore. And now, when you commute to work, you can commute at any time. So, it means that you can have your morning show in your pocket. And you can listen to it, interrupt it, take a phone call or text message somebody or take some Ritalin and say, “Look, I can’t concentrate right now. . . .”

We have to adapt. And what I’m saying to you, Rick, is that the technology is not going to drive it. Content is going to drive it.

APPENDIX J

Critical Factors for Success, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	Receiver penetration. Better distribution of receivers. When receivers are available and competitively priced.	18	10	8
2.	Consumer products hit mass adoption price point. Inexpensive receivers ($50 to $100; less than $250).	16	10	6
3.	New and compelling content. Content is what motivates people to buy radios.	9	4	5
5.	As user-friendly as analog (size and convenience of radios). Ease of tuning. Ease of use.	6	3	3
4.	HD Radio receivers as standard OEM equipment, as standard installation in cars. Preferably not as an option.	5	5	0
6.	Adoption by all key industries. Synchronization of all players.	4	3	1
7.	Access and marketing to consumers.	3	3	0
8.	Variety of new features	3	3	0
9.	Consumer satisfaction, acceptance, and demand.	2	2	0
10.	Regulatory support.	2	1	1
11.	Infrastructure built.	1	1	0
12.	Better receivers.	1	1	0
13.	Flexibility to change for new applications—a platform for innovation.	1	1	0
14.	Industry support.	1	1	0
15.	I don't know how to answer that.	1	1	0

16.	Portable receiver availability (HD chips in cell phones and iPods).	1	1	0
17.	Affordable licensing.	1	1	0
18.	Raise the injection level of the digital power in the HD Radio hybrid mode from 1% to 2% or 3%.	1	1	0
19.	The fee structure slows HD Radio in small markets.	1	1	0
20.	The same type of availability that the existing terrestrial analog radio has, AM and FM. DRM and HD Radio must have a similar kind of coverage.	1	1	0
21.	Greater than 50% of broadcasters are providing HD Radio content.	1	1	0
22.	Digital chip sets with considerably lower power consumption.	1	1	0
23.	Operates as advertised without causing undue interference.	1	1	0
24.	Implementation costs realistic and reasonable.	1	1	0
25.	Broadcaster investment a lowering price point for receiver and consumer satisfaction.	1	1	0
26.	Having compelling programming on the additional channels will make it really roll out.	1	1	0
27.	Getting it integrated into other digital and audio products.	1	1	0
28.	Medium- and small-market broadcasters start broadcasting in HD Radio.	1	1	0
29.	Multicasting.	1	1	0
30.	Data services.	1	1	0
31.	Marketing. The strategy HD radio is pursuing at this point in time, of using stations to market the technology to the public, is appropriate.	1	1	0

32.	The HD Radio Alliance is the critical factor, along with some additional funding in order to bring receiver costs down.	1	1	0
33.	Diversity and cooperation of formats among the broadcasters are critical factors.	1	1	0
34.	The most critical success factor is that you be able to get content on the new technology that you cannot get anywhere else.	1	1	0
35.	Audio quality is not a value proposition. People have been trained on MP3 files and they are happy with them.	1	1	0
36.	DRM is already a success.	1	0	1
37.	Government steps in to seed the market for people to listen.	1	0	1
38.	Cost benefits for the broadcaster.	1	0	1
39.	Increased listener base.	1	0	1
40.	Audience perceives that digital radio is better.	1	0	1
41.	Government dictate to move to digital may overtake market forces.	1	0	1
42.	Simple-to-operate receivers.	1	0	1
43.	Synchronization of all elements of the industry (broadcasters, manufacturers, etc.).	1	0	1
44.	End the chicken-or-egg problem.	1	0	1
45.	Technology needs to be transparent to the listener.	1	0	1
46.	Radio needs to have multi-standard receivers.	1	0	1
47.	Radio needs to be part of the mobile phone.	1	0	1
48.	Makes distant stations as accessible as local stations.	1	0	1

49.	Reasonably good technology to provide the expected quality of service.	1	0	1
50.	Availability of various frequency spectrums for reasonably good migration scenario from analog to digital.	1	0	1
51.	Enough funding for DRM and HD Radio to leave the nascent stage and become fully commercialized.	1	0	1
52.	Having the time and the expertise to make relationships with receiver manufacturers, content providers, and stations.	1	0	1
53.	A developed technical standard.	1	0	1
54.	Transmitters and exciters that are DRM compliant.	1	0	1
55.	Marketing. DRM is not far enough down the path to see how they will get the marketplace to understand their technology.	1	0	1
56.	Receiver power consumption problems are overcome (especially that digital radio receiver chips draw large amounts of power).	1	0	1
57.	Government support. If left to the marketplace, a number of listeners would cling to the analog technology.	1	0	1
58.	Receiver manufacturers being brought on board to get cheap receivers and a wide variety of receivers into the hands of users.	1	0	1
59.	A combination of producing digital content through a transmission network to digitally capable receivers.	1	0	1
60.	A combination of three things: high-quality technology compelling content, and affordable receivers.	1	0	1
61.	The right regulatory regime that awards broadcasters the appropriate licensing.	1	0	1
62.	Recognition by regulators. Recognition means that the standard is accepted, adopted, and protected.	1	0	1
63.	Publicity and marketing to the general public.	1	0	1

APPENDIX K

Critical Factors for Failure, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	Lack of receivers.	14	3	11
2.	If receivers are too expensive. Getting the receiver price point below $99.	12	10	2
3.	If there is no new or compelling content. At least doubling the amount of content on FM with multicasting. Providing choice of content.	8	6	2
4.	If there is apathy. Lack of interest (broadcasters do not go on the air or people do not buy receivers). Disinterest or technology fatigue.	7	4	3
5.	If the price point does not get low enough for receivers.	6	3	3
6.	If HD Radio receivers are not in cars.	5	5	0
7.	If there is a lack of user-friendly receivers. If they are too complicated for people to use.	5	1	4
8.	If digital radio is overtaken by another technology like DVB-H, Wi-Max, or Wi-Fi. Newer technologies could supplant any form of digital radio.	5	1	4
9.	If there is a lack of variety of new features.	4	4	0
10.	Too much competition with other digital platforms such as iPods, DAB, satellite radio, and Internet radio.	4	1	3
11.	If there is no innovation by broadcasters.	3	3	0
12.	Too late coming to market in relation to other emerging technologies.	3	3	0

13.	If there is a standards war where people are confused by the standards of DRM and HD Radio (especially in the mediumwave).	3	1	2
14.	If consumers are unwilling to upgrade to new equipment.	2	1	1
15.	That the marketing is not well engineered; poor publicity to the general public.	2	0	2
16.	If it is not adopted by six industries.	1	1	0
17.	If there are technical issues.	1	1	0
18.	If it causes too much interference.	1	1	0
19.	If professionals are not accepting of digital radio.	1	1	0
20.	If it misses the window of opportunity.	1	1	0
21.	If there are poor quality first-generation receivers.	1	1	0
22.	If there is a lack of a compelling value proposition.	1	1	0
23.	If it does not meet consumer expectations for quality.	1	1	0
24.	If it does not sound as good as analog radio.	1	1	0
25.	If the range (coverage area) is not sufficient.	1	1	0
26.	If portable devices (HD Radios in cell phones and MP3 players) do not appear in a timely fashion	1	1	0
27.	If the radios are unattractive.	1	1	0
28.	If listeners do not think it is creative and innovative enough to buy receivers.	1	1	0
29.	If the technology and licensing is too expensive for medium- and small-market broadcasters.	1	1	0
30.	If consumers do not know what it is.	1	1	0
31.	Too many interference complaints.	1	1	0

32.	If people just do not really care. I think radio is an old medium that is losing audience share anyway.	1	1	0
33.	Broadcasters spend too much time debating and trying to avoid the investment and do not get on the bandwagon.	1	1	0
34.	That the benefits in terms of audio quality and increased programming choices are not all that impressive.	1	1	0
35.	If it is not integrated into other digital and audio products.	1	1	0
36.	If medium- and small-market broadcasters do not transition to HD Radio.	1	1	0
37.	I do not see lack of penetration and lack of receivers being a real deal killer. We are too far along in the process.	1	1	0
38.	If governments get involved with decision-making.	1	0	1
39.	If few consumers see a need to abandon FM.	1	0	1
40.	Lack of operators to invest in a technically savvy staff.	1	0	1
41.	Lack of coordination among all players (lack of synchronization of both value chains).	1	0	1
42.	Lack of regulatory support.	1	0	1
43.	Lack of transmitters.	1	0	1
44.	If, for whatever reasons, no one is listening to it.	1	0	1
45.	It will not fail because of technical reasons.	1	0	1
46.	DRM needs more broadcasters.	1	0	1
47.	DRM needs national broadcasters.	1	0	1
48.	DRM needs commercial broadcasters.	1	0	1
49.	Too much man-made interference from power lines. Broadband over power lines (BPL).	1	0	1
50.	If there is no penetration by 2012.	1	0	1

51.	Negative publicity and bad press.	1	0	1
52.	If there is no reasonably good technology to provide the the expected quality of service	1	0	1
53.	Availability of various frequency spectrums so that you have a reasonably good migration scenario from analog to digital.	1	0	1
54.	Difficulty in persuading receiver manufacturers to make DRM radios because it is not clear what content DRM is offering.	1	0	1
55.	DRM is a loose collection of the organization's members. It is much harder to stay together as a strong organization.	1	0	1
56.	If receiver power consumption problems are not overcome (digital radio receiver chips draw large amounts of power).	1	0	1
57.	Too much discussion and not enough action. The longer it takes them to talk about what they are going to do, the more it creates uncertainty among receiver manufacturers.	1	0	1
58.	If quality broadcasting, receivers, or compelling content is not available in the marketplace.	1	0	1
59.	Lack of coordination among broadcasters, receiver manufacturers, and the DRM Consortium.	1	1	0
60.	Regulation that does not allow the spectrum to be free of interference.	1	0	1
61.	The dispersion of broadcaster's interests among different delivery platforms.	1	0	1
62.	People not interested in listening to radio anymore because they can build their own content on their iPods or other mobile devices.	1	0	1

APPENDIX L

Strengths, Responses in Rank Order

		Respondents Total	HD	DRM
1.	Clarity of the signal. Improved quality of sound. Better audio quality, particularly on the AM and shortwave bands.	31	16	15
2.	New services (data and multimedia).	10	4	6
3.	Ability to distribute more innovative and compelling quality programming through FM-band multicasting.	8	6	2
4.	Does not require new spectrum. It works in existing spectrum and is spectrum efficient.	7	5	2
5.	Reduced digital power requirement to cover the same area provides a cost savings in electricity for shortwave broadcasters.	7	0	7
6.	Evolutionary technology: "digital is better than analog." Radio becomes relevant compared to other forms of media available today.	3	3	0
7.	Transitions terrestrial radio into the digital era. Transitions conventional radio to a digital platform.	3	3	0
8.	It is an upgrade; not a brand new offering. No new Infrastructure.	2	2	0
9.	Flexible platform.	2	2	0
10.	Improved payload.	2	2	0
11.	It is free (no subscription charge to consumers).	2	2	0
12.	Localism and a return to innovative local programming.	2	2	0
13.	Easy for the listener. Smart receivers that tune to the station's name, not the frequency.	2	1	1

14.	For AM, it's a dramatic improvement in audio quality. It will bring AM on par with FM.	2	1	1
15.	DRM can rejuvenate mediumwave and shortwave broadcasting in many parts of the world.	2	1	1
16.	DRM can retrofit 30-year-old transmitters for 1/3 or 1/4 the price of a new transmitter.	2	0	2
17.	Low cost to implement.	1	1	0
18.	Transparent to the listener.	1	1	0
19.	Voluntary nature of the adoption.	1	1	0
20.	Competitive landscape with other digital technologies.	1	1	0
21.	Committed customer base for digital products.	1	1	0
22.	Easier to manage and control from an engineering standpoint.	1	1	0
23.	Significant quality improvement to AM. HD Radio will put AM on a level playing field with FM radio.	1	1	0
24.	Flexibility. You can do things with digital radio that you just cannot do with analog radio.	1	1	0
25.	Radio is local, mobile, and free.	1	1	0
26.	Support of the broadcast industry and the trade associations, the NAB and the CEA.	1	1	0
27.	The light hand at the FCC.	1	1	0
28.	An incredible depth of testing for HD Radio.	1	1	0
29.	DRM is the only solution for HF	1	0	1
30.	DRM in mediumwave is 50/50. HD Radio will try to compete.	1	0	1
31.	DRM does not have strength yet in the FM band.	1	0	1

32.	Low cost per mile.	1	0	1
33.	Low cost per listener.	1	0	1
34.	Upgrade to DRM for existing AM broadcasters is not excessively expensive.	1	0	1
35.	Strong industry support for DRM.	1	0	1
36.	DRM uses existing spectrum on a global level.	1	0	1
37.	Cost effectiveness.	1	0	1
38.	Single frequency networking (SFN).	1	0	1
39.	The high level of error correction that can be introduced into a digital waveform by using a closed loop (feedback).	1	0	1
40.	Transmitters require less filtering for DRM than AM.	1	0	1
41.	The ability to record and preprogram digital radios to record (e.g., TiVo for radio).	1	0	1
42.	The ability to pause the program and continue.	1	0	1
43.	Mobility. DRM does not require line-of-sight.	1	0	1
44.	Ability to serve a large area very quickly. You do not have to build a network of ground-based transmitters. Speed to market.	1	0	1
45.	Covers rural as well as urban areas with high-powered mediumwave and shortwave.	1	0	1
46.	Covers road systems. Good for automotive applications.	1	0	1
47.	Similar to satellite radio but much more economical. No $250 million transponder. No need to broadcast 100 services.	1	0	1
48.	Shortwave is internationally regulated so it is an easy market in which to begin.	1	0	1
49.	It is a technically good standard.	1	0	1

50.	It is adapted to the regulatory environment.	1	0	1
51.	DRM is an open standard. The political environment likes the notion of having a public open standard with the approval of the ITU.	1	0	1
52.	The total DRM system. The operating standard.	1	0	1
53.	The frequency bands that DRM works in (longwave, Mediumwave, and shortwave) are strengths of the system.	1	0	1
54.	DRM allows broadcasters to transition while using existing infrastructure (transmitter, antenna, frequency, etc.).	1	0	1
55.	DRM does not have some of the licensing hurdles that HD Radio does.	1	0	1
56.	There seems to be, at least on the broadcaster side, if not an enthusiasm for DRM at least an openness towards it.	1	0	1
57.	It is immediately deployable.	1	0	1
58.	It can improve and harness the benefits of the HF shortwave with international broadcasting capabilities.	1	0	1
59.	It provides a great fill-in service in hills and valleys.	1	0	1
60.	Shortwave DRM can potentially go into countries where there may be people reliant on FM, where there may be political impacts	1	0	1
61.	DRM uses existing transmitter infrastructure. Broadcasters only need to buy a new exciter.	1	0	1
62.	On AM and shortwave, it is the great distances that the signals can travel. A broadcaster can cover a significant part of the U.S.	1	0	1
63.	DRM respects the allocated channels; a DRM signal is contained within the 9 or 10 KHz bandwidth allocated to a channel.	1	0	1

APPENDIX M

Weaknesses, Responses in Rank Order

		Respondents Total	HD	DRM
1.	High price points for equipment (lack of affordable receivers).	8	4	4
2.	The consumer has to do something (go out and buy a new digital receiver. Old analog receivers will not work).	5	2	3
3.	Sensitivity and poor signal reception quality (there is no "graceful degradation" in digital).	4	0	4
4.	Time and rate-to-market. Narrow window of opportunity.	3	3	0
5.	Poor marketing to consumers (lack of consumer awareness).	3	2	1
6.	Receivers lack quality and quantity at attractive prices.	3	2	1
7.	The consumer has to spend money.	2	2	0
8.	Hard to move five industries at the same time.	2	2	0
9.	Coverage area of the HD digital signal is less than that of the analog FM and not what listeners expect.	2	2	0
10.	Timing of the launch of HD Radio (in comparison to other digital media).	2	1	1
11.	Lack of compelling content.	2	1	1
12.	Man-made noise in the mediumwave and shortwave spectrum. BPL.	2	0	2
13.	Constrained by existing spectrum (particularly AM).	1	1	0
14.	Chip technology becomes more complex.	1	1	0
15.	Getting digital radio to the same price points as analog radio.	1	1	0

16.	Promises are not quite fulfilled (quality is not as good as touted).	1	1	0
17.	Marketplace is confused about what DRM and HD Radio are.	1	1	0
18.	Medium and small markets are not being considered.	1	1	0
19.	Poor audio quality of digital as perceived by audiophiles.	1	1	0
20.	Relearning by consumers to find HD-2 and HD-3 content.	1	1	0
21.	Local programming is more expensive to create.	1	1	0
22.	Anything new takes time for people to learn and feel comfortable with.	1	1	0
23.	Lack of innovation on the technical side.	1	1	0
24.	IBOC may not have been the best algorithm for digital transmission.	1	1	0
25.	Expense of the equipment for small U.S. markets.	1	1	0
26.	Interference with analog stations on the AM side for HD Radio.	1	1	0
27.	Unavailability of low-power capable battery-powered receivers.	1	1	0
28.	May not be perceived as revolutionary a transition as was AM to FM radio.	1	1	0
29.	Causes a certain amount of interference to the analog service.	1	1	0
30.	Because the hybrid system does not sound that much better than analog FM, hard to motivate people to buy new receivers.	1	1	0
31.	HD Radio has been designed for U.S. channel spacing only.	1	1	0

32.	Limited digital bandwidth compared to other platforms.	1	1	0
33.	Lack of receiver availability	1	1	0
34.	It does take the listeners' time because it is advertiser supported since it does not charge a subscription fee	1	1	0
35.	Low RF level of the HD signals compared to analog FM or AM. Digital does not have the same coverage area as analog.	1	1	0
36.	The sharp knee curve of the HD signal; transition and blend from HD to AM.	1	1	0
37.	HD Radio in the AM band has an interference issue.	1	1	0
38.	Hardware costs but insufficient funding to subsidize down to the level the satellite radio companies are subsidizing.	1	1	0
39.	DRM is behind in marketing (particularly in FM).	1	0	1
40.	AM listeners like simple receivers and will not change to a more complex system	1	0	1
41.	DRM does not offer improvements to the larger segment of radio listeners (FM listeners).	1	0	1
42.	None. I can't think of any.	1	0	1
43.	Skilled network planning is required on shortwave for DRM for dynamic frequency planning in the shortwave.	1	0	1
44.	Low bit rate. Struggles with the reproduction of speech. Similar to Internet at 20 kbps.	1	0	1
45.	DRM may not work in multihop shortwave.	1	0	1
46.	There is no DRM business model tied in to drive technology development or subsidize receivers.	1	0	1
47.	It is difficult to acquire the necessary funding for technology development, particularly on the receiver side.	1	0	1

48	There are too many conflicting interests within the DRM Consortium .	1	0	1
49.	DRM Consortium has limited funds for marketing.	1	0	1
50.	Using DRM on shortwave. DRM has more potential success on AM (mediumwave)	1	0	1
51.	Shortwave, with all of its unreliable features of ionospheric propagation, sunspots, and frequency allocation, is a weakness.	1	0	1
52.	Receiver manufacturers must see that there will be a strong market.	1	0	1
53.	Receivers may be too complicated for the general public.	1	0	1
54.	Regulatory permission to use it in the U.S. for community radio domestically on shortwave. Regulatory issues can hold DRM back.	1	0	1
55.	DRM, as it stands today, is just not a convenient hybrid system.	1	0	1
56.	DRM is not a robust signal in the shortwave and is susceptible to jamming.	1	0	1
57.	DRM is not portable.	1	0	1
58.	It [DRM]has the greatest acceptance in shortwave, which is a niche medium, so a smaller potential receiver base.	1	0	1
59.	A smaller group of people would be advocating for it in a market.	1	0	1
60.	DRM might have some acceptance for U.S. broadcasters who do not like an out-of-band solution.	1	0	1
61.	In Canada, where there is a push for Eureka-147 DAB, it [DRM] does not work that well in the prairies.	1	0	1
62.	I think it can supplement Eureka-147 DAB.	1	0	1

63.	A big weakness is DRM stands for "digital rights management," which in the media industry is a horrible thing.	1	0	1
64.	DRM interferes with the reception of traditional analog Broadcasts.	1	0	1
65.	The bands that are proposed for DRM, mainly AM and shortwave, are not that popular.	1	0	1
66.	For the North American market, DRM still has the label of being European. The "not-invented-here syndrome" does not help it.	1	0	1

APPENDIX N

Opportunities, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	Multiple audio streams (more content) and multicasting creates additional competition and provides broadcasters with additional revenue streams.	13	12	1
2.	New and advanced data transmission (datacasting). Innovative data services from broadcasters.	9	7	2
3.	HD is the "savior" of radio; a new lease on life for radio. DRM will be a resurrection of HF broadcasting. It will create a real renaissance in shortwave and make it viable.	7	1	6
4.	Multimedia.	4	3	1
5.	Niche programming in local markets (to develop new and innovative programming).	3	3	0
6.	The increase in audio quality is dramatic in AM radio.	3	3	0
7.	Encryption for conditional access (subscription fee or opting in).	3	2	1
8.	Better audio quality.	3	2	1
9.	Commercial opportunities for broadcasters. Additional revenue streams for the broadcast industry.	3	2	1
10.	New content to rural populations.	3	1	2
11.	DRM can provide local broadcasting in the shortwave band (26 MHz).	3	0	3
12.	Radio can now enter the "digital age." People expect everything to go digital.	2	1	1
13.	Digital can capture a significant share of the AM broadcasting market.	2	0	2

14.	Cost per listener is low.	1	1	0
15.	Interactive.	1	1	0
16.	People spending more time with media.	1	1	0
17.	People open to new technology.	1	1	0
18.	New business opportunities in broadcasting.	1	1	0
19.	New business models.	1	1	0
20.	On-demand content.	1	1	0
21.	Major international growth opportunity.	1	1	0
22.	Music downloads from radio.	1	1	0
23.	"TiVo" for radio.	1	1	0
24.	"Buy" button.	1	1	0
25.	More services in congested spectrum.	1	1	0
26.	Lost opportunity; niche programming would have been good before the Internet and satellite	1	1	0
27.	Radio is an established medium.	1	1	0
28.	Broadens demographics on FM and creates more interest in radio.	1	1	0
29.	Incredible opportunity to enhance programming and services to many different communities.	1	1	0
30.	Low cost, large group-produced content for HD-2 and HD-3 streams.	1	1	0
31.	Continuous traffic and weather programming on an HD-2 or HD-3 stream.	1	1	0
32.	More localized terrestrial broadcasting with multicasting in HD on the FM band.	1	1	0

33.	The proposed merger between Sirius and XM could be an opportunity or a threat.	1	1	0
34.	Free; no subscription fee for HD Radio.	1	1	0
35.	Commercial opportunities for manufacturers.	1	0	1
36.	Regional international broadcasting on shortwave with DRM.	1	0	1
37.	DRM can grow the listener base as other technologies compete for their attention.	1	0	1
38.	AM coverage area and cost per listener.	1	0	1
39.	More cost effective and larger networking with DRM.	1	0	1
40.	Single frequency networks.	1	0	1
41.	More cross-continental and international listening with DRM.	1	0	1
42.	"Smart radios" that can retune themselves.	1	0	1
43.	DRM built for the world market.	1	0	1
44.	Unlimited for DRM.	1	0	1
45.	Great potentials for the consumer.	1	0	1
46.	Delivers radio services digitally, which are less able to be delivered in an analog system.	1	0	1
47.	Can get into nationwide market like Sirius and XM without the expense of a satellite transponder.	1	0	1
48.	A new market for broadcasters and receiver manufacturers.	1	0	1
49.	Opportunity for equipment manufacturers.	1	0	1
50.	Opportunity for broadcasters.	1	0	1

51.	Much desire for people to hear news from other parts of the world using shortwave.	1	0	1
52.	Allows broadcasters to use a tool (shortwave) that they have had for years.	1	0	1
53.	DRM is one more digital radio solution.	1	0	1
54.	DRM digital chips are in other ubiquitous digital devices such as cell phones and iPods.	1	0	1
55.	Serving audiences unable to serve previously.	1	0	1
56.	With DRM in shortwave, international broadcasters can put a clear signal with stereo in territories where they cannot get a license.	1	0	1
57.	Universal digital radio (i.e. the "universal chip").	1	0	1
58.	Collaboration between public and commercial broadcasters similar to the success of DAB in the U.K.	1	0	1
59.	DRM has potential for sparsely populated parts of the world.	1	0	1
60.	DRM can reverse the slide of decreased listenership on shortwave.	1	0	1
61.	DRM is the worldwide standard outside of North and possibly South America for shortwave and mediumwave.	1	0	1
62.	DRM shortwave covers large geographical areas with clarity for people driving long distances.	1	0	1
63.	I wish I had a crystal ball. I suspect, we have not quite found out. A particular opportunity has not been identified.	1	0	1
64.	Providing services to Royal Navy fleets.	1	0	1
65.	DRM's niches are out there waiting to be found.	1	0	1
66.	With DRM, broadcasters can reach distant audiences that do not have Internet access.	1	0	1

67.	Exposing listeners to a diversity of content with DRM.	1	0	1
68.	Using DRM for promoting and distributing products.	1	0	1
69.	Using DRM to produce very diversified content from different countries or groups.	1	0	1

APPENDIX O

Threats, Responses in Rank Order

		Respondents Total	HD	DRM
1.	Satellite radio, TV, wired Internet radio services, iPods and other emerging media. Changes in listening habits in general. More people get their content from more diverse sources.	29	17	12
2.	Ubiquitous wireless Wi-Fi, Wi-Max, or 3G (ubiquitous Internet radio).	9	5	4
3.	Lack of receivers. If receivers are not produced and distributed.	7	1	6
4.	Apathy and lack of interest. That the BBC is reducing DRM transmissions and not enough broadcasters are on the air providing content. Lack of interest by major manufacturers to provide new technology (receivers).	5	1	4
5.	XM and Sirius satellite radio, if they merge and start to produce localized programming.	4	4	0
6.	Cell phones and 3G wireless cell technology .	4	2	2
7.	Competition with HD Radio is a threat to DRM in some countries.			
8.	If equipment costs escalate and it becomes more expensive for equipment at the small market. Cost to implement.	3	3	0
9.	Licensing (both to iBiquity for HD Radio and to the RIAA for performance rights) could be cost prohibitive.	2	2	0
10.	That another new and unknown technology overshadows it.	2	2	0
11.	Failure to adopt quickly. The slowness of the rollout.	2	1	1
12.	HD is a threat to itself. We at the DRM Consortium are our own worst enemy.	2	1	1

13.	None [for HD Radio]. Nothing is a threat to DRM.	2	1	1
14.	Man-made noise in the mediumwave and shortwave spectrum from BPL. Spectrum in some countries is not protected against non-broadcast users, like all the devices that use power-line communication.	2	0	2
15.	Poor marketing to consumers.	1	1	0
16.	Governmental delay.	1	1	0
17.	Unnecessary consideration of other systems.	1	1	0
18.	Lack of innovative and compelling programming.	1	1	0
19.	The Apple iPhone.	1	1	0
20.	The next generation of listeners (who will not be interested in radio).	1	1	0
21.	Social networking	1	1	0
22.	It's over. It's too late. It's not worth it. Nobody wants what they [iBiquity] are delivering.	1	1	0
23.	Over regulation.	1	1	0
24.	Not allowing the end user to have some flexibility with the content.	1	1	0
25.	If the content is locked down so consumers cannot duplicate it.	1	1	0
26.	The dramatic trend of younger listeners away from terrestrial radio to more listener active ways to enjoy digital media.	1	1	0
27.	Late to market in relation to satellite radio, Internet radio, and iPodcasting.	1	1	0
28.	The time lag for small- and medium-market stations to migrate to HD Radio.	1	1	0

29.	HD Radio interference issues in the AM mediumwave band.	1	1	0
30.	The consumer has not yet adopted this technology. It has not yet passed the "wife-and-neighbor test."	1	1	0
31.	Government interference.	1	0	1
32.	DRM content is also already available on the Internet.	1	0	1
33.	Broadcaster cost per listener to transition to DRM.	1	0	1
34.	DRM is easy to jam (sensitive to interference).	1	0	1
35.	Governments can block receivers for forbidden DRM stations.	1	0	1
36.	Synchronization between two value chains: broadcasters and transmitters and receivers and listeners.	1	0	1
37.	Lack of government mandate to transition to digital [as is the case with digital television].	1	0	1
38.	DRM is susceptible to jamming as are all forms of radio.	1	0	1
39.	Video on DVB-H or DMB.	1	0	1
40.	To show attractiveness to the consumer.	1	0	1
41.	The market is being fragmented.	1	0	1
42.	May be unable to manage the expectations of the users.	1	0	1
43.	The time needed to introduce DRM to broadcasters and listeners.	1	0	1
44.	Multiplicity of digital standards.	1	0	1
45.	Diversity of markets worldwide.	1	0	1
46.	The DRM Consortium may not have the focus to drive drive the receiver manufacturers.	1	0	1

47.	If the DRM Consortium does not find a niche and markets the benefits and features that it offers.	1	0	1
48.	The rapid rollout of Wi-Fi-capable radios capable of receiving streaming audio without a computer connection to the Internet.	1	0	1
49.	A lack of regulation or ineffective regulation.	1	0	1

APPENDIX P

Marketing to Broadcasters, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	iBiquity is taking a "shotgun approach," talking somewhat to broadcasters about it via personal selling and teleconferences.	3	3	0
2.	Marketing is only to major markets and groups.	3	3	0
3.	Transmitter manufacturing companies are doing much marketing to broadcasters via personal selling and teleconferences.	3	3	0
4.	Very successful.	3	3	0
5.	Poor. I don't think HD Radio is being marketed well to broadcasters. Marketing is weak to DRM broadcasters.	3	2	1
6.	Broadcasters are excited about HD Radio.	2	2	0
7.	Not marketing so much as fear mongering and trepidation.	2	2	0
8.	Marketing HD Radio transmitters to radio station chief engineers rather than general managers.	2	1	1
9.	Manufacturers are pushing these systems worldwide and trying to convince them that this is the technology that they need to move forward.	2	1	1
10.	Marketing is conducted within the DRM Consortium.	2	0	2
11.	People are waiting for receivers.	2	0	2
12.	Result: Many broadcasters are still skeptical.	1	1	0
13.	iBiquity is very forthcoming with deals.	1	1	0
14.	Awareness building.	1	1	0
15.	Promotion opportunities.	1	1	0

16.	Assistance to broadcasters.	1	1	0
17.	They [iBiquity] are counting on the NAB to market it to broadcasters.	1	1	0
18.	Mostly conducted by iBiquity.	1	1	0
19.	Some marketing to the second tier of broadcasters, but not strongly.	1	1	0
20.	Someone is going to have to step it up with the medium and small guys to continue what they have built so far.	1	1	0
21.	Much more personal selling than there is any sort of ad campaign.	1	1	0
22.	The HD Radio Alliance has done a phenomenal job of pulling competitors together for the greater good of the industry.	1	1	0
23.	Broadcast equipment manufacturers are educating broadcast customers	1	1	0
24.	Most major groups are letting the local chief engineer make the decision on what specific equipment their station should buy.	1	1	0
25.	Most major broadcasters are members of the DRM Consortium, so marketing is not needed.	1	0	1
26.	Everyone is looking at HD Radio in the Western hemisphere.	1	0	1
27.	DRM is competing with DAB/DMB in Europe.	1	0	1
28.	Presentations about DRM to broadcasters.	1	0	1
29.	Strong effort by transmitter manufacturers in marketing to broadcasters in Europe.	1	0	1
30.	Moderately strong effort by transmitter manufacturers in marketing to broadcasters in the Far East.	1	0	1

31.	Extremely limited effort by transmitter manufacturers in marketing to broadcasters in Africa.	1	0	1
32.	Nonexistent effort by transmitter manufacturers in marketing to broadcasters in Latin America.	1	0	1
33.	Incentivized in the U.K. by OFCOM granting longer FM licenses if stations go digital.	1	0	1
34.	DRM marketing is done by the major shortwave broadcasters themselves.	1	0	1
35.	DRM made a statement that the system is in place and everything is ready to go but it was premature with no receivers.	1	0	1
36.	DRM marketing to broadcasters is very slow and just starting.	1	0	1
37.	There are 40 DRM stations on the air.	1	0	1
38.	Completely positive to DRM broadcasters.	1	0	1
39.	There is a lack of receivers.	1	0	1
40.	This is the problem of the chicken or the egg.	1	0	1
41.	Marketing to receiver manufacturers is very difficult. There is not enough content, yet we are showing the possibility of the market.	1	0	1
42.	The DRM Consortium is marketing business-to-business (transmitter and receiver manufacturers).	1	0	1
43.	DRM is not yet ready for marketing to the public.	1	0	1
44.	The DRM Consortium has done the publicity and campaign well [to broadcasters].	1	0	1
45.	With broadcasters, it is identifying the benefit to them.	1	0	1
46.	To develop country plans with volunteers doing the appropriate lobbying.	1	0	1

47.	The DRM Consortium instructs people and broadcasters within country to do whatever they want to do.	1	0	1
48.	The DRM Consortium only has an influencing role.	1	0	1
49.	The DRM Consortium has been successful in getting the attention of public and state broadcasters and also of international broadcasters.	1	0	1
50.	Small local stations might not be aware of that technology and think that DRM is "digital rights management."	1	0	1
51.	What they are wishing for is the DRM receivers to come in the store so that they can start really marketing the technology.	1	0	1
52.	Digital presented in the U.K. as leveling the balance of power of commercial broadcasters with the BBC.	1	0	1

APPENDIX Q

Marketing to the General Public, Responses in Rank Order

		Respondents Total	HD	DRM
1.	Driven by broadcasters.	2	2	0
2.	The HD Radio Alliance is promoting HD Radio to the public.	2	2	0
3.	Little but increasing.	1	1	0
4.	Advertisements will go over voluntary airtime.	1	0	1
5.	Out of the DRM Consortium's hands. It should be done by retailers.	1	0	1
6.	Use other media to market to potential digital listeners.	1	0	1
7.	I am not aware of too much directly to consumers.	1	0	1
8.	Generally, not very much.	1	0	1

APPENDIX R

Role of the Regulators in Public Interest, Convenience, and Necessity, Responses in Rank Order

		Respondents Innovators	HD Radio Regulators	Others
1.	Trend toward deregulation.	1		
2.	Yes.			1
3.	The advantages to the consumer from this technology.		1	
4.	Improving quality and adding additional content within the current allocation scheme is in the public interest.		1	
5.	Radio broadcasters feel that they will become obsolete even faster if they do not go digital.		1	
6.	We can take care of just a disastrous several decades of AM technical regulation that resulted in much more stringent rules.		1	
7.	To revitalize the AM band.		1	
8.	An enormous amount of ability to respond to what the consumer wants.		1	

APPENDIX S

Reasons For FCC Rejection Of Other Technologies, Responses in Rank Order

		Respondents
		HD Radio
1.	No formal request to the FCC by other technologies.	3
2.	Eureka-147 DAB was rejected for a lack of available spectrum.	3
3.	I do not know. I was not involved in standard setting.	1
4.	CAM-D was late to the table and it has never been demonstrated to work in the presence of analog signals.	2

APPENDIX T

Digital Radio's Value to the Consumer, Responses in Rank Order

		Respondents Total	HD	DRM
1.	Better audio, more pleasurable listening experience.	8	5	3
2	New content (multicasting).	7	6	1
3.	New services (datacasting).	4	3	1
4.	More choice, an increase in programming diversity and niche programming. Distant programs on DRM.	3	2	1
5.	More reliable audio signal. Availability.	3	2	1
6.	Program-associated data.	2	1	1
7.	It offers features that people are coming to expect and that only a digital signal can provide, such as recording and time shifting.	2	1	1
8.	Downloads of frequency lists and electronic programming guides (EPGs).	2	0	2
9.	DRM offers high-quality listening in a large geographical area on shortwave.	2	0	2
10.	Cheaper content and services.	1	1	0
11.	Less interference.	1	1	0
12.	It is going to do nothing.	1	1	0
13.	It is a necessary step.	1	1	0
14.	They think that they need to do it to survive.	1	1	0
15.	Single frequency networking	1	0	1
16.	Automatic frequency switching.	1	0	1

17.	The ability to immediately purchase music through iTunes.	1	0	1
18.	Commercials can sound more enjoyable if required disclaimers are sent via text data.	1	0	1

APPENDIX U

New Content's Value to the Consumer, Responses in Rank Order

		Respondents		
		Total	HD	DRM
1.	Provides compelling content to the average listener.	5	4	1
2.	It cannot succeed solely on the ability to make radio "sound better."	3	3	0
3.	"Narrowcasting" or "microcasting" of HD-1 format to niche markets.	2	2	0
4.	More locally oriented programming.	2	2	0
5.	We need a broader menu of programming	2	2	0
6.	Overall, programming content is not up to snuff.	2	2	0
7.	Provide a variety of different content, like FM radio.	2	2	0
8.	A combination of higher-quality audio and new content.	2	1	1
9.	More music formats on AM and on shortwave.	2	0	2
10.	I think DRM needs something more besides sounding better. You cannot just sell a new technology on having it sound better.	2	0	2
11.	Ability to broadcast entire CDs.	1	1	0
12.	Ability to broadcast local bands.	1	1	0
13.	Ability to broadcast classical music.	1	1	0
14.	Ability to broadcast new formats such as "edgy" country music.	1	1	0
15.	Ability to simulcast existing format on HD-1 and multicast on HD-2 and HD-3 streams.	1	1	0

16.	More public interest programming.	1	1	0
17.	NPR use for hearing and sight disabled (books on tape and speech-to-text).	1	1	0
18.	New content is going to be required. What that is going to be, I do not know.	1	1	0
19.	How do you control yourself from putting the best format on the main channel and basically strangle the evolution of the HD?	1	1	0
20.	Multimedia with digital audio, text, and pictures.	1	0	1
21.	DRM makes shortwave more palatable for more people.	1	0	1
22.	DRM makes music programs on shortwave possible.	1	0	1
23.	Content has nothing to do with it.	1	0	1
24.	Content on FM and AM is the same.	1	0	1
25.	International programs could be of increased interest because more foreigners live or work in other countries.	1	0	1
26.	New shortwave broadcasters currently not on the air will provide new DRM content in new ways.	1	0	1
27.	Community content on local radio with DRM on 26 MHz.	1	0	1
28.	Ability to broadcast concerts in their entirety.	1	0	1
29.	It will vary from market to market worldwide. There will be different considerations in different places	1	0	1
30.	When you think about what is missing from the dial, you can find compelling programming.	1	0	1
31.	Particular kinds of programming for particular kinds of people.	1	0	1
32.	Content is what's made Eureka-147 DAB a viable format in the U.K. and where it's lagged elsewhere.	1	0	1

33.	I do not know if DRM is actually well placed to be able to offer new content in the same way that Eureka-147 or even HD Radio can.	1	0	1
34.	DRM does not have to compete the same way that HD Radio does	1	0	1
35.	I do not know if it does allow new content. DRM does not provide the content. Broadcasters provide the content.	1	0	1
36.	DRM will probably not become successful solely on its ability to "sound better."	1	0	1
37.	Listeners have plenty of choices available to them and thus can already gravitate to technologies that "sound better."	1	0	1
38.	DRM serves as a platform extension opportunity for broadcasters, and could provide increased access to content that already exists.	1	0	1

APPENDIX V

Further Recommendations for the Radio Broadcasting Industry

The researcher developed these recommendations based on several issues brought forward by the interviewees in this study and his own observations. They focus on several technical issues concerning the implementation and deployment of HD Radio and DRM. If HD Radio and DRM stakeholders adopt these recommendations to address and resolve these issues, they may increase the likelihood of HD Radio and DRM success in the marketplace.

Provide Compelling Content on HD-2 and HD-3 Streams

Commercial international shortwave radio and most commercial radio in the United States operate according to different paradigms. Whereas the broadcaster and the transmitter are often different entities in international shortwave radio, they are the same in most U.S. commercial radio stations (although, more and more, syndicated programming is simply retransmitted by the local terrestrial broadcaster). Whereas an important factor in U.S. commercial terrestrial radio is the concept of "localism," with content produced by the broadcaster, transmitter operators in the shortwave often produce no original content of their own. Instead, the transmitter operators simply sell time on their facilities for block programming, often in hour or half-hour blocks, to other content providers—the broadcasters—who, in coordination with the ITU, may even change their transmitter's frequency from one program to the next. These broadcasters are often individuals and organizations driven by a particular agenda, such as religious groups or political supporters.

A similar operating paradigm could be helpful for U.S. commercial broadcasting in terms of developing HD Radio HD-2 and HD-3 streams. Organizations currently not considered broadcasters could provide hour-long block programming of content to local radio stations for transmission on their HD-2 and HD-3 streams, and American audiences may consider this programming developed and produced by other entities "compelling." For example, organizations that have a message, such as the National Rifle Association or the National Organization for Women, could develop radio content and then purchase block time from local radio stations for transmission on their HD-2 and HD-3 streams, or record labels could produce hour-long music shows that feature their particular stable of artists. Moreover, foreign language content as well as English teaching lessons may prove compelling for Diaspora communities living in the U.S.[9]

During his interview, an editor of a major radio broadcasting trade publication stated, "There is a need and a hunger and a market opportunity for really unusual programming. . . . My parents are Catholic and they probably would listen to a Catholic sub-channel if they knew they could get it."[10] Providing such content on HD-2 and HD-3 streams could contribute to the successful emergence of HD Radio in the marketplace.

The same holds true for international broadcasters using DRM. Entities that have a particular message for foreign audiences, such as Médecins Sans Frontières (Doctors Without Borders), could become content providers for international shortwave transmitter operators. Using the high-quality stereo signals that DRM has in the shortwave, record labels could feature their artists and provide content for transmission to other countries

[9] XM Radio provides satellite content in Spanish and French as well as in English (xmradio.com).
[10] XM Radio also now offers a satellite Catholic channel (#117) and a Christian talk channel (#170) as part of its lineup (xmradio.com).

where they want to open new markets for their music. Governmental broadcasters could offer foreign language lessons to promote improved international relations.

Use HD Radio to Enforce the Fairness Doctrine

With the change in the administration after the 2008 U.S. election, some have called for a revival of the FCC's Fairness Doctrine. From 1949 to 1987, the Fairness Doctrine required radio and television stations, which the FCC considers public trustees because they use the precious natural resource of electromagnetic spectrum, to air all sides of controversial issues in order to provide fair and balanced coverage. FCC Chairman Mark Fowler argued that because Congress did not mandate the Fairness Doctrine, there was no need to enforce it. Although Congress voted it into law in 1987, President Ronald Reagan, with his philosophy of governmental deregulation, vetoed it (Limburg, n.d.). Now, with a Democratic president and a significant Democratic majority in both houses of Congress, there are calls to revive the Fairness Doctrine.

Much of the concern over reviving the Fairness Doctrine relates to conservative talk radio programming. Today, many talk radio stations, particularly in the AM band, feature one syndicated conservative talk radio host after another, and virtually nothing else. When lawyer Edward Monks studied the content of two radio stations in Eugene, Oregon, a fairly liberal town, he discovered that they aired more than 80 hours per week (4,000 hours per year) of conservative programming without a single show expressing the Democratic viewpoint (Rendall, 2005).

However, Thierer (1993) argued that calls for the return of the Fairness Doctrine are based on several false premises. Scarce spectrum is no longer a concern due to the proliferation of cable television, satellite radio, and Internet radio channels, all of which allow broadcasters to present alternative points of view. He also contended that the FCC, as a government agency, is not in a position to determine what is "fair" or to enforce "fairness"; that "arbitrary enforcement of the Fairness Doctrine will diminish vigorous debate"; (¶14) and that "with the wide diversity of views available today in the expanding broadcast system, there is a simple solution for any family seeking an alternative viewpoint or for any lawmaker irritated by a pugnacious talk-show host. Turn the dial." (¶16)

HD Radio may offer a resolution to the Fairness Doctrine debate as well as serving as a test case to determine a radio station's ability to provide fair and balanced programming to a community. Because FM broadcasters can now transmit three independent streams of content with HD Radio technology and because the Fairness Doctrine does not require individual programs to present both sides of an argument (just equal amounts of time during the broadcast day), broadcasters can transmit politically neutral content on one HD stream, conservative programming on another stream, and liberal programming on another.[11]

WTOP (FM) in Washington, DC is one station that could take such an approach. WTOP (FM and HD-1) is a news station that offers very little editorializing. With HD Radio technology, it could dedicate its HD-2 stream to conservative programming and its HD-3 stream to liberal programming. The stream with the greatest audience share would earn higher ratings and more revenue for the station, which could allow the station to

[11] XM Radio is currently doing this with *America Right* on channel #166 and *America Left* on channel #167. C-SPAN, which presents both sides of the political debate and is considered neutral, can be found on channel #132 (xmradio.com).

increase the rate it charges for commercials on that stream while remaining in compliance with the Fairness Doctrine by offering equal amounts of time to both political viewpoints.

If all talk show hosts were to migrate to HD-2 and HD-3 stations when and if the Fairness Doctrine were to become mandated by law, a majority of their loyal listeners would most likely be willing to spend the $100 necessary to purchase a new HD Radio receiver in order to continue to listen to them and, in the process, help promote the new technology. This, again, would be another example of providing “compelling content” while satisfying a possible future legal requirement.

Raise the Injection Level of HD Radio’s Digital Component

During his interview, a small-market general manager emphatically stressed the need to raise the injection level of HD Radio’s digital component. His observation was consistent with that of the researcher: The digital component of an IBOC signal does not provide coverage equal to the analog component. This manager stressed the importance of raising the injection level of the digital component from its current 1% until it reaches a threshold at which interference with other stations is truly unacceptable. Until this threshold is determined, and until HD Radio stations are transmitting digital signals marginally under that threshold point, HD Radio’s digital capability will not be employed to its maximum capacity.

Provide More Regulatory Support for HD Radio Receivers

Several interviewees cited the need for more regulatory support, particularly for HD Radio. During the rollout of FM radio, the FCC mandated that all future receivers must have two bands, AM and FM (Hodges, 2008; Maloney, 2008). Regarding this regulatory mandate, a DRM transmitter manufacturer stated,

> I think, in FM, it was one of the things that moved it a whole lot faster than it would have moved. And I question whether the lack of that government support will hurt HD Radio as well. Without a mandate, you don't get the penetration of receivers. . . . They're doing the same thing for TV, now for HDTV, that they did for FM radio. But that's not being done for HD Radio, nor is it really able to be done in a lot of cases for DRM, and I think that's going to affect the rollout.

As of this writing (November 2008), iBiquity is petitioning the FCC to require HD Radio capability in all receivers that have satellite radio capability as a condition of the XM Radio-Sirius satellite radio merger. Rep. John D. Dingell (D-MI), chairman of the House Commerce Committee, and Rep. Ed Markey (D-MA), chairman of the Subcommittee on Telecommunications and the Internet, have asked FCC Chairman Kevin Martin to impose certain actions if the XM Radio-Sirius satellite radio merger proposal is approved. In a letter to Martin they wrote, "Device manufacturers should be permitted to incorporate in satellite radio receivers any other technology that would not result in harmful interference with the merged company's network, including HD Radio, iPod ports, Internet connectivity or other technology." (Broache, 2008, ¶5)

This type of congressional and commission support is integral to successful HD Radio rollout in the United States. Although listeners are not clamoring for recouped spectrum in radio, as was the case with the rollout of HDTV and the mandated analog sunset, the HD Radio rollout will not be as dynamic as was that of the other technologies unless there is some encouragement from the regulatory and legislative bodies.

DRM Success by Fiat

When discussing the critical factors for DRM success during his interview, a well-known international media analyst stated, “Government may just overtake the marketplace and force consumers and broadcasters to adopt digital, and then it becomes a viable technology by dictate rather than by market force.” Regarding safeguards in the marketplace, he argued, “Safeguards would be meddlesome. . . . It’s sort of an anti-market safeguard.” Countries characterized by less democracy and market freedom may impose such safeguards, including China, which has made large investments in DRM technology.

When the researcher asked 17 other interviewees, all but 1 of whom were DRM stakeholders, whether DRM could be successful based on governmental fiat rather than on market forces, 11 answered in the affirmative, 5 answered in the affirmative but attached conditions, and only 1, the innovative user, answered in the negative, as indicated in Figure V.1.

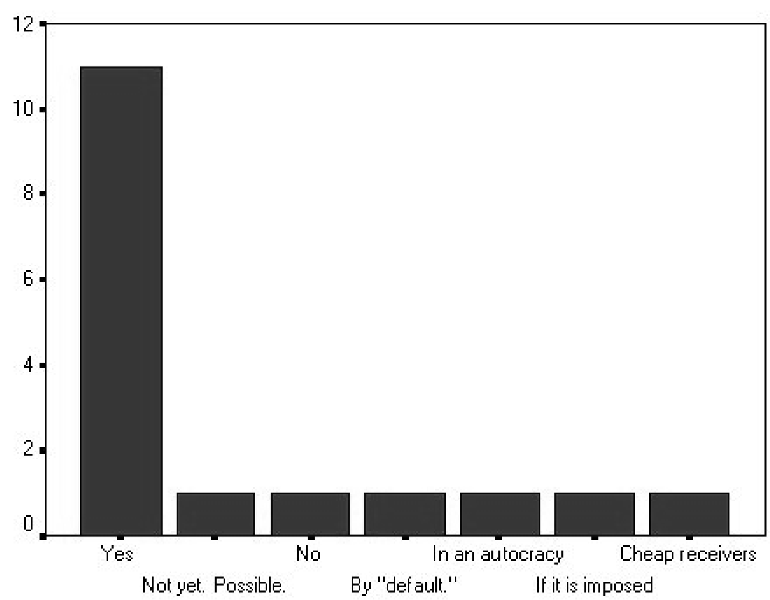


Figure V.1. Participant responses regarding DRM success by fiat.

Through their responses, the interviewees indicated that there is potential for DRM to become successful in some parts of the world not by effective marketing but rather by governmental dictate.

Develop Single Frequency Transmission Networks

One attractive property of digital signals is that when the signals of two stations geographically overlap on the same frequency, the signal strength becomes additive if the content is the same. In contrast, when analog signals overlap on the same frequency, both stations experience interference, even if the content is the same on both signals. This leads to a very interesting deployment of HD Radio and DRM, the use of a *single frequency networks* (SFNs), which stations can use to extend their coverage area, fill dead spots in existing coverage areas (sometimes referred to as "RF holes"), or disperse their signal throughout their coverage area using many small transmitters rather than one large transmitter. SFNs can also create very sophisticated propagation patterns necessary for achieving the most efficient coverage area possible.

A theoretical use of SFNs would be with Radio One's stations in Baltimore and Washington, DC. In each city, Radio One has an urban-rap FM station, an urban-oldies Motown-style FM station, and an inner-city focused AM news and talk station. Currently, these stations require six radio channels and six transmitters. Some of their station's signal is lost to its demographic target because the 50,000-watt WKYS (FM) in Washington, DC sends signals all the way to the Eastern shore of Maryland and West Virginia, where the targeted demographic population does not live. By ringing both cities with low-powered HD Radio transmitters (250 to 500 watts each), as indicated in Figure V.2, it could easily cover both metropolitan areas with all three formats by using one FM channel with HD Radio's three streams. The station could create a large coverage area with a highly sophisticated propagation pattern to reach its target demographic population in these two converging metropolitan areas, as shown in Figure V.3, thus conserving both power and spectrum while creating a highly complex propagation pattern to cover the intended demographic and extending the station's range.

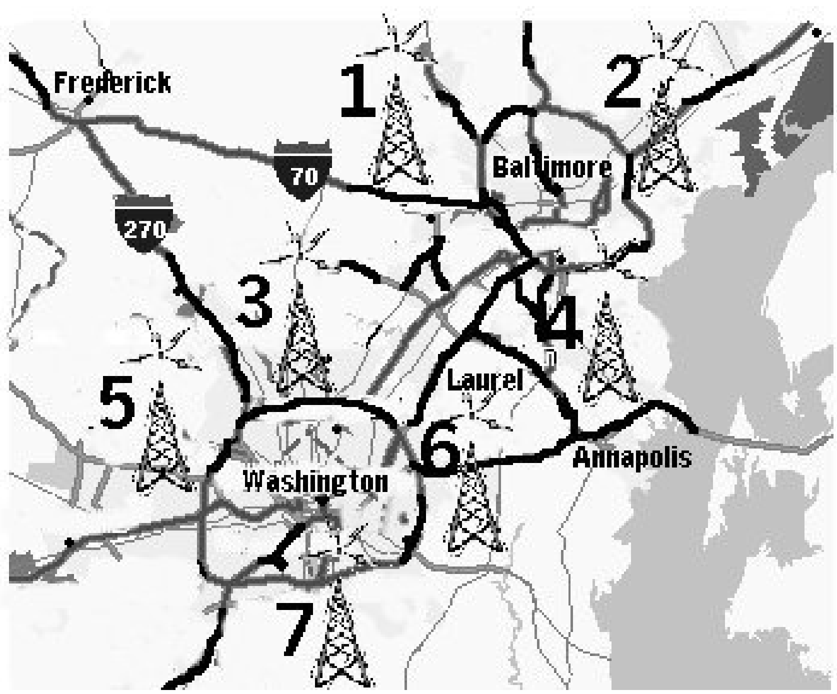


Figure V.2. Radio One SFN transmitter sites.

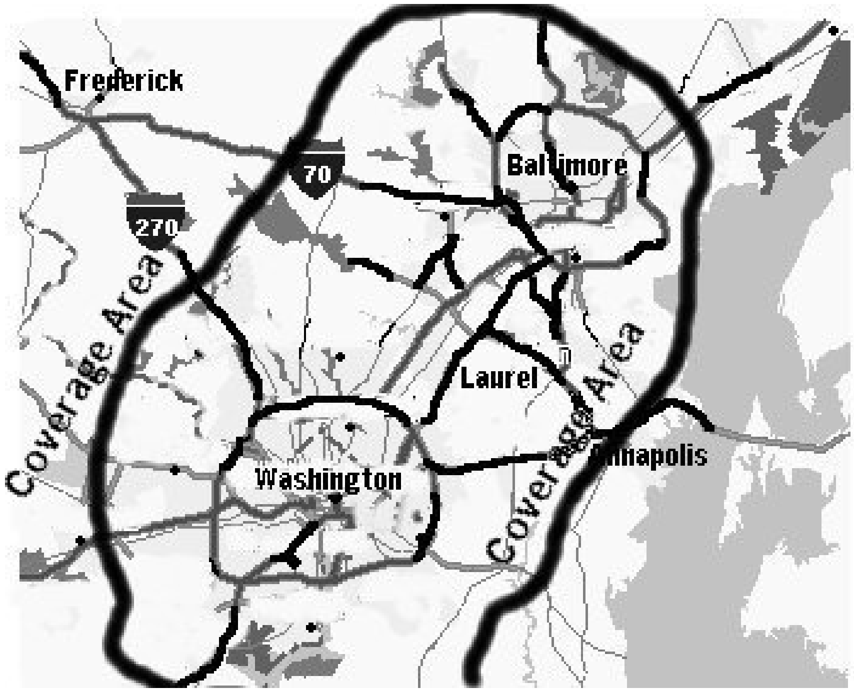


Figure V.3. Radio One SFN coverage area.

SFNs can also be used to fill in RF holes in existing propagation patterns. After listening to many stations using HD Radio for several months, the researcher noted that the coverage area of the HD-2 and HD-3 streams is not equal to the coverage area of the FM analog signal of the station (the HD-1 stream "blends" back into FM in the fringe area). SFN "booster" transmitters of 50-100 watts could enhance the digital stream in the fringe as well as fill in "dead spots" inside the allocated coverage area.

When asked whether they believed that SFNs could be used with digital broadcasting, 64% of the interviewees answered in the affirmative, 13% in the negative, and 23% did not know enough about SFNs to respond. The DRM stakeholders, who were more knowledgeable and enthusiastic about SFNs than the HD Radio stakeholders, supplied 55% of the affirmative responses and only 1 negative response whereas the HD

Radio stakeholders provided 91% of the negative responses and 60% of the uncertain responses, as indicated in Figure V.4.

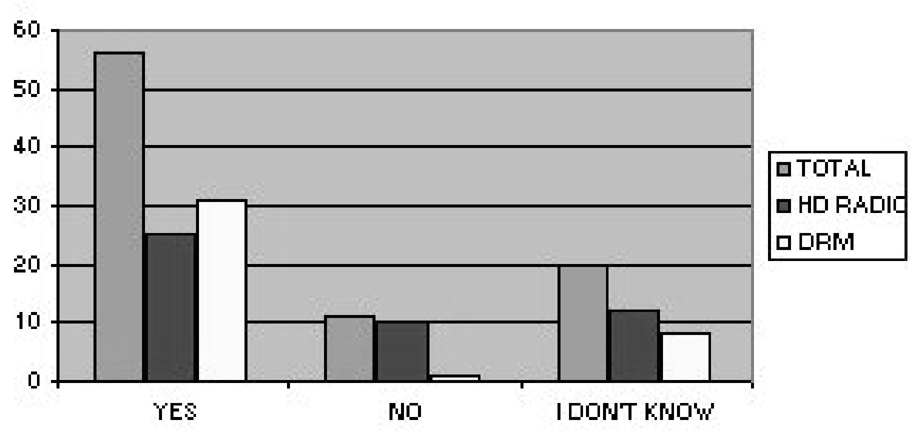


Figure V.4. Participant responses regarding the potential of SFNs.

Whereas an editor of a major trade newspaper expressed, "I love the idea. I think that's the kind of creative thinking and the creative use of the infrastructure that the industry could benefit from," other interviewees were a bit confused with this question, citing difficulties with synchronization in SFNs using analog signals. In this context, the researcher recommends the use of SFNs for only the digital components of HD Radio and DRM.

Develop Strategic Alliances Among Content Providers

Content providers could promote the success of HD Radio and DRM by forming strategic alliances based on Negroponte's model of media convergence and the example of *Radio Margaritaville*, which is available as both an Internet and satellite radio channel. Satellite and Internet radio operators could agree to provide content for the new terrestrial HD streams for reasonable fees so that an FM station with an "oldies" format, for example, could buy content from XM Radio or an Internet provider and put music from the 1950s on its HD-2 stream and music from the 1960s on its HD-3 stream. HD Radio, Internet, and satellite operators would gain from this action; HD Radio operators would obtain content at a reasonable rate to put on their new HD-2 and HD-3 streams and Internet and satellite operators would obtain an ancillary source of income from the terrestrial broadcasters as well as a new promotional outlet.

Content provided by Internet radio's *Radio Margaritaville* and XM Radio's *The'50s* could also be considered part of the fare available on shortwave radio with worldwide distribution using DRM technology, allowing DRM shortwave transmitter operators to receive quality content at reasonable prices. It would also be particularly favorable for *Radio Margaritaville* by allowing it to send a high-quality digital signal to areas of the world where there is little Internet access, as well as XM Radio and Sirius by allowing them to send their digital content to areas that their satellite footprint does not cover.

Strategic alliances could also be formed among the major governmental broadcasters using DRM technology. Countries intent on broadcasting similar messages to the same geographical location could coordinate with the ITU to share one frequency. In that way, each would be responsible for only a part of the broadcast day. Listeners in the target area would then be assured that they would receive credible news and information from the Western world 24 hours a day, 7 days a week at the same location on the shortwave dial. Examples of this are proposed broadcasts in the Pashto language to the Waziristan and Swat Valley regions of the Pakistan-Afghanistan border on one shortwave frequency from the VOA, the BBC, Deutsche Welle, RCI, and RFI, which are all broadcast services from NATO countries fighting the Global War on Terror (GWOT). This could be part of a coordinated effort to fight the war of ideas by not only providing news and information to the people of that region but also by explaining the Western perspective and teaching democracy through talk radio formats that allow inhabitants of that region to call in and express themselves. Having all these stations on one frequency would be convenient for the listeners, be less demanding on the individual broadcast services because each would only be responsible for a segment of the broadcast day, and speak volumes to the unity of effort these NATO allies have regarding their resolve in fighting the GWOT and the war of ideas.

This strategic alliance of transmission could be conducted in conjunction with efforts to seed the marketplace with receivers, as discussed in chapter 5. The Western powers' governmental broadcasters could not only coordinate their broadcasting efforts but also contribute a small amount to purchase DRM receivers at reduced rates that require no electrical infrastructure, place their frequency and their logos on the faces of these radios, and give them away to the people of the target area. Distribution of DRM receivers in addition to a coordinated transmission effort could build a digital audience of disenfranchised listeners in war-torn regions of the world.

As time permitted, the researcher asked several interviewees whether they believed that such a coordinated effort were possible. Their responses were mixed; 59% responded in the affirmative, 26% in the negative, and 15% were uncertain. The DRM participants responded more positively to this idea, with 62% responding in the affirmative, whereas only 55% of the DRM participants did so, as shown in Figure V.5.

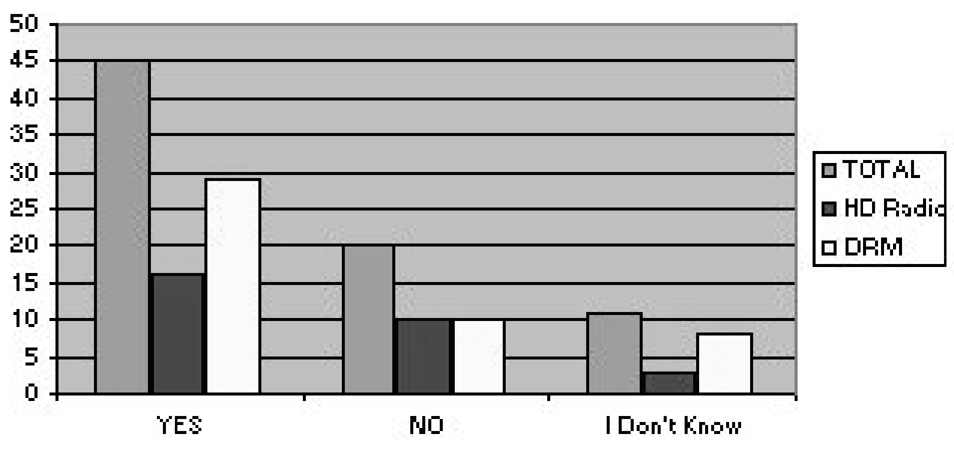


Figure V.5. Participant responses regarding strategic alliances of content providers.

This may be attributed to the animosity from the NAB toward the satellite services. When asked about a strategic alliance with XM Radio for providing content for HD Radio terrestrial stations, a well-known professor of broadcasting at a major Washington, DC university stated, “I think the idea makes good sense. However, to get there, the first thing you have to do is go shoot the NAB leadership because the NAB is arguing against it so strongly. . . . They are so damned short sighted.” A senior manager of a satellite broadcasting company stated, “There is no question that if XM decides to go into that business, we will be available to do that. We have the infrastructure for it. . . . As a matter of fact, somebody may already be running that.” Regulatory issues apparently would not be much of a problem, as one FCC employee stated, “That sounds like a great idea. And we generally don’t care about content, and we authorize LMAs [lease management agreements] all the time. It's permissible, so I don't see it as much different than the LMA concept."

A retired FCC employee who is now a commercial broadcaster was initially against this idea, stating, "As a terrestrial broadcaster I hope they don't do it. I would hate to see, all of a sudden, we transition from an off-air service to, 'Well you can get it off the bird.'" However, after some reflection, he had a novel insight: "If you go to a subscription service on one of your HD channels available, maybe you could rebroadcast Howard Stern on HD since that content indecency is a subscription-based service."[12]

Several of the DRM participants liked the concept but questioned whether there is sufficient political will for several nations to commit to such a collaborative effort. One DRM broadcaster stated, "If the bureaucracy and the administrations can work together on something like that, it sounds like a great idea. A lot of religious stations have done this sort of thing in the past with analog shortwave." A member of the DRM Consortium voiced journalistic and content concerns when he stated, "There would be issues with some broadcasters of editorial independence and a caution that they didn't want their brand to be damaged by somebody else who is the next in the stream with a completely different kind of broadcast." Another DRM broadcaster stated, "That is already taking place in Europe. Specifically, BBC, Deutsche Welle, and RTM in Europe made such an alliance and were going to put quite a bit of money into receivers with a company who could handle large production quickly."

[12] In other words, a terrestrial broadcaster could buy content from the Sirius satellite service and rebroadcast the Howard Stern show on an HD Radio HD-2 or HD-3 subscription-based encrypted channel because this channel would not be bound by the FCC's indecency and community standards rules that apply to free over-the-air services. This channel would be a closed service and not available to the general public except by special subscription.

Strategic alliances, such as these two examples, could jumpstart DRM and HD Radio technologies and keep them on the path toward success.

Use HD Radio and DRM as Data Pipes

As both DRM and HD Radio are essentially one-way data pipes, either could be used for transmitting telemetric data. Following the example mentioned earlier of WRNR (FM) transmitting digital telemetric data over its analog FM SCA, radio stations could use their new digital data capability to send control data to the local electric power company or telephone company in order to control switching devices. They could also use their new digital capacity to send data to cars with onboard navigation devices and provide real-time updates of traffic conditions. Sending digital data would have neither the added expense of producing new and innovative audio content nor the additional costs of advertising and promotion for a new audio stream. Radio stations could develop an ancillary source of income by transmitting telemetric data of this nature and HD Radio, in particular, could become successful from this repurposing.

During his interview, the innovative user described a way in which DRM technology could be used as part of a project he is working on with the U.S. Navy. As e-mail is a form of electronic communication that travels in one direction at a time and does not require a real-time closed loop, the Navy has experimented with sending ship-to-shore (and shore-to-ship) e-mail messages for sailors at sea using DRM technology in the shortwave. By taking this data off the satellite links, the satellite connections can be devoted exclusively for high-priority mission-oriented messaging. This model could be used anywhere on Earth where a conventional landline wire connection to the Internet is impractical. Although the low-bit rate of DRM cannot approximate the speed of a DSL connection, it can provide a low-cost and practical conduit for e-mail over difficult terrain.

Consider Repurposing for Success

Many products developed to fulfill one need have succeeded in the marketplace by fulfilling an entirely different need. One example is Viagra, which Pfizer began developing as a cure for angina and hypertension—until male research subjects in clinical trials began noticing other physiological changes. Since then, it has been marketed to physicians and the general public as an aid for erectile dysfunction, for which it has achieved overwhelming success in the marketplace (Khanna, 2005).

A similar paradigm may hold true for HD Radio and DRM. Although originally designed for radio broadcasting to the general public using the conventional model of audio programming, they could be repurposed to fulfill other purposes, such as serving as a one-way data pipe, that lead them to marketplace success. Another example that the innovative user cited was using DRM as a radio broadcast networking tool. During his interview, he described how we would drive for hours throughout Alaska without being able to hear a single radio station. A shortwave signal using DRM could easily cover all of Alaska. Specifically, strategically placed transmitter sites with shortwave receivers connected to 1,000-watt transmitters could cover the entire state with FM signals. In this scenario, DRM could be used in conjunction with HD Radio. Three DRM transmitters on three shortwave frequencies could be used to network HD Radio stations throughout the entire state. Each unmanned transmitter site could have three DRM shortwave receivers and an HD Radio transmitter. Three separate formats could then be heard on the HD-1/FM, HD-2, and HD-3 streams statewide using overlapping signals as an SFN on one FM-band channel.

Networking in the shortwave is not a new concept. From the 1950s to 1990s, the VOA operated several government-owned shortwave relay stations in an effort to maintain a global network of operations. However, the audio quality of AM transmission in the shortwave was poor and not suitable for network distribution. Eventually, the shortwave network became obsolete and was overtaken by a global satellite network system, which provided a far superior digital audio signal to affiliate AM, FM, and shortwave stations worldwide (Heil, 2003). With DRM technology, however, that same digital quality can now be transmitted in the shortwave and then retransmitted by affiliate AM and FM stations throughout the world. Several interviewees stated that shortwave networking is far more cost effective than satellite networking.

Networking is yet another way DRM can be repurposed for success. By using conventional shortwave transmission techniques, a broadcaster can send a clear, digital DRM audio signal to affiliate stations thousands of miles away at a fraction of the cost of purchasing satellite time to do the same thing.

Deploy Near Vertical Incidence Skywave Transmission of DRM

A transmission method that differs from the standard way shortwave signals are normally deployed is necessary for a shortwave signal to effectively cover a large geographical area, such as the state of Alaska, in the near field. The shortwave bands are the only region of the spectrum that can transmit signals to receiver sites thousands of miles away from the source. Using a vertical antenna, which emits a low angle of radiation skyward, the signal hits the ionosphere and bounces back to the earth at an equally low angle, where it creates a footprint a great distance away from the transmitter site, sometimes 1,500 to 2,000 miles away, as indicated in Figure V.6.

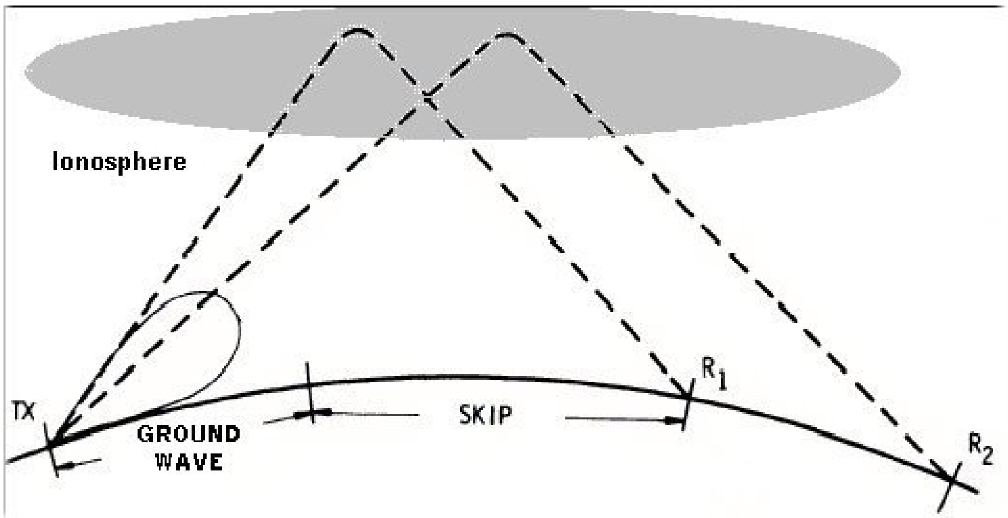


Figure V.6. Shortwave propagation using low angle transmission. From *Le NVIS ou Near Vertical Incidence Skywave,* by D. Auquebon, 2004, retrieved October 14, 2008, from http://pagesperso-orange.fr/f6crp/ba/nvis_1.htm

These low-angle signals can also be reflected off the Earth and reflected skyward for a second time before the signal creates its final footprint on Earth. This “multi-hop” can be received at distances of 3,000 miles away from the transmitter site, as seen in Figure V.7.

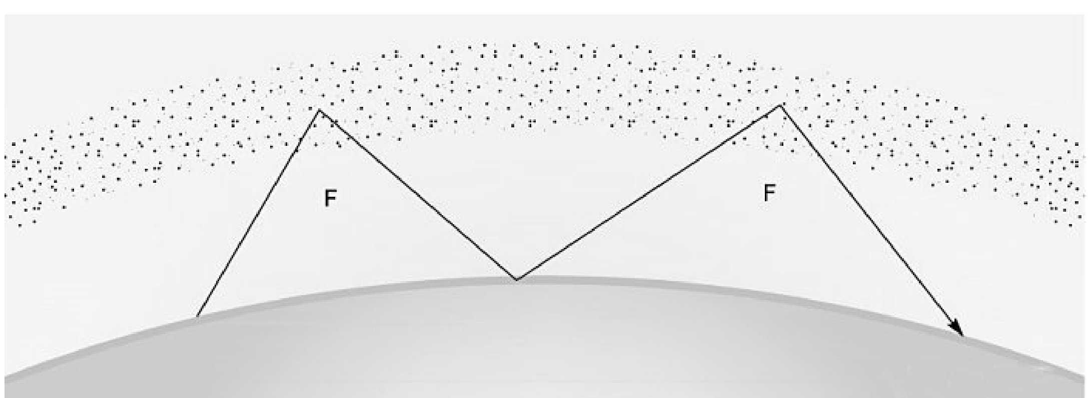


Figure V.7. Multi-hop transmission. From *The ARRL Handbook For Radio Communication*, 82nd Edition (p 20.15). Retrieved February 13, 2009. http://www.arrl.org/news/features/2006/11/30/1/NC0701-Nue02.jpg

However, in order to cover a land mass the size of Alaska, a different type of transmission called *near vertical incidence skywave* (NVIS) transmission is required. Using a horizontal rather than a vertical antenna, NVIS transmission shoots a signal almost directly into the ionosphere, where it returns at an equally sharp angle, providing a footprint in the near field of the transmitter at distances of up to 200 to 1,000 miles away from the transmitter, as shown in Figure V.8.

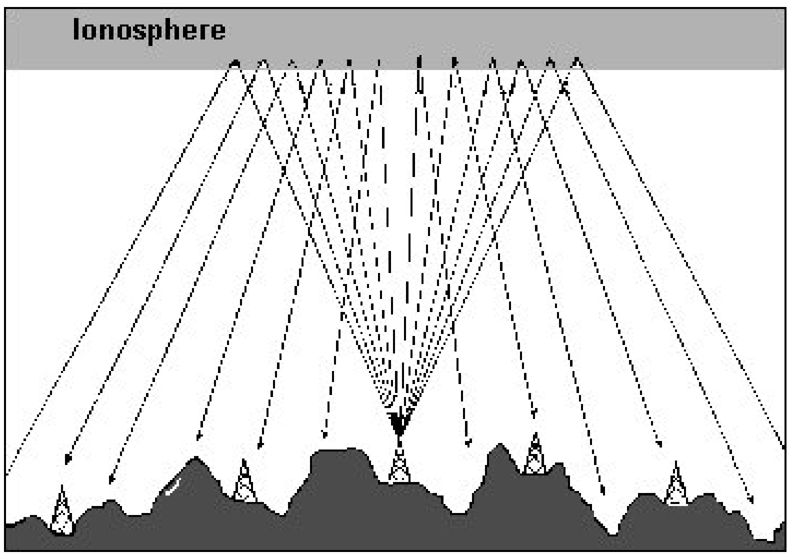


Figure V.8. NVIS transmission. From *Le NVIS ou Near Vertical Incidence Skywave,* by D. Auquebon, 2004, retrieved October 14, 2008, from http://pagesperso-orange.fr/f6crp/elec/images/nvis3.gif

As time permitted, the researcher asked 7 interviewees with engineering backgrounds about NVIS transmission for DRM. All responded that NVIS transmission may allow DRM to be used as a regional broadcast technology. One DRM broadcaster described his use of NVIS transmission:

> As a broadcaster, we use NVIS in Ecuador and have helped others use it in Papua New Guinea, in the Central Africa Republic, and several other African countries. A place like Ecuador or Papua New Guinea, you're dealing with some incredibly difficult terrain, where terrestrial-based FM repeaters are difficult to link without costly satellite uplinks. And so a high-quality NVIS that gives a local countrywide coverage of a small country is very attractive. It's sort of been for [our broadcasting service] one of the things we've really had very high hopes for.

NVIS transmission may be a key ingredient in repurposing DRM as a regional networking tool, for which it may eventually achieve success.

Create the "Universal Chip"

Perhaps the most significant factor in the failure of AM Stereo was the competition that multiple forms of AM Stereo technology faced in the marketplace, particularly among receivers capable of decoding only one version of the technology. A similar challenge is emerging among four types of digital transmission—HD Radio, DRM, Eureka-147 DAB, and satellite radio—and the two forms of analog transmission—AM and FM—whose receivers can decode only one version of digital transmission along with the analog services. The development of a multi-platform receiver containing a "universal chip" that could decode various types of transmission, thus making all of these forms of radio broadcasting accessible to listeners, is necessary to prevent digital radio technology from experiencing the failure of AM Stereo technology.

When time permitted, the researcher asked the interviewees whether they believed that the development of a universal chip would assist in the success of digital radio. Of 85 interviewees who responded to this question, 70% responded affirmatively, 18% responded negatively, and 12% responded that they did not have enough knowledge or information to discuss its potential. Figure V.9 displays their responses.

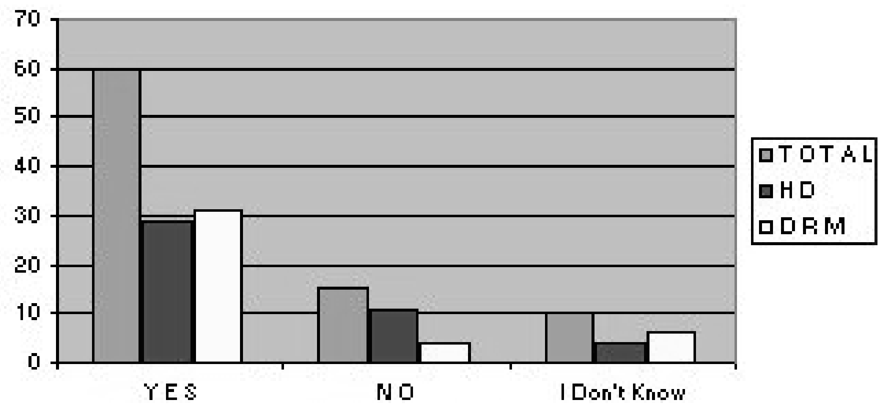


Figure V.9. Participant responses regarding the universal chip.

A DRM broadcaster stated, “I think there’s great value in multi-standard radios, and, as you’ve proposed, the universal chip is a way towards multi-standard.” The innovative DRM user added, “That’s the true sense of diverging platforms or methodologies and convergence, which is where the world is going onto one device.” However, a trade paper writer interested in DRM warned, “I think that’s years away. And I think that the receiver makers are going to sit back and see which one of these technologies really gains traction and then decide who gets in.” One member of the HD Radio “other” category mentioned the possibility of developing a modified version of the chip on a regional basis, such that there would be an AM-FM-HD Radio-satellite radio receiver chip in the United States and an AM-FM-DAB-DRM chip in Europe. The industry is already considering this possibility. The 2009 Toyota Corolla already comes with a factory installed AM-FM-XM Radio that is MP3-player accessible as standard equipment. The only component missing from the regional concept of the universal chip is the HD Radio decoder.

Place HD Radio and DRM Receivers in Electronic Devices

When the researcher asked about half of the interviewees whether they agreed with the concept of creating digital radio capacity in ubiquitous portable electronic devices, such as cell phones and MP3 players, by placing HD Radio and DRM receivers in them, 69% answered in the affirmative, 23% also answered in the affirmative but with a condition or stipulation, and only 8% answered in the negative, as indicated in Figure V.10.

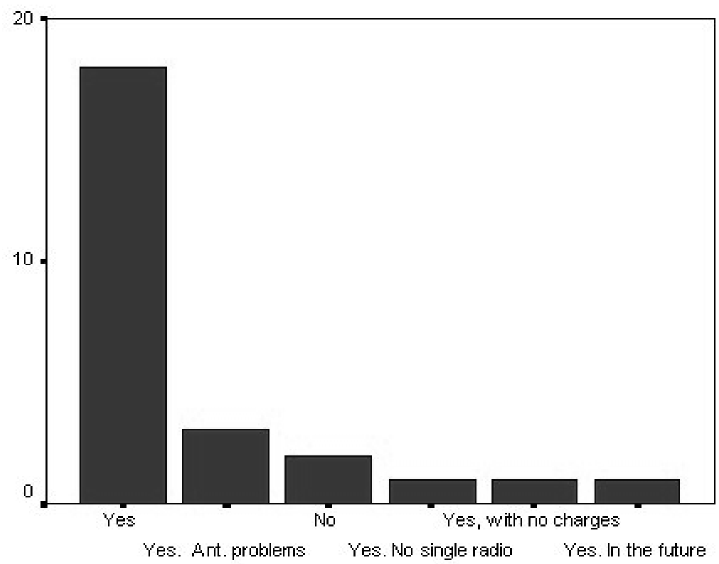


Figure V.10. Participant responses regarding radio chips in other digital devices.

When asked about putting radio chips in other portable electronic devices, a DRM receiver manufacturer responded, “Well I think it’s perfectly feasible. Currently in Europe we have mobile phones with Band 2 FM reception capabilities. In fact, we have now launched DMB capable receivers as well [in cell phones].” A regulator from the FCC also stated, “I think a chip in anything is good. . . . If it means it has to get to the next younger generation into the iPods, the cell phones, and things like that, I think they should encourage it."

Some of the interviewees cited high power consumption issues with putting radio chips in these small devices, but they believe this problem could eventually be overcome. One interviewee, the contrarian, believes this is a bad idea:

> You can put radio on a mobile device and nobody will buy it for that reason. They won't even use it for that reason. Studies show they hardly ever use those devices as a radio. The bottom line is: We're thinking like losers. The future is at the Apple store. The future is on the Internet. . . . We know how to do content. We need to get into the digital interactive world.

Providing the opportunity to listen to digital radio on cell phones and MP3 players may cause some listeners to migrate back to radio but, again, only if there is content available that they want to hear.

Use Fractal Antennas

Three of the interviewees objected to the idea of providing HD Radio and DRM capability in ubiquitous mobile electronic devices because of the antennas required for these radios. HD Radio in the mediumwave and DRM in the shortwave require extensive antennas for adequate reception because the wavelengths of these frequency bands are extremely long. Wavelengths for the various shortwave bands extend from 10 meters to 120 meters in length, and the wavelength for the extreme low end of the mediumwave is an overwhelming 545 meters. How can a tiny electronic device such as a cell phone or an MP3 player contain an antenna that is resonant at such a long wavelength?

A possible solution is the use of fractal antennas, whose physical length is substantially shorter than their electrical length. Fractal antennas are "created using fractal geometry, a self-similar pattern built from the repetition of a simple shape. The inherent qualities of fractals enable the production of high-performance antennas that are typically 50 to 75% smaller than traditional antennas" (Fractal Antenna Systems, n.d.). Figure V.11 displays an example of a fractal antenna.

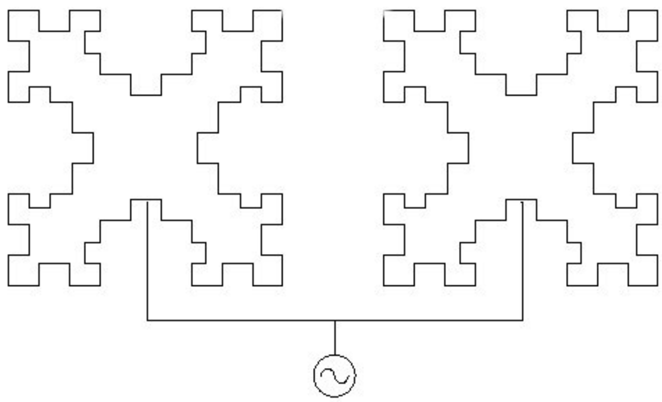


Figure V.11. Fractal antenna design. From *Fractal Antenna Applications,* by J. Gianvittorio, n.d., retrieved February 13, 2009, from http://www.ee.ucla.edu/~johng/fractals/applications_array_geometry.gif

Although almost any length of wire can be resonant to almost any frequency in the spectrum using an adequate tuning circuit,[13] fractal antennas offer the possibility of miniaturizing antennas to the point where a small geometric patterned antenna resonant with the shortwave and mediumwave wavelengths could comfortably fit into an electrical device the size of a cell phone or MP3 player. Although several commercial companies manufacture miniaturized fractal antennas, they do not manufacture antennas for frequencies below 500 MHz. Fractal antennas that are resonant in the mediumwave,

[13] Veteran commercial broadcaster and amateur radio operator Morris Blum often remarked that ham radio operators could use bedsprings for an antenna if they used the right tuning circuits.

shortwave, and FM VHF bands may make HD Radio and DRM technology access in ubiquitous electronic devices possible.

Allow Shortwave Radio for Cross-Continental Broadcasting in the United States

With the exception of the continental United States, areas of the world with large geographical expanses, such as Western Europe, Russia, China, Africa, and South America, have found shortwave a successful medium for broadcasting. Although he finds it virtually impossible to find a shortwave car radio in the United States, the rental car that the researcher used while traveling in the Canary Islands off the coast of Africa in 2008 came with a factory equipped AM-FM-shortwave radio receiver. Why has shortwave radio become successful in almost every area of the world except the United States?

On two separate occasions the researcher posed this question to two attendees of the National Association of Shortwave Broadcasters (NASB) annual conference in two different years. Although one was a general manager of an American commercial shortwave broadcasting station and the other a bureaucrat from the International Bureau of the FCC, both gave the same exact answer. Both stated that after the U.S. Congress passed legislation prohibiting the VOA from broadcasting directly to the continental United States in the shortwave bands, the FCC ruled that no other entity could do so.[14] Consequently, the shortwave bands have been considered solely a medium for international broadcasting. In fact, when a new commercial shortwave station files its

[14] The researcher has found additional anecdotal evidence that the FCC was also heavily lobbied by many of the Clear Channel 50,000-watt mediumwave AM stations in existence at that time who did not want competition from shortwave stations for long-range broadcasting.

construction permit to build its transmitter facilities, it must also indicate to the FCC where its intended external audience will be located.[15]

As time permitted, the researcher asked several of the interviewees about commercial shortwave broadcasting in the United States. A DRM Consortium committee chairman from Europe believes that internal U.S. shortwave broadcasting will not commence until someone takes the initiative: “The first broadcaster who will apply for a shortwave license from the United States to the United States—he must open the door.” Internal shortwave broadcasting in the United States has potential but it may never be realized due to the many hurdles in its way, coupled with the current directions in the media market regarding Internet radio, satellite radio, and MP3 players.

Shortwave radio’s potential to provide cross-continental radio broadcasting in the United States can be increased exponentially by the introduction of DRM technology. Using DRM technology, it would be easy to listen to a shortwave radio station transmitting from Los Angeles or San Francisco providing a near CD-quality digital signal in stereo while listening on a DRM digital car radio and driving from Washington, DC to New York City.

By having access to more stations from more geographical locations in the country, more diversity in program content could be made available for the listening audience. Local styles of music could be heard nationwide, sporting fans could listen to

[15] There is, however, “a wink and a nod” with this procedure. Some commercial shortwave broadcasters identify an intended audience in a country on the opposite side of the United States from their transmitter site with spillover and splatter of their signal throughout the United States. As one commercial shortwave broadcaster stated during his interview, “There are a lot of other stations that are doing the same thing—broadcasting from Maine to Mexico and this sort of thing. And the FCC has just pretty much ignored all this. Nobody wants to make a big issue of it.”

their hometown team's game while traveling, and local political perspectives from distant areas within the country could offer diverse viewpoints on current events to remote or isolated listeners. Shortwave is the only portion of the electromagnetic spectrum that allows for long distance cross-continental wireless communication (with the exception of the expensive process of satellite communication in the UHF). Despite being a precious natural resource, it is highly underutilized in the United States.

Allow Local Broadcasting on 26 MHz

Although shortwave is mostly considered a radio medium for long-distance communication, a portion of the band could be dedicated to local and regional use. The upper extremities of the shortwave bands act much like VHF with line-of-sight propagation. This is the region where amateur operators primarily broadcast in-state on the 10-meter band and unlicensed citizens band enthusiasts operate 5-watt transceivers on the 11-meter band. Researchers have been experimenting with using DRM technology on the 26-MHz band, which may offer the possibility of an entirely new broadcasting band for local and regional use.

Allow VOA Content in the United States

Most of the interviewees who argued that more governmental support is required if HD Radio and DRM are to become successful technologies were referring to support for the production and diffusion of digital radio receivers in the marketplace. However, there are other ways that the government can help. One way is by providing free content for HD Radio broadcasters to use on their HD-2 and HD-3 streams, which the U.S. government already has the potential to do, and would help end the chicken-or-egg syndrome, the most pervasive stumbling block to the success of digitally modulated radio. U.S. listeners may consider programming from the VOA and similar entities, which broadcasters can transmit using their HD audio streams at no cost, to be compelling content. However, even though the International Broadcasting Bureau (IBB), the VOA parent organization, maintains an Office of Marketing and Program Placement to assist affiliate AM and FM stations throughout the world in receiving VOA's satellite signals, decoding them, and then retransmitting them locally, it does nothing to assist or interact with AM and FM stations within the United States.

Although legislation currently precludes the VOA from broadcasting within the United States, it does not preclude U.S. broadcasters from using VOA content if they can access it since this content is public domain. An example of a station that provides VOA programming within the continental United States is WFED (AM) in Washington, DC, which carries VOA's weekend public affairs programs in English as part of its scheduled weekly lineup (Federal News Radio, n.d.). Although VOA programming is specifically designed for U.S. public diplomacy purposes, its distribution for domestic consumption could be justified as public affairs products in coordination with the U.S. General Service Administration Office of Citizen Services.

The only costs to broadcasters of providing VOA programming using HD Radio would be the costs of a new HD exciter and a satellite receiver to receive VOA content and make it available on the HD-2 and HD-3 streams. Diaspora communities of foreign language speakers scattered throughout the United States would, no doubt, find this programming compelling and, if made aware of its existence, would presumably be willing to purchase a new HD Radio receiver in order to listen to it. In this way, free programming content from VOA could help bring about success for HD Radio in the United States

Modify or Repeal Section 501 of the Smith-Mundt Act

Section 501 of the Smith Mundt Act, also known as the U.S. Information and Educational Exchange Act of 1948 (Public Law 80-402), precludes dissemination of U.S. public diplomacy products (including VOA content) within the United States. Although the intent of the Smith-Mundt Act is to “promote the better understanding of the United States among the peoples of the world and to strengthen cooperative international relations” (Pirsein, 1979, as cited in Armstrong, 2008), Section 501 precludes U.S. citizens from accessing U.S. public diplomacy products, including VOA content. If U.S. listeners were able to access such programming via HD-2 and HD-3 streams—at no cost to broadcasters—they may consider it “compelling content,” thus leading it to contribute to the success of HD Radio.

The Smith-Mundt Act domestic prohibition clause was drafted during the 1940s in reaction to fears that drones, incompetents, loafers, Communist sympathizers and Socialists from within the State Department, which had oversight of the VOA at that time, would have direct access to the American public to promote their agenda and undermine the government if VOA could broadcast directly to the continental United States (Armstrong, 2008). With this threat no longer relevant, there have been calls for Section 501 to be modified or eliminated. Of the interviewees whom the researcher asked whether it should be modified or repealed, 71% answered in the affirmative, 11% in the negative, 17% stated did not know how to answer the question, and 1% responded "maybe." Figure V.12 graphically displays their responses.

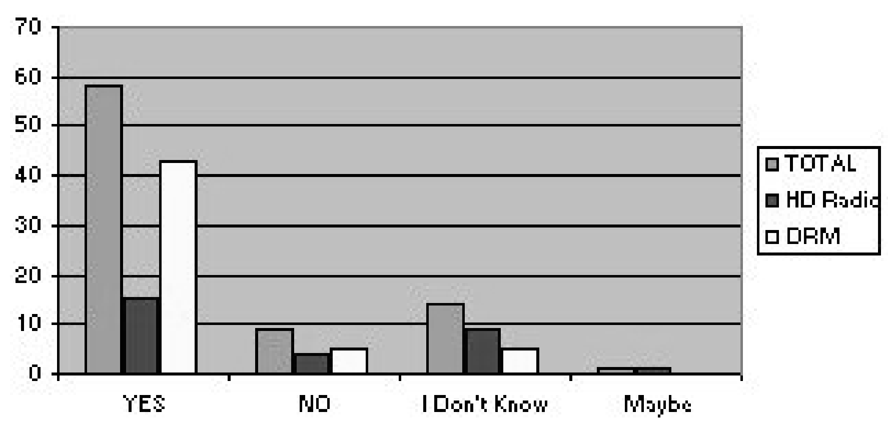


Figure V.12. Participant responses regarding the repeal of the Smith-Mundt Act.

Almost three times as many DRM interviewees than HD Radio stakeholders (43 to 15) answered in the affirmative, and more HD Radio interviewees answered that they did not know the answer than answered in the negative (9 to 4). This indicates that the Smith-Mundt Act's impact is more of a concern for DRM broadcasters and stakeholders because its modification or repeal offers them the possibility of adding more domestic U.S. commercial broadcasting by using the shortwave bands, whereas it offers only the possibility of free VOA programming to HD Radio commercial broadcasters.

From the perspective of opening up the shortwave bands to domestic commercial broadcasting in the United States, a DRM transmitter manufacturer stated, "I think it should be repealed and allow shortwave because even DRM is promoting the idea of using the 26 megahertz band for FM-like broadcast, and yet that's excluded at this point from being used.” An innovator from the DRM Consortium stated that it was the Consortium’s opinion that the Smith-Mundt Act should be amended.

This researcher recommends the modification or repeal of Section 501 of the Smith-Mundt Act to allow the IBB Office of Affiliate Relations to assist American AM and FM radio stations in receiving VOA content for retransmission purposes, which may support the successful rollout of HD Radio by adding more diverse content via HD-2 and HD-3 streams to the airwaves. The researcher believes that VOA products vital to U.S. public diplomacy interests should be made available for domestic consumption. Modification or repeal of Section 501 could also benefit the VOA and its parent organizations in the following ways:

1. Countering the false notion that the VOA is the government’s so-called “propaganda machine.” Once Americans hear the content from VOA, they can judge for themselves whether the programming is fair and balanced or not.

2. Aiding the VOA, the BBG, and the IBB in the budget-approval process. Once members of the House and Senate receive feedback from constituents about their use of VOA products, the budget allocation process for these agencies may be smoother.

Domestic transmission of VOA programming by commercial broadcasters not only by HD-2 and HD-3 streams but also by small daytime-only AM stations may help HD Radio thrive by providing no-cost, high-quality, compelling content. If the Smith-Mundt Act no longer prohibited the transmission of VOA content inside the United States, DRM broadcasters could also use shortwave bands for domestic transcontinental transmission or for local and regional use in the 26 MHz band, and the FCC may take an even more relaxed attitude toward internal commercial shortwave broadcasting.

Pursue Further Development

Further improvements may open new avenues for DRM and HD Radio's use and increase their chances for success. iBiquity is already considering developing second- and third-generation receivers with increased capacities once the system sheds its analog component and becomes an all-digital technology. DRM is studying "smart" receivers that monitor multiple shortwave frequencies on which a digital broadcaster is transmitting that will instantaneously switch to the clearest signal. Development of future products such as these offers the potential for further growth of digital modulation.

Allow Digital Modulation Use in the Amateur Shortwave, VHF, and UHF Bands

Experimentation among amateur or "ham" radio operators has led them to identify the means of communicating with one another using exotic technologies and novel methods, including analog transmission of extremely low-powered digital signals in hostile atmospheric environments, such as the PSK-31 mode. They have also developed slow-scan television in the VHF and UHF regions of the spectrum, and have even bounced relatively low-powered VHF and UHF signals off of the moon, meteor scatters, and satellites in order to successfully communicate with other amateurs on the opposite side of the earth. In fact, an amateur operator from the United Kingdom has already developed a miniaturized fractal antenna that is resonant in the 10-meter shortwave band at 28.400 MHz, as seen in Figure V.13[16] (M0WWA, n.d.).

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[16] Commercial manufacturers of fractal antennas appear to have developed products only for use at frequencies of 500 MHz and above.

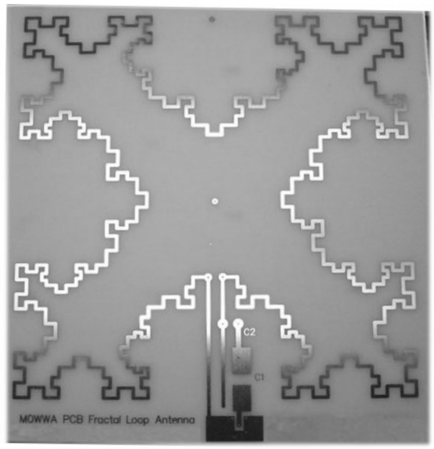

Figure V.13. Amateur-made fractal antenna (picture not to scale). From *10 Meter PCB Fractal Loop Antenna Project*, n.d., retrieved February 13, 2009, from http://www.m0wwa.co.uk/mmedia/fractalmodelII/fractal-MODEL2.jpg

Amateur radio operators have the ability to develop new and innovative ways of using digital modulation that could be helpful in the rollout of the technology. Therefore, the researcher recommends allocating portions of the various shortwave amateur bands for DRM use and the VHF or UHF bands for composite HD Radio digital and analog transmission. Because amateur operators use half of the amount of spectrum required by a commercial AM station for their voice signals in the shortwave, referred to as a single sideband (SSB), it would be of interest to determine how much data could be packed into a relatively tiny 3.5 kHz-wide digital signal. How much improvement in the audio quality can be attained over that of an SSB analog AM signal, and what kind of tinkering would they do with the coding and digital compression? How many ancillary data can be provided? Could a DRM amateur operator using 3.5-kHz of spectrum communicate with another operator located two continents away with a DRM receiver some minimal digital text indicating his or her name, location and call sign in addition to sending an improved high-quality audio signal with only 100 watts of power through a directional antenna? It is experiments such as these that may lead to further progress for HD Radio and DRM.

Reinvigorate the Engineering Component of the FCC

The FCC once had a robust engineering department that independently analyzed new equipment and technologies, evidenced by the fact that the FCC conducted its own analysis of AM Stereo technology. However, during the approval process for HD Radio, the FCC conducted no independent analysis of its own, merely accepting the findings of iBiquity and the NRSC-CEA studies. Many broadcasters and manufacturers in this study indicated that the FCC's lack of independent action has led them to lose respect for the agency. Whereas the regulators in this study indicated that their engineering component is adequate for meeting the agency's needs, the broadcasters and manufacturers overwhelmingly disagree. Based on these findings, the researcher recommends that the FCC reinvigorate its engineering component to at least the point at which it can independently corroborate or disprove the findings of outside organizations presenting their test reports on new broadcast technologies before making a ruling.

APPENDIX W

Further Recommendations for Researchers

The researcher developed this set of recommendations specifically for academic researchers based on several technical issues raised by the stakeholders as well as transference in applying one of the unintended outcomes of this study to another field of endeavor.

Replicate DRM Field Test 2A

The DRM Consortium provided perhaps the most striking demonstration of digital radio's enhanced audio capabilities with its Field Test 2A, which compared and contrasted the audio fidelity of DRM digital modulation and conventional double-sideband amplitude modulation in the shortwave and mediumwave bands. The Consortium conducted the shortwave tests from a transmitter site in Portugal, with receiver sites in Finland and Cyprus, and conducted the mediumwave tests between the United Kingdom and Germany. Each test consisted of a pair of transmissions, one digital and one analog, with each pair of transmissions carrying the same program content on the same frequency within a half hour of each other in the same atmospheric conditions. In each test, the analog signal suffered from the usual problems of poor reception from static, fading, and interference from other stations on the same frequency or adjacent frequencies. In contrast, the digital signal in each instance did not suffer from any of these problems, producing high-quality audio with no anomalies at the reception site. The Consortium presented these audio tests as demonstrations of DRM capabilities to various groups, who were impressed by the results, as well as at the annual symposium of the IEEE Broadcast Technology Society.

However, a noted international media analyst that participated in this study stated that he had difficulties replicating this test with the same results. His particular concern was the robustness of the digital signal and its ability to remain constant at the receiver site during long periods, especially during changing atmospheric conditions. In the closing comments of his interview for this study he explained his position in more detail:

> I'm very skeptical about that demonstration because I have several times tried to replicate that myself and never had any success. And I've never been able to convince anybody from DRM to redo that for me. So I will not believe that until I hear it myself. There's just been a little bit of some shenanigans, I think, involved in those side-by-side tests.

An interesting and important research project for the development of digital radio, particularly in the shortwave, would be replication of DRM Field Test 2A. Researchers may find it valuable to address the following questions: Can a digital shortwave signal emanating from Los Angeles or San Francisco be consistently and clearly heard in Washington, DC or New York City? Can it be heard equally as well whether the listener is stationary or mobile? How effective are transoceanic digital shortwave transmissions? Can digital signals survive "multi-hops" without producing corrupted data? With "smart" receivers monitoring several frequencies simultaneously and instantaneously shifting to the strongest signal, can robustness be improved through multi-frequency or multi-band transmission? The technical capabilities of both HD Radio and DRM can be improved through addressing questions such as these.

Compare Digital and Analog Audio Quality

The primary feature of digital modulation touted by iBiquity and its predecessors to the radio broadcasting industry has been its enhanced audio quality. However, it remains unclear whether the general public can hear the difference between analog and digital signals, particularly if the analog is high-quality FM in stereo. Moreover, stakeholders must consider that the effects of improved digital audio may be negated by road noise, as most of the public listens to radio broadcasts in a mobile environment. This is a particular concern.

The CEA and the NRSC conducted audio perception studies to gauge the general public's perception of the enhanced audio product (Messer, 2001, 2002). Despite the fact that they found that listeners in a closed environment could detect fewer interruptions and anomalies in digital radio, one stakeholder interviewed in this study, a former broadcaster and FCC employee who is now a professor of media studies at George Washington University, remains skeptical whether enhanced audio has any impact at all on listeners. In his interview, he expressed concern that the pervasive use of low-quality "earbuds" currently used by most iPod listeners to listen to compressed MP3 files is training the general public to accept a lower audio quality standard.

Clearly, further testing of listener perception would be helpful, particularly in a mobile environment, to determine whether listeners can detect the "HD effect." Is this improved audio quality perceived by the general audience while listening in a mobile environment ? If so, is this difference in audio quality, in and of itself, a sufficient motivation for listeners to migrate from analog AM and FM to digital radio? Research into audio perception would no doubt be useful to the radio broadcasting industry.

Determine the Coverage Area of Radio Stations

The FCC provides a very clear definition of the coverage area of a radio station, particularly in the FM band: the geographical area around the transmitter site where the station's signal strength is 70 dBu or 3.16 mV/meter or more according to Title 47, section 73.315. (Government Printing Office, 2008) This geographical region is what the FCC calls the *protected area*, where the station is guaranteed to be free of any interference from co-channel or adjacent-channel stations. However, most listeners expect to be able to listen to their favorite stations far outside of a station's protected area, including between the protected areas of two co-channel stations in which either station's signal can be heard but in which neither is protected from interference from the other by the FCC. As listeners often travel in and out of a station's protected area and this "no-man's land" between stations while listening to their radios, they consider the coverage area of a radio station far beyond the protected area established by the FCC.

Broadcast station managers and owners further exacerbate the challenge of defining the coverage area. Even though some radio stations are geographically located on the extreme fringes of a major market area, where their signals cannot cover the metropolitan limits of a major market city, they still claim to be major-market stations, despite capturing only a 1% to 2% share of the listening audience, in an effort to increase their revenue per advertising spot. WRNR (FM), which has a transmitter site on the eastern shore of the Chesapeake Bay in Grasonville, Maryland and studios in Annapolis, Maryland, provides an example of this phenomenon. WRNR's signal does not cover the northwest corner of the city of Baltimore, yet it considers itself a Baltimore station, and often appears in the quarterly Baltimore Arbitron ratings despite receiving less than 2% of the area's audience share. The definition of a radio station's coverage area is particularly important in determining adequate coverage for HD Radio. Both the researcher and a small-market general manger interviewed in this study have observed that the coverage areas of HD Radio digital streams are significantly smaller than those of the analog FM and AM portions of all the radio stations to which they listened with an HD Radio receiver.

Should the digital portion of an HD-Radio signal only cover the FCC-protected area of a station, or should it adequately cover the same amount of geographical area as the analog signal, with reception capability well into the "no-man's land"? If it should provide the same coverage area as the analog signal, should the injection level of the digital signal be increased from the current 1%, as this would undoubtedly exceed FCC mask regarding spurious radiation? As the answers to these questions are beyond the scope of this study, the researcher leaves their determination to future academics.

Analyze the Modification or Repeal of Section 501 of the Smith-Mundt Act

As previously discussed in Appendix V, VOA programming could provide additional compelling content for broadcasters to transmit on their HD-2 and HD-3 streams and help resolve the chicken-or-egg syndrome, as commercial domestic broadcasters could obtain it free of charge. However, VOA programming can only be made available to U.S. broadcasters with IBB support and if the U.S. Congress modifies or repeals Section 501 of the Smith-Mundt Act of 1948. Modification or repeal of the

Smith-Mundt Act can also pave the way for domestic U.S. digital commercial radio broadcasting in the shortwave bands.

Several researchers are currently evaluating the modification or repeal of Section 501. In conjunction with the Heritage Foundation, Johnson and Dale (2003); Johnson (2004); Johnson, Dale, and Cronin (2005); Pilon (2007a, 2007b); and Holmes (2008) have addressed this issue, and Armstrong (2008) and Snyder (1994) have undertaken independent study regarding the lingering effects of the Smith-Mundt Act.

Despite their efforts, no researcher has yet undertaken a study that comprehensively addresses this issue by answering the following questions:

1. Is there a public affairs mission for VOA programming for the domestic market in addition to its international public diplomacy mission? If so, should this public affairs mission be aligned and coordinated with the Office of Citizen Services and Communications within the U.S. General Services Administration in a manner similar to the alignment and coordination that currently exists between VOA's public diplomacy mission and the U.S. Department of State?

2. Should foreign language programming from the U.S. federal government be made available within the continental United States in order to reach non-English-speaking citizens or foreign nationals living in the United States?

3. Should the VOA offer its Special English programs and English-teaching programming in other foreign languages within the continental United States as part of U.S. citizenship immigration reform policy?

4. Should American citizens be able to hear clear descriptions of what their government's official policies are as expressed in VOA editorials?

5. Why is the legal preclusion of broadcasting VOA programming directly to the continental United States not considered self-censorship?

6. Would broadcasters consider government-produced programming an intrusion into the commercial radio marketplace?

a. If federal government-produced programming on radio stations were allowed domestically, would it compete with commercial radio stations and commercial programming?

b. If permitted, should federal government-produced programming on radio stations be included in the Arbitron rating process? Or should it be excluded in a way similar to that of NPR programming?

c. Should VOA programming be encrypted for domestic consumption so that receivers distributed only to foreign nationals can decode it?

7. Is the broadcasting section of the Smith-Mundt Act of 1948 already irrelevant and outdated by technology due to the ubiquitous nature of the Internet, with VOA Internet products already available within the continental United States?

8. Can programming from the U.S. federal government help jumpstart HD Radio HD-2 and HD-3 streams by providing free content for commercial radio broadcasters?

a. Will domestic listeners consider VOA programming compelling?

b. Will domestic listeners consider migrating to HD-2 and HD-3 streams if VOA programming is made available?

c. Will broadcasters see an increase in their total listenership if free VOA programming is made available for their HD-2 and HD-3 streams?

9. Can the VOA build a constituency within the voting public if citizens start listening to its programming?

a. Will elected representatives receive feedback from their constituents who consume this content and see a need for VOA programming on the radio stations in their individual districts and states?

b. Will building a domestic constituency of VOA listeners within the voting public be helpful to the VOA during its annual congressionally mandated budgetary process?

The researcher recommends additional study into the Smith-Mundt Act, particularly the possible effects of modifying or eliminating Section 501 of the Smith-Mundt Act on new and emerging technology and its impact on public diplomacy and public affairs.

Use Fractal Antennas in Electronic Devices

Although Gianvittorio (2000) at UCLA and González-Arbesú, Rius, and Romeu (2004) at the Polytechnic University of Catalunya-Barcelona in Spain have conducted some research into fractal antennas, more research into this area is warranted. Of particular interest is the analysis and development of miniaturized fractal antennas that are sufficiently agile to be resonant from 550 kHz (the low end of the mediumwave AM band) through 108 MHz (the high end of the FM VHF band) and small enough to place onto cell phones or MP3 players. Antennas such as these would be a major breakthrough in digital radio modulation reception in small and popular portable electronic devices.

Determine the Role of Regulators in the Products and Services They Regulate

Unquestionably, the most frustrating aspect of the data collection phase of this study for the researcher was obtaining data from regulators, particularly his inability to interview any ITU regulators regarding the worldwide approval process for DRM. Furthermore, although some of the FCC regulators involved with the HD Radio approval process were extremely forthcoming, others initially appeared reluctant to be interviewed and, when interviewed, provided answers that were not particularly informative. Based on the limited data collected, the only aspect of HD Radio that the FCC seems concerned with now that the technology has been approved is possible interference among stations.

This fact made the researcher pause and wonder if regulators in almost any field consider themselves stakeholders in the success or failure of the products and services that they regulate. Do regulators at the Federal Aviation Administration, for example, consider themselves stakeholders in the success or failure of the airline industry? Do regulators at the Securities and Exchange Commission consider themselves stakeholders in the financial instruments that they regulate? Do they feel any sense of personal responsibility for the current (2009) recession? Do regulators at the Food and Drug Administration consider themselves stakeholders in the success of any of the pharmaceuticals that they approve or simply watchdogs protecting the public interest? Does the Department of Education feel any sense of pride for any success attributed to the No Child Left Behind initiative?

The investigation of regulatory bodies and their affiliation with their respective industries is clearly well beyond the scope of this study. However, an analysis of the regulators' perspectives of their roles and their perceptions of ownership in the success of the products and services that they regulate, or lack thereof, would be a valuable research endeavor. Any researcher who attempts to undertake such an endeavor should bear in mind the difficulties experienced by the researcher of this study in obtaining regulator participation.