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UNIVERSITY OF MIAMI

A CASE STUDY OF HD RADIO DIFFUSION IN THE UNITED STATES

By

John C. C. Halbert

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

May 2015

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UNIVERSITY OF MIAMI

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A CASE STUDY OF HD RADIO DIFFUSION IN THE UNITED STATES

John C. C. Halbert

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HALBERT, JOHN (Ph.D., Communication)
A Case Study of HD Radio Diffusion in the United States (May 2015)

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Despite industry and government endorsements of its many advantages over conventional analog radio and significant consumer marketing efforts, digital radio broadcasting (DAB) continues to languish, unable to attract a critical mass of users either from the broadcasting industry or consumers.

The purpose of this dissertation is to discover why America has not embraced this once-promising digital medium. Approaching the issue from the interrelated perspectives of technology, economics, and regulation, and synthesizing this information using diffusion of innovations theory, the study identifies five major factors inhibiting the growth of HD Radio in the United States. These factors include: (a) the emergence of other audio digital technologies, (b) a poorly-planned rollout and marketing of the product (c) little return on investment for broadcasters, (d) lackluster programming and other associated content, and (e) the overall economic slowdown in the radio industry.

The study also identifies the levels of diffusion through the social systems present in the radio industry and finds that while diffusion has occurred fully through the regulatory system, diffusion has been significantly hampered through the radio industry and listeners. Radio stations converting to HD Radio broadcasting are at a standstill as the return on investment for HD broadcasting in ratings and revenue is not at a substantial level to spur more conversions. Consumers show lackluster interest in the technology in

terms of purchasing sets for themselves; consumers lack awareness of the technology and struggle to differentiate HD Radio from satellite radio competition. In the tech sector, HD Radio has found some success in placing compatible receivers in automobiles, but diffusion through this system is limited at best with few manufacturers lining up to produce more and different sets. The study concludes with recommendations that might reverse the tide of public indifference towards this innovation.

DEDICATION

This work is dedicated to the memory of the author's parents, John N. Halbert and Louise H. Halbert. Their love and support for the author, for whatever path he chose in his life, are the greatest gifts he received from them. Their love of reading, dedication to each other, laughter through the hardest times, and selflessness in making sure their son had the best they could give are memories the author will cherish forever.

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CHAPTER I. INTRODUCTION

In the United States, 93% of persons 12 and older listen to radio each week (Arbitron, 2012). The vast majority of these people listen to traditional analog radio on both the AM and FM broadcasting bands, used by commercial and non-commercial broadcasters. Analog broadcasting is a technology that is now more than 100 years old; today more than 15,000 analog broadcasting stations operate in the United States (Federal Communications Commission, 2012). Unlike full-power television stations[1], which transitioned entirely to digital transmission in 2009 by order of the Federal Communications Commission (Federal Communications Commission, 2009), commercial radio broadcasting in the United States remains firmly an analog-based business. Considering the growth and popularity of digitally-based consumer electronics devices over the past two decades (such as cellular phones, computers, and other equipment), commercial radio's continued foundation in analog technology is unusual and potentially threatening to its future. Indeed, in January 2012, iBiquity founder and Chief Executive Officer Robert Struble, reflecting upon the Consumer Electronics Show (CES) in Las Vegas, noted that:

> AM/FM radio is the only analog technology remaining at CES, everything else is digital…. Every competitor to AM/FM, every other source of information and entertainment and every CE gadget radio listeners are carrying around or enjoying at home or at work, are based on digital technology – except AM/FM. (Struble, 2012, para. 3)

Digital audio broadcasting (DAB) holds great promise for consumers, including more channels of entertainment, noticeably improved audio quality, improved ability to send textual data to receivers, and a signal resistant to static interference. DAB can either

[1] Low-Power Television (LPTV) stations do not have to transition to all-digital broadcasting until September 1, 2015 (Federal Communications Commission, 2013c).

be satellite-based or terrestrially-based. Only one satellite-based DAB provider, SiriusXM, now exists in the United States. SiriusXM provides over 150 full-time channels of audio programming for 23.9 million subscribers (Rocco, 2013; SiriusXM, 2013). Terrestrially-based DAB technology has taken different forms. In Europe, the Eureka 147 system, adopted in 1995, carved out entirely new spectrum space for digital broadcasting (Faller et al., 2002). The Eureka system promised a more efficient use of spectrum space and the ability to vary the number of audio streams within one channel (1,500 kilohertz wide) by modifying the bit rates of each audio stream (O'Neill & Shaw, 2010). In Japan, the ISDB-T_{SB} (Integrated Services Digital Broadcasting Terrestrial for sound broadcasting) system shares assigned spectrum on the UHF band with digital television; ISDB-T_{SB} is a "subset" of the ISDB-T digital standard for terrestrial television (Asami & Sasaki, 2006; Fuseda, 2009). In the United States, despite initial enthusiasm for a Eureka 147-type system from the Consumer Electronics Manufacturers Association (CEMA) and the National Association of Broadcasters (NAB), many existing station owners feared implementation of a system operating on an entirely new block of spectrum. Owners of analog stations were not guaranteed space by the Federal Communications Commission (FCC) in the proposed new digital band, and competition from new digital stations was sure to have both an audience and financial impact on existing analog stations.

In response, U.S. station owners began to advocate an alternative digital system called in-band on-channel (IBOC). This system allowed existing broadcasters to continue broadcasting their analog signals on current channel assignments while simultaneously carrying enhanced digital services, including digital audio and text

(Stavitsky & Huntsberger, 2010). Perhaps most important to existing broadcasters, consumers would not be forced to buy all new equipment to continue receiving broadcasts. Analog signals would continue for existing radios, and the new digital service would be available to consumers who purchased new radios capable of both digital and analog reception.

After several years of development and field testing, IBOC was unveiled to radio industry leaders at the 2002 NAB convention. The IBOC system was officially approved later that year by the FCC and remains the only digital terrestrial radio system allowed in the United States (iBiquity, 2012a; iBiquity, 2012b; Stavitsky & Huntsberger, 2010). The digital radio system and receiving devices are marketed under the name "HD Radio" by iBiquity. Although Eureka 147 and similar systems have been tried in nations outside of Europe, most notably Canada and Australia, so far the IBOC system has been made the exclusive digital audio broadcasting standard only in the United States (Stavitsky & Huntsberger, 2010).

One of the key differences between digital radio and digital television in the United States has been the absence of a transition mandate from the FCC. There remains no date when all radio transmissions must be all-digital, in sharp contrast to the required deadline that was implemented for all full-power television stations.[2] Owners of broadcast companies and their shareholders wanted to ensure the "continued viability of terrestrial radio in the digital age" (Stavitsky & Huntsberger, 2010, p. 126). In other words, owners of commercial broadcast stations did not want their livelihoods threatened by a new set of competitors (in addition to satellite radio, streaming services, personal

[2] The deadline was June 12, 2009 (Federal Communications Commission, 2009).

digital music file audio players, etc.) in the digital spectrum; they wished to control digital radio broadcasting as well as maintain their existing, well-established business.

The lack of a FCC mandate has arguably been a benefit for consumers as well because they do not have to purchase new receiver sets in order to continue enjoying basic radio broadcasts. However, the lack of a "drop dead" date for ceasing analog radio broadcasting has severely retarded the diffusion of digital radio receivers among consumers in the United States. Another factor for the Commission's reluctance to set a mandated transition date has been the cost of consumer HD Radio receiver sets. Initially, HD Radio receivers for home use were priced around $500 (Fleishman, 2005) and, although the price has fallen substantially, the price of an HD Radio receiver cannot compare with that of an analog set. Currently, basic portable HD Radio receivers start around $30 and quickly escalate to higher-end sets that cost $200 or more. In contrast, several pocket-sized AM/FM portable receivers can be found for less than $5 on Amazon.com (Amazon.com, 2012a, 2012b). HD Radio attachments to allow reception capability on mobile devices, such as iPhones, are available; however, they have not been popular items with consumers. iBiquity has not been able to convince mobile device makers to include digital radio reception chips as an internal part of the devices (Riismandel, 2012).

Most worrisome for the industry, despite a massive multi-million dollar awareness campaign by the HD Digital Radio Alliance[3] touting the consumer benefits of

[3] The HD Digital Radio Alliance was formed in 2005 by eight of the radio industry's largest group owners. The original members were Bonneville International Corp., Citadel Broadcasting Corp., Clear Channel Communications Inc., Cumulus Media Inc., Emmis Communications Inc., Entercom Communications Inc., Greater Media Inc., and Infinity Broadcasting. According to CEO Peter Ferrerra, the Alliance was formed specifically for the promotion and public acceptance of HD Radio in the United States (Johnson, 2005). Through 2008, the total financial commitment made by the Alliance for marketing HD Radio was $680

upgrading to the digital radio, awareness of HD Radio is actually diminishing in the crowded consumer electronics landscape. According to a survey conducted by radio consultant Mark Kassoff (2012), fewer American consumers "heard of" HD Radio in 2012 (54%) than they did in 2008 (67%), meaning nearly half of consumers (46%) did not know anything about HD Radio. In a follow-up question, when consumers were asked if they knew anything about HD Radio apart from simply hearing about it, 16% of those respondents said "no." The survey also found that several of those who claimed knowledge about HD Radio were inferring attributes to HD Radio based upon their knowledge of high-definition *television* (HDTV) or confusing HD Radio with satellite-delivered radio (Kassof, 2012). Similarly, a 2012 Public Radio Technology Survey from Jacobs Media and the Public Radio Program Directors Association shows HD Radio lagging well behind every other available media technology in terms of use (Public Radio Program Directors Association, 2013). In this survey, the estimated usage of HD Radio ranked last at 9%, well behind satellite radio (16%), Pandora.com (17%), other Internet radio streaming (43%), MP3 audio devices (55%), and traditional AM/FM radio (87%). Finally, according to Pew Research, only 2% of persons surveyed reported using HD Radio in their primary vehicle (Pew Research Center, 2012).

Given this low adoption and usage rate, the question that arises is whether digital radio is an unsuccessful innovation in today's fragmented digital entertainment world. Compared to HD Radio, personal music players and online audio streaming are two growing areas of audio entertainment outside of both analog and digital broadcasting. These technologies offer a multitude of devices that enable people to program their

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million (*Radio Ink*, 2007). The 2011 marketing commitment made by the Alliance was $110 million (iBiquity, 2012c).

favorite music or spoken-word audio, plus control when, where, and how they listen. Radio station-focused websites, such as TuneIn.com and iHeartRadio.com, feature streaming audio from thousands of stations in the United States and around the world. These sites also link users to pure "Internet-only" stations that do not broadcast signals via terrestrial or satellite means. Pandora.com and Spotify.com offer users the option of creating their own "stations" filled with types of music that fulfill their specific needs, either selected by an algorithm (Pandora) or controlled by the user (Spotify). MySpace.com has evolved into a website where people can discover new music and musicians—a job that radio used to do. One of the most popular sites for young adult music listening is YouTube (Smith, 2012). All these sites can be accessed by mobile cellular "smartphones" and streamed directly to listeners, including into what has been traditional radio's biggest stronghold: the car. Sirius/XM satellite radio also has a presence in the digital audio marketplace by providing dozens of channels of both popular and niche programming segmented for multiple ages and tastes. Even most multichannel video programming distributors, such as cable television and satellite television companies (DirecTV and Dish Network), also offer multiple genre-specific channels of audio music programming. Finally, the explosive growth of tablet computing devices over the past few years has given consumers yet another outlet to access audio programming from various sources with only a few swipes of a fingertip[4].

[4] Indeed, what Kuhn (1962) called a *paradigmatic shift* may be said to have happened the audio entertainment field. A paradigmatic shift occurs when a field of study (Kuhn focused exclusively on hard sciences) has undergone a revolution in thinking, making previous ways of thinking about a field obsolete (Kuhn, 1962). A shift has certainly occurred in how people access all manner of audio entertainment; making previous ways of accessing audio (listening to the radio, buying a record, tape, or compact disc, or hearing a performance) seem limited compared to the wealth of options offered presently.

Despite these challenges, the improvements that a digital audio broadcasting system would bring to the marketplace are enticing. The promise of additional channels of programming on existing spectrum assignments should, in theory, give digital radio broadcasters a chance to reach out to audiences once considered too small to target with multiple new streams of high fidelity programming. This programming could be locally-based, giving more space for station owners to serve their community of license with specifically targeted programming. From a business perspective, terrestrially-based digital radio would not only give the available audience more programming choices, but be far less expensive to operate and maintain than satellite radio or other digital audio services. Importantly, and unlike other digital media providers, terrestrial-based DAB provides these services for free to audiences after initial equipment purchase. There is no ongoing subscription fee or Internet data plan necessary to listen to HD Radio once a consumer possesses a capable receiver. Even so-called "free" service tiers that Pandora, YouTube, Spotify, and other Internet competitors offer still require an Internet subscription to access the service. HD Radio service is delivered freely over-the-air, perceptually the same way that analog radio signals have been delivered to listeners for over 90 years with a listener tuning in via a receiver to hear content. And, if a consumer can tune in using an analog receiver, the upgrade to digital should not place any additional stress in terms of a "learning curve" for the new technology.

Even considering these advantages, the innovation of HD Radio continues to languish. Although several radio ownership groups (many part of the HD Digital Radio Alliance) and National Public Radio (NPR) enthusiastically backed HD Radio at its initial rollout in 2005, many groups are now either delaying implementation or moving

away from the costs associated with upgrading to HD Radio altogether. Without fanfare, NPR ended distribution of three HD Radio streams in October 2012 (Mook, 2012). The second-largest radio ownership group in the United States, Cumulus Broadcasting, has delayed implementation of more HD Radio transmitters for hundreds of its stations nationwide at least twice (Mook, 2012). Clear Channel Music + Entertainment, an original member of the HD Digital Radio Alliance, has removed mentions of HD Radio from station websites and has instead focused on its own streaming audio product, iHeartRadio. Only 17 stations converted to HD Radio in 2011, down from 21 stations in 2010, and well below a peak of 521 stations in 2006 (Mook, 2012). In 2012, more stations ended HD broadcasting than adopted it (Santhanam, Mitchell, & Olmstead, 2013). Out of over 15,000 analog radio stations in the United States, only 2,093 stations have upgraded to HD broadcasting as of December 2012 (Mook, 2012).

Aside from substantial capital investment for new digital transmitting equipment, HD Radio broadcasters must also contend with additional royalty fees for many of these new content channels. Payments to the American Society of Composers, Authors and Publishers (ASCAP), Broadcast Music, Incorporated (BMI), and the Society of European Stage Authors & Composers (SESAC), and licensing music for airplay usually run into thousands of dollars per year—costs that large radio groups, some billions of dollars in debt, may not wish to absorb (Moody's Investor Service, 2012; Robinson, 2012). Required royalty payments to the streaming audio performance organization SoundExchange divert even more money. With few consumers purchasing HD Radio-capable receivers, an even larger issue emerges as to the long-term profitability of this technology. Currently, most HD Radio audience totals (especially for the new HD-2 and

HD-3 channels of audio programming) are miniscule compared to traditional analog listening. This situation means that any commercial advertising placed on these channels cannot possibly command rates that will rapidly make up for the cost of investment in equipment and programming. Without a mandate from the FCC to either force all radios sold in the United States to be HD-capable, and no set deadline from the Commission to cease analog broadcasting, station owners must weigh whether to invest in technology that at present has no payoff. In an industry with major ownership groups that carry substantial debt (Aniero, 2012), including many founding members of the HD Digital Radio Alliance, sinking scarce funds into transitioning to HD Radio broadcasting may not be an attractive option at this point.[5]

Purpose of this examination

The current research on HD Radio is limited to either small consultant-based surveys, research conducted by subjective parties (such as the HD Digital Radio Alliance), or objective analysis of sales performance or listener demographics, including units sold, placement in automobiles, overall audience totals, and similar metrics. However, 12 years after its debut at the 2002 NAB convention and nearly 20 years after its conceptualization, it remains unclear why this technology has failed to capture consumers' attention, considering the expense of marketing campaigns, industry support, a clear standard set by government regulators, and the current appetite for all other things digital. On the surface, positive factors appear to be in place to foster the growth of this technology, yet HD Radio languishes as an afterthought, if even a thought at all, to

[5] The nation's largest broadcaster by station ownership totals, Clear Channel Entertainment + Media, currently has $16 billion in total debt, including $10 billion that is due to lenders by 2016 (Aneiro, 2012). Other large radio ownership groups have also run up extensive debts by purchasing stations and other media properties after the Telecommunications Act of 1996 eliminated national ownership caps (Stilwell, 2006).

consumers. Despite the promotional efforts of an entire industry, HD Radio has yet to reach a critical mass of consumers who have adopted the technology and may never achieve this status. HD Radio has been promoted as the future of terrestrial radio broadcasting in the United States and this work will examine not only its current weaknesses, but whether it is a viable product for the future.

Rationale for this examination

This examination of HD Radio will focus on several levels of data, derived from a complex interacting social system, to address the question of why HD Radio has not diffused in a rapid manner throughout the United States. To examine only one small area of interest would not give the context necessary to explain HD Radio's current status in the marketplace. For example, an experiment asking participants to rate the audio quality of HD Radio broadcasts versus analog broadcasts or a survey asking participants what they know about HD Radio only skims the surface of the overall phenomenon. Although useful, these techniques do not address the fundamental concern for radio industry businesses or consumers looking to adopt new audio technology: is HD Radio an innovation that is worthy of investment or can the consumer function effectively without it? The multitude of influences that can affect the answer to that question demands that a more holistic study be conducted with multiple areas of qualitative data comparison. The only way to do so efficiently is through a case study analysis for HD Radio.

Theoretical approach

One approach that may help explain HD Radio's problems is analysis through diffusion of innovations theory, proposed by Everett Rogers in 1962. Diffusion is defined by Rogers as "the process by which an innovation is communicated through

certain channels over time among the members of a social system" (Rogers, 2003, p. 5). Diffusion is also classified as a "special" type of communication singularly about the spontaneous or planned spread of new ideas throughout the system (Rogers, 2003). Of particular interest, Rogers notes that an innovation does not automatically sell itself; an innovation that, to experts, is vastly superior to a previous innovation may not diffuse through a social system due to a variety of factors (Rogers, 2003). In the case of digital radio broadcasting, even with its noted benefits to businesses and consumers alike, the diffusion process has been slow, halting, and costly. Diffusion of innovations theory can help locate where diffusion has slowed or stopped entirely and help assess what change agents can do to encourage further diffusion of a technology or idea.

In the United States, it is now time to ask whether HD Radio is a failed innovation and what factors have led to its current last-place status in the American digital audio marketplace. Four research questions guided this study:

RQ 1: What regulatory factors have affected the diffusion of HD Radio?

RQ 2: What role has technological advancement in the audio marketplace played in the diffusion of HD Radio?

RQ 3: What business, industry, and consumer factors have affected the diffusion of HD Radio?

RQ 4: Why has HD Radio diffusion slowed in the United States?

This work looks for answers to these research questions by detailing the technical, business, consumer, and regulatory history of HD Radio in the United States and then analyzes the current status of HD Radio through a diffusion of innovations theoretical lens. Due to the complexity of systems and factors involved in the diffusion of HD Radio

in the United States, a case study methodology is employed in order to properly understand the problems HD Radio has faced and continues to battle in its efforts to become a widely-accepted system of mass communication in the marketplace.

Outline

The following chapters will give a detailed description of the many factors that have affected and continue to influence HD Radio in the United States. Chapter 2 explores the theoretical dimensions of marketplace diffusion and consumer choice, critical in the analysis of HD Radio's struggles to gain acceptance into the current audio marketplace among consumers and broadcasters. Insights from research in the diffusion of innovations are presented, and the rationale for a case study approach to studying this particular innovation is explained. At the conclusion of this chapter, the study methodology is explained.

Chapter 3 will examine the technological, economic, and regulatory areas of HD Radio; each area being a vital component in the HD Radio story. Chapter 3 details the technology behind digital audio broadcasting's promise to consumers of additional services and improved over-the-air audio quality. It examines the compression techniques and bitrates necessary to achieve different levels of audio quality, the use of digital sidebands adjacent to existing frequency channels, and the need for transmission systems to add digital capability to traditional analog emissions. This chapter also includes discussion of in-band on-channel transmission versus the Eureka-147 system adopted in other nations, the capabilities of each system, the requirements for implementation of each system, and the operating spectrum each system needs to work efficiently.

Chapter 3 then traces the business and consumer history of digital audio broadcasting in the United States. It examines the founding investors in digital audio broadcasting and the formation of partnerships leading to the development of digital radio systems in Europe and the United States. This chapter will then examine the formation of the iBiquity Corporation and its business models for both broadcasters and consumers, the patents it currently holds, and the licensing fees it charges for use of its proprietary technology. This chapter then analyzes the consumer side of digital audio technology and development of the digital audio broadcasting marketplace in the United States. The consumer product launch and critical reception of DAB and HD Radio in the United States will be examined, in addition to adoption rates for both broadcasters and consumers, plus where HD Radio fits into the current robust consumer audio marketplace competing with technologies such as satellite-delivered DAB, podcasting, Internet-streaming audio, and even traditional analog radio service.

The regulatory history of DAB in the United States and the critical roles the Federal Communications Commission and Congress play in the development of technological standards and spectrum usage in many emerging technologies, including DAB and HD Radio are then detailed. This section examines prior FCC decision-making experience and standard-setting processes assessing new technologies, including FM transmission, color television, AM stereo, and digital television (DTV). Against this backdrop, the Commission's debates and decisions regarding DAB in the United States are more easily understood. Evidence directly from the FCC's DAB docket will be reviewed, from the initial 1999 Notice of Proposed Rulemaking regarding the selection of a digital radio service for the nation through the present day.

Finally, before delving into analysis, Chapter 3 will conclude by appraising the overall state of radio industry economics. The radio industry has undergone a massive change within the past two decades; causes include the passage of the Telecommunications Act of 1996, consolidation of ownership, increased use of computer automation programs, and most recently, the slow recovery from the economic recession of 2008 – 2009. Each of these regulatory, economic, and technology-based changes has had a direct effect on HD Radio's acceptance in the marketplace.-

Chapter 4 will pull together all of the separate areas analyzed through the historical and theoretical framework of the previous chapters to answer the research questions posited regarding the current state of digital audio broadcasting in the United States. This analysis will review not only the separate technological, economic, and regulatory causes of the current state of terrestrial digital radio in the United States, but also which specific factors have most heavily influenced the diffusion of HD Radio.

In closing, Chapter 5 will offer several conclusions that can be drawn from this study of DAB and HD Radio. The chapter will also discuss the variables that will affect DAB's acceptance among consumers and broadcasters, including remedies for current problems. This chapter will also evaluate whether HD Radio and digital audio broadcasting is, currently, a "failed" innovation in the United States, whether it is a technology that needs more time to capture the public's attention to reach the success predicted by its industry proponents, and whether new ideas are needed to cement HD Radio's place in the audio marketplace.

CHAPTER II. THEORETICAL FRAMEWORK AND METHODOLOGY

This chapter reviews the theoretical aspects of this investigation. The primary theoretical focus of this study is *Diffusion of Innovations*, Everett Rogers' seminal work on the topic. The chapter also discusses other insights from researchers who used diffusion theory to study changes in the technology marketplace that will be of assistance as the case of HD Radio is analyzed. Finally, the methodology of the study is discussed.

Diffusion of Innovations

When trying to determine exactly how or why any new idea, product, or entity succeeds or fails, one of the most utilized theoretical frameworks in literature, spanning multiple scholarly disciplines, is diffusion of innovations. Originally published in 1962,[6] *Diffusion of Innovations* (Rogers, 2003) remains a mainstay work in several fields of study, including communication, business, technology, and various social science fields.[7] When a new innovation is introduced in the marketplace, diffusion theory can provide powerful insights on a multiplicity of factors critical to the future success for the innovation or its withering and disappearance.

Diffusion is defined by Rogers as "the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system" (p. 11). Rogers writes that the words "technology" and "innovation" are used, many times, erroneously, albeit synonymously. That distinction should be noted for this study of HD Radio. Similar to Rogers' example of computers having both hardware and software, an examination of HD Radio must include both the viability of the "hardware"

[6] Five editions of *Diffusion of Innovations* have been published; the latest edition (the fifth) was published in 2003 shortly before Rogers' death.

[7] Unless otherwise noted, all citations within the diffusion of innovations section of this chapter are from Rogers (2003).

(the transmitters and radio units themselves—the tools) and the "software" (the streams of content transmitted from broadcasters to receiver audiences—what is done with the tools). Without both working simultaneously, HD Radio as an innovation does not exist. But simply because a technology exists does not mean that it is an innovation; it is what is done with the technology that can create a true innovation.

Innovation

According to Rogers, individuals can evaluate five different characteristics of innovation affect the rate of adoption. These characteristics are (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. Each individual attribute can be applied directly to the HD Radio case.

- *Relative advantage* is "the degree to which an innovation is perceived as better than the idea it supersedes" (p. 15). In other words, the potential buyer of HD Radio technology, whether a radio station owner or a consumer looking for a receiver, asks the question "What can this technology do for me that the existing technology I own cannot do?" For the radio station owner, relative advantage questions can take the form of "will this make me more money?" or "how can I use this to defeat my competitors?" For a consumer, the questions may take the form of "will my reception be better?" or "can I get more programming choices?" Rogers relays one important caveat to relative advantage: it is not all about economic or "practical" objective choices; "social prestige factors, convenience, and satisfaction" (p. 15) each make the perception of relative advantage difficult to ascertain.

- *Compatibility* is defined by Rogers as "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (p. 15). Applied to HD Radio, the expectations of both broadcasters and listeners is that service will continue uninterrupted under a digital system, the radios themselves will look and work in tandem with essentially the same functionality as the old system, and that the choices available up and down the radio dial are at least comparable to what was available under the non-HD system of analog radio. For an industry that operates under the regulatory framework of the FCC, the HD Radio system must be compatible with the legal mandate that locally licensed stations serve the "public interest, convenience, or necessity."
- *Complexity* is "the degree to which an innovation is perceived as difficult to understand or use" (p. 16). Other factors being equal, the less complicated an innovation is to understand, the more rapidly it will be adopted. As a long-standing, near-universally adopted technology in the United States, receiving a radio broadcast is practically second nature to users. Any additional complexity under a digital HD Radio system could retard adoption. For broadcasters, transmitting digital information (rather than analog) is a complex challenge, but one that falls well within the expertise of most station engineers. Therefore, the complexity issue lies mainly with audience members who have no formal training other than years of practice tuning into their favorite stations.

- *Trialability* is "the degree to which an innovation may be experimented with on a limited basis" (p. 16). The HD Radio system is a hybrid system[8] and allows consumers to experience both the digital broadcast and the old-fashioned analog system broadcast. HD receivers are built with so-called "backwards" technology, meaning they can receive both analog and digital signals. For broadcasters, the system allows them to keep their analog signals broadcasting, while upgrading and experimenting with the new digital system of broadcasting. Unlike television broadcasting in the United States, there is no mandate yet to cease broadcasting analog signals; therefore, a radio consumer could try HD Radio, but still rely on the old analog system if he or she for some reason did not like HD Radio.
- Finally, *observability* is "the degree to which the results of an innovation are visible to others" (p.16). The old adage "seeing is believing" could be used to describe this attribute as a primary motivation in the adoption of an innovation. If friends, colleagues, peers, or other respected individuals in a person's life adopt an innovation, it is likely that person will be able to watch the innovation in action and, importantly, get information from a trusted source about the innovation. HD Radio, like many technology products, would like to make their products highly visible to the electronic consumer market, and efforts to increase that visibility are inherent in its marketing strategies. However, this attribute, more so than the others, relies upon a level of awareness of the innovation in the market; if a potential customer either does not know about or does not notice an innovation, that customer will not know exactly what to observe.

[8] Originally, the "HD" in "HD Radio" stood for "hybrid digital"—the HD Radio system is a hybrid of digital and analog broadcasting.

Communication Channels

Rogers observed that "the essence of the diffusion process is the information exchange through which one individual communicates a new idea to one or several others" (p. 18). The communication channel the information flows through can be as complex as a mass media campaign involving multiple mass media or a simple as neighbors chatting over a backyard fence. The key element is whether the information delivered is persuasive enough to directly or indirectly increase the likelihood of adoption. The diffusion process is a "very social" one that relies heavily on interpersonal communication. Mass media is helpful in getting messages about an innovation into the marketplace, but it is face-to-face or mediated (through telephone, computer, or other means) peer communication that tends to be more effective in convincing people to adopt new innovations. Mass communications tend to influence early adopters more so than later adopters of an innovation, due to the fact that there are few peers to question regarding an innovation. For early adopters, mass media channels can be among the only sources of information and provide the impetus to adopt an innovation. Later adopters require much more influence from immediate peers and interpersonal networks.

HD Radio has the peculiarity of being an innovation that is itself a mass media communication channel: radio broadcasting. Considering the power the medium has in communicating new messages to receptive audiences, this peculiarity is a seeming advantage for the innovation. The radio industry could use its own communication channels (the many different radio stations on both the AM and FM broadcasting bands) to spread knowledge of the innovation to its listeners and promote the innovation.

Time

The role of time in the diffusion process is delineated by Rogers into three separate, but related, areas: the innovation-decision process, innovativeness and adopter categories, and the overall rate of adoption of an innovation. The innovation-decision process is broken down into five generally time-ordered stages, and the time needed to process through these steps varies widely by innovation, known as the innovation-decision period. In order, the five stages are:

- *Knowledge:* when a person first learns of an innovation's existence and chooses to learn more about the innovation itself.
- *Persuasion:* the formation of an attitude (positive or negative) regarding the innovation.
- *Decision:* the critical point where a person decides to either accept/adopt an innovation or reject it.
- *Implementation:* occurs when a person begins using an innovation.
- *Confirmation:* the evaluative step whereby the person using the innovation looks to buttress the decision that has already been made by reviewing the decision and its implementation. The original decision may be rejected at this stage if there is information that conflicts or disproves the reasoning of the original decision.

Each of these stages applies to the overall adoption of HD Radio. Consumers must not only be aware that HD Radio exists, but also why it should be adopted and, once adopted, why the innovation should continue to be utilized.

Throughout the entire process, but especially in the persuasion and decision stages, potential adopters are looking to reduce uncertainty about the innovation itself.

People seek information from both mass media and peers to familiarize themselves with the innovation prior to making a commitment to it. Rogers (2003) notes that interpersonal channels are much more important at the persuasion stage than mass media channels where "messages are general in nature, and an individual deciding to adopt wants to know specific information: Will the innovation be beneficial to me in my particular situation?" (p. 21).

When discussing the types of adopters in the marketplace, Rogers places individuals into five categories, classifying them by their levels of innovativeness.[9] In order, from most innovative to least innovative, the adopter categories are innovators, early adopters, early majority, late majority, and laggards.

- *Innovators*: generally the first adopters of a new technology; they are willing risk-takers with new innovations, able to accept higher levels of uncertainty with a new innovation, and do not depend upon the opinions of others to decide whether to adopt an innovation. Rogers considers the first 2.5% of individuals who adopt an innovation to be within this category.
- *Early Adopters*: The following 13.5% of individuals in a system who adopt an innovation, early adopters are considered to have "the highest degree of opinion leadership in most systems" (p. 283). In other words, the roughly 83% of the population that will choose to adopt or not adopt an innovation will look to the early adopters for their opinion before forming their own regarding the innovation—in Rogers' words, they serve as "role models" (p. 283) or opinion leaders. Opinion leaders are defined as individuals who are "able to influence

[9] Innovativeness is defined by Rogers (2003) as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (p. 22).

other individuals' attitudes or overt behavior informally in a desired way with relative frequency" (p. 27). Plainly stated, the approval of opinion leaders of an innovation encourages those who follow to adopt.

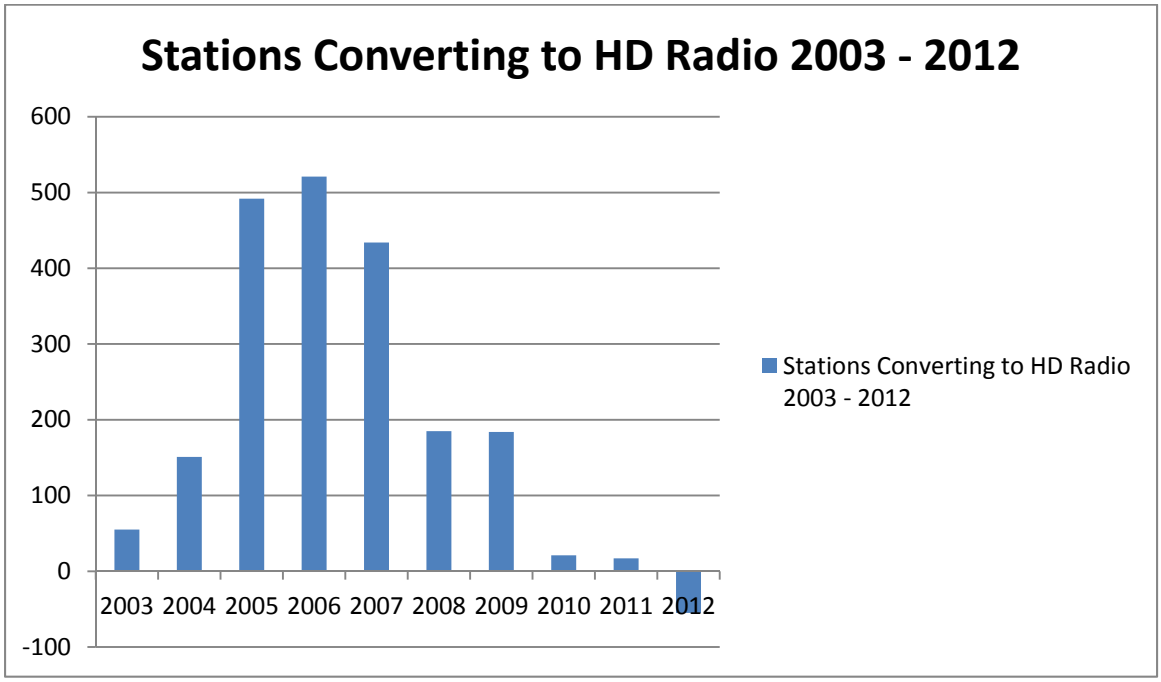
- *Early Majority*: The next 34% of individuals fall into this category; they are still ahead of the average adopter, but lack the stronger opinion leading skills of early adopters. However, once this group accepts and adopts an innovation, the size of the early majority category guarantees access to exponentially more potential adopters, as each person in this category likely has interpersonal connections to spread knowledge about an innovation.
- *Late Majority*: The next 34% of individuals adopt the innovation after at least half of the population adopts an innovation. This group approaches innovation "with a skeptical and cautious air" (p. 284).
- *Laggards*: The final group comprises the final 16% of the population. Laggards tend to focus upon decisions made in the past, traditional values, and have by far the longest decision-making process towards adopting an innovation (if ever). Rogers points out that being a laggard is not necessarily a bad negative thing. For example, a laggard's financial resources may be limited and he or she cannot risk spending money on an innovation that has the risk of failure.

As referenced in the description of adopter categories, there is a rate of adoption, defined by Rogers as "the relative speed with which an innovation is adopted by members of a social system" (p. 23). Plotted as a cumulative distribution curve, the number of adopters usually appears as an "S-shaped" curve, with few adopters in the beginning, a mass of adopters in the middle, and few adopters at the tail (mainly because

there are fewer people left to adopt the innovation). Some innovations are adopted quickly and others slowly; the rate ultimately depends upon perceptions of users as they weigh the attributes of an innovation (e.g., relative advantage, compatibility, complexity, trialability, and observability). Other factors that may speed or slow the rate of adoption is whether an innovation is mandated by law or custom in a social system.

For HD Radio proponents, the voluntary adoption of the technology by individual users and ownership groups has been a primary focus because the FCC has not been forthcoming with a mandate to transition fully from analog broadcasting to full digital broadcasting. The concern has been the rate of adoption. After over 10 years on the electronics marketplace, consumer awareness remains spotty, with many consumers saying they have never even heard of "HD Radio" (Kassof, 2012). Among consumers who had heard of the technology, few are expressing interest in it (Santhanam, Mitchell, & Rosenstiel, 2012b). For calendar year 2012, there were 55 fewer stations broadcasting HD Radio signals than the previous year (Santhanam, Mitchell, & Olmstead, 2013). This regression came after two consecutive years, 2010 and 2011, when fewer than 20 stations began broadcasting HD Radio signals. Simply put, the innovation does not seem to have much forward momentum at the present (see Figure 2.1).

Figure 2.1: Stations converting to HD Radio 2003 – 2012



(Santhanam, Mitchell, & Rosenstiel, 2013)

A Social System

Rogers defines a social system as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members of a social system may be individuals, groups, organizations, or subsystems" (p. 23). As an innovation diffuses through a social system, its structure and participants affect the diffusion in major and minor ways. Social structure within a system and between systems can influence adoption behavior, depending upon the attributes of the innovation and the communication structure of the system to reduce uncertainty about the innovation itself. The role of an innovator can matter much or little within a system; Rogers notes that often an innovator can be perceived as "deviant" from the norms of the social system and held in low regard, rather than exalted for innovativeness.

However, once an innovation has spread beyond innovators to people in the early adopter category, the role of opinion leaders within a social system becomes quite important towards future adoption. Whereas innovators may be seen as people who are "deviant" from the norms of a social system, opinion leaders "exemplify and express the system's structure" by reflecting the system's openness or opposition to change and behaving accordingly (p. 27). Opinion leaders are not formally elected, but have been accorded their influence through demonstration of knowledge or expertise in a field and accessibility—in fact, opinion leaders are generally at the center of the interpersonal communication networks that are critical to an innovation's adoption by individuals. They can influence not only one adopter, but a growing network of adopters throughout the system. The only danger, according to Rogers, is an opinion leader who may "stray" too far from the established social system (rather than "exemplifying" it) when pushing for or against an innovation. The opinion leader runs the danger of becoming, perceptually, a "deviant" from the established system if he or she pushes a system change to an extent that others in the social system do not want (p. 27).

Change Agents' and Their Role

Because the role of opinion leaders is so important in the diffusion process, they are a natural target for so-called change agents. Rogers defines a change agent as "an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency" (p. 27). Whereas opinion leaders are informally created by consensus of a social system, change agents are usually professionals who endeavor to create a change in the social system and stimulate the adoption (or rejection) of new ideas at the behest of an entity that would benefit from such a decision. Change agents use

opinion leaders to carry their messages to the system. As Rogers notes, because of their status and education, change agents tend to be different[10] than the targeted individuals they seek to change, whereas opinion leaders are embedded in the social system and can perform effective communication tasks towards adoption or rejection of an innovation.

Indeed, change agents are not guaranteed success in their efforts. Rogers generalizes several factors that impact the success of a change agent: the overall change agent efforts; whether change agents listen to and respond to feedback from clients; an accurate diagnosis of a client's needs; or empathy with the client's situation. What is striking about these generalizations is that it appears the "failures" of change agents can often be attributed to a change agent walking into a situation with a solution rather than listening to clients with specific problems and needs. Although effort certainly plays a role in success, Rogers pinpoints the interpersonal nature of diffusion and the role two-way communication must play for an innovation to be adopted by a population.

The company that owns the patents for HD Radio, iBiquity, essentially functions in the role of a change agent. As the company responsible for HD Radio's development and implementation, it has a central role in persuading both the broadcasting industry and radio listeners towards the adoption of its product. However, even in the very design of the product (a hybrid-digital system that retains analog system service while providing new digital service), iBiquity realizes that its customers can only be pushed to change so far. The HD system allows for a slow change over time without forcing the radio industry or consumers to choose analog radio over digital or vice versa.

[10] Change agents can differ from the regular population in education status, financial status, ethnic background, and other relevant areas.

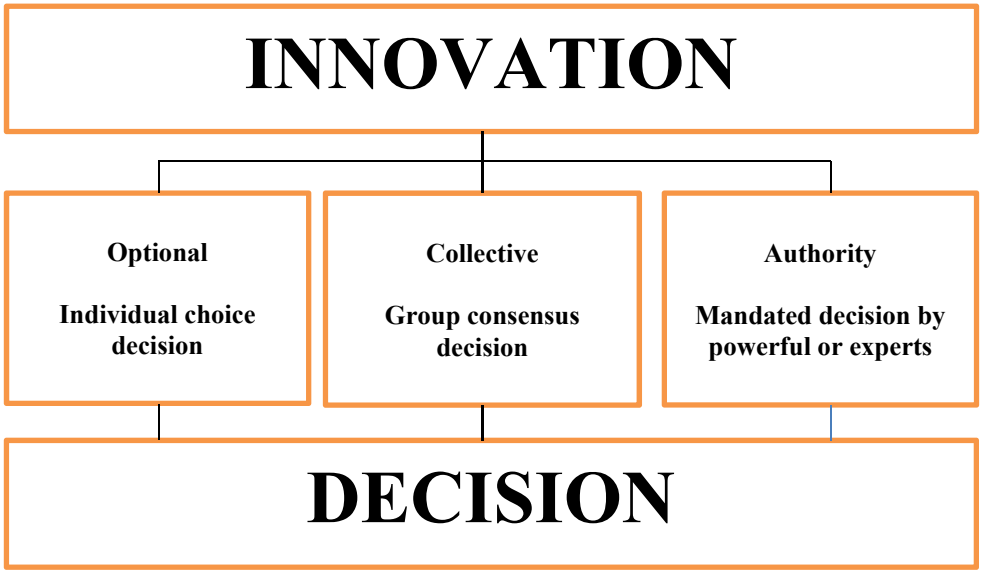
It is important to note that iBiquity is not the only change agent in play. The FCC also plays a substantial change agent-type role in the persuasion of consumers and broadcasters towards adoption or non-adoption of an innovation in this area. As the agency overseeing several aspects of telecommunications in the United States, the FCC has a primary role in spreading knowledge of an innovation and formulating and enforcing rules pertaining to the innovation. One critical difference between a private company, such as iBiquity, taking on a change agent role and the FCC is that the FCC has the additional regulatory powers of a government agency and can mandate, rather than suggest, changes. Should the FCC deem it necessary to force a change in the telecommunications marketplace, it has shown the willingness to do just that in several instances, such as the mandatory conversion to all-digital television broadcasting (Dupagne & Seel, 1998; Sterling & Kittross, 2002).

System Adoption of an Innovation

A system itself can either adopt or reject an innovation; the decisions need not rely solely upon individual members of the system. There are three types of decisions that can be made by a social system regarding an innovation: optional innovation-decisions, collective innovation-decisions, and authority innovation-decisions (see Figure 2.2). Optional innovation-decisions are made exclusively by the individual, who may choose to accept or reject the adoption status by the social system at-large. Collective innovation-decisions are made through a consensus of members of the system; once the decision is made, then everyone and every subsystem that is part of the social system must abide by this decision. Although individual decision-making authority has been taken away, the key difference between collective and authority innovation decisions is

that collective decisions are made *en masse* through a consensus of all members of the system. In the case of authority innovation-decisions, they are made by few persons "who possess power, status, or technical expertise," and the "individual member of the system has little or no influence" on the decision (p. 29). These decisions can be made by authoritarian figures, such as royalty or dictators, elected authority figures, such as legislators, presidents, or employees of the government who hold great power in a particular area through an agency designated to oversee that area.

Figure 2.2: Social-system Decision Options



(Rogers, 2003)

These decisions have consequences for the social system; the results are labeled by Rogers as (1) desirable versus undesirable consequences, (2) direct versus indirect consequences, and (3) anticipated versus unanticipated consequences. Although innovation decisions would always want to fall into the desirable, anticipated, and directly measurable areas, unanticipated, undesirable, and indirect consequences are also borne by the social system and its members.

One of the daunting challenges for HD Radio is the multiple social systems within which it must operate. The topic of mass communications existing within several "systems" has been explored by Ball-Rokeach & DeFleur (1976), positing that dependency on the media to meet needs varies from person to person; how much media dependency there is in a particular person will determine how much effect the media have on them; and how much that effect will affect into society which in turn will feed back into media coverage.

> Mass communication, in other words, involves complex relationships between large sets of interacting variables that are only crudely designated by the terms "media," "audiences," and "society." It is through taking these sets of variables into account individually, interactively, and systematically that amore adequate understanding of mass communications effects can be gained. (Ball-Rokeach & DeFleur, 1976, p. 5)

Building on this understanding, System Theory posits that systems are constructed of interrelated independent parts that constitute a whole (Littlejohn, 2001). Systems are constructed of elements, these elements are related in some way and each element brings a particular attribute to the system, and the system itself exists in an overall environment or context (Littlejohn, 2001). What affects one part of the system, operating independently, may affect the functionality of the rest of the system; likewise, the environment within which the system operates may affect its overall functionality.

Social Systems and HD Radio

On a macro level, there are three different systems, operating independently and interdependently, that HD Radio must navigate. Diffusion through multiple systems is not an easy path. HD Radio, as part of the terrestrial radio industry that is regulated by the Federal Communications Commission, needed to win approval from the Commission

as the digital radio system for the United States before it even began operation. As the chosen system of digital radio, it must maintain a relationship with the FCC and negotiate with the agency on regulated technical items, such as transmission power increases for HD signals. HD Radio must compete within the electronic equipment marketplace, both at the business and consumer levels—each side with its own different needs and uses for the innovation. Finally, HD must also compete in the technology arena, consistently making improvements and additions to its product to produce updates suitable to compete with other electronic devices. Each component of the system—regulatory, marketplace, and technical—in the overall environment of electronic audio entertainment is a different social system that needs to be navigated for maximum diffusion of HD Radio.

Criticisms of Diffusion of Innovations Theory

As no theory can completely explain all phenomena, diffusion theory has its limitations in the context of HD Radio. Rogers himself dedicates a part of a chapter in his book to criticisms of diffusion theory. No theory is immune from problems which can stem from assumptions made to simplify realities or "blind spots" that arise from following a particular way of performing research. One area of criticism is the pro-innovation bias of diffusion research: a bias that *assumes* that an innovation should diffuse and be adopted throughout a social system and that it should not be rejected or reinvented in some way. Pro-innovation bias may stem from a change agent for the innovation funding research (and thereby having a vested interest in showing the innovation's success). Another type of bias is simply that successful diffusions leave successful records that can be examined, whereas unsuccessful diffusions are difficult to

study because they do not leave behind a classic S-curve adoption plot or data that is easily understood.

Rogers suggests "investigat[ing] the broader context in which an innovation diffuses" to "illuminate the broader system in which the diffusion process occurs, and aids in illuminating possible pro-innovation biases" (p. 115). Finding out the reasons "why" an innovation was adopted or rejected, questions "that have seldom been probed effectively by diffusion researchers" (p. 115), can give greater meaning to diffusion research than only pure numbers of a successful adoption. These questions have not been adequately addressed in the case of HD Radio.

Another bias, the individual-blame bias, is defined as "the tendency to hold an individual responsible for his or her problems, rather than the system of which the individual is part" (p. 134). Individual-blame bias can stress that the individual is at fault for not adopting an innovation, rather than examining or understating the role the social system had in the adoption and understanding the underlying causes for the lack of adoption success. In the reverse, a system-blame bias faults the social system rather than individual members for problems. In particular, "late adopters and laggards are often individually blamed for not adopting an innovation" (p. 121) or for being later than others in adoption of an innovation. Rogers notes that, rather than blame, a more careful analysis should consider why the innovation may not have been adopted by these individuals due to financial or other limitations.

Failed Innovation

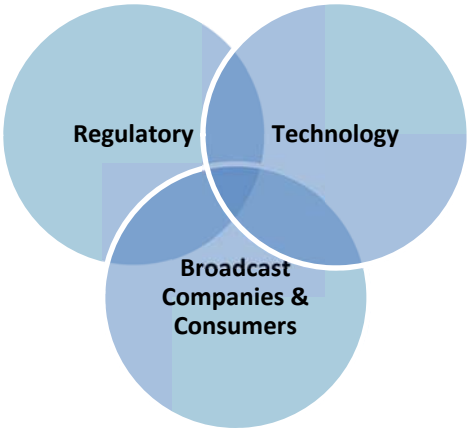
Rogers does not characterize innovations as "failing;" rather, he focuses upon their overall rate of adoption, which may be influenced by any of the aforementioned

factors. Some innovations are adopted quickly and others "level out at less than 20 percent use" (p. 219), never reaching the point where they become mass accepted. However, he quickly notes that diffusion research often studies people—the individuals and characteristics that are different among adopter categories—rather than analyzing how the perceived differences of the innovations themselves affect their adoption. Rogers notes that most of the variance in rates of adoption for any innovation can be explained by the five perceived attributes of innovation: relative advantage, complexity, compatibility, trialability, and observability. Other factors include: the type of innovation-decision, the communication channels used, the overall nature of the social system, and the extent of promotional efforts by change agents. The measurement of a rate of adoption usually is time bound, meaning that measurement takes place over a specific period of time, such as a month or year. A particularly short or exceedingly long period of diffusion measurement may yield different outcomes simply because the period for measurement did not accurately reflect the diffusion taking place.

Application to HD Radio

One of the reasons that the HD Radio case is so complex is that decisions are not being made by a single social system; rather, at least three large social-systems are acting somewhat in concert and each having some degree of influence over other systems' actions. These social systems are the business/consumer system, the regulatory system, and the technology system. Each social system within the industry has some overlap in influence with the other two systems (see Figure 2.3).

Figure 2.3: Social Systems in the Broadcasting Industry



After its initial technical development, the HD radio system needed to be approved by a federal government agency (the FCC). Then, broadcast systems, including new transmitters and other ancillary equipment, needed to be sold to radio station owners across the country so that those owners' stations could begin broadcasting digitally. Radio stations needed to upgrade the analog technology they had used for decades to the newly-approved digital broadcasting standards. Also, at that point, receivers for consumers needed to be sold so that they could receive HD broadcasts. It is important to note in the context of the radio industry, both radio station owners and radio station listeners can be thought of as "consumers" of the technology and put into the same social system as purchasers of radio technology. The station owners are purchasing transmitters and production equipment; the listeners are purchasing receiving equipment. However, both are fundamentally engaging in the same commerce activity.

As these systems interact, the innovation-decision makers in each social system may have some overlap in interest in the other social systems, but remain independent within their own social system and separate from the other systems. The innovation-decision makers at the government level are completely different from the decision

makers at the broadcaster or consumer level, yet a case must be made to each group why HD Radio should be adopted. Decision makers from the technology social system must be convinced that there is a market and a need for the technology or further development and innovation will be curtailed.[11] Furthermore, a successful adoption of the innovation by one of these interlinked social systems does not necessarily mean the innovation will be adopted by all systems involved. Although the FCC has adopted HD Radio as the digital radio system for the United States, that has not and does not mean all radio stations in the United States must adopt the technology at this point.[12]

It is important to also note that all parts of diffusion theory are not equally important to every innovation. Depending upon the innovation and environment, certain parts of the diffusion theory can take on significantly more importance than other parts. For HD Radio, the key parts of diffusion theory include the role of time, communication channels, the social system(s) that HD Radio needs to diffuse through. Further key areas for this study of HD Radio, depending upon the social system (technology, economics, or regulatory) being examined, include the consumer decision process (examining the relative advantage of HD Radio versus standard analog radio by evaluating compatibility, complexity, observability, and trialability) and the decision making process (optional, collective, or authoritarian) helping or hurting HD Radio's diffusion.

Diffusion Communication and Technology Research

There have been numerous diffusion studies focusing on emerging technologies for consumer adoption in the world, including personal computers (e.g., Frans, 1993; Klenow & Goolsbee, 2002), cable television (e.g., Sparkes & Kang, 1986), video cassette

[11] This curtailment could include funding difficulties or outright termination of a line of products deemed unsellable, due to lack of a market to buy the product.
[12] The FCC has not mandated that all broadcasters switch to digital HD Radio broadcasting.

recorders (VCRs) (e.g., Chen & Takada, 1994; Putsis, 1989; Lin, 1987), broadband Internet service (e.g., Tang, 2011), and mobile telephony (e.g., Corner & Wikle, 2008; Wu & Chu, 2010; Yamakawa, Rees, Salas, & Alva, 2013). Most studies employed the basic Rogers model of diffusion of innovation to understand consumer perceptions and adoption of an innovation and why the innovation has or has not continued to diffuse through the population.

Lumping emerging technologies together under one umbrella, Carey and Moss (1985) identified three criteria for the acceptance of new telecommunication services. "It must be cost-competitive with other ways of doing things; it must be compatible with users' skills as well as their work or home environment; and, it must provide a specific service concept which the user values" (Carey & Moss, 1985, p. 145). Importantly, they also noted that several communication technologies did not catch on in a rapid-growth time frame. For example, the authors state that cable television required more than 30 years to penetrate one third of U.S. households, while the video cassette recorder needed only a decade to achieve 20% penetration (Carey & Moss, 1985). Similar to cable television, the telephone grew slowly for a period of time, from its invention in the 1870s through the end of the 19th century, only to explode in growth in the 20th century due to business, farming, and then household desire to have the technology (Huurdeman, 2003). Even though there is an acknowledgment of variability in growth among emerging technologies, a slow early growth for communication technologies may not bode well for future growth:

> Curiously, this research provides few examples of technologies that had a slow growth for the first five years followed by a large growth rate in years five through ten. Yet, such a growth curve is commonly suggested

> by those who are marketing new technologies that have a poor early sales record. (Cary & Moss, 1985, p. 147)

Van den Bulte (2000) reflects upon the variables that affect the speed of a media innovation diffusing through a population:

> Some products included in this study required large investments in complementary infrastructure to be commercially viable or had multiple standards competing early on in the U.S. market. For such products, even innovative consumers may postpone adoption until the supporting infrastructure is sufficiently well developed or the uncertainty on the dominant standard has been resolved….Why buy a color TV set, for instance, if your local station does not have color equipment or carries only very little programming content in color. (Van den Bulte, 2000, p. 372)

Most importantly, Van den Bulte's study notes a "sizable and significant change" (p. 377) in the speed of the diffusion of technology products from 1924 to the mid-1990s; if technology products are going to be successfully diffused, they do so much more quickly than in previous decades. Practically speaking, businesses—product developers who invest millions or perhaps billions of dollars into an innovation—have a much shorter window of opportunity to gain a foothold in the market and attempt to recoup their investment dollars. Conversely, consumers have a narrower window to try out a product and a shorter time frame to make a decision and commitment to a new innovation. Van den Bulte's research suggests that products that do not achieve at least 5% household penetration within the mean time period of the study (12.5 years) took longer to diffuse through the population than those with faster "time to 5%" diffusion (Van den Bulte, 2000). Changes in the nature of the product itself, whether they were technical improvements or greater utility for the consumer was discovered, were also found to have a significant acceleration impact on the rate of diffusion. This finding may partially explain the slow diffusion of some products that later "caught on" with the general

public, such as color television. Color television broadcasting was developed in the 1950s, but color-compatible sets took about 20 years to reach 50% diffusion into American homes (Sterling & Kittross, 2002) due to the expense of receiver sets and a lack of color network programming on a schedule-wide basis.[13] Once the utility—color television programs—became standard throughout network television, the product essentially "changed" (to use Van den Bulte's term), and color television began to diffuse more rapidly into American homes.

As a new technology, HD Radio absolutely has uncertainty surrounding it. This uncertainty can only dissipate as more consumers come into contact with the product and learn if the product has usefulness to the prospective adopter. What are the factors that adopter should weigh in choosing HD Radio—is it a risk to adopt new technology in an rapidly changing electronic media environment that would ultimately be obsolete? Are there any potential losses by choosing HD Radio—monetary (higher costs than analog radio), content losses (missing programming only offered on satellite radio or podcasts but not on HD Radio), or listening ability (more or less interference)?

Methodology

Understanding the current status of HD Radio in the United States requires an examination of the three key areas influencing broadcasting: technology, economics, and regulation by the government. In order for HD Radio to have a successful diffusion, through a process described by Rogers (2003), the product must successfully be adopted through these social-systems over time. These three areas constitute the overall

[13] The first all-color prime-time network broadcasts (all shows were broadcast in color) occurred in 1966 on CBS (Castleman & Podrazik, 1982).

environment for diffusion, and a halt to diffusion in one area could seriously harm diffusion through the environment.

The Complex Social Systems of HD Radio

The audio technology marketplace is an ultra-competitive field. The technological challenges involved with the development of HD Radio broadcasting are only part of a larger audio technology marketplace that has changed dramatically over the past 20 years. Technological advancement has brought plenty of competitors to radio in the audio entertainment marketplace, such as MP3 players, tablet computers, and satellite radio receivers. Economic competitors with new business models may feature a combination of advertising and subscription fees, thereby accessing dual revenue streams while syphoning more dollars away from traditional broadcasters. In this environment, iBiquity Corporation, owners of the patented technology of digital HD Radio, must convince both broadcasters and consumers that the product they offer—in both hardware and content—is capable of delivering a quality product to today's station owners and listeners. The FCC, the regulatory system, influences adoption by determining rules for both the broadcaster and listener: what equipment is approved, when new technology will be "phased in" (if at all), and setting policies for HD Radio.

Considering the complexity of understanding the complete nature and status of HD Radio in the United States, a case study approach to examine these issues is warranted. The complexity of multiple social system interaction in regards to HD Radio's diffusion, including data from several different sources and perspectives, can only be understood fully when presented in context. This complexity is a primary reason that a case study is the best course of examination. Case studies have a long history of

helping students and others interested in a particular business or industry understand the complex problems and develop solutions to business problems (Halbert & McDowell, 2013).

Purpose of Case Study Research

Baxter and Jack (2008) state that a case study "ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood" (p. 544). Yin (2003) defends the case study from accusations that it is not as valid a form of research as quantitative methods, such as surveys and experimentation, stating that "the distinctive need for case studies arises out of the desire to understand complex social phenomena" (p. 2). He continues:

> In brief, the case study method allows investigators to retain the holistic and meaningful characteristics of real life events—such as individual life cycles, organizational and managerial processes, neighborhood change, international relations, and the maturation of industries. (Yin, 2003, p. 2)

Yin notes that case studies are appropriate when a researcher wants to know the "how" and "why" about a phenomenon rather than "what?" Asking "how" or "why" can be better answered by tracing events over time, reviewing all available records, or interviewing participants in the phenomenon, rather than only counting instances of the phenomenon or manipulating it.

A case study method should also be considered when a researcher cannot manipulate the behavior of those in the event or phenomenon being studied (Yin, 2003). Yin differentiates the case study from a history by noting that case studies add "two sources of evidence not usually included in a historian's repertoire: direct observation of the events being studied and interviews of the persons involved in the events" (Yin, 2003, p. 8). The contemporary observation, including ongoing data analysis and observation, is

critical in differentiating a case study from a historical recounting of events years, decades, or centuries ago.

A case study is used not only to describe a phenomenon, but also the contextual environment in which it is taking place. Yin (2003) observes that "the boundaries between phenomenon and context are not clearly evident" (p. 13). This distinction separates this methodological approach from other research methods that seek to isolate a phenomenon of study and focus only upon the phenomenon and not the conditions that lead to its occurrence. Once again, Yin (2003) notes that a historian would examine the conditions surrounding a phenomenon, but would most likely do so with non-contemporary events. A case study works with contemporary events.

Finally, a case study is appropriate when the amount of data and variables of interest exceed what could possibly be learned by other methods. Yin points to surveys as a method that would attempt to describe the phenomenon and its context, yet there are only so many variables that can be analyzed at one time (Yin, 2003). In this situation, voluminous data in context can only be handled by the "all-encompassing method" of a case study as a "comprehensive research strategy" (Yin, 2003, p. 14).

In summary, Yin defines the case study as an empirical inquiry that:

- investigates a contemporary phenomenon within its real-life context, especially when
- the boundaries between phenomenon and context are not clearly evident
- copes with the technically distinctive situation in which there will be many more variables of interest than data points and as one result
- relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
- benefits from the prior development of theoretical propositions to guide data collection and analysis. (Yin, 2003, pp. 13-14)

Rationale for Case Study Research

Case studies may be focused upon a single case or multiple case studies. For a single case study design, Yin gives five rationales: 1.) it represents the critical case in testing a well formulated theory, 2.) it is a unique or extreme case, 3.) it is a representative or typical case, 4.) it is a revelatory case, and 5.) it is a longitudinal case (Yin, 2003). Multiple case studies are used to explore differences in between and within cases with an eye towards finding replication across different cases (Baxter & Jack, 2008). Case studies also need to have boundaries, defining what will be examined and what will not be to "indicate the breadth and depth of the study and not simply the sample to be included" (Baxter & Jack, 2008). Evidence for case studies can come from six sources: documentation, archival records, interviews, direct observation, participant observation, and physical artifacts (Yin, 2003).

The Importance of Context

For HD Radio, this method is necessary to capture the entire context of the development of HD Radio over a multi-year time frame. Focusing only on one area, such as sales of units to consumers, sales of units to broadcasters, or HD Radio's interaction with the FCC, would only tell a limited part of the story of the overall environment of the innovation. It is only by examining the technical, regulatory, and business social systems and how those systems both interact with each other and influence the innovation can we gain a better understanding of HD Radio.

Procedures for a case study of HD Radio

This study will employ the rationale of a single case study, as only one product's diffusion is being examined. This case, therefore, can fit the description of what Yin

calls a "critical case," meaning that the case meets the conditions for testing a theory against the theory's major propositions. Yin states that the "single case can then be used to determine whether a theory's propositions are correct or whether some alternative set of explanations might be more relevant" (2003, p. 40). A critical case study on a singular, unique subject can help build theory and "refocus future investigations in an entire field" (Yin, 2003, p. 40).

Yin notes that "properly done…data collection is likely to lead to large amounts of documentary evidence, taking the form of published reports, publications, memoranda, and other documents collected about the case" (p. 77). The documentary evidence will be arranged to form a chronological order of events that demonstrate how the innovation, HD Radio, moved (or did not move) through each of the three key social systems over the course of several years. Documentary evidence from all social systems being investigated (regulatory, technical, and economics) will be the primary sources of evidence in the case of HD Radio. These documents from disparate sources form a contextual history of HD Radio from many different perspectives, yet never previously put together under one study. This study takes data from a number of publicly available sources, including published academic studies, radio industry research from syndicated research companies such as Arbitron, research conducted by industry consultants, sales reports, company financial data, government regulatory agency and legislative documents, and other historical data. Not only will the three key areas—technology, economics, and government regulation—be examined in depth, a general examination of the radio broadcasting industry will also be featured to show the overall context of HD Radio. Much of the examination will rely on documents and records from media and

industry sources and government archives. Interviews with relevant persons within the HD Radio industry were attempted, but only one relevant interview with an official at iBiquity came to fruition.

The analysis of the collected data will be matched against the theoretical structure of Roger's diffusion of innovations theory in order to assess "where" HD Radio stands currently in the diffusion process and, more importantly, "how" and "why" it got there. Pattern-matching analysis demonstrates how well the theory holds up against real-world data and, in a case study analysis, shows how multiple systems have affected the overall environment for the innovation to diffuse. Detailed raw sales data, which privately-held iBiquity Corporation does not release for HD Radio, may lead to conclusions on where HD Radio is within the diffusion process, but it cannot reveal why diffusion has been lackluster, nor how decision processes within the FCC, within iBiquity, or among consumers may have influenced the pace of diffusion for HD Radio. Only a case study investigation may reveal this information through careful analysis of data in the areas of influence.

This analysis will then be used to answer the four research questions outlined in the introductory chapter:

RQ 1: What regulatory factors have affected the diffusion of HD Radio?

RQ 2: What role has technological advancement in the audio marketplace played in the diffusion of HD Radio?

RQ 3: What business, industry, and consumer factors have affected the diffusion of HD Radio?

RQ 4: Why has HD Radio diffusion slowed in the United States?

In answering these research questions, guided by the diffusion of innovations framework, a clear understanding of where HD Radio is in the diffusion process will be evident. The next chapter will review the evidence gathered in the technology, economic, and regulatory areas to answer the above research questions.

CHAPTER III. LITERATURE REVIEW OF TECHNICAL, ECONOMIC, REGULATORY, AND INDUSTRY ENVIRONMENT ASPECTS OF HD RADIO

This chapter examines the development of digital audio broadcasting in the United States and around the world. This examination will include all three "social systems" defined in the previous chapter: technical, regulatory, and economic. After an initial description of analog technology and its inherent problems, digital audio technology is detailed, along with the process of converting analog sound into digital files. A full examination of the major digital broadcasting systems of the world follows, including a technological review of the digital in-band on-channel iBiquity HD Radio system and a consideration of the criticisms of HD Radio technology, including reception and tuning problems, and efforts to alleviate these problems.

Next, a review of the economic social system concerning HD Radio, from the initial interest of developing an all-digital broadcast system to the companies that researched and developed the technology. The chapter then discusses the formation of iBiquity, its proprietary HD Radio system, and the companies licensed to produce HD capable transmitters and receivers, and the business arrangements involved for both broadcasters and equipment manufacturers. From there, a comprehensive examination of the digital audio marketplace is undertaken, with particular focus upon the effects of these competitors on digital broadcasters.

The following section traces the regulatory history of the in-band, on-channel (IBOC) digital hybrid broadcasting system from proposal to adoption by the Federal Communications Commission (FCC). Unlike many countries throughout the world, the United States does not have a nationalized system of broadcasting where the government

controls all broadcasts. Instead, through policies and philosophies established in the 1920s and continued to this day, the United States allows private interests to own radio stations that are licensed and regulated by the federal government. The need for regulation of the privatized radio industry is examined, along with the regulatory histories of relevant 20th century innovations.

Finally, this chapter goes beyond the social systems identified in the diffusion of HD Radio and chronicles changes in the radio industry itself over the past two decades—the time of HD Radio's existence as an innovation. Although the basic business model of selling airtime to advertisers has changed little since the 1920s, several factors, including changes in the law, changes in the audio marketplace, changes in technology inside and outside of the studio, and national recessions and recoveries have all played a part in making the radio industry much different than it was at the advent of digital broadcasting in the 1990s or when iBiquity's in-band on-channel HD Radio system was adopted by the FCC in 2002.

Throughout these sections, an understanding of how HD Radio has diffused through these separate areas will be discussed. Each "social system" has had a varied amount of diffusion of HD Radio; this chapter will outline how much HD Radio has diffused through each system and the overall environment.

Technology

Analog broadcasting and recording

Television, other video and audio recordings or transmission, cellular telephony, and every other major medium of signal transmission or duplication, has gone digital. Radio continues to employ, as its major means of technology, the same analog signal

generation that has been in place for decades. The original technology of audio recording and transmission is analog-based.[14] An analog recording device makes an analogous physical representation of sound waves upon a physical object, usually a cylinder, disc, or magnetic tape. Elsea (1996) describes the process for a phonograph record:

> Displacement of the microphone diaphragm is transformed into a wiggley groove on a moving piece of vinyl. A stylus tracing the wiggles exactly reproduces the motion of the diaphragm at the time the recording was made. Electricity is really incidental to the process, used as a convenient way to connect the microphone to the cutter and the pickup to the speaker. (Elsea, 1996)

The process is similar for magnetic audio tape. Magnetic recording "heads" make a physical pattern on plastic tape coated with iron oxide analogous to the sound wave that is being recorded (Elsea, 1996). At playback, both the disc player and the tape player read the physical information on the recording devices and transduce (i.e., convert) the patterns back into audible sound.

Analog radio broadcasting works upon these same technical principles and has worked fundamentally the same way for over 90 years. For an analog broadcast, sound wave energy is transduced into electrical patterns mimicking the sound wave. These electrical patterns are then superimposed upon a carrier wave and transmitted to receivers, which transduce the electrical patterns back into audible sound (McGregor, Driscoll, & McDowell, 2010). The process is essentially the same for AM and FM band transmissions. Although a stable technology now, analog broadcasting has been refined over decades of use aimed towards providing a better listening experience for the end user. These improvements include legal limitations on interference and technical

[14] The word "analog" is a short version of the word "analogy," meaning "of or relating to a device or process in which data is represented by physical quantities that change continuously" (Merriam-Webster, 2014)

enhancements, increases in signal strength, miniaturization of radios to allow easy portability, and development of other technology to enhance overall sound quality, such as FM stereo broadcasting (Scannell, 2010).

Despite its decades of service as a robust communication medium, analog broadcasting still faces many of the fundamental problems and limitations that it faced in its early years of service. For AM listeners, electrical interference from lightning or man-made electrical fields can degrade signal quality for a user, making the band unlistenable due to static interference. The narrow channel and limited dynamic range of AM gives both voice and music far less than lifelike quality. FM is mostly impervious to electrical interference, due to its modulation scheme, and boasts a marked improvement in audio fidelity compared to AM, including almost universal stereo sound on FM radio stations. FM has limitations, though. For instance, multi-path distortion, a common interference source, is caused when radio waves bounce off physical objects, such as buildings, and arrive at the receiver at slightly different times causing a fading signal quality, remains a problem (Poole, 2014).

Until the 1980s, these quality issues were minor considerations, since the material broadcast was also analog-sourced (a phonograph record or tape player). Records are well known to have “pops” and “clicks,” and tape has an audible “hiss” that affects the fidelity of playback audio; imperfections were exacerbated with increased use, worsening fidelity. In this all-analog chain from source to reception, broadcasters delivered the best sound they could, considering the limitations of both the source material and the broadcast channel. The audience may not tolerate signal interruption and substantial interference when listening, but did accept that AM and FM sound from broadcasters was

less than perfect because they were familiar with the same "pop" or "hiss" issues on their home phonograph and tape players.

Digital audio

Consumer audio devices advanced considerably in 1983 with the introduction of the digital compact disc (CD). The CD solved a number of audio fidelity problems. Discs were marketed as practically indestructible and able to be played endlessly. There was no loss of audio fidelity because information is read by a laser beam and no physical contact occurred between the CD and the information reading mechanism[15] (Sterling & Kittross, 2002). The information read on the disc was in binary code,[16] a digital computer language, which was then converted by a digital-to-analog microprocessor within the player. No physical contact between the disc and the reader meant that the low end "hum" of the phonograph and "hiss" of the tape was eliminated; the laser beam simply read the information on the disc. The audio fidelity of CDs was markedly higher than either a record or audio tape, and consumers rapidly accepted the new technology. Prices fell from an initial $800 for a player in 1983 to $150 by 1987 as a CD "boom" ensued, rapidly relegating cassette tapes to second-place status and displacing phonograph record sales completely (Sterling & Kittross, 2002). Consumers accepted and adopted the world's first digital audio technology by the end of the 1980s.

A digital representation of analog sound is only possible through a process called pulse code modulation. In pulse code modulation, high-speed sampling of an analog wave "cuts" the wave into many sections. The amplitude of each sampled section of the

[15] Unlike a phonograph record where a needle physically contacts the disc in the "groove" or magnetic tape which must physically pass over playback and recording heads.

[16] Binary code is a numeric system of 0's and 1's that computers use to perform storage and computational tasks. The code represents instructions to the computer to turn on (1) or turn off (2) (Beach, 2004)

wave is quantized, meaning it is given a specific numeric value by the computer. This value is then converted into digital code (McGregor et al., 2010). Upon playback, the result is a faithful high fidelity reproduction of the original analog sound.

Consumer exposure to higher fidelity audio in their homes, better than analog broadcasting (even with many broadcasters switching audio source material to CDs) stimulated interest in a fully digital broadcasting system. Only with a digital system could the vast improvement in fidelity be fully appreciated by radio listeners, plus new services could also be offered which would extend new areas of usefulness to radio broadcasting, including both text and audio data (Ala-Fossi, 2010). However, a large problem needed to be resolved in order for digital broadcasting to work efficiently. A digital file converted without compression directly from the analog source required a large amount of bandwidth[17] for broadcast (Sterling & Kittross, 2002) and a large amount of storage space.[18] Without a significant increase in the capacity of each radio channel, transmitting an uncompressed digital reproduction of an analog sound recording would be impossible. Data compression and perceptual coding technology were the solution to this problem.

The goal of pulse code modulation is to reproduce analog sound "as is;" one of the goals of data compression and perceptual coding is to reproduce analog sound as the human ear can perceive it (Sellars, 2000). The human ear has a limited audible range; consequentially, there is no need to reproduce information that is imperceptible to the ear,

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[17] Bandwidth is "the maximum data transfer rate of a network or Internet connection. It measures how much data can be sent over a specific connection in a given amount of time" (Tech Terms, 2013).

[18] One minute of uncompressed stereo audio requires approximately 10 megabytes (MB) of storage space (Sellars, 2000). The amount of storage space necessary for thousands of uncompressed audio files is substantial. The costs of a digital system, if even possible, were prohibitive in the 1980s and into the 1990s. The price of 1GB of hard drive storage in the mid-1980s was above $100,000; 1GB of hard drive storage had fallen by 2010 to 10 cents (Komorowski, 2010).

because that information would take additional storage space and bandwidth. As described by Sellars (2000), "a certain amount of audio data is deemed to be unnecessary, and sufficiently unimportant that it can be discarded or ignored without an unacceptable degradation in sound quality" (para. 23). When this irrelevant information is discarded, the overall size of the file decreases, allowing for more information to be stored on a computer hard disk or transmitted on a channel.[19]

A popular compression technique for consumer audio files is MPEG[20] 1 Audio Layer 3, more popularly known as MP3. MP3 compression reduces a full audio reproduction file on a CD to only one-tenth of its original size while still delivering acceptable audio quality (Sellars, 2000). Other compression techniques perform the same function: to reduce the size of an audio or video digital file to one that is easily storable and transmitted without perceptually altering its overall quality. Perceptual coding and digital audio compression are also used for digital radio broadcasting; different standards are used for the major digital broadcasting systems used in the world today. For example, the European standard for the Eureka 147 system is MP2 (O'Neill, 2010); however, in the United States, the proprietary iBiquity IBOC codec is called High Definition Coding (HDC) (iBiquity, 2013), a lossy codec designed to supply higher quality audio with lower bit rates than MP2 (Grabianowski, 2013). Compression is vital for each system in order to transmit suitable quality audio within the channel bandwidth allotted.

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[19] This is called a "lossy" compression method; information is discarded in order to shrink the size of computer files. There are also "lossless" compression methods that do not eliminate redundant or unnecessary information to achieve file size reduction. Lossless compression creates an exact replica of the original file, but breaks up the large file up into smaller files for later reassembly (Corbett, 2011; The Economist, 2012).

[20] The acronym "MPEG" stands for "Moving Pictures Experts Group," which defines itself as "a working group of ISO/IEC with the mission to develop standards for coded representation of digital audio and video and related data" (Moving Pictures Experts Group, 2013).

Around the world, several different systems of terrestrial digital audio broadcasting have been developed since the mid-1980s. The major systems are IBOC (In-Band On-Channel), Eureka 147, DRM (Digital Radio Mondiale), and ISDB-$_{TSB}$ (Integrated Services Digital Broadcasting for Terrestrial Sound Broadcast).

In-Band On-Channel (IBOC)

As opposed to most broadcasting environments in the world, the United States places most of its broadcast facilities in the hands of private owners and investors, rather than the government. Broadcast stations are regulated by the FCC, [21] since the passage of both the Radio Act of 1927 and Communications Act of 1934, which requires broadcasters to operate in the "public interest, convenience, and necessity" (Federal Communications Commission, 2008). In this context, with private business concerns playing a major role in industry regulatory decisions, the digital system that would be adopted needed to effectively address those concerns (Maxon, 2007).

The National Association of Broadcasters (NAB) in 1991 proposed adopting the Eureka 147 DAB system as the U.S. national standard for digital radio (Stavitsky & Huntsberger, 2010). However, many U.S. radio station owners saw a system that featured assigning new spectrum, perhaps to operators other than themselves, as an immediate threat. They lobbied for the rejection of DAB, in both terrestrial and satellite-based forms, and promoted a different digital system designed to operate within the existing AM and FM bands (Ala-Fossi, 2010). That system, which took nearly a decade to develop, was in-band on-channel (IBOC). IBOC allows for the continued broadcast of

[21] The FCC was created with the passage of the Communications Act of 1934. Prior to this law, the Radio Act of 1927 created the Federal Radio Commission (FRC) which was the initial agency charged with regulating radio. The 1927 Act also included a charge for stations to operate in the "public interest, convenience, and necessity" (Federal Communications Commission, 2008a).

analog signals, but adds the capability of digital signals to be broadcast concurrently. On FM, the analog signal remains in its usual space on the center frequency within the 200 kHz (0.2 MHz) channel; the digital information is broadcast on the upper and lower sidebands to each channel. Each digitally-encoded sideband is 100 kHz wide, meaning each HD capable transmitter is technically occupying (including carrier channel and sidebands—which are on adjacent channels) 400 kHz of spectrum (Maxon, 2007). AM IBOC also expands beyond the traditional 10 kHz channel assignment for AM stations; an additional 10 kHz of bandwidth (5 kHz on upper and lower sidebands) is used (Ray, 2008). This spacing was originally intended to limit co-channel interference, which is distortion caused by an undesired signal affecting a desired signal (McGregor, et al., 2010).[22] IBOC takes up this spacing, but because the signals are at low power and digital, analog receivers should not notice interference. Besides audio data, IBOC for FM and AM has the expanded ability to broadcast textual or visual data messages to receivers such as traffic information or artist and song information.

The development of IBOC was difficult; at least 19 different proposals for IBOC or in-band adjacent-channel (IBAC) systems failed by the end of the 1990s (Ala-Fossi, 2010). The difference between IBOC and IBAC on FM is the location of the 200 kHz digital signal in each method. IBOC symmetrically "surrounds" the carrier wave with 100 kHz-wide digital sidebands. The digital information is transmitted upon the generated upper and lower sidebands of the carrier wave. On the other hand, IBAC is asymmetrical, putting the entire 200 kHz digital area on one side of the carrier wave. According to Maxon (2007), the fact that IBOC technically operates on an "adjacent"

[22] A spectrum mask on HD transmissions is mandated by the FCC to limit excessive radiation from these sidebands from causing interference to co-channels.

frequency does not mean IBOC is an adjacent channel scheme. The IBOC system relies upon channel spacing (200 kHz for FM, 10 kHz for AM) and receiver characteristics in weeding out desirable/undesirable signals (based upon signal strength) to create the "space" for IBOC channels. Maxon (2007) states that "[w]hile it is convenient to think of the FM "channel" in the U.S.A. as a simple 200 kHz wide slot reserved for the exclusive use of a station, the idea of a "channel" has a richer context" (p. 269). In this perspective, spacing requirements create additional spectrum area for a station to transmit data and still be considered "on-channel."

For example, FCC spacing rules require 200 kHz of space between FM radio stations; however, it is highly unlikely in one geographical area that one 50,000 watt station will be at 93.1 MHz and another equally powerful radio station will be assigned 93.3 MHz. The FCC assigns spectrum to avoid adjacent channel interference; otherwise, two powerful signals so close together would produce such interference. IBOC only uses one-half (100 kHz) of the next adjacent channel and does so under lower power. Under the IBOC system, the power levels used to transmit digital information are extremely low when compared to those of the analog signal. When the FCC approved IBOC in 2002, it allowed stations to transmit digital signals at 1% of their analog power, otherwise known as effective radiated power (ERP) (Federal Communications Commission, 2002). This low-power limit was adopted to help limit any sideband interference issues with either adjacent channels or the main analog signal. Receivers also help mitigate interference issues that may arise; receivers can filter out undesirable signals if they are at least 6 dB weaker than the desired signal. In other words, if there is an overlap of data, the receiver is generally able to pick out the desired signal based upon strength of the signal (Maxon,

2007). The symmetry of IBOC is in contrast to IBAC, which loads 200 kHz (a full adjacent channel) of digital information only on one side of the analog carrier frequency. According to Maxon (2007):

> By occupying a full adjacent channel, the IBAC signal will impinge on the reception of a second-adjacent analog signal in a way that IBOC does not. Also, if the power levels required to make the IBAC signal work are greater than that of the IBOC signal, IBAC may potentially interfere with first-adjacent reception within the protected area of the first-adjacent station. (p. 268)

However, IBOC systems still run a risk of adjacent channel interference because the upper and lower sidebands on which they operate are above and below the carrier wave of adjacent frequencies. The risk of adjacent channel interference is especially acute with AM stations converting to IBOC systems; sky-wave propagation at night causes signals to travel farther. The sidebands, now encoded with digital information, also travel through sky-wave propagation, which may interfere with distant stations operating on an adjacent frequency. On both AM and FM channels, special filters are used to further limit any interference to adjacent frequencies. However, at HD Radio's rollout in 2003, AM HD broadcasting at night was outright prohibited by the FCC until further testing could be done (Federal Communications Commission, 2002).

IBOC Operation and Criticism

In the IBOC system, it is an FCC requirement that both the analog signal and the main digital signal (known as HD-1 under the HD Radio system) are simulcast. Other digital channels are also broadcast through an IBOC system, but not carried by the original analog station. First, the analog signal and digital signals, including textual data, are "bundled" together from the transmission source. The analog signal has been

digitized using the Audio Electronic Society-3 (AES-3) digital format (Ray, 2008). Then, the digital signal is compressed with iBiquity's proprietary HDC coding system and sent to the station's HD-enabled multiplex transmitter set where it is transmitted over the air (iBiquity, 2013). According to iBiquity's website, FM radio stations have 150 Kbps per second of bandwidth to use for digital programming. A typical full-digital broadcast uses 96kps (iBiquity, 2013). Similar to other DAB systems, HD Radio broadcasters have the option to configure how much bandwidth they wish to allot to different channels, dependent upon whether programming is music or voice-only (iBiquity, 2013). On the listener's end, HD Radio-enabled receivers first access the carrier wave with the analog signal, then the digital signal in monaural, then a full stereo HD signal. This detection mechanism results in a slight reception delay when an HD receiver is tuned to a channel as the receiver processes through these steps. The receivers are designed to sort through any multipath distortion to provide a clean, near-CD quality digital audio reception (iBiquity, 2013). Should the digital signal be lost by the receiver, the hybrid analog and digital receivers revert to the analog signal until the digital signal is able to be received once again.

The low power level used for HD Radio transmissions (1% of ERP) also caused reception problems for listeners, who complained of signal dropouts in areas where ordinary analog reception was acceptable. Paul Riismandel, writing for the website RadioSurvivor.com, highlighted reception problems in his review of his first HD Radio receiver purchase in 2010:

> Listening to HD Radio is not necessarily the most user-friendly experience. The digital HD signal is broadcast at much lower power than the analog signal–in order to lessen interference with adjoining stations. Therefore I had to adjust my antenna carefully to pull in HD signals….

> However, keeping that HD signal was sometimes difficult. Just walking across the room could cause the HD signal to drop out. The HD signal also seemed more susceptible to electrical interference than analog FM. For instance, my wife was shredding documents in the next room, and every time she shredded something the HD channel would drop out, then take 10 – 30 seconds to come back in after she stopped. (Riismandel, 2010)

Riismandel concluded:

> On some stations it was difficult to listen to the HD channels for any length of time. They just wouldn't stay tuned in, no matter how carefully I adjusted the antenna and tried not to move around. It's not a big deal if I'm listening to the primary HD channel, since the tuner smoothly falls back to analog, which sounds just as good. But it is frustrating if you're listening to an HD2 or HD3 channel, since it goes away altogether. No slow degradation, no static–it's either on or off. Given the somewhat delicate nature of tuning in HD stations, I have real doubts how many average radio listeners are willing to devote the patience necessary to tune in HD channels. (Riismandel, 2010)

In January 2010, the FCC issued an Order approving voluntary increases in power for HD Radio stations. If they chose to, stations could now strengthen their digital signals up to 10% ERP (Federal Communication Commission, 2010). In approving this Order, the Commission also set up interference mitigation and remediation provisions to handle any complaints about interference from increased power HD stations (Federal Communications Commission, 2010b). If interference complaints were submitted, an offending station could be forced to return back to the 1% power level. The power increase was approved after the Commission reviewed supporting studies submitted by iBiquity and NPR; the Commission also noted, "[b]ased on our analysis of these documents and data, as well as five years of interference-free FM hybrid digital operations by approximately 1500 stations, we are convinced that an immediate voluntary 6 dB increase in FM Digital ERP is appropriate for all FM stations" (Federal Communications Commission, 2010b). However, because this is a voluntary decision to

be made at the station level, not all HD stations have increased digital power to 10% ERP.

Eureka 147

Digital audio broadcasting (DAB) development began in earnest in Europe in the mid-1980s. It began "as a collaboration between Institut für Rundfunktechnik (IRT)…and the Centre Commun D'Etudes de Télédiffusion et Télécommunication (CCETT)" (O'Neill & Shaw, 2010, p. 32). These two entities were instrumental in developing the audio compression and a new frequency modulation system for DAB. IRT developed the audio data compression system and CCETT developed the new frequency modulation system. By 1986, a group of 19 broadcast organizations from across Europe was formed to officially develop DAB[23] and, in 1987, the Eureka 147 project was founded to develop a digital radio system that "would produce improved reception compared to FM…and with the potential to offer additional services such as text and other data, conditional access, enhanced traffic services, and picture transmission" (O'Neill & Shaw, 2010, p. 32). The overall goals of the project were:

- Audio quality comparable to that of a CD
- Unimpaired mobile reception in a car, even at high speeds
- Efficient frequency spectrum utilization
- Transmission capacity for ancillary data
- Low transmitting power
- Terrestrial, cable, and satellite delivery options
- Easy-to-operate receivers
- European or better world-wide standardization (Hoag, Lauterbach, Meier-Englen, & Schulze, 2001, p. 5)

The ability to transmit multiple audio streams within a channel with varying levels of quality (depending upon the needs of the program being transmitted) was also a goal.

[23] By 1993, the number of participating organizations had grown to 53 (Hoag et al., 2001).

This ability was due to a new form of modulation called Coded Orthogonal Frequency Division Multiplex (COFDM) (Poole, 2013). Multiplexing is defined as "sending multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end" (Rouse, 2005, para. 1). According to Hoag et al. (2001), multiplexing along with the ability to vary bit rates during transmission increases spectrum efficiency since bit rates can be "split optimally between different services of a DAB ensemble" (p. 4). Thus, if on one allocated channel there are four audio streams comprised of two music streams and two voice-only streams, higher bit rate transmissions could be assigned to the music streams to increase their fidelity and lower bit rate transmissions to voice-only streams that do not require higher bit rates to reproduce audio in good quality. A typical bit rate is 128 Kbps for quality music audio (Poole, 2013). Each audio stream is sent digitally coded from the transmission source, compressed to MP2 specifications, then multiplexed at the main service channel (MSC) multiplexer. The information is sent to the OFDM multiplexer to form the digital transmission, which is delivered to the transmitter where it is broadcast (World DAB, 2013). The transmitting power needed for DAB is much lower compared to analog broadcasts; DAB for local broadcasts consumes half as much power as analog while covering the same land area (World DAB, 2013).

A significant decision regarding terrestrial DAB in Europe was the assigning of new spectrum for digital broadcasts using the Eureka 147 system. Instead of operating on the traditional AM or FM frequency bands, the Eureka system would instead operate on entirely new spectrum bands. Currently, terrestrial DAB has frequency bands for broadcasters, including Band I (48.0 – 68.0 MHz), Band III (170.0 – 240.0 MHz), and the

L-Band (1452.0 to 1467.5 MHz). Frequency ranges for DAB were assigned to European nations in 1995 at the Wiesbaden World Radio Conference. Each frequency channel bandwidth is 1,500 kHz (1.5 MHz) wide and could be divided up by COFDM to carry multiple audio streams, typically between 5 and 10 audio streams in addition to textual data streams (Jauert, Lax, Shaw, & Ala-Fossi, 2010). This flexibility could be used by national organizations (such as the British Broadcasting Corporation in Great Britain) or by local broadcast stations; all that needed to happen was the assignation of a frequency block and the entity that controlled it could begin a full range of multiplex broadcasts and data transmission. In 1995, the European DAB Forum, later reestablished as the World DAB Forum in 1997, was formed to "coordinate the DAB standard and promote its adoption" (O'Neil & Shaw, 2010, p. 33). After the "project" phase was completed, the Eureka 147 project merged into the World DAB Forum. Currently, there are more than 30 countries with regular DAB service and more than 12 million DAB receivers sold worldwide (World DAB, 2013).

The most significant potential change to DAB occurred in 2006 with the introduction of the DAB+ system. DAB+ is based on DAB, but uses newer MPEG4 compression instead of the original DAB MPEG2 compression. This technology allows for lower transmitted kilobytes per second without perceptual loss in audio quality. Audio quality tests performed by the European Broadcasting Union (EBU) rated audio "good to excellent" at only 48 Kbps; "excellent" audio was achieved with a 64 Kbps stream, far below the 128 Kbps usually needed for quality transmission of music on the original DAB system (World DAB, 2013). With a lower transmission rate, spectrum efficiency increases and more channels of audio can be offered to consumers on existing

1.5 MHz DAB multiplex. WorldDAB.org claims this system allows up to three times as many services than the original DAB (World DAB, 2013). Whereas the original DAB could only offer monaural or stereo service, DAB+ can offer surround sound, plus other improved features. New DAB+ receivers are backwards compatible with standard DAB broadcasts so that listeners are able to receive both types of digital broadcasts. DAB+ is slowly being rolled out in Europe, with Malta being the first country to launch a DAB+ network in 2008 and other nations such as Italy, Germany, Switzerland, and the Netherlands expressing interest in DAB+. Australia in 2009 selected DAB+ as its official standard in 2009 (World DAB, 2013). Nations can choose to offer DAB, DAB+, or a combination of both services (World DMB, 2012).

Digital Radio Mondiale (DRM)

DRM is a digital system developed by the Digital Radio Mondiale consortium, formed in 1998[24] to develop digital service for bands under 30MHz (Maxon, 2007), which includes the traditional AM band in the United States and several short, medium, and long-wave bands. Over the past few years, service has been extended to bands below 120 MHz (Maxon, 2007). DRM is primarily considered a way to digitize worldwide broadcasting on international frequency bands (Maxon, 2007) and calls itself "the future of global radio" (Digital Radio Mondiale, 2013). The DRM system was proposed in 1988, but was not field-tested until 2000 and did not officially debut with equipment and receivers until 2003 (Franke, 2012).

[24] The DRM consortium is "an international not-for-profit organization composed of broadcasters, network providers, transmitter and receiver manufacturers, universities, broadcasting unions and research Institutes" (Digital Radio Mondiale, 2013). Members include corporations, such as Dolby Laboratories Inc., Harris Broadcast, JVC/Kenwood, and Sony International, and other organizations, such as Radio France, Radio Vaticana, and the International Broadcasting Bureau (Digital Radio Mondiale, 2013).

DRM has a number of consumer features for receivers similar to receivers for DAB and IBOC, such as the ability to pause programming and live textual data streams (Digital Radio Mondiale, 2013). DRM uses COFDM transmission and MP4 audio compression; like other digital audio systems, it has the ability to adjust bit rates for programs that need higher or lower bit rates for quality sound (Maxon, 2007). The DRM wave can fit on a 9 or 10 kHz channels,[25] meaning not only can it be applied to shortwave and commercial AM bands internationally that use 9 kHz channels, but also could be used to digitize the United States AM band that has 10 kHz channels. There have also been hybrid versions of DRM proposed (but not adopted), whereby the DRM signal is transmitted on the 10 kHz channel with the analog signal broadcast on a 5 kHz sideband (Maxon, 2007).

One of DRMs major selling points for broadcasters has been cost relative to service and quality, promising revenue costs that are "no higher to those of analogue Short and Medium Wave broadcasts and offer excellent value for money given the wide area coverage and the superior sound quality" (Digital Radio Mondiale, 2013). In addition, DRM has developed receiver chips that are compatible with receiving DAB and DAB+, claiming the additional functionality can be achieved for minimal cost to the consumer.

Drawbacks to DRM exist both on the broadcaster and consumer ends. For consumers, moderate-to-cheaply priced radios are still not on the market; the receivers that do exist on the market consume power at a much higher rate than the analog receivers they replace (Franke, 2012). Adil Mina, chairperson of the DRM USA Group,

[25] 9 kHz would be DRM's most compact configuration. DRM can use channels up to 20 kHz wide (Franke, 2012).

said that the small, power-efficient receiver is critical for consumer acceptance. "That's what most people are looking for. It's the one that should be like your BlackBerry, your telephone, that can sit for two days, three days, without you having to go back and charge it" (Franke, 2012, para. 7). For broadcasters, the complex COFDM transmission also increases electrical power costs, in addition to purchasing new transmitter equipment.

ISDB-T_{SB}

ISDB-T_{SB} is a digital audio broadcasting platform developed in Japan with the support of the Digital Broadcasting Experts Group (DiBEG) (Maxon, 2007). It is part of the ISDB standard that integrates digital multimedia services including digital terrestrial television broadcasting (ISDB-T), digital cable (ISDB-C), and digital satellite broadcasting (ISDB-S) (Saito, Hasimoto, Minematsu, Nomoto, & Matsumura, 2000). The ISDB system is primarily designed for television broadcasting, but is flexible in its design to allow for audio-only service (Maxon, 2007). The service, similar to other digital broadcasting services, uses COFDM in transmitting digital information; ISDB-T_{SB} uses MPEG-2 AAC (Advanced Audio Coding) compression (Fuseda, 2009), and the bit rate is 128 Kbps (Saito et. al, 2000). One ISDB channel is 5.6 MHz, partitioned by the system into 13 429 kHz channel segments. Up to 3 segments of the channel can be used for audio data (NHK, 1999). Within one of those segments, up to 7 CD-quality audio channels may operate, with adjustable bit rate quality (Maxon, 2007).

ISDB service has gained a strong foothold not only in Japan, but also in South America where a number of nations have adopted the standard and started digital terrestrial television broadcasting.[26] ISDB, including ISDB-T_{SB}, operates on the

[26] Japan began ISDB-T service in 2003 and achieved national conversion to the ISDB-T standard by 2011. Brazil adopted ISDB-T in 2006 and began service in late 2007. Other South American nations adopting

traditional VHF and UHF frequency bands for television; no additional spectrum needs to be assigned. Japan continued broadcasting analog audio and video channels along with digital counterparts on both the VHF and UHF bands until the planned full-digital conversion by 2011 (Fuseda, 2009). The Japanese government confirmed the shutdown of analog signals in July 2011 (Ministry of Internal Affairs and Communications of the Government of Japan, 2011).

Comparing IBOC and Eureka 147

The two systems considered for digital radio in the United states, the HD Radio IBOC system and the Eureka 147 DAB system, have comparable benefits, many of which can be found in the promotional literature for each system. These benefits include near-CD quality sound, lower power usage, greater spectrum efficiency, more audio channels for listeners, textual data services (greater than current analog radio broadcast data service (RBDS) systems), and the virtual elimination of background noise, such as pops, clicks, and other static interference. However, each system has had its detractors in separate notable areas.

For Eureka 147 DAB, listeners have experienced persistent sound quality issues. It is a serious issue because the premise of upgrading to digital broadcasting is based upon superior sound quality compared to its analog counterpart. Lax (2010) notes several consumer surveys that concluded that such phrases as "CD-quality sound" and "digital radio" were what distinguished DAB from analog radio. According to O'Neill (2010), "no other feature has attracted the same degree of ire and listener frustration as the audio quality of DAB" (p. 92). Some of the most vocal criticism has come from audio "purists"

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and inaugurating ISDB-T service include Venezuela, Paraguay, Argentina, and Peru. Chile, Ecuador, Uruguay, and Bolivia have adopted ISDB-T, but have not begun broadcasting (Digital Broadcasting Experts Group (DiBEG), 2013).

who claim to hear the difference between true CD-quality audio and the compressed versions available on DAB systems (either MP2 or MP4). These audiophiles argue that the compression techniques used, plus additional compression to make the station appear louder than its competitors, degrade the overall fidelity of the broadcast music.

Disappointing these audio enthusiasts can be seen as a major blow since early market research regarding digital radio identified these types of early adopters of digital technology as critical to overall adoption (O'Neill, 2010). However, ordinary consumers also perceive the inferior sound. O'Neill (2010) points to a consumer survey conducted by Ofcom,[27] which showed a degree of consumer dissatisfaction with DAB audio in several areas (Ofcom, 2007); however, follow-up research by Ofcom revealed that most listeners perceived the sound quality as either excellent or very good (O'Neill, 2010). Several technology writers and bloggers take issue with this conclusion, having written about deficiencies, such as dull or muffled sound, poor stereophonic sound, "swishing" vocals, sibilant speech,[28] and monaural service where analog stereo FM service was once heard. For example, Robjohns (2009), a technical editor for the magazine *Sound On Sound* in Great Britain, wrote:

> [W]hat I find rather less acceptable is the claim that "consumer satisfaction is high". They didn't ask me or anyone I know, and most of us certainly wouldn't have given that answer!.... The sound quality of current DAB services is — both subjectively and technically — inferior to that achievable with FM, varying from just about acceptable to utterly atrocious, depending on the bit-rate allocated to each service. DAB was conceived to use bit-rates at least twice as high as those often employed now. Squeezing double or triple the number of programmes and services

[27] Ofcom is "the Independent regulator and competition authority for the UK communications industries. We regulate the TV and radio sectors, fixed line telecoms, mobiles, postal services, plus the airwaves over which wireless devices operate" (Ofcom, 2013).

[28] Sibilant sound usually is evident when a person pronounces "s" and this sound is heard by a listener as either "sh" or has a lisp-pronunciation characteristic.

> into the available multiplex bandwidth quickly destroyed the notion of audio quality, despite the marketing hype. (Longjohns, 2009)

The perceived "downgrade" to inferior quality sound as compared to analog service has also made many ordinary listeners upset. In 2006, the British Broadcasting Corporation's (BBC) digital Radio 3 channel[29] decided to reduce its signal quality by 20% in order to make bandwidth room for an additional channel on the multiplex. Listeners reacted strongly and swiftly:

> "Some instruments sounded distorted," complained one fan on the website Friends of Radio 3, an informal pressure group. "Unlistenable unless through a table radio," raged another. "Rubbish," "miserable" and "dreadful" were some of the more polite assessments…. In the beginning, the champions of DAB boasted it would provide "CD quality" sound. But with broadcasters clamouring *[sic]* for space on the digital airwaves, the only way to pack more in is to reduce the broadcast quality of others….The digital versions of Radio 1 and 2, for example, now broadcast at significantly lower rates than when they launched - and now stream at only slightly over 60% of what audio engineers (including the authors of a BBC report first drawn up in 1994) deem "CD quality." If you can get good FM reception, it often provides better quality than DAB. (Johnson, 2006)

Johnson (2006) also explored how the radio industry in the United Kingdom contributed to the perception that DAB was always CD-quality and how those claims have had to be retracted due to broadcasters' implementation of DAB service:

> Even radio stations have been caught up by the hype. In one case the Advertising Standards Authority judged that Jazz FM…had mistakenly claimed that its digital option offered listeners CD-quality sound. "While we recognised that it is possible to transmit services at bit rates sufficiently high for most listeners to equate with CD quality," said the adjudication, "broadcasters can choose to transmit at lower bit rates or in mono." In fact, the ASA statement does not go far enough - not only can broadcasters opt for lower quality, they actively choose to. (Johnson, 2006)

Ofcom concluded the criticisms were coming from a very vocal minority of critics and the tradeoffs between amount of content and quality had not affected most listeners of

[29] BBC Radio 3 broadcasts a mix of classical music, jazz, world music, and drama programming.

DAB (O'Neil, 2010). In an interview, Pure Digital's[30] marketing director Colin Crawford discussed the issues of quality perception and its actual importance for consumers of DAB:

> A lot of the bad feeling about DAB is around the bit-rate issue. It certainly started there, at least. And this is fair enough, because in the very early days when the BBC started talking about and promoting DAB, they talked about it as a replacement with the main benefit of improving the audio quality of radio listening. And that held for a while and then they realised *[sic]* that that was wrong…that was actually seen to be the least important benefit, from the consumer perspective. For consumers, more content is easily the number one benefit of DAB. Ease of use, boring though that may be, is number two. (Hartley, 2009)

More efficient coding techniques available with the newer DAB+ system may address the sound quality issues criticized with original DAB; however, broadcasters will still be able to vary bit rate transmissions. Consequently, if the majority of listeners are happy with the sound of existing DAB service, it is conceivable that DAB+ broadcasters would attempt to offer more content rather than better audio quality. However, the quality of digital broadcasts remains a contentious issue.

In the United States, the IBOC system has had its share of technical critics also focusing on sound quality issues. IBOC also transmits at an average lower bit rate per station (96 Kbps) than DAB; iBiquity claims its proprietary HDC compression method gives its broadcasts better sound quality at extremely low bit rates. There are mixed reviews regarding quality. *Consumer Reports* (2011) stated:

> In our tests, HD Radio can live up to its promise of improved sound. The HD Radio sound quality delivers deeper bass, higher treble, more stereo separation, and a greater dynamic range (the difference between the loudest and quietest sounds) than FM or AM signals…. Moreover, the HD signal from AM stations is in stereo, and there is no background noise—

[30] Pure Digital is a "leading manufacturer of wireless music and internet radio systems, the number one supplier of digital radios in Europe and Australia…Pure radios support all the broadcast standards in the DAB family used across all key markets in Europe and beyond" (Pure Digital, 2013).

> the hiss or crackle you occasionally hear with standard radio. (Consumer Reports, 2011)

As with DAB, there are many critics of what is perceived as over-compressed audio on HD Radio. Riismandel (2010) said:

> While I welcome the lower noise floor of HD, I otherwise don't perceive any other significant increase in fidelity….Much of commercial FM is over compressed, and I found that if a station's analog signal was so over processed, so was the primary HD channel….The second HD channels typically sound like a good webcast station. That is, they sound like medium-quality MP3s with bitrates of 128 kbps or lower. I hear more compression and less dynamic range than the analog side, and some rolling off at the high end. (Riismandel, 2010)

Under an IBOC system, the digital content on sidebands coexists with the analog content on the carrier channel. Under this hybrid system, the analog fidelity for traditional AM and FM radio sets must be preserved while offering digital content on the sidebands. What has drawn the ire of critics is a "self-interference" issue between HD signals and their base analog signal. According to Beezley (2012), the digital sidebands can interfere in two ways: the sidebands may overlap the analog signal, or detection of sidebands by analog tuners may occur. In either instance, the digital data that is detected by an analog tuner is perceived as noise to a listener—noise that interferes with the enjoyment of an analog signal (Beezley, 2012). Although there are remedies for analog listeners, from different types of noise filtration or switching to monaural mode while listening on FM, the additional noise on the FM channel is a signal degrading side effect of operating in the IBOC analog/digital hybrid mode. On AM, interference has been an even thornier issue with groups such as Citadel ceasing AM HD broadcasts because of unacceptable interference (Stinson, 2007). Digital power levels at 1% of analog ERP were enforced to

minimize these interference issues; now with stations allowed to voluntarily increase power to 10% of analog ERP, additional interference issues may arise.

There are some anecdotal technical criticisms of complexity in the tuning equipment. Although it appears iBiquity has attempted to make the use of HD Radio as close to the experience of using an old analog radio, criticism remains on at least two fronts. Although HD Radio receivers are ostensibly built to replicate as close as possible analog receivers, the tuning process of an HD receiver is slower than simply "spinning the knob" on an analog set. Riismandel explains:

> [O]ne of the great experiences of analog radio listening is scanning the dial looking for a good (or tolerable) song, or simply just trying to see what you'll find. This is not a pleasure one will enjoy with HD radio. In my experience so far it really just isn't practical to scan HD stations. It simply takes too long to get the HD signal locked in. (Riismandel, 2010)

An HD Radio receiver takes longer to "lock in" because of the way signals are accessed by the receiver. The analog signal is acquired first by the receiver and demodulated; only then is the digital signal accessed and the digital audio is blended over as the analog signal is, which is no longer used by the receiver as long as the digital signal is available (Ray, 2008). In sum, the tuning process is not necessarily more difficult than previous analog receivers; however, it does take slightly longer to get to "HD Radio" signals.

Once a listener has tuned in a station, the internal switching between analog signal and the HD-1 simulcast may also feature a "delay" between the two signals, making the radio station almost impossible for a listener to enjoy. HD Radio receivers are built to revert to the analog signal if the digital signal for the HD-1 channel is lost; once the digital signal is reacquired, it will once again be blended over the analog signal.[31] Since a digital signal takes about 8 seconds longer to process, a delay must be set up and

[31] HD-2 and HD-3 signals have no analog "back-up." If those signals are lost, the listener hears nothing.

synchronized on the analog signal output to match the digital signal output (HD Radio Alliance, 2013). According to Ray (2008), this delay is the result of both the "signal processing times of the digital audio and the transmission of error correction data" (p. 34). Proper synchronization between the digital and analog signals ensures that when a receiver reverts to analog, there is not a "ping pong" delay where the listener hears audio a few seconds ahead of where the digital signal is, nor does the listener hear a repeat of content heard on the analog side when the receiver reverts to the digital signal. It is up to the individual broadcaster to ensure that the interleaving process is smooth and the timing between the analog and digital signal is accurate. In fact, the HD Radio Alliance warns that, "[t]ime and level alignment is one of the most, if not the most important technical parameter when implementing HD Radio technology. The radio listener will not tolerate a station that jumps back and forth" (HD Radio Alliance, 2013, para. 13).

Even with this warning, depending upon over 2,000 individual hybrid digital analog stations to maintain perfect timing is a challenge. Anecdotal evidence from the Internet indicates that intermittent problems still exist maintaining a perfect blending of analog and digital. Victor Godinez of the *Dallas Morning News* described his experience with an HD Radio receiver while trying to listen to the local ESPN affiliate:

> My new stereo will always lock on to the digital HD signal when possible. However, when that signal isn't strong enough, it drops down to the analog signal. But radio stations have to properly synchronize the analog and digital broadcasts so that when your receiver switches from one signal to the other, the audio playing through your speakers sounds seamless. Well, that's not happening with 103.3. For the last few days, my audio has been skipping and repeating like crazy when I listen to the station in my car. And it's driving me insane. If I could simply turn off the HD receiver on my radio when listening to 103.3 and just listen to the analog broadcast, that would be fine. But my stereo doesn't seem to have a "digital off" switch. (Godinez, 2011)

Godinez provided an update a few days later which noted the issue may have been resolved, but the incident underscores the technical challenge of a hybrid analog/digital signal and the maintenance required to provide the promise of "seamless" transitions and listening experience to the consumer.

The problem of weaker digital signals causing reception problems has inspired a start-up group named Digital Power Radio (DPR) to tackle the problem from the receiver end rather than focusing on increased signal power. DPR has proposed testing of a chipset it has developed for HD Radio receivers which it claims is more sensitive to weaker signals and therefore improves HD Radio reception for the consumer and coverage for the broadcaster (Inside Radio, 2013). Invented by George Washington University Professor Brana Vojcic, the chipset is only for receiver devices; no costs or transmitter changes will be incurred on the broadcaster's end (MacLane, 2013). Former FCC chairman Mark Fowler, Managing Member for DPR, claims that the chipset "provides a growth vehicle for the broadcast industry into all kinds of radios, including mobile handset platforms, such as smart phones" (Stimson, 2013, para. 3). George Beasley, CEO of Beasley Broadcast Group, sees the chipset as a "game changer" that "will provide coverage gains of approximately 5 dB hybrid for FM signals in mobile handsets/smart phones and tabletops in buildings, and approximately 7 dB of gains into auto receivers for hybrid FM broadcast signals. Similar gains will be realized for AM hybrid broadcasts" (Stimson, 2013, para. 4). So far, iBiquity has not officially responded to Digital Power Radio's requests to test their chip using iBiquity's proprietary system.

Digital broadcasting, no matter what the system, is still a medium in development with a range of systems available across the globe. In the United States, iBiquity is the

FCC-approved provider of digital broadcasting technology to stations across the country, with authority to license their proprietary system to manufacturers of transmitting and receiving equipment. In Chapter 4, the business foundations of iBiquity are discussed, including the company's journey into a changing consumer electronics market.

Economics

Early Interest in DAB

In the United States, interest in the electronics industry in digital audio broadcasting (DAB) began in the early 1980s, with similar interest arising in both Europe and Asia (Stavitsky & Huntsberger, 2010). This interest was due in part to positive consumer reaction to the clarity and fidelity of the all-digital compact disc player introduced in 1983. The goal of DAB was to provide compact disc quality digital audio broadcasts that would replace the old amplitude modulation (AM) and frequency modulation (FM) technologies. Several platforms were considered, including satellite, cable, and terrestrial antenna transmission (Hoeg & Lauterbach, 2001).

The first digital transmission system considered before the FCC was from a small start-up company named Satellite CD Radio Incorporated. In 1990, they asked the Commission for space on the S-band portion of the radio spectrum to transmit from satellites capable of multi-channel digital audio (Stavitsky & Huntsberger, 2010). Terrestrial commercial broadcasters, greatly concerned that coast-to-coast digital broadcasting would destroy the business model of thousands of local broadcasters, actively campaigned against the petition. Their arguments centered on terrestrial radio's local service focus, its FCC-mandated charge to operate in the public interest, and its vital role in emergency situations. The National Association of Broadcasters (NAB) requested

that the FCC deny the petition of Satellite CD Radio and remains a vocal opponent to digital satellite broadcasting on behalf of its members (Wooley, 2004). The Commission did not outright deny the company's petition; instead, it continued to study the issue for the next five years, including a *Notice of Proposed Rulemaking* (*NPRM*) regarding allocation of spectrum for satellite radio and accepting more applications from other companies interested in providing satellite service (Federal Communications Commission, 1995). Satellite radio would not really emerge as a competitor in the marketplace until 2001 when the rebranded Satellite CD Radio, now called Sirius Satellite Radio, and another entrant named American Mobile Satellite, later renamed XM, were given final FCC approval and began operation.

In the early 1990s, the NAB did support a terrestrial-based digital audio broadcast system that Europe would soon adopt called Eureka 147. The Eureka 147 digital audio broadcasting system was developed in the 1980s in large part by consumer electronics companies Philips, Thomson, and Bosch (Stavitsky & Huntsberger, 2010). At the time, Japanese manufacturers, such as Sony and JVC, were becoming the foremost names in consumer electronics. Development of DAB was seen as an effort by Europe to "provide a long term counterbalance to the increasing dominance of the countries of the Far East in the consumer electronics sector" (Ala-Fossi, 2010, p. 46).

The Eureka 147 approach would carve out new spectrum allocations on the L-band and allow licensees to broadcast of up to six streams of high quality audio, but there were several problems with the NAB's proposal to adopt the system in the United States. Commercial terrestrial broadcasters were again frightened by what they viewed as more competition, with no assurances that digital licenses and allocations would be reserved

for them. In addition, the United States Department of Defense wanted to reserve the L-band in conjunction with the development of new military weaponry (Stavitsky & Huntsberger, 2010). In fact, the North Atlantic Treaty Organization (NATO) currently controls part of the L-band between 40 and 60 GHz.

IBOC: The Chosen System

Ultimately, it was a commercial ownership group that developed and proposed a system that would allow digital broadcasting, but also allow incumbent analog broadcasters to control those digital frequencies, thereby keeping existing economic structures in place and curtailing new competition. A joint venture of CBS Radio, Westinghouse/Group W Broadcasting, and the Gannett Company proposed the in-band on-channel (IBOC) system as a solution for broadcasters who wanted to enhance their sound to digital quality, but not give up existing licenses or open the spectrum to competitors. Looking towards the future, the IBOC system seen as eventually allowing a "smoother" consumer transition to an eventual all-digital radio system. Broadcasts could continue as normal to analog receivers until such time as digital capable receivers saturated the market, at which time the system could safely convert from a hybrid to all digital. IBOC would undergo seven years of testing until the CBS/Gannett/Westinghouse partnership, now operating under the name USA Digital Radio, petitioned the FCC in 1999 to select IBOC as the standard for digital broadcasting in the United States (Federal Communications Commission, 1999). USA Digital Radio merged with Lucent Digital Radio to form iBiquity Digital Corporation in 2000 with the goal of "driv[ing] forward the consumer mass adoption of HD Radio Technology in the United States and other countries worldwide" (iBiquity, 2012a, para. 2). In 2002, IBOC was selected as the

exclusive digital radio system in the United States (Federal Communications Commission, 2002).

HD Radio is a proprietary system, meaning that iBiquity owns all of the patents that make the system operate. A search of patent records reveals that iBiquity holds around 70 patents, including major system patents for FM in-band on-channel digital audio broadcasting (patent nos. 6430227 and 6510175), method and apparatus for AM compatible digital broadcasting (patent nos. 6452977 and 6487256), and the method and system for simultaneously broadcasting and receiving digital and analog signals (patent no. 6563880) (United States Patent and Trademark Office, 2013). Each station wishing to undertake digital IBOC broadcasting must license their HD Radio operation through iBiquity; that license grants the station the ability to use "all patents, software, and trademarks" (iBiquity, 2012b, para. 1). Stations may purchase HD Radio equipment from either iBiquity or resellers, but a number of functions on HD Radio transmitting equipment are password protected and the passwords are issued by iBiquity. For the consumer, HD Radio receiving units have the "blending" ability to receive both analog and digital signals. The HD-1 signal is a digital simulcast of the original analog signal available to ordinary radio sets. For HD-2 and HD-3 channels that have no analog counterpart, audio service ceases if the digital signal is lost. As with digital television broadcasts, there is no "fading" to an HD Radio signal; a receiver will either receive 100% of the digital transmission or none, known widely as the digital "cliff effect."

Each radio station that wishes to have an HD Radio system must pay a licensing fee to iBiquity, and that fee has been recently reduced. According to Rick Greenhut, iBiquity's U.S. Director of Broadcast Sales, the commercial station licensing agreement

calls for a one-time main channel (HD-1) audio licensing fee of $12,500[32]; no other fees are required, and the HD-1 channel is licensed by iBiquity to broadcast using HD Radio technology in perpetuity.[33] Early supporters of HD Radio were allowed to buy what Greenhut called "bulk licenses" and received a lower rate than the current fee (R. Greenhut, personal communication, 2013). The additional channels, HD-2 and HD-3, differ from the HD-1 channel in that they are subject to *annual* licensing fees. The fees charged by iBiquity are a minimum of $1,000 per supplemental channel or 3% of supplemental channel-only generated revenue, whichever is the higher amount. Non-commercial stations do not have to pay the licensing fee for supplemental channels. A similar mechanism is set up for auxiliary data channel fees: iBiquity demands 3% of revenue generated from this channel of service unless the station is not-for-profit (iBiquity, 2013a).

Content and Fees

The content available on the multicast HD Radio channels (HD-2 and HD-3 channels) varies widely and programming decisions are left to the individual stations that purchase equipment. These channels have been used to provide niche music and talk formats, experimental programming, or an FM platform for an AM radio station's programming. The additional channels can also carry emergency information or other news and traffic congestion information. There has been no uniform decision by station owners as to content. Clear Channel Radio began its "Format Lab" in 2006, a centralized audio service that featured dozens of music and talk content for HD2 and HD-3 channels

[32] The one-time licensing fee for the HD-1 channel had been $25,000 (iBiquity, 2009); the fee was halved in 2013 (R. Greenhut, personal communication, 2013).
[33] The station must still maintain its FCC license; the license from iBiquity is only for the use of its proprietary technology.

(Wilkerson, 2006). By 2009, Clear Channel cut the number of available formats when it began concentrating on its iHeartRadio.com website. Clear Channel and other ownership groups have had other ideas for HD channel usage. Some owners have set up localized automated programming for the additional HD channels or have migrated content from an AM property onto an HD-2 or HD-3 channel of one of their FM properties. As a specific example, KEZK-FM in St. Louis, Missouri, broadcasts its sister station, KMOX-AM, on its HD-3 channel

In 2005, roughly two years since the start of commercial HD Radio broadcasting, members of the newly-formed HD Digital Radio Alliance, a consortium comprised of many of radio's largest ownership companies, voluntarily pledged that HD-2 and HD-3 content would be commercial-free through 2007. This pledge was later extended into 2008 (HD Digital Radio Alliance, 2008). Even though the pledge has since expired, many HD Radio subchannels remain commercial-free today. iBiquity views these subchannels as a great economic opportunity for radio broadcasters. Robert Struble, CEO of iBiquity, contends that monetizing these HD subchannels would change everything, whether that monetization is selling commercial announcements, textual information, or leasing HD Radio subchannels to different groups interested in broadcasting (Struble, 2011).

HD Radio Begins Broadcasting

After approval of the IBOC system by the FCC in 2002 and the subsequent introduction of HD Radio at the NAB convention, some FM and AM stations began digital broadcasts in 2003 in anticipation of the consumer rollout of HD Radio capable receivers. On January 5, 2004, Nathan Franzen of Cedar Rapids, Iowa, became the first

purchaser of an HD Radio receiver when he bought a Kenwood KTC-HR100 HD Radio tuner and had it installed in his 2001 Pontiac Grand Am (iBiquity, 2004). The first HD-2 station to be heard by Mr. Franzen was KZIA HD-2, broadcasting in Cedar Rapids. The manufacturer of the tuner, Kenwood, was also the first licensee from iBiquity allowed to manufacture devices capable of receiving HD Radio (iBiquity, 2004). Two days later, consumer HD Radio receivers were officially unveiled in Las Vegas at the International Consumer Electronics Show (Radio Advertising Bureau, 2012a). Showcased at the event were consumer models from Kenwood, JVC, Delphi, Visteon, Sanyo, Alpine, Fujitsu/Eclipse, Onkyo, and Panasonic (iBiquity, 2003). The rollout to consumers remained slow, with manufacturers such as Alpine and Delphi not making available consumer models for purchase until 2005, but in many markets the receivers were still hard to find and substantially more expensive than their analog-only counterparts. The first coordinated national rollout of HD Radio, in conjunction with the HD Digital Radio Alliance, began in 2006 and was spearheaded in New York City, Houston, Los Angeles, Dallas/Fort Worth, Chicago, Philadelphia, and Washington, DC (HD Digital Radio Alliance, 2006a). This launch coincided with the announcement of a partnership with Radio Shack to bring HD Radio units to consumers eventually through their 5,000-plus stores nationwide (HD Digital Radio Alliance, 2006a).

As it has been the case for many new technologies, the initial prices for HD Radio sets were extremely high, with available "tabletop" models priced anywhere between $500 and $900. The high cost of an HD Radio receiver was a competitive disadvantage compared to the cost of analog radio; moreover, HD Radio sets were also comparatively

expensive when matched against satellite radio tuners, which cost anywhere from $100 to $300 in 2005 (*Silicon Valley Business Journal*, 2005).

Knowing that a majority of radio listening occurs in passenger cars and trucks, iBiquity began an intensive effort to enlist automobile manufacturers as supporters of HD Radio and get HD-capable receivers into vehicles. Although the receivers were expensive as stand-alone purchases, putting receivers into cars effectively "masks" the cost of the expensive receiver within a product worth many thousands of dollars more. Since Kenwood, Panasonic, and JVC pioneered HD Radio receivers for vehicles in 2004, the goal of reaching consumers in the car continues to be a top priority for iBiquity, with 31 automakers offering various models of original equipment manufacturer (OEM) HD Radios in March 2013 (HD Digital Radio Alliance, 2013a). BMW became the first manufacturer to commit to HD Radio in 2005, electing to place HD Radio receivers in all BMW 6 and BMW 7 Series 2006 models; it would become the first manufacturer to feature HD Radio in all its products in 2007 (iBiquity, 2007). Unfortunately, this rollout was almost as slow as the tabletop receiver rollout was; agreements with Ford, Mercury, Lincoln, Mercedes-Benz, Hyundai, Scion, and Volvo for select vehicles within each brand would not be completed until 2008. Other manufacturers have continued to add OEM HD Radio receivers in select models, including Kia, Land Rover, Volkswagen, Toyota, and Audi. Add-on HD Radio tuners that could interface with most existing car radios were also introduced by 2007 (CNET.com, 2007b).

HD Radio Consumer Marketplace

During this time period, iBiquity faced a "chicken or egg" problem: it needed to get HD-capable receivers into cars so that listeners could hear the broadcasts; however,

did consumers really need a HD receiver outside of larger markets where the majority of HD Radio stations were located? Little, if any, evidence existed that there was a consumer demand for HD Radio sets in cars, at least not the same as demand for satellite radio receivers. However, without the receivers right in front of them in their cars, consumers could never hear an HD broadcast or want to try the technology.

Given consumer tastes for other portable electronic devices, such as the Sony Walkman or the Apple iPod, it is surprising that a stand-alone *portable* HD Radio receiver was not introduced to consumers until 2009, when Insignia released the NS-HD01 with a suggested retail price of $49.99 (Murph, 2009). The device was only sold in Best Buy stores nationwide, limiting its exposure to many consumers.[34] Later that same year, Microsoft leapt into the HD Radio realm by including HD on its Zune media player. The Zune HD was only sold for a limited time, and by 2011 Microsoft announced that it would no longer be developing any new Zune media devices and instead it would concentrate all efforts on the Xbox and the development of the Windows smartphone (Manjoo, 2012; Riismandel, 2011).

For broadcasters, much more effort has been expended to bring both analog and HD Radio reception microchips to smartphones and other existing portable electronic devices, such as Apple iPods. Broadcasters have contended that installing radio reception capability is critical in emergency situations when radio can disseminate critical information to listeners (Radio Ink, 2012a). Apple's iPod Nano has an FM tuner installed, but no other Apple device has either the analog reception chip or an HD Radio-capable reception chip. Furthermore, no smartphone manufacturer committed to

[34] Best Buy continues to offer an Insignia HD tabletop radio model in 2013 (model NS-HDRAD), priced at $51.99 (BestBuy, 2013).

installing HD Radio chips in their devices. A new, low-power consuming HD Radio chip, developed by Intel, Emmis Interactive, iBiquity and the NAB, was introduced at a press conference in April 2012 in hopes that smartphone manufacturers, particularly Apple, would include it in their next generation of smartphones (Radio Ink, 2012a). Unfortunately for broadcasters, when Apple released the iPhone5 in September, 2012, it did not have any radio reception capabilities internally (Pikover, 2012). However, iBiquity has developed an HD Radio "app" for the iPhone, and it currently sells it in Apple's iTunes store. The app only works used in conjunction with an external adapter device (for tuning navigation) that attaches to the iPhone itself (iBiquity, 2013b). The overall experience is cumbersome for consumers, and iBiquity continues to lobby smartphone manufacturers to provide HD Radio capability internally. Because many HD-2 and HD-3 radio stations are also streamed online and so few phones have even analog FM chipsets (Radio Ink, 2012a), smartphone manufacturers have openly questioned the need to add another technology to receive these audio streams. The need for these individual radio chips may not be readily apparent for consumers who can simply stream audio from an ordinary radio station app, rather than receive an over-the-air signal.

Initial Reviews of the HD Radio Experience

Early reviews for HD Radio capable receiver units were lackluster. *Consumer Reports* noted that early models were limited and prices were high; therefore, the reviewer suggested that customers should wait before investing in the promising technology (*Consumer Reports*, 2006). CNET.com Senior Editor John Falcone reviewed one of the earliest consumer tabletop models, the Boston Acoustics Receptor Radio HD.

In an online video review, Falcone commented that although HD Radio was all digital and free (unlike satellite radio), "the main drawback with the Receptor HD is that it is just a radio. There's no CD player…no other added functions besides the radio stations you can pull in off the air" (Falcone, 2006). Falcone concludes that for the expense of buying this set, he expected much more than "just a radio" (Falcone, 2006). Other models later reviewed by CNET, including the Cambridge SoundWorks Radio 820HD, the Polk Audio I-Sonic ES2, and the Sangean HDR-1, continued to be criticized for their lack of additional features besides HD Radio, especially considering the expense of the units.[35] Critics were a bit kinder to automobile HD units. For example, the JVC KD HDR1 unit reviewed by CNET in 2007 was rated excellent by reviewers who favorably reviewed its features and its extremely competitive price (under $200) with analog automobile receivers of the time (CNET.com, 2007a). JVC also introduced the KT-HDP1 Portable HD Radio, an inexpensive[36] HD Radio tuner add-on that was compatible with almost any in-car stereo that had FM playback capabilities (CNET.com, 2007b). Another HD Radio add-on unit from Sony (XDR-F1HD) was given an "excellent" review from CNET, which called it "arguably the best--and most affordable--way to add HD radio to any stereo system." (CNET.com, 2008, para. 3). Interestingly, CNET, one of the leading technology media websites in the world, has not published a new review on a HD Radio receiver since December, 2010.

Availability of HD Receivers

Product availability, according to the Alliance's own promotional materials, should not be an issue. According to the Alliance website, national and local chain

[35] Suggested retail prices for each unit were $250 - $600 in 2007.
[36] The KT-HDP1 retailed for $69.

stores, as well as independent retail shops, have agreed to carry HD Radio receivers and related accessories. National chains include Wal-Mart, Best Buy, Sears, Costco, and RadioShack; regional chains including Fry's, ABC Warehouse, and Brandsmart USA also contribute to a purported 14,000 retailers, including independent stores, where a consumer could learn about and purchase an HD Radio set. The Alliance also boasts that online retailers Amazon, NewEgg, Crutchfield, and EBay are consumer outlets for HD purchases (HD Digital Radio Alliance, 2013b).

Despite this impressive-looking roster of retailers, there is some anecdotal evidence that actually finding information about and purchasing an HD Radio is still a challenge, due to confusion among retail sales associates and even their superiors. In 2010, Tom Ray, formerly vice president and corporate director of engineering for Buckley Broadcasting, wrote an industry-targeted article detailing his difficulties explaining HD Radio to sales personnel at his local Ford dealership.

> In April I went to my local dealership in Newburgh, N.Y. and made a deal; then I made "the" statement: I said I wanted to purchase a factory-built in-dash HD Radio and have it installed in the Escape. Lisa, the sweet sales person, promptly pointed to the Sirius sign and said that the car came with Sirius. Um, no, I told her. I said HD Radio. She got the head of the parts department. Nope — never heard of it. She got the head of the service department. Nope — never heard of it. She brought over the owner of the dealership, who went to his office and came back with what amounted to a ream of paper. It contained nothing about HD Radio from Ford. (Ray, 2010, paras. 5 - 8)

Ray continued his quest by calling the corporate offices of the Ford Motor Company:

> I was shuttled from department to department, speaking [with] several department managers who shuffled through paperwork in the background. I started with the normal customer service route. These were the people who first told me I was their first HD Radio call, ever. I then called back and asked for the president's office and got a nice woman who told me she was one of the president's assistants who also told me I was the first HD Radio call, ever. I identified myself as being the VP/CDOE of

> Buckley/WOR Radio, told her why I was calling and looking. She sent me to the head of audio accessories/entertainment. He couldn't help me. I was then passed around to department managers in Customer Service, Research, PR and Engineering. No one could assist me without pointing me to www.hdradio.com. I would like to think that I am somewhat "in the know" about HD Radio. (Ray, 2010, paras. 24 & 25)

Ray concludes:

> I would like to think that in this respect, I am more than the "average" consumer. But this consumer has had extreme difficulty getting HD Radio for his new vehicle. Is this typical of what Joe Consumer encounters? And what about the statement from everyone I spoke with at Ford who told me that I was their first HD Radio call? Add to the mix the fact that it appears adding HD Radio to a vehicle is going to be fairly costly and I wonder, why would Joe Consumer even bother? (Ray, 2010, paras. 32 & 33)

Miller (2013), in an article marking HD Radio's 10-year anniversary as a consumer product, also noted the problems consumers still face in getting an HD Radio, which belie the HD Radio Alliance's materials.

> Product availability is scarce, too. There are few home sound systems and table radios with HD, and almost no portable devices, since the Microsoft Zune went out of production last year. A list of available receivers can be found [on www.hdradio.com]….but most of these products aren't on the shelves of your favorite electronics retail store. (Miller, 2013, para. 16 & 17)

Consumer Evaluations and Criticism

Consumer response, indicated by both radio ratings and sales figures, has been tepid at best. Many consumer reviews focused on reception problems and lack of truly innovative programming available on the additional audio streams. As early as 2007, critics, citing murky but demonstrably low sales figures for HD Radio, were already calling the endeavor a "dud" or "failure." Richard Harker, writing in the radio industry publication FMQB, noted the sales disparity between other technologies and HD Radio.

> Apple took 74 days to sell one million iPhones. Despite mixed reviews, numerous glitches, a long-term service agreement, and a $600 initial price

> tag, they managed to move nearly 700,000 the first weekend….In March 1997, the DVD was launched. The first year, 350,000 DVD players were sold. … [T]here are over 15 million satellite subscribers and something like 10 million radios sold. Sales figures for HD Radio sales are hard to come by and sketchy at best. HD Radio has been around for three years now, and last year there were perhaps a couple of hundred thousand sold. (Harker, 2007, paras. 1 - 4)

Harker also noted the public's perception of HD Radio versus the promises made about HD service:

> What buzz HD Radio has ranges from mildly tepid to strongly negative. And mostly true. There are serious issues of coverage. Early adopters who bought HD radios report serious drop-outs, poor coverage, and interference. The engineers of iBiquity may argue otherwise and defend the system, but the industry has a serious PR problem with the very people we need to get the word out on HD. (Harker, 2007, para. 7)

Also in 2007, *Washington Post* blogger Marc Fisher wrote that after nearly three years on the market, HD Radio was barely making any headway in the United States. Consumer awareness remained extremely limited about the product and, as such, there was little interest in terrestrial digital radio. Fisher noted the disparity between the diffusion of digital audio broadcasting in the United States and Great Britain.

> [T]he same technology is being adopted quickly and happily in Britain. About 6 million digital radios have been sold there, while only a few hundred thousand have moved off the shelves in this country's much larger market. The main difference: British commercial and public broadcasters are providing extensive new and live content on digital stations, while U.S. media companies use their extra channels mainly to provide canned, automated music programming. (Fisher, 2007, paras. 3 & 4)

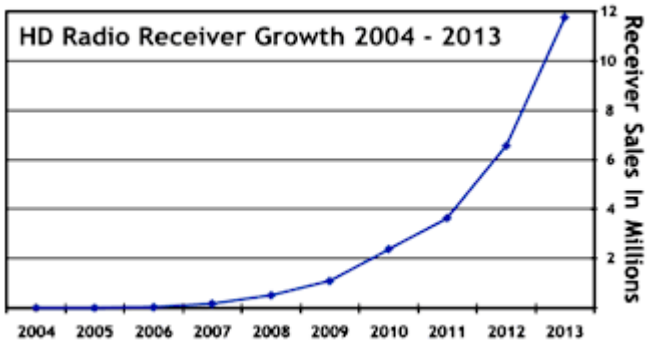
The article also notes a confusion between satellite-delivered digital radio and terrestrially-based HD Radio on the consumer sales level, including sales professionals who should know the difference.

> HD Radio has lagged far behind pay satellite radio in winning the curiosity of listeners. "It's been so frustrating," [WAMU general manager Caryn] Mathes says. "We're right across from a Best Buy and we'd go in

> there incognito to ask about HD Radio, and invariably we'd be taken to the satellite section," where clerks would point to the XM radios. (Fisher, 2007, paras. 17 & 18)

What has slightly brightened the outlook for HD Radio are sales figures that also include units in cars. When HD Radio compatible receivers are installed in automobiles as standard or optional equipment, the company counts those as "sold" HD Radio receivers. By 2010, iBiquity CEO Struble estimated that "more than 3 million HD Radio sets were in the hands of consumers" (Palenchar, 2010, para. 2). By 2012, Struble announced that sales of home and in-car units reached 2 million sets in calendar year 2011 and that iBiquity projected sales of 3.3 million units per year in both 2012 and 2013 (Mook, 2012).

Figure 3.1: HD Radio Receiver Growth 2004 – 2013

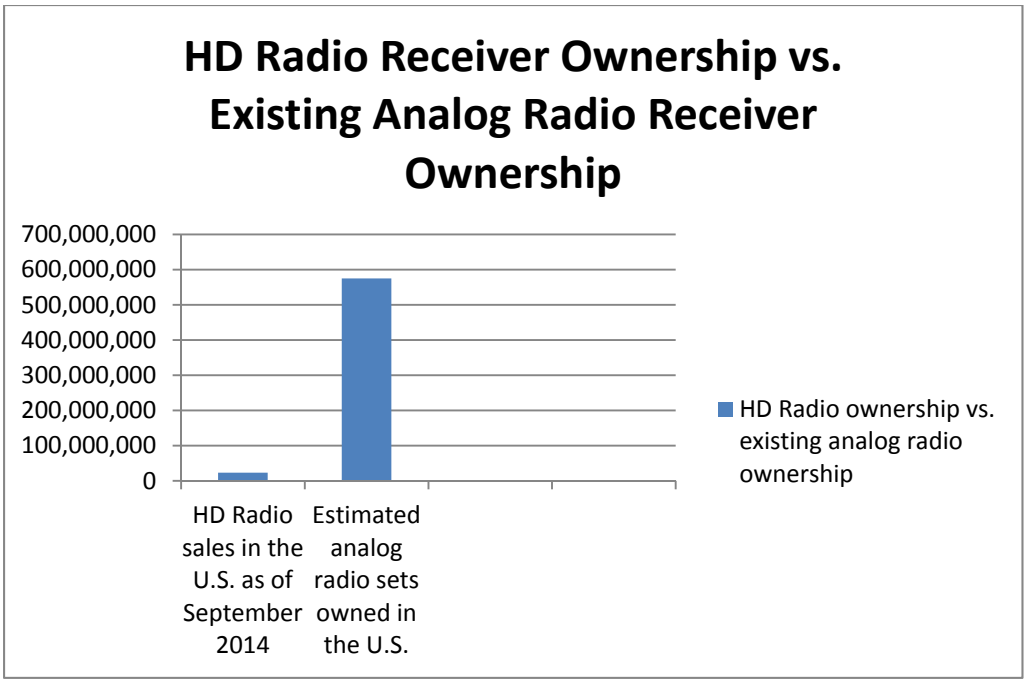


(iBiquity, 2013)

Although these overall numbers look promising, they are only a small proportion of the total number of analog receivers in the United States being sold. To illustrate the sales challenge HD Radio faces, in 1997 the United Nations Educational, Scientific and Cultural Organization (UNESCO) estimated that the number of radio receivers owned in the United States totaled 575 million, prior to the introduction of any digital service (United Nations Educational, Scientific and Cultural Organization, 1997). Because

analog broadcasting has continued even with the introduction of DAB, there is no reason to suspect that ownership of analog radio has dwindled proportional to an upsurge in HD Radio ownership in the intervening 15 years.

Figure 3.2: HD Radio Receiver Ownership vs. Existing Analog Radio Receiver Ownership



(iBiquity, 2014; United Nations Educational, Scientific and Cultural Organization, 1997)

Ratings

HD Radio entered the market with low receiver sales figures and confusion among potential consumers; therefore, it is no surprise that audience ratings for HD-only radio stations are practically non-existent. In the May 2010 Arbitron radio ratings, the Washington D.C. NPR affiliate WAMU-FM HD-2 became the first non-commercial public radio HD-2 audio channel to be rated by Arbitron (Robins, 2010). This achievement came shortly after the first commercial station made Arbitron's monthly

ratings (Robins, 2010). HD-only second and third channel audio streams remain rarities on monthly ratings reports in all markets, despite the apparent increase in HD Radio unit sales for both automobile and home receivers. In Portable People Meter (PPM) rated markets, all HD signals, including HD subchannels, are encoded with station identifiers in the same manner as the analog frequency in order to measure listening. Diary-based ratings markets may be an even more difficult challenge since listeners cannot simply report a frequency in their diary; they must also identify the HD-2 or HD-3 stream by some other identifier, such as format name or slogan (Valentine, 2013).

Certainly, the slow diffusion of HD radio units diminishes the chances of HD-2 and HD-3 stations capturing listeners' attention, but importantly, the universe of HD Radio signals remains only a fraction of existing analog radio. In early 2013, iBiquity's website reported a total of 2,042 HD Radio stations broadcasting in the United States (iBiquity, 2013c). According to the FCC, there were 15,196 full-power commercial and educational analog radio stations as of December 2012; thus, HD Radio stations accounted for only 13.4% of the analog total (Federal Communications Commission, 2013a). Few stations now convert to HD broadcasting; only 17 stations added HD capability in 2011, down from a peak of 521 station conversions in 2006 (Santhanam, Mitchell, & Rosenstiel, 2012a). 55 more stations ceased HD broadcasts than adopted the technology in 2012 (Santhanam, Mitchell, & Olmstead, 2013).

Marketing HD Radio

In an attempt to educate consumers and increase sales, the HD Digital Radio Alliance has infused hundreds of millions of dollars in cash and donated airtime to raise awareness and interest in HD Radio and encourages listeners that "It's Time To

Upgrade!," a slogan used for many HD Radio promotional advertisements. At the 2005 consumer rollout of HD Radio technology, the Alliance promised $200 million in commercial airtime "to promote HD digital radio and the new HD2 multicast channels" (HD Digital Radio Alliance, 2006b, para. 4). In 2007, that airtime commitment among Alliance partners was increased to $250 million and further commitments of $230 million were made for 2008 for a total of $680 million in promotional airtime (Brass, 2006; Radio Ink, 2007).

Promotional efforts continued into 2010. For the calendar year in 2010, the Alliance aired 1,135,215 radio commercials, making it the fifth largest radio advertiser of the year in number of commercials, ranking behind Geico Insurance, Home Depot, McDonald's, and Verizon (Media Monitors, 2010). But, more recently, the Alliance has reduced its promotional efforts in both dollar amount and commercial inventory. In 2011, the announced promotional commitment by the Alliance fell to $110 million and those dollars were concentrated on 650 radio stations in the nation's top 100 markets by population (HD Digital Radio Alliance, 2010). The commitment slowed further in 2012 and, by year's end, the Alliance had fallen from radio's seventh-largest advertiser to number fifty-seven (Inside Radio, 2013a).

These promotional campaigns by the Alliance are not without critics. Radio consultant Fred Jacobs noted on his blog the "snarky" attitude of one particular commercial which sought to portray analog radio as old-fashioned and weak. Jacobs questioned this "relative advantage"-type of approach, especially since HD Radio could have promoted its attributes against *competitors*, such as subscription-based satellite radio and music downloading (Jacobs, 2007). In the end, Jacobs did not understand why

HD Radio chose to market itself *against* traditional AM/FM radio, especially considering "those are the same stations that are expected to invest millions of dollars of their precious air time running these commercials" (Jacobs, 2007, para. 5).

These marketing efforts have produced some limited success. According to Arbitron, by 2011 a slim majority of Americans had at least heard of HD Radio, with only the 55 and over demographic group falling below a 50% level. However, despite the intense promotional effort through the Alliance and other avenues, the percentage of Americans who say they are very interested in HD radio never rose above 8% of respondents from 2006 through 2010 (Santhanam, Mitchell, & Rosenstiel, 2012a). Other industry studies show widely different awareness statistics and marketing efforts have not eliminated the confusion among consumers about HD Radio, how it works, if a subscription is needed, or whether they have ever heard an HD broadcast (J.D. Power and Associates, 2012; Kasoff, 2012b). For example, radio consultant Alan Burns surveyed 2,000 female radio listeners ages 15 - 54 and found only 25% of those surveyed were aware of HD Radio. Among that population, only about half knew that at a HD-compatible receiver was necessary to hear HD radio and two thirds of those respondents thought a subscription was needed to hear HD programming or did not know if one was needed (Stimson, 2012).

Audio Marketplace Competitors

The struggles of HD Radio to break through stand in contrast to several other competitors in the audio marketplace. Competitors to audio analog and HD Radio broadcasting include devices, such as smartphones and digital audio players, and content providers, such as Internet audio streamers.

Although radio remains the second most prevalent media in people's lives behind television, there is gloomy news behind that statistic. According to Arbitron, when asked whether they "like" or "love" different types of audio capable devices and services, only 22% said they "love" local AM/FM Radio (Santhanam et al., 2012a). This number pales in comparison to respondents who said they "love" their iPhone (66%), iPad (53%), Android phone (49%), digital video recorder (48%), and other types of smartphones (48%). Santhanam et al. (2012a) of the Pew Research Center posit "that people listen to AM/FM out convenience rather than out of deeper appreciation for the content" (para. 7). Indeed, the majority of conventional radio listening is not at home, but in a car where a radio is usually the only source of entertainment available to drivers. However, the days of terrestrial radio being the only entertainment available in a car are counted. From 2010 to 2011, the number of cellphone owners who listened to streaming online audio through a cellphone connected to the car's audio system nearly doubled from 6% to 11% (Arbitron, 2011). This figure does not count those who use other audio devices, such as MP3 players, which are connected through the car's auxiliary input or Bluetooth, to hear content. Doubly dangerous to local radio operators, not only can smartphones stream audio from services, such as Pandora, Spotify, iHeartRadio, and TuneIn, the devices can also stream out-of-town radio stations, in addition to podcasts and other digital data stored on the phone's internal memory. This capability sharply increases the number of competitors at home, at work, and in the car for traditional terrestrial broadcasters. In addition to smartphones, integrated digital dashboards on automobiles offering voice-activated 4G connectivity to Internet-based entertainment options in the car continue to be introduced by automobile manufacturers and after-market equipment manufacturers

(Fruhlinger, 2012; Schmidt, 2012). These Internet-connected systems, introduced by Ford, Mini Cooper, Mercedes-Benz, and others, are eliminating the long-standing position of radio as the only entertainment possible in vehicles. The critical questions are whether these integrated dashboard systems will include HD Radio as a standard feature or if it is even necessary to receive local over-the-air signals in a digital dashboard that can access content via the Internet.

Smartphones

The connectivity and capabilities of smartphones must be considered a primary threat to both analog and digital radio broadcasting. According to Nielsen (2012a), smartphone penetration in the American market among all manufacturers reached 50% of the United States, outnumbering feature phones[37] for the first time. In 2011, market penetration was only 36% for all smartphones. Android phones lead the smartphone market (52%), followed by Apple's iPhone (35%) and RIM Blackberry (7%) (Nielsen, 2012a). This market penetration is likely to increase in 2013 and the foreseeable future, as nearly two thirds of new cellphone buyers are choosing smartphones over feature phones (Nielsen, 2012a). Moreover, the passionate consumer response to these devices, especially Apple's iPhone, overwhelms every other type of electronic device. Upon the announcement of the release of a new iPhone, users camp out for days in front of Apple stores nationwide to be first in line to acquire the latest version (Associated Press, 2012; KTVU-TV, 2012). Applications (or "apps") for each smartphone operating system make streaming audio services easy and deliver quality audio. Even for consumers with capped data plans, streaming audio on a smartphone for a limited period of time every day should

[37] A feature phone is generally acknowledged to be a cellular phone with substantially less capability than a smartphone. It may be used for telephone calls and text messaging and may also have limited Internet capabilities, but usually cannot download apps and other software designed for smartphone usage.

not be a financial impediment to its use. For a user who streams 1 hour of audio per day for 30 days, Verizon estimates data usage for that period at 1.76 gigabytes; 1 hour of video streaming per day would result in 7.32 gigabytes per month on a 3G or 4G capable smartphone (Verizon Wireless, 2013).

Internet audio programming

The overall market for Internet-delivered audio continues to grow. The average self-reported amount of time spent with all sources of online radio[38] has nearly doubled in the last five years, from 6 hours 13 minutes per week in 2008 to 11 hours 56 minutes per week in 2013 (Arbitron, 2013). This market includes both traditional AM and FM broadcasters who stream their terrestrial signals via the Internet, plus Internet-only pure-play audio streaming services including Pandora, Spotify, iHeartRadio, Grooveshark, Jango, Slacker Radio, and other smaller independent "webcasters" that have no connection to terrestrial broadcasting. Many are free, but some have either additional subscription components or are subscription only (such as Verizon's Rhapsody service). These broadband audio services are also gaining listeners when directly compared to the audio streams of terrestrial radio stations. In 2011, Arbitron reported the percentage of people who listen to Internet-only audio streams reached an all-time high of 57%, an increase from 48% in 2006. Listeners choosing to enjoy webcasts of streaming radio stations fell in that same five-year period from 46% to 40% (Santhanam, Mitchell, & Rosenstiel, Audio: By the Numbers, 2012b). Now that listeners have increased mobile options through smartphones and integrated dashboards, the overall market for online audio is expected to continue to grow.

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[38] "Online radio" is defined by Arbitron as "Listening to AM/FM radio stations online and/or listening to audio content available only on the Internet" (Arbitron, 2013).

Services available via the Internet can be considered "free"[39] or "paid," depending upon whether a listener has to pay the streaming audio service a separate fee in addition to standard fees paid for Internet service. Although streaming audio can come from a variety of online sources, four of the largest competitors are Pandora, Spotify, iHeartRadio, and TuneIn.com. Although a thorough examination of these services is beyond the scope of this work, it is important to review their operational models to understand how streaming audio can impact the prospect of HD Radio.

Pandora began as the Music Genome Project in 2000, which sought to code music patterns within songs and thereby create pseudo "radio stations" by linking together songs to fit an individual user's preferences (Pandora, 2013a). Listeners type an artist, song, or genre of music into an initial search engine, and Pandora finds the requested item and plays it. It then follows that initial search item with songs that, according to its coding, are similar to the original requested item. Listeners have no direct choices about what songs are coming next; those choices are entirely made by the Pandora program. Listeners can create up to 100 "radio stations" as they like, each based upon a particular genre, artist, or song. The Music Genome Project began streaming audio in 2004 under the name Pandora (Pandora, 2013a). As of January 2013, the service remains the largest online audio streamer in the world, with 125 million registered users and 65 million active users (Team, 2012). Total listener hours for January 2013 were up over 47% from the prior year (Pandora, 2013b).

Pandora's biggest problem has been profitability (Leske, 2012). At its beginning, Pandora used an advertising-based business model exclusively. Advertisements are

[39] Although no direct cost is billed to the listener, "free" services are generally supported by sponsor-paid advertising.

played in between songs after every four to six selections, many times with a visual component displayed on user screens. In 2009, Pandora began offering Pandora One, a yearly $36 subscription service that promised higher audio quality (streaming at 192 kbs), fewer interruptions, and no visual or audio advertisements (Pandora, 2013c). Pandora began offering this service as a response to continued financial losses, exacerbated by the 2007 increased song royalty costs imposed by the United States Copyright Royalty Board (Kafka, 2012; Masnick, 2009). Although Pandora and other Internet broadcasters eventually negotiated for a lower rate than initially imposed, the additional royalty fees have hampered its efforts to become a profitable enterprise. As of January 2012, Pandora had lost a total of $105 million over the previous five fiscal years and has never turned a profit in its history (Rogowski, 2012).

Much of Pandora's profitability problem, and a major problem for all Internet audio providers, can be traced to royalty payments required for music streams. Royalties are payments made for the right to use copyrighted music in live performance, broadcast, satellite, or Internet audio streaming contexts. Broadcasters, including HD Radio channels,[40] only pay fees to music licensing societies, such as the American Society of Composers, Authors, and Publishers (ASCAP), Broadcast Music Incorporated (BMI), and the Society of European Stage Authors and Composers (SESAC), for content transmitted over-the-air. If content is streamed on the Internet or transmitted through cable audio services or satellite services, royalties must also be paid to SoundExchange—the "sole entity in the United States to collect and distribute these digital performance

[40] Although HD Radio is a digital over-the-air transmission, it is not considered a digital stream in the same manner as an Internet, cable, or satellite transmission. Therefore, terrestrial broadcasters do not have to pay SoundExchange performance rights royalties for HD Radio unless streamed over the Internet (S. O'Malley, personal communication, 2013).

royalties" (SoundExchange, 2013). The key difference between the music licensing societies and SoundExchange is that SoundExchange collects royalties owed from *performance* of the actual sound recordings; ASCAP, BMI, and SESAC collect royalties owed for the *music compositions* embodied in the sound recording (S. Elton, University of Miami, personal communication, 2013). Over-the-air broadcasters that stream their signals on the Internet must pay SoundExchange in addition to what they pay to ASCAP, BMI, and SESAC.

One estimate is that Pandora pays nearly 50% of its revenue in royalty payments (Duncan, 2012). In comparison with other audio services on other platforms, this cost is a substantial disadvantage. Duncan (2012) and Villasenor (2012) estimate that companies that provide cable television audio services, such as Music Choice,[41] pay only 15% of their gross revenue towards royalties and SiriusXM pays only 8% of its gross revenue towards royalties. In February 2013, Pandora announced the reinstatement of monthly 40-hour listening caps for users of its free, advertising-supported stream. Pandora cited rising song royalty costs and its need to limit those outlays as the reason for the cap, but noted that 96% of its users listen fewer than 40 hours per month and would therefore be unaffected by the change (Pandora, 2013d). These caps were lifted for mobile users (but not laptop computer or desktop computer users) in August 2013.

Another "pure play" option for online streaming is terrestrial radio giant Clear Channel Media + Entertainment's iHeartRadio. Debuting in April 2008 as iheartmusic.com, the website was created as a platform for music videos, entertainment news, and a place to find most of Clear Channel's 850 radio station websites and their

[41] The dominant cable television audio service is called Music Choice (Oxenford, 2013b). Music Choice offers a variety of music-formatted audio streams and on-demand music services.

associated audio streams. The site was rebranded as "iHeartRadio" with the release of the free radio station streaming app for Apple products in October 2008 (Ankeny, 2011). Since then, iHeartRadio (later shortened to iHeart.com) has grown beyond simply streaming radio stations to offering music videos, including live performances, and other content. Offerings have grown well beyond only streams of Clear Channel stations; in 2012, major radio ownership groups, such as Cumulus Media, Cox Radio, Emmis Communications, and Salem Communications, signed up with iHeartRadio to have their stations streamed via the service (Osborne, 2012). It serves as a streaming platform for over 1,500 radio stations (IHeart.com, 2013). Furthermore, iHeartRadio supports listener-created Internet stations, similar to Pandora and the "radio" feature on Spotify, with over 15 million songs available for registered users. Although user data is tightly controlled by the company, Clear Channel claimed in a January 2013 press release that iHeartRadio "is the fastest digital service to reach 20 million registered users in internet history, faster than all other popular digital entertainment and social platforms, including Facebook, Twitter, Pandora, Spotify and Instagram" (Clear Channel Media + Entertainment, 2013, para. 7).

Another aggregator[42] of radio streams is TuneIn.com. Founded in 2002 as RadioTime, TuneIn is a central location to find the internet streams of more than 70,000 AM, FM, HD, Internet-only, and LPFM (low-power FM) radio stations and radio networks from around the world, including major U.S. radio ownership groups, such as CBS Radio (Polivka, 2012) and Salem Communications (Salem Communications, 2012), plus access to over two million on-demand programs (Lardinois, 2012). Station owners

[42] In the context of digital media, an aggregator is a website that links to information from multiple Internet sources and consolidates it on one Internet website for easier access for consumers.

grant permission for their audio streams to be included on TuneIn. TuneIn, as a conduit for broadcaster audio streams, does not pay royalties; those payments are made by the individual stations that are streaming content. Users can stream stations on desktop and laptop computers as well as mobile devices and other consoles, such as Roku and Boxee. TuneIn claims 30 million active users and has seen explosive growth over the past few years, including 267% growth in mobile listening from 2011 to 2012 and a corresponding 348% increase in total listening hours (Lardinois, 2012).

As a free application, TuneIn is also aiming directly at a traditional radio stronghold: in-car listening. TuneIn announced in January 2012 that it will be integrated into Ford Motor Company's Sync AppLink platform which would allow users to access and control by voice command TuneIn content (Kim, 2012). Users will be able to make voice searches for songs, artists, specific radio stations, podcasts, and genres of music while driving. TuneIn also announced that its Android app would allow much of the same functionality. TuneIn chief executive officer John Donham said that, "[t]he Ford deal is just the beginning for us. I think a lot of listening will shift to digital. We're seeing people using the digital dashboard rather than their analog dash" (Kim, 2012, para. 8).

TuneIn makes money through display advertisements on users' devices; it does not interrupt broadcast programming to insert its own audio commercials (Radio Ink, 2012b), although Donham indicated the service will start "pre-roll" audio advertisements[43] in the future (Andrews, 2012). TuneIn does not have a premium subscription service tier, but Donham points to TuneIn's mobile apps (Radio Ink, 2012b);

[43] These "pre-roll" advertisements would be heard before TuneIn links to the broadcast station's stream; the advertisements would not interrupt programming after linking to the stream.

one allows free listening with display ads and the other, named TuneIn Radio Pro, allows listeners to record programming available on TuneIn for a one-time-only purchasing fee[44] (Andrews, 2012; TuneIn Radio, 2013). After purchase, the TuneIn Radio Pro still permits users free access to all of TuneIn's content.

Moving beyond the "pure play" audio streamers, user-controlled services are making a significant impact in the audio marketplace. Spotify is one such interactive streaming service, developed in 2006 by Spotify AB in Sweden and rolled out to consumers in select countries by 2008. Spotify began service to the United States on July 14, 2011, making it a late entry into the American audio marketplace (Buskirk, 2012). Although it is a streaming audio service, Spotify differs from Pandora in a very significant way: users may choose the specific songs and artists they want to hear.

This capability also means that Spotify pays royalties to artists in a much different way. Instead of adhering to the statutory rates set by the Copyright Royalty Board for non-interactive services, Spotify directly negotiates with rights holders, including artists, record labels, and music publishers for the royalties it pays (Spotify, 2013b). Spotify keeps these agreements confidential. Artists and songwriters are paid "according to their specific contractual agreements" (Spotify, 2013b, para. 7) and "in relation to an artist's popularity on the service" (Spotify, 2013b, para. 9). In addition, Spotify also has a "radio" feature that allows playback similar to Pandora based upon song, artist, or genre attributes (Chandler, 2013).

Like Pandora, Spotify has both free and subscription tiers. Free users are limited to 10 hours per month, split into 2.5 hours per week. The subscription "Unlimited" tier

[44] TuneIn allows radio station audio streamers to opt out of allowing users to record their stream; TuneIn Pro will not allow the recording of any entity that opts out.

costs $4.99 per month and is commercial-free and allows for unlimited streaming, but is limited to non-mobile desktop and laptop computers. The "premium" tier allows streaming to tablets and smartphones for a charge of $9.99 per month and also allows users to download content for off-line listening (Spotify, 2013a).

As of December 2012, Spotify had 20 million active users in 17 countries and 5 million subscribers, including 1 million in the United States (Sisario, 2012). From 2011 to 2012, the service grew by nearly 2 million subscribers globally. Spotify co-founder Daniel Ek boasted at a New York event that "We did in one year what it took others a decade to do" (Bradshaw & Edgecliffe-Johnson, 2012, para. 4).

Finally, it should be noted that YouTube has become a prime source to listen to millions of recorded songs uploaded by both record labels and users, in addition to viewing music videos, live performances, and live video streams from major cultural, political, and social events. Because the site supports both video and audio, YouTube has become a "go-to" site for people looking to listen immediately to a particular song. Official music videos or audio with a "placeholder" picture are often uploaded by record labels, but many YouTube videos are user-generated audio or video files uploaded for other's enjoyment. Teens are the group taking advantage of this instant, free, music source. According to a 2012 Nielsen study, more teenagers listen to music online through YouTube (64%) than any other source including radio (56%), iTunes (53%), or on a CD (50%) (Nielsen, 2012b). Although radio (48%) maintains a large advantage in terms of music discovery, YouTube (7%) is steadily gaining on friends and family (10%) as a source for young people to hear or hear about new music (Nielsen, 2012b). Files on

YouTube cannot be legally downloaded from the site, but its importance as an audio source cannot be underestimated.

There may be a major shake-up in the streaming audio marketplace on the horizon. Several technology-sector giants have launched or have shown interest in starting their own music services. Microsoft debuted the Xbox Music Pass, a $9.99 streaming service, in October 2012 (Gupta & Grover, 2013). And, according to published reports, Google, Apple, and Amazon.com are each in planning stages of offering subscription music streaming services of their own (Gupta & Grover, 2013; Titlow, 2013). Each of these businesses brings a tremendous amount of financial capital into the streaming marketplace. Whereas Pandora, which only exists as an audio streamer and operates at a loss, Google, Apple, or Amazon—each with highly diversified product lines—would be able to confine any loss to only a sector of the company. Overall, the company would remain profitable because other company divisions could make up the loss. Pandora does not have other divisions to provide this type of support. Also, Google, Apple, and Amazon each manufacture hardware products that can be pre-loaded with their own streaming music service. All three entities have the business leverage to directly negotiate with labels and artists for lower royalty payment rates (Titlow, 2013) and Google, Apple, and Amazon say that they expect the streaming audio business to be profitable for them (Gupta & Grover, 2013).

Other Personal Audio Devices

Personal audio devices that do not stream audio from an Internet source must also be considered competitors to radio broadcasting in the audio marketplace. Since the introduction of 8-track and portable cassette players (in particular, the Sony Walkman) in

the 1970s, broadcasters have long recognized the personal programming power these devices hold. Consumers bought millions of Walkmans (Shiloy, 2007) and other cassette based devices and, when portable compact disc (CD) players emerged on the market in 1983, they became hugely popular items as well.

The catalyst for the digital revolution of personal audio devices was the emergence of digital audio compression technology and the development of digital personal media players in the late 1990s. The first commercial device, The Audio Player from Audible.com, had 4 megabytes of memory, enough for up to 2 hours of audio. Other hard drive based audio devices were also introduced, but none captured the public's imagination until the debut of Apple's iPod in October, 2001 (Apple Inc., 2013). The iPod originally offered the convenience of "1,000 songs in your pocket" from a 5-gigabyte internal hard drive (Apple Inc., 2013, para. 2). It quickly became the dominant personal audio player on the market, and the iPod product line became available in three separate models with different storage capacities and features: the Classic iPod, the Nano, and the Shuffle. Current "Classic iPod" models offer 160 GB of storage, enough for approximately 40,000 songs (Apple Inc., 2013). The devices also store video, text, and other application data. Apple supports the various iPod models by offering content and apps through its iTunes digital music store, launched in 2003 and offering millions of songs and more than 250,000 apps available for purchase and download. Apple's tablet computer, the iPad, also has music storage and playback capability and can also download songs from iTunes. In 2012, the iPod remains the best-selling MP3 player in most countries and retains a market share of over 70% (MacTech.com, 2012). Dozens of other personal audio device manufacturers compete for the remaining share of

consumers. Most devices accept several compressed formats, including MP3 and Windows Media Audio for playback.

Satellite Radio

As opposed to either analog or HD Radio systems, satellite radio is a monthly subscription-based service. In February 2007, the two satellite radio providers, Sirius Satellite Radio and XM, announced that they would merge operations to form one digital satellite radio company known simply as SiriusXM radio (Ellis & LaMonica, 2007). The merger approval process would prove to be the longest to date in United States history, as concerns were raised over former competitors now becoming a monopoly over an entire segment of audio broadcasting in the United States. Main issues included possible unconstrained price increases, a less competitive marketplace for audio consumers, and harm to other audio marketplace competitors (Kharif, 2008). In March 2008, the U.S. Department of Justice approved the SiriusXM merger. In July of that same year, the FCC approved the merger by a 3-2 vote (Federal Communication Commission, 2008b). In approving the merger and refuting marketplace monopoly arguments raised by critics, the Justice Department stated that "the evidence did not support defining a market limited to the two satellite radio firms that would exclude various alternative sources for audio entertainment, and similarly did not establish that the combined firm could profitably sustain an increased price to satellite radio consumers" (United States Department of Justice, 2008, para. 3). In other words, competition from other audio entertainment sources would constrain the newly merged company from unreasonably raising prices for equipment and content. Consumers would have the choice to go elsewhere in the

marketplace[45] for audio entertainment if they were dissatisfied with satellite radio, which means that a merged SiriusXM company was not a "monopoly" over all audio entertainment.

The newly-merged company has continued to grow and, as of 2012, has 23,900,000 subscribers who can listen via satellite broadcasts and online streaming (SiriusXM, 2013b). The company has created several subscription packages, including an "All Access" annual plan for $199, monthly packages carrying the names "Sirius Premier" (140 channels for $17.99 per month) and "Sirius Select" (130 channels for $14.99 per month), and an "a la carte" option that allows subscribers to pick the channels they want. Smaller "Specialty Plans" offer service for as low as $9.99 per month for commercial free music, news and sports talk, or family-friendly content. If subscribers want online streaming access to SiriusXM programming, they can pay additional fees on any available plan (SiriusXM, 2013a).

Financially, SiriusXM appears to be on an upswing. In January 2013, Sirius XM announced it had netted over 2 million new subscribers in calendar year 2012 (SiriusXM, 2013b). One month later, the company announced that revenue was up 13% in 2012 over 2011 (Inside Radio, 2013b). Foreshadowing a competitive impact on iBiquity and HD Radio, SiriusXM has now achieved a remarkably high penetration rate in new cars (estimated at 67 – 68%) and garners much of its revenue and subscriber growth to listening in vehicles. As these cars age and enter the used car market, SiriusXM expects to reap even more subscribers from second, third, and fourth owners of these vehicles (Team, 2013).

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[45]Audio marketplace options include terrestrial radio, personal audio players, and streaming services delivered to mobile telephones (U.S. Department of Justice, 2008).

Analog Radio

Traditional analog broadcast radio remains the bedrock technology of the audio marketplace and, because of its near-universal presence in homes and cars, must be considered as a competitor to the technology that seeks to replace it. Throughout its history, radio programming has evolved in response to changing competition within the industry and from outside competitors. As television began to take away radio's scripted series and stars, the medium turned to music programming and appealed to the young by converting many stations to rock and roll-based music outlets, almost all on the AM band.[46] When listeners discovered FM broadcasting and its superior audio quality in the 1970s, music-formatted stations flourished on FM, and AM music stations either switched formats or, if possible, migrated music formats to a co-owned FM signal. AM broadcasters, now a second choice for popular music listening, switched their focus to news and talk radio, particularly conservative Republican talk with hosts such as Rush Limbaugh, Sean Hannity, and Glenn Beck, that continue to dominate AM radio stations in the United States. Other AM stations have focused upon religious or foreign language and music programming (Sterling & Kitross, 2002).

Radio's business models have both commercial and non-commercial branches and have remained largely unchanged over the decades. Commercial stations sell on-air advertising to clients who wish to reach the broadcast audience; the advertisers make it possible for broadcasters to continue to provide "free" programming. In recent years, additional advertising revenue streams from station website advertising sales and what is

[46] Rock and roll programming FM would begin by the late 1960s.

described as "non-traditional revenue" (NTR)[47] have contributed to overall finances, but on-air advertising remains the staple funding of commercial radio. Non-commercial stations financially operate by accepting charitable grants, donations, government contributions, or by self-funding (Halbert & McDowell, 2013). Generally, commercial radio stations are owned by private companies while non-commercial stations are more often owned by educational institutions, school boards, religious groups, and others who are "broadly representative of the educational, cultural, and civic groups in the community" (Waldman, 2011, p. 314).

According to the FCC, there were 15,196 radio stations in the United States as of December 2012. Of this total, 3,860 were FM educational (non-commercial) stations (Federal Communications Commission, 2013a). All commercial and non-commercial stations are licensed by the FCC to serve specific communities in the "public interest, convenience, or necessity" (Federal Communications Commission, 2008a, para. 2) and must renew those licenses every eight years upon review of their record of performance.

Today, even in the face of several competing technologies, analog radio broadcasting's household penetration and audience levels remain high. According to Arbitron, 93% of Americans reported owning at least one radio in 2011. This percentage has changed little over the past few years, but is slightly down from 96% in 2001 (Santhanam, Mitchell, & Rosenstiel, 2012b). The Radio Advertising Bureau (RAB) noted that 92.8% of Americans over the age of 12 listen to the radio each week and that radio's total weekly audience is estimated at 241,512,000 listeners (Radio Advertising

[47] Non-traditional revenue can include any revenue generating activity that is not tied to a traditional paid on-air advertising schedule (Paskvan, 2010). Examples include, but are not limited to, online coupon sales to listeners, promotional events and festivals that the station produces and receives money from vendors for their participation, and ticket sales revenue from music concerts the station promotes and produces.

Bureau, 2012b). Radio's daily reach was estimated at 77% of all adults in 2011. Analog radio users also have remarkably similar percentages when compared side by side; user levels by age and gender hover between 91% and 95% with only a significant drop-off occurring with persons over the age of 65 (RAB, 2012b). Only television has a higher household penetration level at 98% (Santhanam et al., 2012b).

Much industry discussion centers on radio's relevance to the audience, especially younger persons who have grown up in an age of incredible choice when it comes to audio entertainment. The NAB, RAB, and Arbitron have countered that radio has maintained consistent levels of listenership among younger users, even as more audio options have come to the marketplace. The RAB (2012b) noted weekly reach among teens between 89.8% (male) and 92.8% (female), despite the emergence of Internet-based technologies and personal digital media devices. At first, these statistics show that the 90-year-old, analog-based radio industry appears to be adapting to a rapidly changing audio marketplace remarkably well. However, one troubling area is time spent listening (TSL) to radio. The Radio Advertising Bureau reported that TSL has declined sharply since 2007, from a weekly total of 19 hours 46 minutes to 14 hours 46 minutes (RAB, 2012b). A 5-hour weekly TSL erosion over a 5-year time period must be seen as a serious problem for the industry as it competes with new entrants.

Coexistence of old and new technology is not a new phenomenon. Although the population adopts a new technology, it is not automatic that the existing technology will be discarded. The introduction of television, cassette recorders, CD players, and streaming audio failed to kill radio broadcasting as an effective, money-generating business. Although harmed like many businesses during the economic downturn of 2008

– 2009, the radio industry has seen positive growth since that period. For calendar year 2012, the RAB reported total commercial radio industry revenue of $16.48 billion and noted that this figure marked three consecutive years of revenue growth (RAB, 2013).

Where Does HD Radio Fit?

HD Radio is an innovation that enters a crowded marketplace; however, it obviously does not enter as a completely unknown type of product to either broadcasters or listeners. Local stations still broadcast, but now do so with digital transmitters in addition to the analog versions. The additional HD-2 and HD-3 signals, when used, are programmed almost exactly as the main analog/HD-1 channel is programmed. There is focus on a particular format, time allotted for promotional and station identification announcements, and, if there are any, time for commercials. On the consumer side, ordinary radio listening is a near-universal experience and those who buy HD Radio receivers are promised to still receive the stations they already know, plus additional audio content channels with greatly improved audio fidelity. Receivers have been made to function similarly to analog tabletop, personal, and in-car models that have been on the market for decades with familiar volume and tuning buttons or knobs. The additional features of HD radio—ability to pause live broadcasts, the ability to "tag" songs[48] for later purchase through iTunes, and more—do not severely complicate the listening experience. Perhaps this is one of the problems with HD Radio—a lack of clear differentiation between the existing analog product and the new digital product. In a world where content can be delivered on demand to individual customers, persuading

[48] According to iBiquity, "iTunes tagging enables consumers (using HD Radio receivers that have been equipped with a special "Tag" button) to "tag" songs that they hear on the radio for subsequent preview and purchase on iTunes." (iBiquity, 2014, para. 1)

consumers to spend the money to switch to a digital-based version of a familiar product does not appear to be an easy sale.

HD Radio seeks to replace a familiar, ubiquitous technology. In the case of HD Radio, it is a technology that has been part of American life for almost a century and is still accessed by more than 90% of the population each week. Moreover, there appears to still be a general satisfaction with radio as it currently exists. In 2012, consultant Mark Kasoff polled 649 persons ages 18 – 64 and found that a clear majority of listeners (60%) were either "100%" satisfied with current radio or "mostly satisfied" with radio. Listeners rated their favorite station even higher, with 33% "mostly satisfied" and almost half (48%) "100% satisfied" with that individual station (Kassof, 2012a). While this survey may reflect more satisfaction in programming rather than technology, it underscores the point that from the perspective of many listeners, current analog radio works for them just fine and the improvements HD Radio promises may not be as revolutionary as necessary to make an impact. The product, as it exists, is satisfactory. Kasoff concluded that, given the sometimes negative press coverage of radio, "that people in the industry are harder on radio than listeners are" (Kasoff, 2012a, para. 8).

But consumers will ultimately not decide whether they get to keep the analog radio system. The Federal Communications Commission, the regulatory agency for over-the-air television and radio, has stated that a long-term goal of the agency is to implement an all-digital broadcasting system in the United States; in accomplishing this goal, the Commission has demanded as little disruption as possible to the public during the transition period (Federal Communications Commission, 1999). Full-power television converted to a digital system in 2009, but radio continues as a mainly analog medium

with no end date in sight. Only through examining the records of the FCC and the decisions it has made, plus the effect these decisions had on the broadcasting marketplace could the FCC's actions regarding HD Radio be understood in full.

Regulation

Purpose of the FCC

Government regulation is defined as "a rule or order issued by an executive authority or regulatory agency of a government and having the force of law" (Merriam-Webster, 2013) The Federal Communications Commission (FCC) "regulates interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories" (Federal Communications Commission, 2013e). Although originally created by Congressional passage of the Communications Act of 1934 to regulate radio broadcasting[49] and telephony, in time the FCC's regulatory purview would include over-the-air television broadcasting and aspects of cable television and satellite communication, and broadband Internet service (Federal Communications Commission, 2013e). The stated mission of the FCC is "[to] ensure that the American people have available, at reasonable costs and without discrimination, rapid, efficient, Nation- and world-wide communication services; whether by radio, television, wire, satellite, or cable" (FCC, 2013e, para. 5). Through the work of seven internal bureaus, the FCC "seeks to capitalize on its competencies in:

- Promoting competition, innovation, and investment in broadband services and facilities;
- Supporting the nation's economy by ensuring an appropriate competitive framework for the unfolding of the communications revolution;

[49] The precursor to the FCC was the FRC (Federal Radio Commission), created by Congress in 1927 to govern radio broadcasting exclusively (Sterling & Kitross, 2002).

- Encouraging the highest and best use of spectrum domestically and internationally;
- Revising media regulations so that new technologies flourish alongside diversity and localism;
- Providing leadership in strengthening the defense of the nation's communications infrastructure. (Federal Communications Commission, 2013e, para. 2)

When a new technology is developed that will affect wired or wireless communication business, the FCC has a central role in formulating regulations that impact the introduction and growth of the technology. Digital Audio Broadcasting (DAB) is no different. The FCC began exploring the feasibility of both DAB and satellite digital audio radio service (SDARS) in 1990; however, since systems for terrestrial digital radio broadcasting were not technically possible at the time, focus shifted to satellite digital service. While the Commission reaffirmed its commitment to over-the-air, localized, free radio broadcasting, it recognized the possibilities of digital broadcasting expanding service to local communities. Local broadcasters argued that the digital satellite services being contemplated could not match the localized content that only they could provide as local broadcasters. The Commission agreed, while continuing to encourage the development of a digitized system. Even at this early stage, the basic promises of more available content, efficient compression of data, and clearer sound quality were all noted by the Commission:

> [W]e anticipate that technical advances will soon permit both AM and FM broadcasters to offer improved digital sound. . . . Some of the systems being tested are designed specifically to permit digital broadcasting within the existing AM and FM bands. We fully support these developments, and we see great promise in these innovations for providing improved services to consumers. (FCC, 1999, p. 4).

Nonetheless, the Commission pushed ahead with satellite digital audio service as terrestrial systems continued to be developed. Terrestrial digital audio broadcasting

service was not considered for several years until the end of the 1990s, when technological advancements and implementation of DAB systems in other nations in Europe and in Canada had brought the issue again to the fore. In a *Notice of Proposed Rulemaking* (NPRM), dated November 1, 1999, the Commission reaffirmed its commitment to transitioning to an all-digital radio platform, through a "rapid and non-disruptive transition to DAB for broadcasters and listeners," while upholding the policy objectives of service to the public interest and protection of existing broadcasters. It stated:

> We begin with the settled determination that fostering the development and implementation of terrestrial DAB is in the public interest….The goal of introducing terrestrial DAB service is most fundamentally grounded on the promise of digital technology to provide vastly improved radio service to the public. It is our goal to authorize a DAB service that permits broadcasters and listeners to realize fully the superior technical performance capabilities of this technology….The Commission also remains firmly committed to the related goals of "supporting a vibrant and vital terrestrial radio service for the public" and creating DAB opportunities for existing radio broadcasters. We must ensure that the introduction of DAB does not weaken the vitality of our free, over-the-air radio broadcast service, which provides service to virtually all Americans through a strong, independent system of privately owned and operated stations. (FCC, 1999, p. 9)

The specific objective of this NPRM was "to seek to determine which DAB model and/or system would best promote our above-stated public policy objectives" (FCC, 1999). This is known commonly as standardization and the process of determining those standards is called standards setting. As noted by Braun (1994) in his exhaustive book on AM stereo development, everyone is surrounded by the results of standardization in everyday life. There are *uniformity* standards, such as one worldwide standard system for air traffic control. There are *interchangeability* standards, such as making sure products by different manufacturers "fit." Items affected by

interchangeability standards include common things, such as light bulbs and sockets or standard household electrical outlets. Finally, there are *quality* standards, such as minimum cleanliness standards for food processing (Braun, 1994).

One of the major benefits of having set standards in any consumer industry is financial. Most consumers have a limited amount of money to spend on new items and a uniform standard for those items ensures that marketplace competition is limited to an array of products within the standard. Competing products in the same market featuring different technology systems are usually incompatible with each other; the consumer must often choose which product benefits him most and leave the other products behind. Having a standard reduces the risk for the buyer that he or she will buy a soon-to-be obsolete piece of equipment. It is best for the consumer when it can be reasonably assumed that the purchased item will be compatible with existing systems that support other types of similar items.

The FCC is no stranger to setting standards; in fact, it is one of the agency's core purposes (Federal Communications Commission, 2013e). From the start, the FCC has been actively involved in setting standards for over-the-air radio and television broadcasting and, in particular, the use of the spectrum and broadcast equipment. Standardization activities included roles in the development of FM broadcasting, AM stereo broadcasting, and digital television broadcasting.

The Commission's standard-setting decisions can have enormous impacts, especially when millions or billions of dollars of capital investment can follow its mandates. Setting a poor standard runs the risk of "locking in" an inferior technology; not setting a standard can also run risks. In the case of AM stereo, Braun quotes FCC

Commissioner Abbott Washburn's rationale for dissenting from the decision to rely upon the marketplace to decide which standard for AM stereo was better:

> I differ with [the other commissioners] in assessing the consequences of multiple systems being offered to the public versus a single, nationwide system. The competing systems are technically incompatible….Will the public accept these inconveniences and added costs, when they can already receive a universal FM stereo signal that is at least as good as AM stereo would be? (Braun, 1994)

When a choice of technologies is present, the question is often whether the truly superior technology among the competitors is being chosen as a nationwide standard. Although the FCC does not have a history strewn with overtly bad decisions when it comes to standards setting, on occasion the Commission decided to stifle new technology, reverse earlier mandates, or even wait for Congress to act. When the commission has reversed itself on a major standards decision,[50] it has done so because a superior method or technology would have been a better decision, because a technological advancement far exceeds what is available under the existing standard, or, as a political matter, has bowed to business concerns of industry leaders. The latter is evident in the case of FM radio standards setting.

FM Radio

Frequency modulation (FM) broadcasting was developed by Edwin Howard Armstrong in the early 1930s, with Armstrong patenting his invention on December 26, 1933. Armstrong developed FM with the backing of David Sarnoff, chairman of the Radio Corporation of America (RCA), and sought to eliminate the problems of static interference common with AM broadcasting (Sterling & Kittross, 2002). Armstrong's invention was demonstrated several times before being officially shown to the FCC in

[50] A major FCC reversal was the switch to the RCA Color Compatible color television system from the previously-approved CBS color system in December 1953 (Reitan, 1997; Sterling & Kittross, 2002).

1936, proving to the Commission, the superior fidelity of this transmission method (RadioElectronics.com, 2013; Tsividis, 2013). However, entrenched business interests were already raising concerns about the innovation. Transition costs to FM, for both consumers and stations, would be large. Stations would have to invest in new transmitters and consumers in capable receiver units, replacing AM receivers purchased only within the previous decade. In addition, this new modulation scheme threatened the business interests of the now-established AM stations and networks. Despite the obvious improvement in quality, the radio industry reacted in ways to choke off, not encourage, the growth of FM (Tsividis, 2013).

Yet Armstrong persisted and the first broadcast FM station was granted a license and began transmission in Alpine, New Jersey, in 1939. By 1940, after much lobbying by Armstrong himself, FM broadcasting was given a permanent place on the spectrum from the FCC, which sectioned off a band from 42MHz to 50MHz (Bjerg, 2006). Receiver units were manufactured for consumers by companies, such as Zenith, Philco, and Emerson. Calling his FM station network the "Yankee Network," Armstrong's broadcasts throughout affiliate FM stations in the New England states continued throughout World War II (Sterling & Kittross, 2002). A *New York Times* article dated March 1, 1942, summed up the status of FM:

> Twenty-four FM stations are now operating commercially in the country, six others are nearly ready for that category, ten are operating experimentally with no immediate prospect of commercialism, fifty-five applications are pending and forty FM stations are under construction. The census of FM receivers in use from coast to coast, as of Jan. 1, 1942--except in the military service--topped 255,000, 50,000 of which are in the New York area. FM Broadcasters, Inc., which made the survey, estimates that 200,000 additional receivers will be produced by Spring. (Kennedy Jr., 1942, paras. 9 & 10)

By 1945, with the war winding down, the industry was focused on a new development they were sure would be a hit with consumers: television. Introduced at the World's Fair in 1939 by RCA chairman Sarnoff, production had been held in check because the materials were needed for the war effort. Now, looking at the future, RCA was heavily invested in television and ready to begin mass production of television receiver sets as soon as the war was finished (Sterling & Kittross, 2002). Sarnoff, the most powerful individual in the radio industry and a man who knew Armstrong's FM invention was superior to his AM-based business, lobbied the FCC personally to "solve" two problems. Sarnoff lobbied to move the FM broadcasting band to the range of 88MHZ to 108MHz, thereby freeing space for 6MHz television channels on the now-vacated lower band. Furthermore, by changing the already standardized position of the FM band, it would make all existing transmitters and receivers obsolete, mortally wounding Armstrong's competing enterprise (Tsividis, 2013). In a decision announced June 27, 1945, over the strong objections of Armstrong, four panels of the Radio Technical Planning Board, and various engineers at several different corporations, the FCC changed the FM frequency allocation to the higher band, citing fewer interference problems and a look towards the future for FM's most robust development (Young & Young, 2010).

The ruling was devastating for Armstrong and FM. With all previously-sold equipment now unusable and the tremendous cost of re-equipping both stations and consumers with radios that could receive the new band, FM languished for another two decades as listeners continued to use the near universal AM technology. Although the FCC at the time maintained that the higher frequency band would insure less interference

and room to grow for FM, the consensus among many historians remains that Sarnoff's lobbying of the FCC—which led to the decision that destroyed Armstrong's FM network—was a direct competitive rebuke to Armstrong for having dared challenge Sarnoff's AM-based RCA empire or threaten its profits with a competing technology (PBS, 2013).

AM Stereo

The inherent technical inadequacies of AM were well known and an impetus for Edwin Howard Armstrong to develop FM. AM is prone to electrical static interruptions, such as during a lightning storm or proximity to high tension electrical wires. AM has a narrow 10kHz channel in which to operate and its dynamic range is less than the full range a human ear can process, meaning the sound is less than lifelike quality. The development of FM highlighted the glaring weaknesses of AM by demonstrating resistance to most static interference and a greatly expanded dynamic range and fidelity.

AM stereo is more challenging technically than FM due to its much narrower channel, as compared with FM (Braun, 1994). There were crude attempts at stereo sound as far back as the 1920s, when broadcasters would experiment by putting half the sound on one AM frequency and half on a separate frequency. Aside from wasting spectrum space, the practical implication was that if a listener did not have two radios, that listener would only be receiving half of a broadcast (Braun, 1994; Sterling & Kittross, 2002). By the 1950s, as FM stereo systems were being petitioned before the FCC, AM stereo tests were progressing. Several companies, including RCA and Philco, petitioned the FCC for approval of their AM stereo systems by 1959 (Federal Communications Commission, 2014), with RCA successfully testing the first "true stereo" AM system that same year

(Braun, 1994). Consideration for AM and FM stereo and television stereo sound was ongoing, through the work of the National Radio Systems Committee (NSRC), throughout 1960 and into early 1961. The FCC, though pressured to approve stereo for all three services, chose to proceed only with FM at this time. The Commission viewed the costs for implementing stereo on FM to be lower than either AM or television of the time, and in the case of AM, the technical inferiority and likelihood of co-channel interference made it a proposition the Commission was not yet prepared to handle (Braun, 1994). In October 1961, the final decision of the FCC denying rulemaking in the matter of AM stereo was issued, with the Commission stating that neither the public or industry seemed to desire AM stereo at the time and that FM had far more potential to develop stereo broadcasting (Federal Communications Commission 61-1154, 1961). It is important to remember that AM broadcasting was still dominant in the early 1960s and the position of the FCC and many in the radio industry regarded AM stereo as an "unnecessary frill" (Braun, 1994, p. 45).

Suddenly, with competition brewing on the FM dial, discussion of AM stereo began anew. Tests of at least one AM stereo system (the Kahn single-sideband system) began by 1975 and "several major companies, including RCA, Magnavox, and Motorola renewed work on AM stereo during this time" (Braun, 1994, p. 48). Eventually six companies would petition the Commission for approval of their system as the standard for AM stereo broadcasting.

The Commission studied the issue in depth for a considerable amount of time, from 1977 through 1980, noting in its own webpage history of AM stereo the intention "to choose a single AM stereo system as the standard for the AM broadcast band" at that

time (Federal Communications Commission, 2014). In April 1980, in a 4-2 vote, the Commission did recommend choosing the system promoted by Magnavox as standard and prepared to issue an official *Report and Order* (Federal Communications Commission, 1980). However, the decision was attacked immediately by competitors and engineers; the system was allegedly "technically deficient" due to audible popping noises, although the Commission had previously stated that any one of the five systems was technically sufficient. Competitors were also incensed over the secrecy of the analysis used by the Office of Science and Technology (OST) to judge their systems; they had no idea how their systems were judged, what criteria was used, or why they lost to the Magnavox system. The FCC issued a *Further Notice of Proposed Rulemaking* instead of issuing a final *Report and Order* on the subject, claiming it needed more information (Braun, 1994).

By the autumn of 1980, a further petition by two of the companies that lost, Kahn and Hazeltine, asked the FCC for a marketplace approach to determining which system would be the standard approved (Braun, 1994). At this same time, coinciding with the election of Ronald Reagan in November 1980, a wave of deregulatory fervor hit not only the FCC, but other federal agencies as well. Reagan appointed a Republican majority to the FCC, and the new commissioners were strong advocates of deregulation. By 1982, the Commission by a 6 – 1 vote approved AM stereo without designating a specific system standard (Federal Communications Commission, 1982). The rationale for this decision was to let the marketplace decide the standard as long as the decision did not interfere with existing spectrum services. As Sterling and Kittross (2002) note, the

Commission did not say *which* marketplace among consumers, station owners, or manufacturers was deciding the issue. In defending its decision, the Commission stated:

> It is recognized that allowing the market to determine the selection of an AM stereo system or systems is a bold, new step for the Commission to take….Although some costs may be incurred….the potential benefits are substantial and should not be ignored. Therefore, we believe that pursuing the course of action set forth herein best serves the consumer well-being and furthers the Commission's mandate to regulate in the public interest. (FCC 82-111, 1982, p. 14, para. 59)

In addition, the Commission made clear that choosing this course of action, it hoped to avoid more lawsuits and delay the launch of AM stereo service. The lone dissenting commissioner, Abbott Washburn, predicted marketplace confusion and inconvenience from the decision (Braun, 1994).

The consequences of this FCC AM stereo decision bore out Washburn's concerns. Station owners, not knowing which system would eventually be the one to "win" the market, were hesitant to make any decision regarding implementing AM stereo transmitters, severely hampering sales. Through 1989, only about 10% of stations had adopted one system or another (Sterling & Kittross, 2002). Throughout the 1980s, the number of competing systems eventually dropped to only 2 competitors, Motorola (C-Quam system) and the Kahn/Hazeltine system, but diffusion of AM stereo remained painfully slow. Out of those that did adopt a system, the vast majority chose the C-Quam system over other competitors. Consumers were equally confused, although General Motors did place its faith in the C-Quam system and installed AM Stereo capable receivers in many of its models. By 1992, Congress stepped in to pressure the FCC by demanding that a national AM stereo standard be set. In October 1993, the FCC chose Motorola's C-Quam system as the national standard, bringing to a close one of the most

divisive standards setting battles in the Commission's history. They noted the objections to the standard in their *Report and Order*, but stated that the C-Quam system "has proven to be technically acceptable for providing excellent quality AM stereo service at a price that is affordable to both broadcasters and consumers" (Federal Communications Commission, 92-298, 1993, p. 3). At the time of the adoption of the national standard and 11 years past the "marketplace decision" ruling, only 13% of stations had adopted AM stereo technology. In 2013, the FCC does not keep official records of stations continuing to broadcast in AM stereo, but unofficial "volunteer" lists maintained on the Internet put the number of existing AM stereo stations in the United States around 300. As of December 2012, the FCC lists a total of 4,738 AM radio stations in the United States, meaning that at best the existing AM stereo stations comprise only 7% of the total amount of AM stations (FCC, 2013). Since the majority of AM stations feature spoken word instead of music programming, the addition of stereo is most likely a moot issue. It is important to also note that the C-Quam AM stereo system is incompatible with in-band on-channel HD Radio on AM.

The non-adoption of a standard for AM stereo is widely considered to be a blunder by the FCC, and the commitment to a political philosophy of deregulation actually ended up hurting the market players who wished to provide AM stereo. Furthermore, the FCC was understaffed and inundated with testimony and documentation that it simply could not adequately study in the time frame necessary to make an optimal choice (Braun, 1994). As Washburn (1982) noted at the time, the Commission's purpose for 50 years was to establish technical standards in various areas of broadcasting; therefore, this decision was a true departure from decades of precedents in setting

standards. Instead, Braun (1994) argued that the FCC made a decision "that was merely 'justified' because it would work reasonably well, but did not reflect the optimum choice" (p. 172).

Digital Television

Perhaps no other area is more apt for comparison to terrestrial digital audio broadcasting than the lengthy managed transition from analog to digital television (DTV). The FCC, which had set the original standards for television broadcasting in the 1940s, sought to establish the standards for DTV and HDTV that promised a host of benefits superior to a standard that had existed for decades.

The original analog standard of television broadcasting was set by the National Television System Committee (NTSC) in 1941and was modified as further innovations were developed. These innovations included color television, closed captioning, and stereo sound for television (Benton, 2012). By 1987, the FCC had begun to study "advanced television service" and the possibilities of bringing HDTV to American consumers. Over 23 analog HDTV systems, most of them compatible with existing receivers, were submitted to the FCC for approval, and the process dragged into 1990 (Dupagne & Seel, 1998). On June 1, 1990, an American company named General Instrument (GI) announced a game-changing advance: GI would design an all-digital HDTV system (Benton, 2013; Dupagne & Seel, 1998). Digital systems offered a host of advancements and improvements over existing analog systems, including a sharper picture resolution up to 1080 active scanning lines, variable frames per second, multi-channel CD quality sound capability, and the ability to send multiple television broadcast signals on one channel (known as multicasting). The Commission gave final approval of

the ATSC (Advanced Television Systems Committee) standards for HDTV on Christmas Eve of 1996. In this approval, the time frame for dropping NTSC standards and 100% adoption for ATSC digital standards was slated for 2006. However, even with the steady drop of prices for consumer equipment,[51] the original deadline of ending analog television broadcasts for full-power stations under the NTSC standard was looming. The original 2006 date was eventually changed to February 17, 2009, as part of the Digital Television Transition and Public Safety Act of 2005, which itself is a section of the Deficit Reduction Act of 2005 (Deficit Reduction Act of 2005, 2005). This change occurred partially in response to digital television facility construction delays, plus growing concern from television broadcasters that many fewer people would be able to receive their broadcasts should a transition happen any earlier. By October 2006, although sales for HDTV sets were "strong," less than 20% of households actually owned at least one HDTV-compatible set (Lieberman, 2006). Further complicating the transition, only one third of consumers was aware of the upcoming digital transition, according to a survey by the Leichtman Research Group (Lieberman, 2006).

The Commission played a fairly active consumer advocate role during this transition time, adopting several measures that included phase-in of digital tuners in all television sets over a five year period (2002 – 2007), plus an aggressive public awareness campaign on the transition to digital called "Get It!," and a website www.dtv.gov to inform viewers about the upcoming changes. Another effort to smooth the transition was the NTIA "TV Converter Box Coupon Program," which allowed consumers to request up to two $40 coupons—funded by the government—towards the purchase of a digital

[51] By 2012, the average cost for a HDTV set had fallen dramatically. 32-inch sets that cost thousands of dollars, on average, in 1998 cost less than $500 and the average cost for a 42-inch set was under $800 (Tuttle, 2012).

converter box that could be hooked up to an analog-only set and receive digital broadcasts (National Telecommunications and Information Administration, 2013). This coupon program was so successful that it ran out of money with 3.7 million homes still on the waiting list for coupons (CNN, 2009).

Although these efforts brought about more awareness of the digital transition and many consumers had purchased new HDTV-compatible sets or received coupons for converter boxes, one more delay was brought about due to an act of Congress. Just prior to the February 17th transition deadline, Congress passed and President Barack Obama signed the DTV Delay Act that postponed the shutoff of analog TV service to June 12, 2009 (S. 352--111th Congress: DTV Delay Act., 2009). The primary concern of Congress was the elimination of service to millions of low and moderate income Americans who had neither purchased new equipment or, even at that late date, had heard about the transition.

The FCC had not enacted this delay, but it was applauded at the highest levels of the Commission. Acting FCC Chairman Michael Copps stated that "the additional four months provided by the law affords urgently needed time for a more phased transition, including a consumer-friendly converter box coupon program, stepped-up consumer outreach and support -- particularly for vulnerable populations (CNN, 2009).

Commissioner Jonathan Adelstein, though supportive overall, was more blunt:

> We remain far from ready, despite the heroic efforts of FCC staff, performing under great odds and inadequate leadership. As I've said before, this national transition has been mismanaged and plagued by the lack of a coherent and coordinated strategy. More time was desperately needed to correct the mistakes that many, including leaders in Congress, the Government Accountability Office, and every current member of the FCC, have long raised. (Federal Communications Commission, 2009c)

The FCC continued to play an active role, implementing the DTV Delay Act and heightening awareness of the new transition date. The Commission issued a series of press releases starting 10 days prior to the transition with such objectives as "debunking" digital television myths, touting the benefits of digital television, finding a good antenna for over the air service, encouragement from the White House for Americans to prepare for the transition, and resources to help people through the transition. At an open meeting nine days prior to the final switch, Chairman Copps had a noticeably brighter outlook than he had four months prior.

> The good news is that we are in considerably better shape now than we were four months ago. We were nowhere near ready for a nationwide transition in February. Had we flipped the switch then, we would have faced a consumer debacle that would have made New Coke look like a stroke of marketing genius….There are the obvious signs of progress—the number of unprepared households continues to drop and the massive coupon backlog has been cleared. Probably more than half of the unprepared households we had back in early February are prepared today. So while I have no doubt that there will be disruption, we are working every day, all day, to resolve what we can between now and June 12 and in the important days immediately following June 12. (Federal Communications Commission, 2009b, para. 2, para. 7)

The transition occurred as scheduled on June 12, 2009, when all full-power television stations were mandated to permanently switch off their analog signals.[52] After all the concerns over the effects of the transition to digital service, the actual changeover appeared to go smoothly (Reardon, 2009). The FCC received its highest-ever amount of calls the day of the transition, but had hired 4,000 people to answer viewer questions (Reardon, 2009). One year after the transition, electronics advice and review site Retrevo.com surveyed 200 of its users regarding the transition and over half of

[52] Low-power television stations (LPTV) were allowed to continue broadcasting analog signals; the transition date for LPTV digital conversion is scheduled for September 1, 2015, by the FCC (Federal Communications Commission, 2013c).

respondents said they were unaffected by the change (Eisner, 2010). Fifty-one percent said the change was a "good thing," although 26% said they "didn't know" (Eisner, 2010) if it was or not.

HD Radio's Approval Process

The regulatory journey of HD Radio is built on these past experiences at the FCC and, similar to other innovations, has charted its own path due to business concerns, viability of the technology, and its timing when joining the marketplace. As previously noted, the Commission had taken notice of terrestrial digital radio systems, including in band on channel (IBOC) systems, proposed since the 1980s. However, in the Commission's view, none of the proposed systems was viable at that time. The Commission instead turned its attention to satellite-delivered digital audio radio throughout most of the 1990s, but expressed the conviction that "existing radio broadcasters can and should have the opportunity to take advantage of new digital radio technologies" (Federal Communications Commission, 1999, p. 4). By the end of the decade, system technology had progressed to the point where USADR (USA Digital Radio, Inc.) filed a *Petition for Rulemaking* on October 7, 1998, asking the Commission to adopt IBOC as the digital radio system for the country and establish a 12-year timeline for transition from analog to all-digital system[53] (Federal Communications Commission, 1998). Several radio companies filed comments in enthusiasitic support of this petition, including large operaters Clear Channel Communications, Cumulus Media, the Walt Disney Company, Susquehanna Radio Corporation, CBS Corporation, and Bonneville

[53] At this time, Lucent Technologies, Inc. was developing a competing IBOC system. In comments filed with the FCC regarding USADR's petition, Lucent indicated it would not seek a "sunset" timeline for analog broadcasting "because all-digital transmissions would be expected not to interfere with other stations' analog signals, and broadcasters would be able to initiate all-digital service at any time" (Federal Communications Commission, 1999, p. 5).

International Corporation. For the most part, the major ownership groups not only supported the start of terrestrial digital service, but even at this early stage gave great support to the IBOC system and encouraged the FCC to set the IBOC as standard. The NRSC restarted a dormant subcommittee and tasked it with evaluating the IBOC systems now being considered for a nationwide standard. The FCC took up the issue again and issued its *Notice of Proposed Rulemaking* on November 1, 1999, to finally determine a digital radio system for the United States (Federal Communications Commission, 1999).

The viability of an IBOC hybrid analog/digital system appears to be the crucial step in approving terrestrial digital service in the United States. Concerns about viability were mainly due to technological concerns; the Eureka-type DAB system in Europe used portions of the L-band that were reserved for military usage in the United States and other spectrum already authorized for mobile telephones and amateur usage (Federal Communications Commission, 1999). However, the compatibility with the existing analog system, meaning that listeners and broadcasters would not have to switch systems right away, also weighed heavily as a factor to adopt IBOC. Although the IBOC system was still undergoing tests to prove its compatibility with AM and FM broadcasting in the late 1990s, the enthusiasm for the technology was unmistakable in both the USADR and radio industry filings and in the Commission's *NPRM* filing.

> [W]e continue to believe that IBOC systems hold great promise. These systems may be able to facilitate a seamless transition to an all-digital radio broadcast environment by affording all broadcasters a concurrent digital and analog broadcast opportunity. Moreover, IBOC is the only approach that, to date, has attracted a substantial number of adherents. (Federal Communications Commission, 1999, p. 10)

Indeed, at the time of the *NPRM* filing, the Commission noted that no other proponents of non-IBOC DAB systems, including Eureka-147, had filed responses to USADR's

original *Petition for Rulemaking* (Federal Communications Commission, 1999). The Commission indicated that it did not prefer any sort of "new spectrum" DAB system, commenting, "a workable IBOC system would be superior to a new-spectrum DAB system….[permitting] a fast transition to DAB that preserves the benefits of the existing radio broadcast service while leveraging the considerable resources and expertise of the radio broadcast industry" (Federal Communications Commission, 1999, p. 15). However, the *NPRM* asked for comments on a new spectrum DAB system, including how licenses would be assigned to existing broadcasters and new entrants, who should have priorty for license assignment on any proposed new spectrum, and whether a portion of the television spectrum (specifically, Channel 6) should be used for low-power FM (LPFM) and DAB service (Federal Communications Commission, 1999).

Within the *NPRM*, the Commission stated its tenative criteria for selection of a DAB system:

> In reaching this fundamental determination, we propose to apply the following evaluative criteria: (1) enhanced audio fidelity; (2) robustness to interference and other signal impairments; (3) compatibility with existing analog service; (4) spectrum efficiency; (5) flexibility, (6) auxiliary capacity; (7) extensibility; (8) accommodation for existing broadcasters; (9) coverage; and (10) implementation costs/affordability of equipment. (Federal Communications Commission, 1999, p. 10)

The Commission further addressed the "vitality" of the terrestrial radio system and made it clear that it was not interested in any system that would "weaken the vitality of our free, over-the-air radio broadcast service, which provides service to virtually all Americans through a strong, independent system of privately owned and operated stations" (Federal Communications Commission, 1999, p. 9). The Commission firmly threw its support behind existing broadcasters in the NPRM who they find as "the group

best suited to introduce this new service to the public" (Federal Communications Commission, 1999, p. 9) and conceded that system testing should be done by the private sector in order to take advantage of the expertise from the broadcasting and technology industries. In short, the FCC wished to approve a system that would provide better sound and a clear signal that maintained existing coverage, a system that enhanced existing services and provided new ones, used little or no additional spectrum space, provided equipment at an affordable cost for broadcasters for the eventual transition, while at the same time maintaining existing service to provide a smooth transition for listeners. It was a massive task.

Comments on the NPRM

Upon the filing of the NPRM, the commentary period began for interested parties, including station owners, equipment manufacturers, and the general public. In short order, several enthusiasitic letters and comments from radio station owners and individual personnel[54] from radio stations, pressing the FCC to approve the IBOC digital radio system were received. Most letters and comments stressed the need for one digital system to be approved and that the FCC should not allow a systems "competition" to happen, as it had happened with AM stereo broadcasting.

A typical letter from a station ownership group supporting IBOC during this period urged the FCC to approve the system rapidly. Many letters claimed the IBOC system best served the public interest goals the Commission had stated—including

[54] Some of the radio ownership groups filing comments of support for the adoption of IBOC include Willis Broadcasting Corporation, Cox Radio, Inc., Susquehanna Radio Corp., Entercom Communications Corp., Infinity Broadcasting Corporation, and Gulf Coast Broadcasting Company (Federal Communications Commission, 2013b). Although not a station ownership group, National Public Radio also threw its support behind the implementation of the IBOC system (National Public Radio, 2000). Individual station personnel, such as general managers, also wrote supporting comments on station letterhead.

maintaining the vitality of analog broadcasting. Most, if not all, supportive letters also stated that digital radio would improve radio service, provide better sound, and urge the FCC to encourage a rapid transition to digital. As a specific example, Infinity Broadcasting's comment letter in response to the *NPRM* begins:

> Infinity believes that an in-band, on-channel ("IBOC") digital audio broadcasting ("DAB") approach is the only viable DAB system that will enable the industry to successfully and expeditiously implement DAB, and urges that the Commission, prior to the end of this year, select a single IBOC system as the industry standard for DAB. Analog broadcast radio faces significant competitive challenges from the high fidelity offered by media that utilize digital technology; therefore, terrestrial broadcasters must be provided the opportunity to offer at least an equivalent digital service to the public. The IBOC system developed by USA Digital Radio, Inc. ("USADR") will provide a vastly improved service to the public, offering enhanced sound fidelity, improved robustness, and providing broadcasters the ability to offer enhanced auxiliary services that are significantly more robust and of a higher quality than today's subcarrier services. (Infinity Broadcasting, 1999)

The National Association of Broadcasters, the broadcasting industry's main lobbying group in Washington, DC, also wrote comments in full support of digital radio service and IBOC technology. The NAB called the IBOC DAB system the most "realistic" option for digital radio service to "best promote the Commission's public policy objectives" and "be able to achieve the Commission's goals more quickly than any other alternative spectrum approaches" (National Association of Broadcasters, 2000, p. 4).

Not all comments were positive. Individual citizens and public interest groups submitted several comments decrying the planned move to a digital system—even one that promised to continue analog service for at least a while. Many of the negative comments focused upon what commenters perceived as a non-needed "improvement" for radio broadcasting when analog signals worked perfectly well for them. In addition, many commenters discussed the economic impact on low income individuals forced to

buy additional equipment. For example, a commenter identified as Richard Harnett states:

> I am perplexed by this proposal. I have not heard that the public is clamoring for more fidelity on the AM band. It is predominately used for talk radio where the AM is acceptable. Efforts to convert AM to stereo was not supported by the public - because it wasn't needed…. Soon HDTV (high dollar TV) will force the average viewer to purchase either a new, very expensive television or a set top box… Now the same thing is being proposed with conversion of the AM and FM bands to digital. The only people that will gain from this are the manufacturers of new digital radios and those that own land fills that will be over-flowing with the discarded radios and TV. (Hartnett, 2000, para. 1)

Another commenter, identified as Erich Loepke, voiced his concerns:

> In response to comments made by several equipment manufacturers, they stand to make a lot of money by a forced conversion of radio by FCC mandate. One in particular wants a "sunset date" on which every non-IBOC radio becomes useless. The sunset date serves only the interest of the equipment manufacturers. It doesn't even serve the interests of the broadcasters. What happens if IBOC isn't accepted by a majority of the public and the sunset date rolls around? Listenership will drop off considerably, and those without IBOC radios face two choices: Buy an IBOC radio, or just plain do without radio altogether. I've seen or heard nothing (except a survey conducted at the behest of Lucent) that indicates a public desire for IBOC. (Loepke, 2000, para. 3)

However, individual citizen comments were not the only commenters expressing skepticism. A handful of organizations submitted comments regarding the NPRM urging caution in the enthusiasm for adopting a digital system. Although not necessarily as negative as the individual commenters, these organizations aired issues that needed to be considered beyond the basic question of "should we approve the IBOC system?" Of these, the comments by Sony Electronics, Inc., while supportive of the IBOC digital system and a hard sunset date for analog radio if approved, stood out for their apprehensive tone regarding the proposed IBOC system and stunning prescience regarding the future of digital entertainment. The company stated:

> Sony Electronics Inc. recognizes the inevitability of terrestrial digital radio and the exciting benefits it can offer the consumer in the future. Sony has had experience launching new technologies in consumer markets throughout the world and has learned from its successes and failures. One obvious lesson that is sometimes too easy to ignore when enticed with new technology is the importance of weighing value against the cost to the consumer….it remains to be seen whether or not the proposed IBOC system can attract a market larger than simply the "early adopters" in the interim before an all-digital system is deployed. (Sony Electronics, Inc., 2000, p. 2)

Sony's apprehensiveness stemmed from experience in the European market and what it considers the reason for Eureka-147's slow development:

> It is not clear that the proposed IBOC solutions offer a value-added service that will attract an adequate customer base to launch terrestrial digital broadcasting in the United States. IBOC needs to have enough bandwidth to offer more than a slightly improved audio quality. Sony has seen a very slow market penetration in Europe with DAB, which employs the Eureka-147 standard. The disappointing ramp-up is attributable to a service that offers little more than improved audio. It is questionable whether the service differentiates adequately from analog radio to justify the higher consumer price for the receiver. Since manufacturing costs decrease with an increase in sales volume, there needs to be more of an impetus for the average consumer to adopt DAB. This impetus is either derived from a variety of new channels or new value-added services. S-DARS in the U.S. has chosen both methods. (Sony Electronics, Inc., 2000, p. 3)

In one of its replies to submitted comments, USADR responded to Sony's statements by saying:

> USADR also believes that the experience of Eureka-147 in Europe is not particularly instructive when considering DAB options for the United States. Because Eureka-147 was implemented in new spectrum, it required an allotment for new stations and a significant change in behavior for listeners to move to new stations. IBOC implementation will not bear the same burden. Of equal significance is the fact that the European and American radio markets are quite different. The United States has a much stronger commercial radio industry with significantly more entrepreneurial activity than has traditionally characterized European broadcasting….Commercial broadcasters and the strong consumer electronics industry in the United States will have incentives to provide consumer education and promotion of the benefits of IBOC technology. (USA Digital Radio, 2000, p. 5)

Another commenting organization expressing caution, the United States Small Business Administration, filed statements regarding the impact of the adoption of IBOC on small broadcasters:

> The Commission offers little discussion of the impact that IBOC DAB may have on small business and offers scant reassurance that small broadcasters, which constitute 96% of all audio radio stations, would be able to afford digital equipment. The Commission seems convinced that DAB conversion is in the public interest….[b]ut the Commission offers no preliminary analysis of how expensive digital equipment would be to manufacture or install….It is premature to decide that DAB should replace analog radio. (U.S. Small Business Administration, 2000, pp. 2-3)

IBOC Tests and Results

In the midst of the debate over IBOC, USA Digital Radio and Lucent Technologies merged and created iBiquity Digital Corporation in 2000 (iBiquity Digital Corporation, 2013). This development eliminated any decision the FCC would have to make in choosing between the competing USADR IBOC and Lucent Technologies IBOC systems; the new entity, iBiquity, would present only one IBOC system to the Commision for approval. In the meantime, IBOC testing continued through 2000 and 2001 on the proposed IBOC system by the NRSC subcommittee on DAB. These tests were performed to confirm that the addition of digital service would not impact existing analog service for either the broadcaster transmitting the digital signals or any adjacent frequency. The report from the NRSC was released in December 2001, and indicated that the IBOC system would not significantly impact analog broadcasting and would provide a great improvement in the audio fidelity and experience of radio listeners:

> Based on careful evaluation of the test data, the NRSC has concluded that the performance of the iBiquity FM IBOC system as tested represents a significant improvement over today's existing analog services….So, after nearly a decade of encouraging the development of IBOC DAB and now

> culminating with the formulation and execution of a comprehensive test program, the NRSC believes that the iBiquity FM IBOC system as tested will offer FM broadcasters significantly enhanced performance over that which is presently available from traditional analog FM broadcasting. The NRSC therefore recommends that the iBiquity FM IBOC system as tested by the NRSC should be authorized by the FCC as an enhancement to FM broadcasting in the U.S., charting the course for an efficient transition to digital broadcasting with minimal impact on existing analog FM reception and no new spectrum requirements. (National Radio Systems Committee, 2001, p. 9)

After the release of the NRSC study, the FCC in 2002 asked for comments regarding these findings. The Commission once again received several letters of support for the IBOC system from the radio broadcasting industry, including station owners and various individual executives writing on their own volition. For example, Susquehanna Broadcasting Corporation submitted these observations:

> The NRSC report and the December 6, 2001submission of iBiquity provide an abundance of evidence that IBOC does work and that it works well. Certainly within the pages of these massive submissions shortcomings can be found but, taken in their entirety, these documents show this hybrid IBOC system offers a definite improvement over existing FM in the United States. (Susquehanna Radio Corporation, 2002, p. 2)

Susquehanna concludes its remarks by stating:

> The opportunity to develop a new transmission service without the need for a new spectrum allocation does not occur often. IBOC, by its inherent design, must use the same spectrum as its analog service. With IBOC, the transition to digital would be the least disruptive to existing FM service and the least demanding on commission resources in insuring that this transition occurs in timely fashion and in the best interest of the public. Susquehanna urges the commission to take whatever action it deems appropriate to adopt the iBiquity FM IBOC system as the standard form of digital broadcasting for the United States and authorize the commencement of this new service at the earliest possible date. (Susquehanna Radio Corporation, 2002, p. 4)

Similar letters were filed by other large broadcasting companies, all expressing their hopes that the Commission would act quickly to approve the iBiquity IBOC system as the

terrestrial digital radio system in the United States.[55] And similar to the original NPRM in 1999, support also came from the NAB, National Public Radio, the Consumer Electronics Manufacturing Association, and various equipment manufacturers, such as Harris Corporation and Kenwood USA Corporation (Federal Communications Commission, 2013b).

Conversely, individual citizen commenters submitted several letters to the FCC, almost all opposing the implementation of IBOC, after the release of the NRSC study. Some of the letter writing campaign was coordinated; a form letter available from the Virginia Center for Public Press[56] was submitted, many times virtually unchanged, by several commenters (Federal Communications Commission, 2013b). Another fairly organized campaign led people to submit several letters, very similar in structure, decrying the effect the IBOC system would have on low-power FM (LPFM) service and that the better course of action was to implement a Eureka-147 system in the U.S. Many of these similar letters were submitted to the Commission on the same day.

However, other commenters submitted original work expressing fear over the IBOC system taking away their radio stations, large corporate broadcasters taking over the radio industry in general, and making large amounts of money on a forced digital transition, and the expense of being forced to buy new equipment. Commenter Phillip Meyer writes:

> I am writing in concern that the Big Broadcasters, lead [*sic*] by the National Association of Broadcasters (NAB) are pressuring the Federal

[55] Large broadcasting companies encouraging the FCC to act and adopt iBiquity's IBOC system in comment letters similar to Susquehanna's include Clear Channel Communications, Infinity Broadcasting Corporation, Radio One, Inc., The Walt Disney Company and ABC, Inc., Bonneville International Corporation, Cox Radio, Inc., and Emmis Communications (Federal Communications Commission, 2013b).

[56] The Virginia Center for Public Press, founded in 1991, owns and operates a LPFM, volunteer-staffed community radio station (WRIR-LPFM) in Richmond, Virginia (GiveRichmond.org, 2013).

> Communication Commission (FCC) to force a standard for "Digital Audio Broadcasting" (DAB) that calls for the "mandatory sunsetting" (prohibition) of analog FM broadcasting. DO NOT LET THIS OCCUR!!! Let the public decide if digital radio is worth the sacrifice of money and programming values! We want a choice, not the same old homogenized corporate radio stations. (Meyer, 2002, para 1)

Another commenter, V.J. Redding, adds:

> I am not in favor of IBOC because the way it is currently constituted, it will cause me to have to buy all new receivers to hear radio. I believe that this is not in the customers *[sic]* or radio listeners *[sic]* best interest to be forced to buy all new equipment to listen to the radio. (Redding, 2002, para. 1)

Several other individual comment submissions to the FCC challenge the proposed implementation of IBOC for AM on the grounds that not enough research had been completed on the interference effects of skywave propagation and digital signals, in addition to what they construed as a potentially lower quality AM signal.[57] Still others longed for a repeal of the 1996 Telecommunications Act, which eliminated national ownership caps for radio and, for many commenters, was the source of an impersonal, non-local service radio they did not wish to see extended on an IBOC system.

First Report and Order

After nearly three years of study, commentary, and input from broadcasters, equipment manufacturers, and the general public, the FCC adopted the *First Report and Order* on October 10, 2002. This document officially selected the in-band on-channel system "as the technology that will permit AM and FM radio broadcasters to introduce digital operations efficiently and rapidly" (Federal Communications Commission, 2002, p. 1). It allowed stations to start broadcasting digital signals immediately as long as the

[57] Several commenters wrote that the AM standard proposed would narrow the analog channel by half (from 10 kHz to 5 kHz) and they did not wish to see a degradation of analog AM service (Federal Communications Commission, 2013b).

IBOC system was used. The only restriction was for AM digital transmissions; the Commission decided not to allow nighttime AM digital broadcasting pending further study on nighttime skywave propagation interference concerns[58] (Federal Communications Commission, 2002). The Commission concluded that setting a digital standard was necessary to "facilitate the development and commercialization of digital services for terrestrial broadcasters" (Federal Communications Commission, 2002, p. 1). Stations were allowed to apply to the FCC to begin broadcasting in hybrid analog/digital mode immediately. Stations were also mandated to carry the programming heard on their analog stream on their main digital channel. No additional digital streams of audio were authorized at this point.

It was clear that the Commission leaned heavily upon the input and expertise of both broadcasters and IBOC developers in reaching its decision in the *First Report and Order*. The Commission noted that not only was iBiquity the only active IBOC developer, but "[a]mong its strategic partners, iBiquity lists most of the largest broadcast group owners, as well as manufacturers of broadcast equipment, consumer electronics, and semiconductors" (Federal Communications Commission, 2002, p. 2). The Commission noted that most every major broadcasting-related industry group had filed comments in support of IBOC, including the NAB and the Consumer Electronics Association. The *Report and Order* authorized stations to begin transmitting digitally,

[58] A *Petition for Reconsideration* was filed two months after the *First Report and Order* was issued, seeking to overturn this restriction of AM nighttime IBOC. The petitioner, Glen Clark and Associates (an engineering firm), stated that delaying IBOC on AM could damage their ability to compete in the new digital area, the interference issue was confined to a handful of stations that may conflict, and that the issues involved could be addressed in other ways rather than an outright prohibition (Glen Clark and Associates, 2002). The issues in this *Petition* were addressed in the *Second Report and Order* which allowed AM nighttime IBOC broadcasts (Federal Communications Commission, 2007).

pending a *Further Report and Order* to be issued by the FCC detailing station licensing procedures and service rule changes (Federal Communications Commission, 2002).

The *Report* also addressed the concerns brought through comments from such as the Virginia Center for Public Press and the Amherst Alliance and from individual commenters pushing for additional spectrum or a Eureka 147-type system to be adopted in lieu of IBOC:

> This is not a feasible alternative. In dramatic contrast to IBOC, Eureka 147 has no active domestic proponent and no appreciable support within the broadcast industry. It is a technology that would require significant broadcaster investments in new transmission facilities and impose major service area changes on incumbent broadcasters….We conclude, therefore, that the selection of any DAB system, including Eureka 147, which would require new spectrum, including channel 6, would impede the rapid development of DAB. Moreover, without a specific spectrum allotment and a specific technology, we simply do not have a defined out-of-band option to consider, much less to evaluate, against the DAB criteria enumerated in the NPRM. Accordingly, we will no longer consider this approach in this proceeding. (Federal Communications Commission, 2002, p. 4)

In answering other commenter's concerns about the Commission's selection of a single standard with patented technology and the possibility of high or unfair costs of conversion to a digital radio system, the Commission stated:

> Although we share commenters' concerns about costs, we believe for the reasons discussed below that it is necessary to define a single DAB standard to ensure the rapid and efficient development of DAB service. According to iBiquity, the estimated costs of implementing its hybrid IBOC system range from $30,000 to $200,000, with an average cost of $75,000…. The cost estimates provided by iBiquity do not seem unreasonable when compared with digital conversion costs in other services. Radio broadcasters can implement IBOC using their existing towers, antennas, and transmission line, making the technology inherently less costly than, for example, the digital television conversion…. iBiquity agrees to abide by the guidelines common to open standards, which require that licenses be available to all parties on fair terms. iBiquity also states that it will adhere to the Commission's patent policy. (Federal Communications Commission, 2002, p. 13)

A Further Notice of Proposed Rulemaking

Stations began to experiment and adopt the IBOC technology, marketed as "HD Radio," and the consumer rollout of HD Radio began to take shape by 2003. One year later, the Commission issued a *Further Notice of Proposed Rulemaking* (FNPRM) to address issues not covered in the *First Report and Order*. These issues had been lingering since the 2002 *Report,* and stations were operating on an "interim basis" until the Commission decided to start the promised process of making permanent operational rules. Many issues were covered in the *FNPRM*: whether there should be an official "conversion" policy—including a mandated conversion to all digital; should there be a requirement that broadcasters provide a certain minimum amount of high-definition audio; and whether broadcasters should undertake digital audio multicasting, which would allow a station to not only carry its main channel analog audio stream in digital, but also offer one or two separate streams of audio only available to listeners with an HD Radio set (Federal Communications Commission, 2004). The Commission sought answers to whether the additional audio streams should be used for commercial purposes or community service purposes, such as public safety announcements, radio reading services for the blind, and others. Interestingly, the Commission also sought answers to whether the digital channels could be offered to listeners on a subscription basis, under the question "Should we allow for subscription services as long as the licensee provides at least one free audio stream, as we do for digital television?" (Federal Communications Commission, 2004, p. 12). The Commission stressed in the *FNPRM* that it was looking to adopt rules for this new digital service that were consistent with its public interest, convenience, and necessity mandate. Also in the *FNPRM*, the Commission laid out

proposals for power limits for FM operating power and asked for further comments on AM IBOC operation, especially nighttime operation (Federal Communications Commission, 2004).

A flurry of comments and replies to comments were filed over the next 2½ years as broadcasters and individual commenters primarily discussed two main issues from the FNPRM. First, the debate regarding approval for AM nighttime IBOC was continued by several commenters, many professing to be "professional engineers" or having other profound relevant experience. These commenters were opposed to nighttime AM because of the interference feared from the digital sidebands to first adjacent frequencies, especially distant first adjacent frequencies at night. Fears of on-air signal "splatter" were commonplace in many of these letters and comments to the Commission.

In its reply to these comments, iBiquity refuted these claims of massive interference and used one commenter's case to illustrate its point.

> Several of the reports of AM interference have been overblown. For example, in one analysis presented in the comments, David Hershberger emphasizes concerns about interference from IBOC operations on KXNT in Las Vegas, Nevada. Mr. Hershberger's comments deemphasize the fact that he is concerned about receiving the signal in an area of extremely low analog signal level. It also is important to note Mr. Hershberger chose to use a receiver with 16 kHz IF bandwidth. Only specialized devices, representing a small minority of the receivers sold each year, have this bandwidth. Typical AM receivers use 3.5 kHz IF bandwidth and would be much less likely to experience the interference Mr. Hershberger encountered. Certainly, this limited example in very specific circumstances should not be used to halt the development of HD Radio technology which has the ability to transform AM radio. (iBiquity Corporation, 2004, p. 4)

The second issue receiving a number of comments was digital multiplexing and supplemental audio channels. An overwhelming number of individuals and, most notably, public broadcasters, enthusiastically supported the extension of service beyond

simply digitizing the main analog audio stream. The prospect of "additional" radio stations drew support in the comments that discussed serving underrepresented populations and giving communities the opportunity to have more access to broadcast radio than ever before.

The essence of a vast majority of comments to the Commission from public radio stations regarding multiplexing are similar to these statements made by station KQED-FM in San Francisco, California:

> The overriding motivation for KQED's election to implement DAB, however, is the opportunity to provide our listeners with additional programming through a supplemental audio channel….KQED will likely retain our existing wide variety of news, public affairs and cultural affairs programming on our primary channel. The best use of a second audio channel to expand our programming to meet a broader spectrum of community needs is currently under discussion. Program formats presently being seriously considered include: Spanish language programming, classical music offerings, and in-depth international news coverage. Any of these program formats would allow us to meet one or more of the following KQED goals: to reach wider audiences, to provide a voice to and to reach underserved segments of the community, to provide programming that equips Northern Californians to make better-informed public policy choices, and to fill gaps in educational programming which are not being met by other stations. (KQED-FM, 2004, pp. 1-2)

More letters of support poured in from other parties interested in supplemental audio broadcasts, including disability service providers and community groups interested in broadcasting, but unable to find space on existing stations. Multiplexing would, however, involve a tradeoff—stations would have to lower the bit rate on the main channel digital audio stream transmission in order to allow room for a secondary audio stream. In other words, stations would have to slightly degrade the fidelity of one digital stream to enable the creation of another. As evidenced by the enthusiasm in the comments, many stations were willing to accept this tradeoff for expanded service.

The FCC Issues Another Report and Order

It took almost three years for the Commission to progress from a *Notice of Proposed Rulemaking* to a final *Report and Order*. In March 2007, the FCC adopted the *Second Report and Order, First Order on Reconsideration, and Second Further Notice of Proposed Rulemaking* (Federal Communications Commission, 2007). In this expansive Report, the Commission issued several rulings on the many areas from the FNPRM of 2004. The goal was to establish permanent requirements and policies for IBOC DAB broadcasting in the United States (Federal Communications Commission, 2007).

In the *Report*, the Commission summarizes its decisions:

> [The FCC]
> • Refrains from imposing a mandatory conversion schedule for radio stations to commence digital broadcast operations;
> • Allows FM radio stations to operate in the extended hybrid digital mode;
> • Requires that each local radio station broadcasting in digital mode provide a free over-the-air digital signal at least comparable in audio quality to its analog signal;
> • Continues to require that the main digital broadcast stream simulcast the material aired on the analog signal;
> • Adopts a flexible bandwidth policy permitting a radio station to transmit high quality audio, multiple program streams, and datacasting services at its discretion;
> • Allows radio stations to time broker unused digital bandwidth to third parties, subject to certain regulatory requirements;
> • Applies existing programming and operational statutory and regulatory requirements to all free DAB programming streams, but defers the issue of whether and how to apply any specific new public interest requirements;
> • Authorizes AM nighttime operations and FM dual antenna configurations;
> • Considers and addresses other technical matters, such as FM translator and booster operations and TV Channel 6 interference issues;
> • Defers discussion of whether the Commission should impose content control requirements that would prevent listeners from archiving and redistributing digital musical recordings transmitted by digital broadcast stations;
> • Recognizes that further negotiations between the United States and the international community are taking place to resolve possible disputes

> about the implementation and operation of DAB by domestic radio stations;
> • Dismisses several pending Petitions for Reconsideration and Petitions for Rulemaking that asked, inter alia, the Commission to reconsider the adoption of iBiquity's IBOC system as the technology chosen for DAB transmission;
> • Seeks further comment on appropriate limits to the amount of subscription services that may be offered by radio stations. (Federal Communications Commission, 2007, p. 3)

The Commission addressed several important items that would impact the future for HD Radio in this *Report*. First, with respect to mandating a timetable for conversion to an all-digital radio system, the Commission noted that the majority of commenters favored a marketplace transition, not one mandated by the agency. They note that, unlike digital television, there was no statute forcing the issue, there were no additional bandwidth requirements to consider, and "there is no evidence in the record that marketplace forces cannot propel the DAB conversion forward, and effective markets tend to provide better solutions than regulatory schemes" (Federal Communications Commission, 2007, p. 8).

The adoption of extended hybrid service, meaning that stations could carry additional audio streams in addition to their main channel audio service, was considered by the Commission to be a positive step both technically and for listeners in general. The Commission felt confident that any interference issues would be minor and able to be resolved by the stations themselves or by the Commission should they arise. For listeners, the Commission stated that more choices of programming would offer greater service to underserved communities and non-English speaking residents (Federal Communications Commission, 2007). The FCC also supported the notion, proposed by the NAB, that the programming choices for these additional channels would be left to the

licensee, rather than government mandate. In order to best serve the public, the idea of scaling bit rates to best serve an audience was also left up to the licensee.[59] Finally, after this Report was issued, stations could offer additional streams of programming without the approval of the Commission and time broker those streams to groups and individuals seeking airtime for underrepresented listeners (Federal Communications Commission, 2007).

Aside from what multiplexing *could* do, the Commission also commented upon what these additional streams of programming *should* do—stimulate interest in terrestrial digital radio

> Further, allowing radio stations the flexibility to provide multicast services will allow them to offer a mix of services that can promote increased consumer acceptance of DAB, which, in tum, will likely speed the conversion process. Additionally, diversity of programming services may result from multicasting and provide programming to unserved and underserved segments of the population. (Federal Communications Commission, 2007, p. 15)

Power Increase Battle

With the essential regulations and policies now set by both the *First Report and Order* and the *Second Report and Order*, and challenges to the system swept away by these rulings, IBOC was firmly entrenched as "the future" by 2007. Although many commenters continued to protest the Commission's decision to allow AM IBOC broadcasts at night, it was another challenge in the technical area that presented a regulatory concern.

In 2004, power levels for FM digital transmissions were set at 1% of the analog signal's effective radiated power (ERP) (Federal Communications Commission, 2010a).

[59] For example, a talk program does not need as high of a bit rate transmission as a music program does for good quality sound. Stations would be left to decide what bit rate they would transmit for main channel and supplemental channel audio.

This power level for FM digital signals remained unchanged with the release of the *Second Report and Order*; however, some stations that had initiated IBOC broadcasts began to clamor for a power increase (Federal Communications Commission, 2007). Although digital broadcasts require lower power than the analog transmissions, it became apparent to some broadcasters that 1% ERP simply did not give them enough power to match their analog coverage contours (Federal Communications Commission, 2010a). Within the coverage contours, the signal was weaker than the analog counterpart and reception problems were reported in buildings and other areas where the signal could not penetrate. Portable mobile coverage was also affected since digitally-capable receivers were having a hard time "locking in" to the weak digital signals.

In 2007, at the request of stations experiencing these issues, the Commission decided to test whether allowing FM stations to voluntarily increase power to a maximum of 10% ERP would be an effective solution to the problem (Federal Communications Commission, 2010a). In 2008, "a group consisting of 18 radio group owners that operate over 1,200 commercial and noncommercial educational ("NCE") FM stations and the four largest broadcast transmission equipment manufacturers" asked the FCC to allow the increase in power" (Federal Communications Commission, 2010a, p. 2).

What the Commission had to consider was whether this power increase would cause interference with other broadcasters on the first or second adjacent channel frequency. As with many other filings over the past decade, the issue of station interference had to be navigated again when considering this change. The issue was opened to comments, which were split between those who wanted the ability to increase power and those vehemently opposing power increases in fear of interference.

Studies spearheaded by National Public Radio (NPR) and iBiquity were commissioned and performed through 2009. These studies included stations experimenting with power increases up to 10% ERP. These studies concluded that an increase in power would be acceptable without harm to the existing analog signal of most FM radio stations. The study included the caveat that the Commission adopt specific procedures dealing with any interference issues and reserve the right to revisit the issue in the future should widespread interference become a major problem (Federal Communications Commission, 2010a).

In the *Order* dated January 27, 2010, the FCC allowed eligible FM stations to voluntarily increase their power up to 10% ERP maximum, provided they notify the FCC's Media Bureau within 10 days of the start of increased power service. The Commission based this ruling on two factors. First, it had not received any "well documented" interference complaints since 2004 (Federal Communications Commission, 2010b, p. 6). Second, increases in power were tested at experimental stations, and no interference was reported in any of these experiments.

> Since May 2006, the Media Bureau issued a total of 15 experimental authorizations to permit operations at up to 10% FM IBOC Power, including authorizations for ten grandfathered short-spaced stations with as many as four first-adjacent channel short spacings. Some of these short spacings are severe. These stations operated their FM digital facilities with different levels of increased FM Digital ERP throughout the experimental period, with the preponderance of the time spent operating with the maximum permissible FM Digital ERP of -10 dBc. The Bureau did not receive any complaints of interference to analog FM stations from licensees of analog FM stations or the listening public as a result of the experimental operations. (Federal Communications Commission, 2010b, pp. 6-7)

In short, there was nothing in the field experiments to indicate that a massive outbreak of interference would occur, even with short-spaced stations increasing digital power to

10% ERP. However, "out of an abundance of caution" (Federal Communications Commission, 2010b, p. 10), the FCC did take the suggestion of the NPR study and put in place procedures should any interference be documented and reported.

The procedures demand that the conflicting stations try to come to an agreement amongst themselves. Failing that, the station claiming interference from another station's broadcasts must document six instances of interference within its protected signal contour (with documentation) before it can bring the matter before the Commission. If the Commission does not respond within a 90-day period, the interfering station must reduce power back to 1% ERP, pending a FCC decision on the complaint (Federal Communications Commission, 2010b).

Since the *Order* regarding power increases, no major shifts in IBOC matters have happened at the Commission. The regulatory environment for IBOC and HD Radio is remarkably stable, with no severely pressing matters on the FCCs agenda. A visual survey of docket 99-325 (the IBOC docket) shows a fairly inactive docket without the activity of the past decade (Federal Communications Commission, 2013b).

The regulatory journey of IBOC and HD Radio, in most respects, was a fairly straightforward one. Certainly helped by the fact that USADR and Lucent merged into one company in the early 2000s and by no viable alternate spectrum system, such as Eureka 147, being put before the Commission, IBOC's difficulties were rather minor when compared to emergent technologies needing FCC approval in the past. Broadcasters were extremely enthusiastic for the system, which also allowed them to keep their existing analog stations while promising to aid the transition to the digital system. Other industry representatives, including lobbying groups and equipment

manufacturers, were equally supportive and saw IBOC as a road to a greater future with radio on par with all of the digital technologies emerging in the early part of the 21st century. The few naysayers, at least in comments to the FCC, were listeners and advocates who fretted about additional costs for receivers and "more of the same"-type of broadcasting they had been receiving from newly-consolidated larger broadcasting companies.

Lessons from Technologies Approved by FCC

There were a number of lessons learned by the FCC through each of the processes of approving new technology. Some of the lessons could be viewed as collective knowledge, while other lessons were learned through the individual approval processes themselves.

Collectively, it is evident from these examples that the FCC progresses through each technological innovation approval process in a manner individualized to that innovation. Although the Commission has its standard procedure when discussing rule changes and adoption,[60] the journeys of innovations such as FM radio and AM stereo are vastly different because the circumstances and political motivations surrounding the innovations were different. These circumstances include time, technology, input from expert groups advising the FCC, consumer demand, and the FCC's orientation towards mandating a change rather than letting the marketplace decide. Secondly, the Commission responds to a degree to the concerns of the marketplace, whether that

[60] The standard rulemaking procedure for the FCC follows a basic process. First, a *Notice of Inquiry* is issued, seeking information on a broad area. Next is a *Notice of Proposed Rulemaking*, where the FCC proposes a rule or rule change and seeks comment from interested parties. Afterwards, there may be a *Further Notice of Proposed Rulemaking* where comments have been taken into account and the proposed rule adjusted accordingly. Finally, the Commission issues a *Report and Order* containing the new rule or adjusted rule. A *Petition for Reconsideration* may be filed by parties that are not satisfied with the new rule (Federal Communications Commission, 2013e).

marketplace is on the level of the businesses it regulates or the listeners or viewers it is mandated to serve. This responsibility can be a "double-edged sword" concerning the competitive arena when it comes to standard setting. For example, after it became obvious that UHF stations were not going to be viable unless it was mandated that UHF tuners be included in all television sets, the FCC acted and mandated the change. However, malevolent actions, such as moving the FM band under pressure from radio titan David Sarnoff which destroyed FM inventor Edwin Howard Armstrong's fledgling FM network, also could fall under this "responsiveness" to industry.

Another theme that runs through these major FCC innovation decisions is that the FCC is not and never has been afraid to change standards once standards were set, if there is a demonstrated need for standards or other rules to change. As evidenced by the movement of FM to a higher frequency range, the switch of color television systems from the originally approved CBS system to the RCA system in the 1950s, and the need for (finally) a decision for an AM stereo standard, the Commission has not been shy about changing its mind, with the caveat that it may take many years or even decades for it to do so. The postponement of digital television transition deadlines also reinforces the view that the FCC can and does act when market and industry forces demonstrate a need to have a problem relieved through regulatory action.

Looking into the particulars of the individual cases, one of the most prominent lessons learned by the Commission has to be the innovation failure of AM stereo, when the Commission decided to let the marketplace decide which system it preferred as standard. Under the deregulatory fever that was sweeping many parts of the federal government by the 1970s and into the 1980s, it was decided to adopt no standard and let

the marketplace decide which version of AM stereo was best. One of the unintended consequences of this decision was the complete uncertainty on the part of both broadcasters and consumers over which system to choose. Broadcasters were reluctant to invest thousands of dollars into a system that might be the "loser" in the battle, which would force them to spend even more money to reinstall the "winning" system. Consumers faced the same choice, but also confusion over what they were supposed to be buying in order to receive AM stereo broadcasts. By the time the FCC finally adopted the C-Quam system in the 1990s, the decision hardly mattered because the public's attention had moved completely away from AM as a music medium. FM was the dominant music band and AM was relegated to mostly talk-based broadcasting.

The adoption of digital television standards and the process of implementation can be seen as the FCC learning from the AM stereo debacle and not wishing to repeat the mistakes of the previous two decades. The adoption of standards was especially important with DTV considering that the transition process to digital television would not simply alter television viewing, but fundamentally transform it in the United States. This transition was simply too important to leave it up to a marketplace decision with competing systems for both broadcasters and consumers. The DTV transition had the FCC reasserting itself as a determinant of standard systems for broadcast rather than a spectator; as such, this transition could also serve as a guide for the transition of radio broadcasting from analog to digital. In fact, since the AM stereo decision, the FCC has set many transition deadlines, seeking avoid the problems evident in the AM stereo story. In 2012, in response to the growing demands for broadband Internet and wireless communication service, the Commission instituted the Technology Transitions Policy

Task Force. As FCC Chairman Julius Genachowski stated at the founding of the Task Force, the body is charged with finding "how can we best ensure that our nation's communications policies continue to drive a virtuous cycle of innovation and investment, promote competition, and protect consumers?" in a broadband Internet world (Federal Communications Commission, 2012b).

Finally, the Commission has demonstrated its willingness to issue mandates for inclusion of specific technology that will bring greater utility to the consumer in iterations of already existing devices. Specifically, the mandate within the All Channels Receiver Act (1962) to include UHF tuners with all television sets and, more recently, the FCC's mandate that phased in digital tuners for all television sets starting in the year 2002, demonstrate that the Commission in some circumstances will act to enhance service choices to consumers through its power should it be deemed necessary. In the case of UHF, the necessity was determined to be more channels of programming for greater public service. In the case of digital tuners for television, it was preparing for the eventual technological necessity of having those tuners to receive television broadcasts; much later, those tuners would be able to receive additional content streams from multicasting digital television stations. Both of these instances differ from other innovation progressions through the Commission. Nobody was forced to manufacture or purchase a FM tuner to be included with an AM radio set. Nobody was forced to manufacture or buy a color TV when color broadcasting was introduced. However, for both UHF and DTV, the FCC (and in the case of UHF, Congress) used its authority to force inclusion. There has been no serious effort in HD Radio's history to make the transition to HD broadcasting mandatory, either through FCC or congressional action. In

fact, in iBiquity's own materials, the company clearly states that the transition to HD Radio is a decision that will be left to the marketplace to decide (iBiquity, 2014). The Commission has remarked that it undertakes mandates when there is a significant public interest for it to do so when setting standards:

> [T]he traditional rationale for mandating a standard arises when two conditions are met: first, there would be a substantial public benefit from a standard; second, private industry either will not, or cannot, achieve a standard because the private costs of participating in the standard-setting process outweigh the private benefits, or a number of different standards have been developed and private industry cannot reach consensus on a single standard….We noted that mandated standards might provide needed certainty to consumers, licensees, and equipment manufacturers, particularly where the launch of a new technology is involved. Moreover, we reasoned that standard-setting would help obviate the "chicken and egg" dilemma that can impede the introduction and acceptance of new technology and impose additional costs on consumers. We also recognized, however, that mandatory standards can have drawbacks, including potential deterrence of technical innovation-particularly where a technology is new and further development can reasonably be anticipated to occur-and curtailment of some forms of competition. (Federal Communications Commission, 1999, p. 20)

By 2007, IBOC and HD Radio had cleared the regulatory hurdles and stood alone on the field as the only approved digital radio system by the FCC. HD Radio's path through the regulatory system had followed a textbook pattern of innovation-decision diffusion process. The agency was aware of digital audio broadcasting (*knowledge*) as far back as the late 1980s, but rejected further study until the technology advanced. As soon as it became feasible, the FCC moved to not only gathering knowledge about the new technology, but sought out presentations from potential manufacturers and comments from the public and other interested parties about digital radio (*persuasion*). It is at this stage the FCC could accept or reject HD Radio as a viable system. However, a *decision* was made, to choose HD Radio as the digital broadcasting system for the United

States, and steps were immediately taken to begin the *implementation* of HD digital broadcasting. Implementation included technical guidance, no deadline for a transition to digital, and the approval of the agency for all future moves in the marketplace for HD Radio. The final innovation-decision diffusion stage, *confirmation*, can be found in subsequent proceedings of the FCC where it has affirmed that HD Radio is the digital radio system in the United States (Federal Communications Commission, 2007) and has never entertained switching to another system since the approval of HD Radio.

Through the examination of other innovation-decision processes in the past, the lens through which HD Radio was approved is absolutely clear. The Commission had learned from past experiences with innovations such as AM stereo and digital television broadcasting, which therefore guided its approach to HD Radio. It is apparent that the FCC wanted to approve one system to avoid the pitfalls seen in the AM stereo debacle and also recognized, with far more analog radios to replace than television sets and the radio industry's fear of obsolescence should all those analog radios become inoperable, that a mandated transition date would not work for radio as it had for television.

Radio industry support was critical for the approval of HD Radio; however, in an industry that was going through an upheaval due to deregulation and changes in financial and ownership structures, would HD Radio be a useful innovation in the competitive radio industry?

The Radio Industry

HD Radio does not occupy its own closed-off section of the digital entertainment universe; it is a part of the overall radio and audio entertainment industry. The economic robustness of this industry is a factor in the adoption of HD Radio technology because of

the costs involved in upgrading, the promotional time and expense needed to promote new technology, and the programming necessary to fill new digital channels with content.

Ownership

Any analysis of the current state of the industry must examine radio ownership and how regulatory changes over the last 20 years have dramatically affected the industry landscape. What remains true is that radio stations can be owned by an individual, a company, or a non-profit organization; however, one of the largest changes in radio is the *number of stations* that one person, company, or other organization is permitted to own. Although it remains that not everyone who wants a license to broadcast can have one,[61] the FCC throughout its history has been concerned with providing a diversity of viewpoints. One way to achieve this goal of having different viewpoints represented was thought to be through diversity of ownership of local radio stations. After having no formal rules on the number radio stations one entity could own throughout the 1930s and 1940s, by 1950 the FCC had settled on rules allowing the ownership of one AM and one FM radio station per market and a total ownership of seven AM and seven FM radio stations nationally (Federal Communications Commission, 2000). These rules would remain in place until 1985, when the maximum number of radio stations one owner could possess was increased to 12 AM and 12 FM stations.[62]

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[61] The Supreme Court decision in *Red Lion Broadcasting Co. v. Federal Communications Commission* (1969) firmly established this principle. Justice White states in the majority opinion, "Where there are substantially more individuals who want to broadcast than there are frequencies to allocate, it is idle to posit an unbridgeable First Amendment right to broadcast comparable to the right of every individual to speak, write, or publish. If 100 persons want broadcast licenses but there are only 10 frequencies to allocate….only a few can be licensed and the rest must be barred from the airwaves. It would be strange if the First Amendment, aimed at protecting and furthering communications, prevented the Government from making radio communication possible by requiring licenses to broadcast and by limiting the number of licenses so as not to overcrowd the spectrum" (*Red Lion Broadcasting, Co. v. Federal Communications Commission*, 1969).

[62] The local rules limiting ownership to one AM and one FM station remained intact.

Further relaxation of radio ownership limitations were adopted by the FCC throughout the early 1990's. In 1992, the Commission conceived a formula for ownership that allowed one entity to own two AM and two FM stations in markets with more than 15 radio stations as long as combined total ownership share of the market was less than 25%; in markets with fewer than 15 radio stations, owners could have three radio stations, as long as no more than two were AM or FM and the combined ownership in the market was less than 50%. National ownership limits were expanded modestly at this time, with owners now allowed to own a total of 18 AM and 18 FM stations (36 total). In 1994, the FCC again relaxed ownership limitations by now allowing one owner to have 20 AM and 20 FM properties, plus "non-controlling attributable interest in 3 AM and 3 FM if they [the stations] are controlled by minorities or small business" (Federal Communications Commission, 2000, p. 21). The rule changes were incremental, but represented the greatest relaxation of ownership rules at the FCC since its establishment by Congress in the 1930s.

The business environment of radio and every other telecommunications industry participant changed dramatically when the United States Congress passed the Telecommunications Act of 1996. The Act, an expansive updating of the original Communications Act of 1934,[63] would fundamentally change the business relationship ordinary Americans would have with telecommunication companies and how those companies could compete with each other for consumers. Krattenmaker (1996) posited

[63] However, the Telecommunications Act of 1996 did not *replace* the Communications Act of 1934; it merely *amended* the 1934 Act. The law governing electronic communications in the United States remains the 1934 Act (McGregor, Driscoll, & McDowell, 2010).

the Act was passed for two reasons: "technological convergence"[64] and "legal balkanization."[65] He explained why both issues needed to be addressed together in one piece of legislation:

> First, a consensus formed that issues of technological convergence should be answered more commonly by marketplace forces, and less frequently by regulatory fiat. Policy makers believe (or profess to believe) that if telephony, radio, and television are to merge - or not to merge - that result should be driven by consumers making choices in open markets that express their preferences. Regulation is at most a second-best method for deciding who will offer what telecommunications services to whom…. Accompanying the conclusion that we should subject convergence issues to the marketplace, then, was the conclusion that predation could (perhaps must) be avoided by appropriate regulatory oversight. The FCC's job description needed to be rewritten. The agency should not decide who could enter what markets, but rather should monitor the conditions under which such entry took place and the responses to such entry by those already there - "entrenched interests," if you prefer. Tear down entry barriers, but replace them with specific regulatory instruments to hunt down predators. (Krattenmaker, 1996, pp. 8-9)

The 1996 Act either eliminated or rewrote a number of rules and regulations in an effort to end the "balkanization" or legal barriers between telecommunication industries. The law was an effort to increase marketplace competition and take advantage of all that new technology, including the emerging Internet, had to offer. As President Clinton noted at the signing ceremony for the bill:

> [The] revolution has been held back by outdated laws, designed for a time when there was one phone company, three TV networks, no such thing as a personal computer. Today, with the stroke of a pen, our laws will catch up with our future. We will help to create an open marketplace where competition and innovation can move as quick as light. (Clinton, 1996)

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[64] Krattenmaker explains "technological convergence" as "a convergence of devices accompanied by a plethora of transmission paths. The telecommunications receiver is a radio, computer, television, telephone, VCR, and fax machine all rolled into one. We can get information to such devices by broadcast, microwave, satellite, tape or disk, copper wire, or optic fiber" (Krattenmaker, 1996, p. 6)

[65] Krattenmaker defines "legal balkanization" as "a series of governmentally imposed entry barriers that sought to force the new and the old technologies into a Procrustean bed. These barriers attempted both to confine certain devices to certain limited uses and to limit the transmission paths telecommunications providers might employ" (Krattenmaker, 1996, p. 6).

The changes in rules were massive. Companies that for decades were only permitted to operate in one area of telecommunications business were now allowed to compete in other areas of the marketplace (McGregor et al., 2010). For example, longstanding telephone service company AT&T provides television service with its AT&T U-Verse business. Conversely, many cable television providers provide local and long-distance telephone service through VoIP (voice over Internet Protocol) technology.[66] Other provisions of the Act included new television station ownership limits, the end of cable television rate regulation, content control devices in the form of a "V-chip," and, similarly, the mandated scrambling of cable television channels with primarily sexually-oriented programming (Telecommunications Act, 1996; see also Krattenmaker, 1996).

Effects of the 1996 Telecommunications Act on the Radio Industry

The Act impacted radio in two major ways. First, the Act eliminated ownership caps on the number of radio station licenses one owner could hold nationally. Locally, ownership caps were scaled depending upon the size of the overall radio market:

> In markets with 45 or more stations, 8 stations with no more than 5 in either AM or FM. In markets with 30 - 44 stations: 7 radio with no more than 4 in either service. In markets with 15-29 stations: 6 radio stations with no more than 4 in either service. In markets with fewer than 15 stations:5 radio stations with no more than 3 in either service. (Federal Communications Commission, 2000)

With the national ownership cap lifted and the local cap greatly expanded, over the next four to six years the entire ownership structure of the radio industry changed. Sterling (2006) describes the frenzy of radio station ownership consolidation of this period:

> Whereas CBS was the largest radio owner in terms of revenue with thirty-nine stations and 6% of overall radio revenue, a month after the new law

[66] The Act does stipulate that any competition must be non-predatory in nature.

> was passed, by late 1998, Infinity, with 158 stations and nearly 17% of revenue, had taken the lead. Over the next four years, station transfers (sales) expanded greatly, and prices for good properties shot up accordingly. Many long-time station operators sold out to the growing radio groups. The number of owners of radio stations dropped by a quarter (from 5,100 to about 3,800) between 1996 and 2001.26 By March 2002-just five years after the amendments were passed-the radio industry had consolidated to the structure it still holds today. Clear Channel, with 1,156 stations across the country, took in nearly 27% of total industry revenue. Adding Infinity, 184 stations and nearly 18% of revenue, the top two group owners controlled more than 44% of total radio revenue in the country. (Sterling, 2006, p. 600)

This ownership consolidation, placing so many stations in the hands of so few owners, also led to consolidation in other areas of the industry. Cost efficiencies could now be squeezed out of the new ownership groups. Both on-air personnel and office staff were eliminated, either due to redundancy of positions (i.e., there is no reason to keep two receptionists on staff when only one will sit at the front door) or with the advance of technology. As the 2000s dawned, computer technology allowed radio stations the ability to store music digitally on hard drives and the ability to store a disc jockey's (DJ's) recorded shows. Known in the industry as "voice-tracking" or automation, this technology allowed a DJ to record only the voice portions of a show for later playback between music segments. An efficient radio personality could record the voice portions of a five-hour show in perhaps one half hour; radio management soon realized that they could have one person record several shows, eliminating the need for separate "live" disc jockeys. Many on-air jobs were lost due to automation. A study released in 2006 by the Future of Music coalition found that cities with a large degree of radio ownership consolidation had greater job losses and slower wage growth among DJs, news personnel, and broadcast technicians (Future of Music Coalition, 2006).

The efficiencies created by the elimination of jobs were needed by a number of the newly-formed ownership groups because of the debt they took on in order to buy so many radio properties. As previously noted by Sterling (2006), many long-time individual or small group radio owners sold their properties to the rapidly expanding groups in the late 1990s. As sales increased, so did the prices these properties could command. The higher the price paid, the more debt accrued to the new owner.

The "poster child" for the consolidation of the radio industry is San Antonio-based Clear Channel Communications, now known as Clear Channel Media + Entertainment. At the end of its station buying and consolidation frenzy from 1996 to 2001, Clear Channel stood as the largest radio company in the United States, acquiring over 1,100 radio stations (Future of Music Coalition, 2007). Today, Clear Channel is still the largest radio station operator in the United States and owns about 850 radio stations serving 150 cities across the country[67] (Clear Channel Media + Entertainment, 2013). In order to acquire these radio stations, Clear Channel took on enormous debt. At the time of its leveraged buyout by Bain Capital and Thomas H. Lee Partners in 2008, Clear Channel had $5 billion in outstanding debt (Fabrikant, 2009). Bain and Lee paid $18 billion to purchase the company, leaving the company, including all of its radio and outdoor advertising assets, well over $20 billion in debt. As of 2013, the company remains mired in this debt, utilizing different financial tactics to manage it and still operate (Nolter, 2013). The quadrupling of debt and the pressures of repayment have caused thousands of employees at Clear Channel's radio stations to lose their jobs in

[67] Clear Channel also owns outdoor advertising locations throughout the United States (Clear Channel Media + Entertainment, 2013). Until 2005, Clear Channel owned Live Nation, one of the largest live event companies in the world. Until 2008, Clear Channel owned several television stations, before selling these to Providence Equity Partners in 2007 for over $1 billion (*The Wall Street Journal*, 2007).

many rounds of job consolidation, including 1,850 employees in a mass layoff on January 20th, 2009[68] (Sass, 2009), and another 590 employees only 3 months later in April 2009 (Shea, 2009). Media news reports document many further examples of Clear Channel's efforts to eliminate employees and consolidate job functions to reduce costs (CNYRadio.com, 2010; Stetler, 2011; Turner, 2012). Although Clear Channel has the largest debt to overcome, other radio groups, most prominiently Cumulus Broadcasting,[69] have also taken on sizable debts from their own growth spurts (Nolter, 2011).

These large radio corporations used their size to create economies of scale,[70] using internal cost efficiencies to bring lower costs to advertising clients (*Advertising Age*, 1998). For example, an advertiser seeking to air commercials on six local radio stations prior to the 1996 Act would have had to negotiate with several different salespeople from the different stations. After the Act, one owner, who has reduced costs by automating and eliminating redundant positions, could now offer six (or perhaps more) stations to one client at a lower cost than before under separate ownership. Instead of having perhaps a dozen or more radio station owners in one large market, consolidation left many cities with fewer than half a dozen major ownership groups of 4 or more stations.

By the turn of the century, the second major effect of the Telecommunications Act dealt with station licensing. In addition to extending the length of a radio station's license term to eight years (as opposed to seven years under previous policy), a new

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[68] January 20th, 2009, was Inauguration Day for President-elect Barack Obama. There was speculation at the time that Clear Channel timed the mass layoff of 1,850 employees for this day because news coverage would be focused exclusively on the Inauguration and not actions by the company (Crain, 2009).

[69] Cumulus is the largest radio-only company (no other media related businesses), with over 500 stations under its ownership (Nolter, 2011b)

[70] *The Economist* defines economies of scale as "factors that cause the average cost of producing something to fall as the volume of its output increases" (*The Economist*, 2008, para. 1).

provision of the law that Sterling (2006) termed "renewal expectancy" for stations that operated normally within the bounds of FCC policies was enacted. Since the establishment of the FCC in 1934, when a broadcast radio or television license came up for renewal, that renewal could be challenged by another party and both parties would be entitled to a comparative renewal hearing. At this hearing, each side would have to make its case why it would be the superior choice to receive the license to serve listeners in the public interest, convenience, and necessity from the FCC. Although relatively few hearings actually took place, Sterling (2006) notes that the specter of the hearings "kept legions of attorneys busy at a high cost to broadcasters even if licenses were nearly always renewed" (Sterling, 2006, p. 595).

Under Section 309(k) of the new law, comparative renewals were completely eliminated and a new renewal process was adopted. License renewals would be judged by criteria that plainly would be easy for most radio station owners to demonstrate. In an order adopted by the Commission in April 1996, shortly after the Act was signed into law, the FCC stated

> …the Commission shall grant the application if it finds, with respect to that station, during the preceding term of its license --
> (A) the station has served the public interest, convenience, and necessity;
> (B) there have been no serious violations by the licensee of this Act or the rules and regulations of the Commission; and
> (C) there have been no other violations by the licensee of this Act or the rules and regulations of the Commission which, taken together, would constitute a pattern of abuse. (Federal Communications Commission, 1996, para. 4)

These three conditions for nearly all responsible broadcasters are very easy to meet and represent a lower regulatory barrier for renewal. Broadcasters no longer had to fear not receiving a license, except for those who had noteworthy violations or a pattern of

consistent violations of FCC policy or the law. Renewals became, in effect, automatic for existing license holders.

With the license renewal process becoming simply a review by the FCC to see if the most basic requirements for licensure were met in the term period, it was easy for large radio corporations to contend they were operating in the FCC-mandated "public interest, convenience, and necessity." The newer licensing process also removed any practical hope that citizens in areas where corporately-owned stations were becoming increasingly automated, loaded with programming voice-tracked or originating from outside the area, would be able to dislodge the license from the corporate holder. The license holder only had to show no substantial violations and some type of operation "in the public interest",[71] and the new rules practically guaranteed renewal.

The Basic Terrestrial Radio Business Model

The revolution in the radio business and ownership structure with the passage of the Telecommunications Act had been incredible. However, the majority of revenue generated by radio broadcasting continued to be produced in the same manner it had been for decades—advertising. The first station to experiment with commercial advertising was WEAF-AM in New York City; it was the first station to begin what it called "toll broadcasting" (McGregor et al., 2010) when it sold 10 minutes of time to a real estate firm that wished to promote the Hawthorne Court Apartments in Jackson Heights, New York. The price paid for the time was $50 (McDonough, 2012). With the exponential growth of home radio sales by the mid-1920s, the practice of selling airtime to

[71] Operating in the "public interest, convenience, and necessity" has not meant keeping local personalities on the air or having a specific percentage of locally-generated content. Providing local weather and traffic reports or perhaps a public affairs show once per week can satisfy the standard of programming in the public interest. These items are often documented in a station's quarterly programming reports.

commercial interests became commonplace as businesses recognized the opportunity to present their products to home audiences.

This arrangement of trading time for advertising dollars has been the bedrock of radio industry finance ever since, comprising the vast majority of cash flow to stations. Over time, further advertising arrangements between advertisers and radio stations were developed, including program sponsorships sold to one advertiser, participating sponsorships (multiple sponsors could be presented instead of only one per program), and product placement. However, the majority of radio advertising is still the exchange of a set amount of airtime[72] for a certain dollar amount; advertisers pay this amount to reach the audience the station attracts. In 2012, the Radio Advertising Bureau (RAB) reported spot revenues for the radio industry exceeded $14 billion (Radio Advertising Bureau, 2013). Although listeners received the programs for "free" over-the-air (they physically paid no actual dollars to receive broadcasts), they "paid" for programming by listening to broadcasts featuring commercials from paying advertisers.

In recent years, due to financial pressures and new technological opportunities, radio stations have expanded their revenue opportunities beyond the traditional on-air advertising model. Two increasingly contributory areas of revenue are from the Internet and from off-air activities (also known in the industry as "Non-traditional Revenue" or "NTR"). Radio station websites offer multiple opportunities for advertisers, not only by inserting commercials into a station that is streaming audio on their website, but also by offering visual advertisements throughout various webpages. Advertisements can also be offered by stations via their official station Facebook or Twitter feeds, plus offered

[72] The majority of airtime sold is in 60-, 30-, or 15-second increments; however, program length advertisements or "block time" (sold by the station to an advertising client that can range in length anywhere from one half-hour to multiple hours) arrangements are available on many radio stations.

through individual radio personalities on the station. Other digital revenue could be generated by inserting advertising messages into a station's radio broadcast data system (RBDS)[73] or message marketing where a station sends text messages to listeners who have registered their phone numbers with the radio station to receive such messages (Paskvan, 2010). Classified as "digital revenue" by the RAB, this segment has grown year-over-year since the RAB began keeping records on digital revenue in 2009. In 2012, digital revenue grew over 8% from 2011, from $709 million to $767 million (Radio Advertising Bureau, 2013), with expectations of further growth in 2013.

Non-traditional revenue areas, classified as "off-air" revenues by RAB, can be almost any other radio station activity that generates revenue. Sources of NTR include station promotions and events, such as concerts, street fairs, bridal fairs, or other appearances where revenue can be generated from both event sponsors paying the station to participate and individuals paying an entrance fee (Paskvan, 2010). This area also shows slow but steady growth since 2009, accounting for over $1.5 billion in additional revenues to the radio industry (Radio Advertising Bureau, 2013).

These additional sources of revenue to radio stations have become critically important in the wake of the 2008 – 2009 economic recession[74] and the slow economic recovery since the end of the "official" recession in June 2009 (Irwin, 2010). Although a slight increase in 2013 in overall revenue continues a recent growth trend for the industry, it still falls short of the revenue figures for radio as recently as 2008, when the

[73] The RBDS is usually used to send textual station information, such as song title and artist information or station call letters and positioning statements.
[74] Many economists call this economic recession "The Great Recession" due to its length and status as the worst recession since the Great Depression of the 1930s (Center on Budget and Policy Priorities, 2013).

industry generated $18.3 billion (Radio Advertising Bureau, 2013).[75] The recession deeply affected advertising expenditures and radio revenues, and the slow recovery continues to mark the industry as one of stagnant growth (Radio Advertising Bureau, 2013). With the exception of digital revenues, including streaming audio and website advertising revenues, radio has seen scant growth in overall revenues and has yet to climb to its pre-recession level.

Figure 3.3: ANNUAL RADIO INDUSTRY REVENUE (in millions)

YEAR	NETWORK	SPOT	DIGITAL	OFF-AIR	TOTAL
2013	1,122.0	14,054.0	889.0	1,584.0	17,649.0
2012	1,163.0	14,205.0	767.0	1,510.0	17,645.0
2011	1,136.0	14,060.0	709.0	1,491.0	17,396.0
2010	1,102.0	14,181.0	615.0	1,389.0	17,287.0
2009	1,048.0	13,203.0	480.0	1,298.0	16,029.0

(Radio Advertising Bureau, 2013)

The downturn did not only affect commercial radio; even non-profit National Public Radio was affected by the downturn in underwriting[76] (Kasler, 2009). As with commercial radio, NPR and public radio outlets have faced a slow climb back to pre-recession levels of revenue. This climb has not been made any easier by the numerous competitors in the audio marketplace, especially Internet competitors.

The effects of consolidation, technology advancement, and the sluggish economy have left the radio industry in much different shape than the industry that existed prior to

[75] Additionally, the 2008 number does not include any digital (Internet) revenue; the RAB did not begin reporting digital revenue figures until 2009 (Poole, 2013).
[76] However, NPR's listener contributions actually increased in 2009 to over $3 million, up from roughly $2.9 million in 2008 (Kasler, 2009).

recession and certainly prior to the passage of the Telecommunications Act of 1996. That the industry has seen some revenue growth since 2009 is not a reflection of increased on-air advertising ("spot") sales; that area has remained stagnant around $14 billion. NTR growth has occurred over the past four years to $1.5 billion, but still has not eclipsed the $1.7 billion seen in 2008 (Radio Advertising Bureau, 2013). The true growth area for the radio business during the recession has been the digital Internet revenue. Since 2009 when the RAB began tracking sales, this area has grown from $480 million to $767 million with further growth expected in the coming years. Radio station owners have poured millions of dollars into their Internet sites and are seeing some return with growing revenues. As the Internet and mobile devices continue their explosive growth in popularity, it is not hard to imagine that accessing a radio station by its website may become as popular as accessing it by its frequency. Station Internet sites are often populated with features and information provided by a central content hub, then populated locally with the station-specific graphics and information.

Spot ad revenue remains essentially flat for the industry, rising roughly 1% in 2012 over 2011 (Radio Advertising Bureau, 2013). According to media industry analyst BIA/Kelsey (2013), slow growth is expected to continue over the next four years through 2017, with fastest growth coming from digital online sources. Expected annual growth rates are 10.8% for online versus only 2.5% for over-the-air ad sales (BIA/Kelsey, 2013). In real dollars, "BIA/Kelsey forecasts radio's online revenue growth will reach $818 million by 2017, while the industry's combined total revenue will reach $17 billion by 2017" (BIA/Kelsey, 2013). It is worthwhile to note that even though this forecast is positive on growth, that growth to the year 2017 still does not return radio's total revenue

to pre-2008 recession levels, when total revenue was $18.3 billion. To put it plainly, the radio industry is not flush with cash and a rapidly growing stream of revenue.

Although digital revenue is the growth area for radio ownership, digital competition is the fierce competitor for both listeners and ad revenue. Even though large audio streaming companies, such as Pandora, are not turning a profit, that does not mean they are not taking both listeners and advertising dollars off the table, locally and nationally.

From an human resources standpoint, the downsizing and consolidation of job functions has led to great cost savings; however, even with that savings, the largest radio consolidators, such as Clear Channel and Cumulus, do not have enough savings to cover their massive debts. In particular, Clear Channel has had to shift debt loads around its balance sheets, using other lines of credit so that maturing debts can be pushed farther into the future (Nolter, 2013). With automation computers running programming, nationally or locally syndicated hosts filling hours on-air, voicetracking by company DJs, and remaining employees taking jobs that require hours of multi-tasking in different areas (in order to fill the void left by fired employees), it is safe to say that many radio stations are running on "skeleton crews"—and further reductions in staff will not generate the massive cost savings of previous layoffs, simply because not as many people work in radio today. And with flat-to-slow revenue growth, especially in over-the-air advertising sales where the vast majority of money is generated for station ownership, paying off incurred debt will continue to be challenging for radio station owners.

Summary

It is in this challenging business environment where iBiquity seeks to make the case that HD Radio is a worthwhile and needed innovation for broadcasters to adopt. The radio industry's massive overhaul from an industry with literally thousands of private owners to one with publicly traded large consolidated corporations has been breathtaking to witness. The corporations that control broadcast licenses have shown their willingness to invest in digital technologies, including HD Radio, despite economic headwinds. Yet, industry and consumer adoption in HD Radio technology is miniscule and has remained so after a decade on the market. After reviewing the technological, business, and regulatory histories of HD Radio, plus the economic conditions the innovation finds itself battling, the questions of "Is HD Radio a failed innovation?" and "How should HD Radio proceed from this point forward?" must be analyzed and addressed.

CHAPTER IV. ANALYSIS OF THE STATUS OF HD RADIO IN THE UNITED STATES

This chapter reviews and synthesizes the evidence, laid out in the preceding chapter, of the state of the innovation known as HD Radio in the United States. Through government documents and records, news and review articles, and other empirical evidence, a reasonable understanding can be derived about the current status of HD Radio in the United States. This understanding is viewed through the prism of diffusion of innovation theory and its varied components. The primary components that are focused upon are time and social systems, and the primary attributes of the technology are its observability, trialability, and compatibility.

Overview

To either a casual observer or a researcher, it is apparent that HD Radio is, at best, a struggling innovation. Considering its low public awareness and the stagnation of adoption by radio stations over the past few years, HD Radio has come to a near-standstill in market penetration for both broadcasters and consumers. While the overall number of HD Radios is in the market continues to trickle upwards, mainly due to their placement in an increasing number of automobiles, consumers have generally not electively sought out HD as a preferred instrument for listening to audio. Instead, they tend to choose either their own portable digital devices, such as iPods, for audio programming or satellite radio as their digital radio technology. Within roughly the same amount of time on the market, satellite radio has grown to over twenty million *subscribers*—people who pay a fee in order to receive satellite radio broadcasts. In comparison, HD Radio, a free over-the-air service available to anyone with a capable receiver, recently announced it has a total of only four million *listeners*. The number of

HD-capable receivers, presently 15 million in the consumer market (Struble, 2013), pales in comparison to the number of analog receivers owned by American households which number in the hundreds of millions. To sum, HD Radio has fewer listeners than satellite radio and, notably, still has fewer receivers in the market to reach potential listeners than satellite radio has subscribers (15 million HD Radio receivers versus over 20 million satellite radio subscribers, who presumably own a capable satellite radio receiver). HD Radio has not only *not* penetrated the digital market, it has yet to make an impact replacing traditional analog radio, evidenced by the chasm between HD Radio sets in the market versus analog sets. As for actual listeners to HD Radio, it is low, evidenced by the rare, lowly-rated appearances of HD Radio-only stations in Arbitron ratings.

The larger question is why the innovation of HD Radio has failed to sufficiently diffuse to a majority of the listening public or broadcasters. For the answer to this question, the evidence examined must be beyond one area (for example, looking at only the broadcasting industry's role in HD Radio's diffusion) and take into account all areas of HD Radio's potential diffusion. The areas that have been examined so far have been the technology behind HD Radio, the corporate and consumer marketplace history of HD Radio, the regulatory aspect of digital radio in the United States, and an analysis of the radio industry as a whole. It is the intermixture of factors between these areas that has created the environment that HD Radio must work within to succeed or fail. This chapter examines those areas and brings them together to achieve a more complete understanding of the current status of HD radio.

Diffusion—the radio "social system" interaction

In broadcast media, the relationship between the social systems of regulation, consumer and industry economics, and technology development are highly interconnected. The radio industry is primarily concerned with how to make money with this mass communication medium and actively seeks to do so in a stable environment. As with any business, customers are needed to purchase the product; in radio's case, a purchase includes not only the actual item (the radio receiver or transmitter), but the utility of the device (transmitting a radio program or hearing it on the receiver's end). The device they are purchasing promises to deliver sound through a technology that has been well developed over the course of a century. Even with modifications in equipment, such as digital tuners for more precise tuning into a frequency, a basic radio, whether analog or digitally tuned, detects signals over-the-air and transduces them into sound for the human ear. The spectrum for radio broadcasting has been limited by the government of the United States through the Federal Communications Commission agency and it is through this agency that other rules and regulations have been either enacted or enforced.

Should any one of these systems react slowly to change or outright fail to recognize changing dynamics, either within or outside their own system, an impasse would be a near-certainty to develop. For example, if a product in a government-regulated industry is developed and tested, but fails to win government approval for consumer sales, the product will never be brought to market. Conversely, if the government approves a type of product, but industry fails to produce a product or consumers are indifferent to the product, again the product will fail. If the product is

approved by government and industry produces the product for consumers, there is no guarantee that the product will be a one that is worthwhile to consumers in general.

In the case of HD Radio, for the innovation to diffuse it would have to rely on all social systems working together to diffuse the innovation to enough adopters; a hold-up in one system could delay or outright halt diffusion in all systems. In addition, as Rogers (2003) noted, viability of technology may be limited by what the end user can actually do with the technology—in other words, the "hardware" may be completely sound in its construction, but if the "software"—the utility of the innovation—is not perceived as valuable, both the hardware and software will likely face a difficult diffusion process.

RQ 1: What regulatory factors have affected the diffusion of HD Radio?

The FCC has been an early and consistent supporter of digital technology in broadcasting and digital audio broadcasting has benefited from this support. Although the Commission decided to effectively table terrestrial-based digital audio broadcasting in the early 1990's in favor of focusing on satellite digital delivery (Federal Communications Commission, 1999), this pause was more due to technological limitations of the time rather than a view that terrestrial DAB was not worthwhile.

In its *NPRM* of November 1, 1999, the Commission clearly reinforces its view that a transition to an all-digital platform for audio and video broadcasting is a long-range goal that it intends to fulfill (Federal Communications Commission, 1999). The reasons the Commission gives are rooted in its charge to serve "the public interest"; by allowing consumers the opportunity to experience the benefits of digital technology, digital audio broadcasting provides a better experience for all radio consumers.

In subsequent filings, the Commission has never backed off of these sentiments, even when faced with challenges from both the public at-large and other interested parties who filed comments with the FCC regarding the implementation of digital broadcasting. From the initial discussions and approval processes to decide a digital audio broadcasting standard to the present day, the Commission has steadfastly shown its support for continued refinement of the technology and improved service to broadcast listeners.

It is fair to say that the innovation of HD Radio has fully diffused through the regulatory area because of this demonstrated support and lack of any material demonstrating hesitancy on the part of the FCC for at least the past 20 years. The only hesitancy came at the outset of the digital era, when the Commission determined that the technology for terrestrially-based DAB was simply not viable and shelved terrestrial DAB until such time as the technology developed. Aside from that delay, the Commission has overtly supported development, implementation, and solutions to technical challenges involving HD Radio and continues to do so.

It is fair to say that past experiences have guided the Commission's actions regarding HD Radio, particularly the regulatory journeys of DTV and AM Stereo. The saga of the AM stereo innovation is seen by many broadcasting historians and observers as a monumental regulatory blunder, due to the fact that market competition did not allow any one technology to gain market dominance; therefore, consumer and broadcaster confusion over which system to purchase ruined diffusion of that technology. The Commission was loathe to repeat any sort of deregulatory, market-based competition with a new technology. When deciding what the standard should be for digital audio

broadcasting in the United States, the Commission did its due diligence and steered the choice towards the system not only favored by circumstances,[77] but also by the broadcasting industry[78] to enhance the chances for overall success of digital audio broadcasting. In this respect, the FCC could encourage a digital radio conversion in the same manner they had encouraged a digital television conversion among consumers. It would encourage consumers and industry officials that the Commission was fully in support of the "digital revolution" and that the Commission would be actively advancing digital technology as the future of broadcasting.

According to Rogers' (2003) classic definition, diffusion takes place with an innovation, "communicated through certain channels over time among members of a social system" (p. 11). Within this area, the innovation of HD Radio was communicated through the regulatory structure as an advantageous system over existing analog broadcasting. Over the course of many years, this digital system was debated among members of that system until it was formally adopted by the system as the standard for digital broadcasting in the United States in 2002 (Federal Communications Commission, 2002). Among the topics debated in the regulatory arena were the relative advantages of HD Radio, the complexity of the hybrid system, and the compatibility with existing technology.[79] The FCC insisted on system testing throughout the process, during which IBOC was tested under a number of conditions to determine performance. Finally, throughout the process of the NPRM, the Commission kept the process open to industry

[77] Eureka-147 had been ruled out due to spectrum availability and the competitors for IBOC business (Lucent Technologies and USADR) had merged into one company by the year 2000.
[78] Numerous support letters for the HD Radio system were submitted by radio station owners and other associated industry technology suppliers and interested parties in response to the initial NPRE dated November 1, 1999.
[79] Considering that HD Radio is a hybrid analog/digital platform, the consideration of compatibility with existing technology so radio listeners would continue to receive programming where they were used to receiving was a primary concern.

and other interested parties and actively sought their input regarding digital radio systems.

This process took years, during which the regulatory system went through the classic diffusion steps. The FCC first acquired *knowledge* of the innovation through meetings and reports, then the Commission was *persuaded* to select IBOC for the terrestrial digital audio broadcasting standard. After a *decision* was made by the Commission, IBOC was *implemented* as the only approved digital broadcast standard for the United States. Despite several challenges in commentary letters submitted to the FCC, the Commission has stood firm by its decision (*confirmation*) to choose IBOC and HD Radio, noting that it was the most feasible system available at the time of the decision with the largest amount of support among the broadcast industry.

RQ 2: What role has technological advancement in the audio marketplace played in the diffusion of HD Radio?

HD radio was greeted with tremendous enthusiasm in the broadcasting industry when proposed as the digital audio broadcasting system for the United States and at its industry and consumer rollout in 2003. A tremendous amount of industry support was logged by the FCC in comments related to the NPRM of November 1, 1999, which the FCC asked for industry perspective on digital radio systems. Although several of the letters heralded the promise of digital technology, nearly all also mention that the selection of IBOC would be beneficial since neither consumers nor broadcasters would have to either give up their existing analog signals or be "stuck" with an old technology (analog). Everyone, consumers and broadcasters, would be able to use the technology and hardware they already owned while a gradual transition was made to an all-digital

system. Nobody gave any sort of date range for the eventual all-digital transition, but opinion was nearly unanimous that digital was the future, that it provided enhanced sound, more service possibilities for listeners, and that the FCC should act as soon as possible to approve the HD Radio system.

The FCC did indeed approve the system, and the HD Digital Radio Alliance was formed between some of the largest radio station ownership groups to provide promotional support for the new venture. The members of the Alliance pledged hundreds of millions of dollars in promotional airtime for HD Radio, promoting its arrival on the marketplace to consumers, digital broadcasting advantages, program advantages, and attempting to persuade listeners that now was the time to purchase a digital-capable receiver. This initial marketing push coincided with release of receivers into the consumer market and initial discounts for broadcasters who wished to purchase IBOC transmitting equipment.

What this initial push was struggling against was the genuine revolution that was taking place in the audio marketplace with the debut of devices like the Apple iPod for personal music and streaming audio from services like Pandora (or broadcasters themselves). These new and digitally-based ways to listen to audio transformed the audio marketplace from one locked into a paradigm where only radio was an efficient, portable source of entertainment to one where multiple devices could provide portable entertainment. Furthermore, streaming audio services could be customizable to music tastes, either through complex proprietary algorithms that services used to provide music it thought listeners enjoyed to MP3 devices that are entirely programmed by the user. These devices also minimized or completely eliminated commercial or sponsorship

messages that listeners found annoying and felt interrupted their programming. HD Radio debuted at nearly the exact time this shift in portability, customizability, and digital advancement occurred, leaving it appearing like a digital version of the same old radio that had been around for decades. Although some new features were included with HD Radio, including the promise of more channels of content and digital sound, it could not promise the selling point of customizable content or other features inherent in the new devices.

RQ 3: What business, industry, and consumer factors have affected the diffusion of HD Radio?

Broadcasters began to install IBOC equipment as it became available, primarily in medium-sized markets and above. Since an IBOC transmitter set could cost upwards of $100,000 per station, this was seen as a significant expense. However, many major and large-market stations began to broadcast in HD. At the peak of activity in 2006, over 500 radio stations converted to HD broadcasting. However, the pace of conversions began to slow in 2007; with the massive economic downturn in 2008 continuing into 2009, HD conversions plummeted to fewer than 200. By 2011, only 17 stations converted to HD broadcasting. By December 2012, a few stations that had converted to HD Radio had stopped broadcasting in HD, dropping the total number of HD Radio stations from 2,103 to 2,048 (Santhanam, Mitchell, & Olmstead, 2013).

This precipitous decline can be blamed partially on the economic downturn in general. This national economic crisis forced cutbacks in nearly every segment of the economy and hit radio particularly hard. Radio advertising revenue fell by double digit percentages from 2008 to 2009 and, as of 2013, has not rebounded to pre-crisis levels

(Radio Advertising Bureau, 2013). The decline can also be attributed to the fact that there does not appear to be an immediate return on investment for stations that choose to install HD Radio equipment. If there is some return, it is difficult to quantify it at this time. The HD-1 channel simulcasts the programming from the analog frequency, so determining how many listeners are choosing HD broadcasts over the regular analog broadcasts is problematic. Additional programming channels (the HD-2 and HD-3 signals) have miniscule audiences as measured by Arbitron. It is telling that KSHE-HD2 in St. Louis, Missouri, is the first HD2 station in a top 50 market to be rated for consecutive months, meaning that listeners had reported listening to the station (Radio Ink, 2013). The HD2 station has been on the air since 2006; it took 7 years to build up enough of an audience to be rated in consecutive months in 2013. For station ownership, whose livelihood depends upon advertising sales, being unable to sell a sizable, stable audience to an advertiser is a non-starter. Installing equipment worth thousands of dollars to digitally broadcast a "main" analog station that can already be heard on existing radios and additional channels that draw few listeners is not an enticing proposition to many stations. With groups, such as Clear Channel, billions of dollars in debt, investing more money to convert more stations to HD without seeing a financial return is unlikely to happen.

Despite a few minor success stories, such as KSHE-HD2, the outlook for advertising revenue on additional HD Radio-only channels is grim. There are very few listeners, and radio station advertising sales departments have a difficult task asking for sponsorship money for programming that does not draw an audience. Given the slow

penetration of HD Radio sets into the hands of consumers, the chances that there will be a tremendous expansion of audience in the near-term future is minimal.

Perhaps in a normal economic environment with little debt, the radio industry could afford to float HD Radio as "the future" and not worry about losing money in the investment for several years. However, with advertising for terrestrial analog stations suffering and many radio stations operating under ownership that has accumulated billions of dollars in debt, every dollar spent is being scrutinized for the potential of return on investment. As it stands, HD Radio has very little to offer for return on investment, other than some slow-to-moderate growth in the automobile sector and hope for the future. Unfortunately, for an innovation that is utterly dependent upon the broadcasting industry to adopt it and then promote it to its listeners, the industry backing away from HD conversion, as it has for the past few years, is an ominous sign.

The number of marketing dollars has also waned for HD in the past few years. The last press release touting the level of industry support for HD was in 2011 and promoted a $110 million in radio inventory committed for a promotional effort to increase HD Radio awareness. Since iBiquity is a privately-held company, information on other endeavors is difficult to find. It is fair to say that these promotional efforts have been of limited success, with the percentage of HD Radio public awareness actually decreasing from 2011 to 2012 (Kassof, 2012). The industry backtrack on support for HD Radio comes as radio has aggressively marketed online audio efforts, such as Clear Channel's iHeart platform[80] that features streaming stations from around the world. The promotion of "digital" audio has noticeably shifted to online efforts rather than terrestrial

[80] Other radio ownership groups also use the iHeartRadio platform for their stations, provide streaming solutions internally, or contract with aggregators such as TuneIn.

broadcast efforts. After hundreds of millions of dollars in promotional airtime given to HD Radio by members of the HD Radio Alliance, the industry has completely shifted to promotion of online listening and few, if any, HD Radio marketing efforts are heard.

Strictly by the number of HD conversions at the station level, HD Radio remains firmly in an "early adopters" category of diffusion. With 2,048 stations broadcasting HD signals in 2012 out of over 15,000 radio stations in the United States, the number of HD stations hovers around 14% of all radio stations in the country. It is worth noting that the overwhelming majority of HD broadcasters are on FM. If only FM stations are considered, the numbers are somewhat more encouraging. With roughly 10,000 FM stations in the nation, HD Radio could be considered within the early majority phase of diffusion in the industry. HD broadcasting has passed the innovator (the first 2.5%) and early adopter (the next 13.5%) areas with nearly 20 percent of FM broadcasters providing HD broadcasts. Under the normal diffusion distribution, this is where an innovation is supposed to "take off" with vastly increased adoption among a population of adopters. Yet, at this critical level, HD Radio has experienced a net negative in adopting stations, with over 50 fewer HD stations in 2012 compared with 2011. The pace of adoption is not increasing and has not since a peak adoption year of over 500 stations.

Time has also given stations an opportunity to consider many more factors regarding adoption. Rogers outlines the five steps during the innovator-decision period as knowledge, persuasion, decision, implementation, and confirmation (Rogers, 2003). Since the industry now has a decade of experience with HD Radio, and the initial enthusiasm has waned, it appears that many station owners have resisted diffusion at two steps: persuasion and confirmation. Station ownership considering converting to HD

Radio are being circumstantially persuaded to not adopt due to low, nearly-unsellable audience estimates from Arbitron and the costs associated with converting to HD broadcasting. Although iBiquity continues to release positive press items talking about increased receiver sales and implementation in many car models, station owners look at low ratings and minimal sales numbers, and many appear to be deciding they do not wish to proceed with a conversion unless the ratings and potential sales can be increased.

The confirmation stage must be mentioned because of the recent decrease in HD stations. Although it is a minor decrease of 55 HD signals that are now defunct, it raises the possibility that station ownership, after not seeing a robust return on investment, have reevaluated their decision to adopt HD Radio. Critical mass has not been achieved in order to move the innovation to mass adoption by broadcasters (or, by extension, consumers). The decision to shut down HD broadcasts can be understood in hard economic terms—if there is no apparent financial or other rational benefit to the broadcaster to transmit HD Radio, why continue to commit resources to do it? Stations may be asking themselves if the digital platform that contributes increasing amounts of revenue to the bottom line is Internet-based (RAB, 2013), with streaming audio a key feature of station websites, why not concentrate on that instead of HD Radio? In short, HD Radio does not show an economic benefit to broadcasters, forcing them to (1) not adopt the technology, (2) resist persuasion to adopt, or (3) reevaluate whether having it is indeed a benefit in the short-term or long-term. Now that the initial enthusiasm for the product has waned, diffusion has halted in this system and shows signs of disintegrating if more stations decide to shut off HD.

The consumer market for HD Radio has been marked by several glaring problems

that continue to present a full decade after the rollout of HD Radio. Consumer awareness of HD Radio is low and consumer confusion regarding the differences between HD Radio, satellite radio, and other digital "radio" experiences (such as online streaming) is profound. Availability of HD-capable receivers, in the same manner as analog radio sets are available in various models and styles, is still not on par with analog radio set offerings. The expense of purchasing a HD receiver remains well above the replacement cost of purchasing a regular analog receiver. Most problematic, the overall consumer need to have an HD Radio has not been established, slowing diffusion.

HD radio stations were already on the air by the time digitally capable receivers began a piecemeal rollout to the public in late 2003. Receiver availability was a problem, with several manufacturers delaying initial offerings until 2005, but iBiquity claimed several manufacturers were on board and producing receivers (iBiquity, 2003). Even so, the first coordinated consumer rollout, with promotional advertisements and large market exposure, did not occur until 2006, a full three years after initial rollout of the product and broadcasters transmitting HD signals (HD Radio Alliance, 2006a). This lag time between initial approval and the coordinated rollout campaign, despite the purported availability of receiver units for consumers, severely hampered the diffusion of not only the receivers themselves, but also the overall product. Without a number of capable receivers on the market for consumers to choose from and with little coordinated effort to educate consumers about HD Radio and where to get receivers, consumers were faced with a new product and very little information about why they should purchase it.

Furthermore, satellite radio competitors XM and Sirius Satellite Radio capitalized on HD Radio's understated rollout by positioning their products as "digital" and heavily

promoting a lineup of channels that included commercial free genres and celebrity-programmed or themed offerings. In other words, as HD Radio was struggling to coordinate a rollout of its product and capture any of the spotlight for its product, satellite competitors were effectively positioning themselves as *the* upgrade from traditional radio in the consumer's mind. In the meantime, iBiquity's HD Radio campaign was not focused upon the differences between satellite and HD Radio—it was focused upon the differences between analog AM/FM and HD Radio sound and programming options. Industry observers, including radio consultant Fred Jacobs (2007), found this campaign absurd since the commercials were demonizing the very medium HD was relying upon to promote itself to the public, rather than tout its advantages versus its satellite radio competitors.

At roughly the same time, Apple's iPod and other competitors' digital file playback devices were revolutionizing the personal audio marketplace. Audio file players were allowing consumers to not only have a digital audio device, but one they could control and program to their own specific tastes without commercials and other necessities of traditional radio. Owners of these devices could set up RSS ("real simple syndication") feeds so that audio content would download directly to their devices, bypassing the need to tune into any radio (terrestrial or satellite) at a specific time to hear content they generally liked, but not tailored specifically to themselves. The players ranged in price, but a lower end model could be bought for a relatively small amount of money.[81] Again, at the exact moment HD Radio was struggling to launch an effective consumer education and rollout campaign, consumers were discovering products that

[81] Although the iPod and other stand-alone audio file players remain popular today, the recent explosion in sales of smartphones must also be taken into account in this area, given that most, if not all, smartphones have audio file storage and playback capabilities.

allowed them time-shifting program freedom and personal control—perceived as upgrades from traditional radio's rigid formatting and control of content.

One of iBiquity's ongoing marketing strategies for HD Radio has been the focus on getting HD Radio into cars; consider that the first HD Radio sold was a Kenwood car stereo (iBiquity, 2004) and the current focus on the automotive sector today. This is not a decision without considerable merit, because many listeners spend the most time with radio in their cars. Cars are also the stronghold of satellite radio. However, given consumer enjoyment of personal audio players and the wide availability of portable analog radios (e.g., Sony's Walkman), it is stunning that the first tabletop HD Radio, made by Insignia and sold exclusively at Best Buy stores, did not appear on the consumer marketplace until 2009.[82] Viewed in the most positive light, this situation must be considered an error on the part of iBiquity to not have ensured availability of portable HD radio sets. Since the 1950s and the introduction of the small, portable transistor radio, one of radio's strongest selling points is its easy portability. Unlike a bulky television, a small radio is an entertainment device that a person could take anywhere—an idea capitalized upon from the 1950s through the present with several small and portable radios available to the general consumer. Now, if a consumer wishes to purchase an HD receiver, that consumer is forced to purchase either a car radio or a receiver intended for a home stereo system, with only one notable exception, the Insignia model. iBiquity's CEO admitted that the marketplace for portable devices was a paramount concern.

> Portables represent radio's future. To stay ubiquitous, to maintain its reach, radio must be on the devices that people carry. As the numbers show, with the major digital advances of the last several years, AM/FM has been getting trounced in the portables battle. (Struble, 2008b, para. 7)

[82] The Insignia model and one model from Audiovox are the only two portable HD radio models on the market today.

Although the marketplace for overall radio portables was also shrinking, according to Struble, iBiquity was enthusiastic to make portable devices.

> If AM/FM continues to lose ground on the devices people carry, it will compound the industry's difficulty. But if we work together to penetrate MP3 players, mobile phones and PNDs, radio can extend its reach and remain the most ubiquitous medium. (Struble, 2008b, para. 22)

If overall receiver availability hampered sales, the inability of sales personnel at the store level to inform potential customers of the advantages of owning a HD Radio was worse. Instead of creating a hunger for the technology, evidence from potential consumers suggests that salespersons in various settings (automobile sales and retail sales) were hard-pressed to sell HD Radio's advantages over other technologies (Miller, 2013; Miller, 2013). Locked in a competitive struggle with satellite radio for the "digital radio" distinction, it is clear that when a consumer entered a store and asked about "digital radio", the likelihood existed that they would be steered towards Sirius or XM satellite radio, not an HD Radio (Fisher, 2007). Miller's (2013) observations that the list of available receivers found on the HD Radio website are not found in actual stores further demonstrates that there is a wide gap in purported availability of receivers for consumers and actual availability. Although anecdotal, Fisher's (2007) in-store experience of asking about HD Radio at a local Best Buy retailer and being taken to the area where satellite radio was sold, plus Ray's (2010) experience at a Ford dealership trying to get an HD Radio for his vehicle, should have been clear indicators to iBiquity that its technology was not being differentiated from its satellite competitors by sales personnel.

For any product, the peer-to-peer persuasion to adopt a product is a key factor in any diffusion process. In the case of HD Radio, consumer word-of-mouth is practically non-existent in the literature. There are some positive consumer product reviews, mostly focusing upon the sound quality over FM (and certainly AM), but among actual consumers, awareness of free, over-the-air digital radio remains low (Kassof, 2012). With awareness of HD Radio at such a low level, let alone consumers with receivers to "tell the story" and persuade others to get one, it is difficult to imagine any peer-to-peer persuasion happening on any substantial level. If any persuasion is happening, it is in the satellite radio market, where a growing subscriber base for SiriusXM indicates that consumers are willing to pay for what they consider to be an "upgrade" from traditional radio, instead of utilizing HD Radio's free over-the-air digital system by purchasing a capable receiver.

The overall consumer audio marketplace has changed tremendously over the past two decades. The growth of digital personal audio devices has been tremendous, as has the growth of satellite radio. Differentiation in the "radio" market is difficult, with HD Radio trying to separate itself from satellite on one level, but also competing against online offerings, most of which also throw the term "radio" around in their offerings. For example, both Pandora and iHeartRadio offer users the chance to create their own "radio stations" that are keyed off of the user's preferences in music style, era, and other determinants. However, these "radio stations" have no transmitter, no license to operate, or anything similar to an actual radio station other than the ability to string songs together. The word "radio" has been appropriated by competitors to describe entities that are not radio in the traditional sense, damaging the traditional definition of what is a radio

station and what is not. Instead of an area called "radio," HD Radio must compete with others who define themselves as "satellite radio" and "Internet radio" and, so far, appears to be losing this branding battle.

The branding problems, evidenced by low consumer awareness, are extremely troubling when the hundreds of millions of dollars of promotional advertising committed by the radio industry to iBiquity and HD Radio are taken into account. In 2006, the HD Radio Alliance began its first large, coordinated consumer rollout and received commitments from Alliance members of $200 million in promotional airtime for the product (HD Radio Alliance, 2006b). Over the next five years, the Alliance committed itself to well over $600 million more in advertising for HD Radio. The Alliance is comprised of some of radio's largest group owners, so this advertising commitment was not on isolated, fringe broadcast stations. HD Radio advertising was heard on mainstream commercial radio stations with large audiences, many likely receptive to digital technology advancements. The overall conclusion drawn has to be that this years-long advertising commitment was almost wholly ineffective, given two simple factors: (1) traditional analog radio is listened to by at least 93% of the population per week and that (2) even with this population reach, HD Radio was unable to persuade listeners to buy an HD Radio, but nearly half of consumers are unaware that HD Radio even exists (Kassof, 2012).

The consumer area that iBiquity is currently focusing upon in sales and marketing is the automotive sector. This area has driven most of HD Radio's growth over the past few years and expects to remain a strong point. iBiquity states that 33 manufacturers are installing HD Radios into 165 models, 80 of those models featuring HD Radio as

standard equipment (iBiquity, 2013). The impact of auto sales, in both new installs and aftermarket receiver sales, drives the total number of receivers in the marketplace. According to iBiquity, out of the 15 million receivers in the market, 12 million of those are automotive (2013).

By sheer numbers, consumers who have bought sets are firmly in the innovators category of adopters at this point. There are hundreds of millions of analog radio sets in the United States; sales of new analog radio sets remain at millions per year (Struble, 2008b). There have not been enough sales of receivers, even with the massive push in the automotive sector, to lift HD Radio out of the innovators category.

Consumer perceptions about HD radio also appear to be lukewarm. Again, including HD Radio with automobile radio receivers is one way to get the technology into people's lives; it is another matter entirely for a consumer to willingly buy the individual product. This is where HD Radio has faltered badly. The reviews of the product in reputable technology magazines and blogs note many of the advantages of HD Radio, yet none tells the reader that this is a technology that is a must-have. To a great degree, an HD Radio set is built in a way that tries to positively fulfill Rogers' (2003) characteristics of an adopted innovation. The advantages of HD Radio are promoted endlessly in the literature. An HD Radio set is designed to be "backward" compatible with the existing analog broadcasting system—and, from the other end, the hybrid broadcast transmission system of HD Radio is designed to include both analog and digital signals and not force a choice of one system or the other. HD Radio sets have been designed to look and work substantially like analog radio sets.

Unfortunately, the other two characteristics of an innovation have proven to be the most challenging for HD Radio. Trialability and observability are characteristics that have been lacking in this consumer diffusion, most likely due to customer and salesperson confusion over what the product is and what it is not. If customers are not able to observe and try out the correct product, these two diffusion characteristics cannot be met. As noted earlier, there are documented stories about customers asking for "HD Radio" and being taken to "satellite radio" displays or sales materials (Fisher, 2007; Ray, 2010).

iBiquity, in an effort to get HD Radios into the customer's hands, has taken a strong lead to reverse the perceived lack of trialability and observability by strongly focusing on the automobile sector. Not only do HD Radio sets that are included as standard or optional equipment on new cars drive the total number of units sold for iBiquity, this tactic also gets the HD Radio set to the customer without the customer consciously having to choose it. In other words, the customer walks into a dealership and purchases a new car, but may not have actively chosen to have an HD Radio. However, once the customer tries to listen to the radio, he or she will enter the "trialability" stage of diffusion. The customer will likely then test every feature of the HD Radio and make a decision about whether it works, what kind of sound does it have, what programming is available, and more. iBiquity likely hopes that the more cars that get into the market with the HD Radio set as standard equipment, the more consumers will clamor for the technology and actively choose to purchase an individual HD Radio set, instead of having it included within a larger purchase.

iBiquity has been forced to take this automobile placement route because of a complete failure over time of HD Radio in the innovation-decision process on the part of the consumer. According to Rogers, the five steps in the innovation-decision process are knowledge, persuasion, decision, implementation, and confirmation (2003). Rogers notes that there are widely-disparate times that innovations move through these steps, but they generally move in the same time ordered sequence. In the case of HD Radio, evidence suggests that this entire process has been short-circuited because the initial step—knowledge—has not been achieved to a great enough degree. Consumer knowledge and awareness of HD Radio and its attributes compared to satellite radio and other competitors is not high. Consultant Mark Kassof (2012) put awareness at 54 percent of adults surveyed. Arbitron (2011) had roughly the same percentage. In the Pew Research State of the Media poll, respondents claiming to be "very interested" in HD Radio did not rise above 8% from 2006 through 2010—the most intense years for on-air HD Radio promotion from the HD Radio Alliance. iBiquity has received millions of dollars in promotional airtime and used other resources to promote HD Radio, yet roughly one of every two potential customers is unaware of what it actually is. Unless the potential adopter has clear, quality information about an innovation, there is no possible way that the adopter can be moved to the next stage—persuasion—about the product. Those who are unaware or uninformed about an innovation will reject the innovation out-of-hand. No matter how much time is given or promotional effort exerted, unless knowledge of the innovation is attained, the process is effectively stopped in market circumstances.

The consumers that have adopted HD technology do not appear to be overly-enthusiastic about it. Harker (2007) called the consumer reaction "tepid" due to signal

coverage issues and interference. Fisher (2007) noted in his comparison between British and American digital audio broadcasting that the British used their extra channels for more live programming content, while the American digital channels were automated music offerings. No matter the misgivings, the overall tone of the reviews of HD Radio has not been that this innovation is a "must-have" for consumers. With such a limited diffusion into the consumer market at this point and little certain knowledge of HD Radio among consumers, it has been impossible for consumer opinion leaders to guide new potential customers to the HD Radio innovation. Friends are not telling friends about HD Radio, and, noting the "tepid" response, consumers likely are seeking information from other sources, including online electronics reviews. These reviews have also been decidedly mixed, with many (Beezley, 2012; Godinez, 2012; Riismandel, 2010) highlighting problems with the technology. Although *Consumer Reports* (2011) gave HD Radio high marks for clean, hiss-free sound, that one positive in the review is overwhelmed with other negatives about the technology that would not encourage an ordinary consumer that HD Radio is a must-have technology. In short, with a dearth of actual people to talk to because so few people have willingly adopted HD Radio, the opinion leaders that most consumers find are tech writers and bloggers who have given lukewarm reviews to HD Radio. Change agents seeking to display the positives of a switch to HD Radio are being met by a two-pronged problem in influencing adoption among consumers: a lack of opinion leaders because the innovation has not progressed past the "innovators" stage at the consumer level and professional critics with tepid reviews found online that influence the electronics-buying consumer.

That HD Radio has not diffused more rapidly through the consumer area does not indicate future success according to research done by Carey and Moss (1985) and Van den Bulte (2000). Although there are notable innovations that have taken years, perhaps decades, to penetrate the market, Carey and Moss note that few innovations that are slow growing early on grow rapidly in later years. Van den Bulte (2000) noted that technology diffuses very rapidly and that this diffusion has increased in speed for each new technology since the 1920s. For comparison's sake, Harker (2007) described the difference between Apple's iPhone diffusion and HD Radio, commenting that while 700,000 iPhones were sold on the first weekend they were available, perhaps only a couple hundred thousand HD Radios total were sold in 2006.[83] In both theoretical and practical measurements, HD Radio's consumer diffusion thus far has been poor.

What could make HD Radio a "must have" device are new regulatory rules that compel an HD tuner to be included into every new radio sold in the United States. A firm digital transition deadline also could compel consumers to purchase an HD Radio to ensure they receive programming. However, since no action on either of those ideas has been forthcoming from the Commission, HD Radio remains subject to open market forces and has not had diffused as well as its digital audio competitors, including satellite radio, Internet radio, and personal audio devices.

Influence of Diffusion Communication Channels

One of the components of diffusion that has a high influence on potential adopters is communication channels. Rogers (2003) notes that messages through the mass media

[83] Considering that 2006 was the first *coordinated* roll-out promotional campaign for HD Radio featuring millions of dollars of advertising promotion, sales of only 200,000 or so units in a *year* in comparison with Apple's sale of 700,000 units in a *weekend* effectively demonstrates how difficult HD Radio's marketplace diffusion has been.

tend to influence early adopters of a technology more so than later adopters. Later adopters need much more influence from their peers and mass media messaging tends to not be as effective. In the case of HD Radio, with the support of the radio industry and station ownership behind it, any marketing campaign would utilize existing analog radio stations to promote the innovation. iBiquity has focused much of its marketing strategy on the generous amounts of airtime donated by the HD Radio Alliance and continues to call upon the radio industry to promote HD Radio wherever it can on-air and on station websites.

Considering HD Radio's problems in penetrating the marketplace, another mass promotional campaign could enhance the visibility of the product and attempt to convert more users. However, the Bass Model (1969) indicates that yet another promotional campaign may be a futile attempt, given that so much time has elapsed since the rollout of HD Radio (over a decade) and that interpersonal persuasion to adopt HD Radio appears to be at a standstill. Despite millions of dollars in promotional airtime and more visibility on station websites, the number of adopters continues to be driven mainly by HD receivers being placed as standard equipment in automobiles, not voluntary consumer conversion that effective advertising or interpersonal channels would enhance. In addition, because HD Radio has been on the market for a decade, the chances of recapturing the excitement of it being a "new" product are slim. Compared to other marketplace competitors' initial sales, HD Radio's sales figures lagged far behind at the start (Harker, 2007). Without the growth of interpersonal persuasion among users, and noting the failure of past promotional efforts to jump-start HD Radio sales, the Bass

Model indicates that putting money into a mass promotional effort at this time would have little effect.

RQ 4: Why has HD Radio diffusion slowed in the United States?

In the case of HD Radio, there is no one, distinct cause for its slow diffusion. Rather, it has been a situation of "harm by a thousand cuts"—changing marketplace factors, industry support, consumer expectations, business problems, vision, and other assorted problems that have kept HD Radio in the background of digital technologies available to the consumer and, thusly, a failed innovation.

Although the regulatory sector has been fully supportive since its inception, HD Radio's troubles are within two other important sectors. HD Radio has primarily failed to diffuse through the consumer sector. The available consumer numbers are awful, although iBiquity is touting projected receiver sales figures on an impressive growth curve over the next few years.[84] Nonetheless, consumer knowledge or awareness about the product is low and has been mired there for years. Furthermore, the broadcasting industry has pulled back severely on converting new stations to HD-capable broadcasting, seeing a net loss of stations broadcasting in HD in 2012 (Santhanam et al., 2013). Without stations converting to HD, there can be no "buzz" about new content, additional channels, or HD Radio being a growing technology that everyone should support. If the industry itself cannot get behind the innovation, then consumers likely will not follow either.

Nonetheless, HD Radio diffusion has slowed due to a number of other factors besides a seemingly general industry malaise regarding the innovation. The evidence

[84] This growth is driven by iBiquity's plan to bring HD Radio into most new cars and trucks available in the United States.

suggests five major factors have combined to inhibit the growth of HD Radio as a viable digital mass medium: emergence of other digital technologies, a poorly-planned rollout and marketing of the product, little return on investment for broadcasters, lackluster programming and other content, and the economic slowdown in the radio industry. Each of these factors will be discussed below.

Emergence of New Technology

When the FCC originally contemplated a digital radio system for the United States in the late 1980s, portable audio technology consisted of portable analog radios and cassette tape players. Almost one decade later, the FCC pursued a digital radio system with a *Notice of Proposed Rulemaking* to choose a digital radio system for the nation; however, the technology landscape was beginning to change. Computer programs allowing consumers to compress audio into easily portable and transferrable files were beginning to become popular. There were few portable audio-file playing devices at that time, and most people enjoyed these files at desktop or laptop computers. But, similar to a decade earlier, there was no audio entertainment technology that could compete with analog radio, a nearly universal fixture in cars and for portable entertainment.

The revolution in portable audio entertainment began in earnest with the arrival of Apple's iPod in 2001. Suddenly, a portable device, programmed by the user, that could store thousands of songs or other audio entertainment, could compete on the same level as a radio station. Other players that could store MP3 or similar audio files would sell by the millions to consumers who wanted to hear what they wanted to hear when they wanted to hear it. This development struck at the heart of one of radio's greatest

strengths—portability. No longer were consumers constrained to what the radio station programmed; they could now program every one of their favorite songs for endless listening on a portable device the same size as their old portable radios.

At roughly the same time, two companies named Sirius Satellite Radio and XM were given final approval from the FCC to operate as satellite-delivered audio entertainment. While a terrestrial digital radio system was being considered by the FCC, digitally-delivered satellite radio was debuting on the market in 2001. Both satellite radio companies promoted celebrity-programmed music and talk channels and a variety of commercial-free channels for a small subscription fee per month. Satellite radio promised nationwide coverage, clear and dynamic digital sound, and attacked terrestrial radio on two fronts. First, it promised more entertainment variety with channels playing more obscure music than found on terrestrial radio stations, appealing to people who were tired of "Top 40"-style repetitive playlists on terrestrial radio stations. Second, offering several genres of commercial-free music appealed to listeners who may enjoy music on radio, but abhorred regular advertising interruptions common to all commercial radio stations.

Both MP3 audio file players and satellite radio debuted on the market to great fanfare while digital radio was still winding its way through the approval process at the FCC. When HD Radio was finally approved as the digital radio system in the United States in 2002, these other innovations already had a one year head-start in the market. As HD Radio product was slow to rollout to the consumer market, perceptually, that head-start appeared even longer as satellite radio continued to add subscribers and MP3 devices, including the immensely-popular iPod, gathered adherents to the technology.

It is reasonable to say that when HD Radio was premiered to the public, promising digital sound and more channels of audio programming, it sounded similar to satellite radio in many ways. HD Radio's promise of a digital sound "upgrade" for radio, while true, was not groundbreaking to consumers, who by this time were used to digital sound in nearly every area of entertainment, including compact discs, satellite radio, and MP3 devices. They could also receive "digital radio" through their computers from streaming audio suppliers like Pandora; along with being digital, Pandora also tailored its streaming audio to the personal taste of users, something HD Radio could not do. As the decade of the 2000s progressed, more streaming audio servers came online, including Spotify, iHeartRadio, and others.

Each of these streaming audio servers further took the focus away from radio as the primary source of audio entertainment programming by offering customization to personal tastes of consumers. HD Radio could offer only the same programming that was on terrestrial radio, but now in digital form. Even with HD Radio digital subchannels offered by 2005 that the industry promised would bring more variety to the radio dial, those channels were still controlled by radio stations, not the consumer.

Each of these major technological developments in the audio marketplace—the MP3 player, satellite radio, and Internet streaming audio—changed the marketplace dramatically and altered radio's dominance as the audio entertainment leader. Looking back, HD Radio's timing to the marketplace was unfortunate, as it hit the market after both MP3 players and satellite radio. Internet streaming audio further allowed listeners to listen to "more" radio, digitally streamed, without being tied to a local station. Since listeners already had all of these technologies available to them by the time of HD Radio

approval in 2002, and analog radio still worked well for many of them, it is rather easy to view HD Radio as an unnecessary or superfluous technology for the consumer. If someone could get digital entertainment from all other sources, many times customized to personal tastes, why was it necessary to also have radio, which acceptably works for millions of listeners, "upgrade" to digital? In other words, consumers, already possessing tools to access tremendous amounts of digital audio content, have not found it necessary to move to digital terrestrial radio, because there are already ways to access that content through a universally available device (an ordinary radio) on analog channels. The additional utility of HD Radio is not readily apparent to consumers.

Poor Consumer Rollout and Differentiation of Product

At the time of HD Radio's approval as the digital radio system for the United States in late 2002, iBiquity began the process of establishing agreements with manufacturers to make HD Radio sets. It took a full year after FCC approval for iBiquity to unveil consumer HD Radio receivers at the International Consumer Electronics Show in January 2004 (RAB, 2012a). Nine manufacturers, including electronics giants such as Kenwood, JVC, and Panasonic, presented HD Radio sets and indicating that a vast array of consumer products would be produced from reputable manufacturers. An agreement was reached with Radio Shack to sell HD Radio in 5,000 outlets nationwide (HD Radio Alliance, 2006a). According to the HD Radio Alliance, 14,000 retailers nationwide carry HD Radio products (HD Radio Alliance, 2013b).

As good as this narrative sounds, the reality was much different. Two of the nine manufacturers at that initial unveiling did not roll out their receivers until 2005 (Alpine and Delphi). Initial prices were high, especially compared to satellite radio receivers

(*Silicon Valley Business Journal*, 2005). The first coordinated rollout of products did not happen until 2006, a full three years after FCC approval. Even with the coordinated rollout and millions of dollars of promotional advertisements run on radio stations nationwide, HD Radio sales were dismal. According to iBiquity, only 28,000 HD Radio sets were sold nationwide (Struble, 2013) in 2006, a shockingly poor result. Although annual sales have grown, they have been at a snail's pace. During the height of HD Radio promotion on radio in 2007 and 2008, when hundreds of millions of dollars of advertising were given by the HD Radio Alliance to promote HD Radio, only 140,000 units were sold in 2007 and 366,000 were sold in 2008.

There is no doubt that iBiquity's self-disclosed sales figures show more unit sales year-over-year. Driven by placement in automobiles, HD Radio is poised to have its best sales year in 2013 (Struble, 2013). Yet, compared with other technologies that have debuted, HD Radio's growth is painfully slow. Harker (2007) notes that it took Apple only 74 days to sell one million iPhones. HD Radio did not reach one million units sold until 2009, according to iBiquity's figures.

Also, these figures from iBiquity are labeled by some technology writers as sketchy, and many question them due to real-life experience and observation. Miller (2013) notes that consumer product availability for HD Radio, a full decade after debuting, is "scarce." Despite a list of manufacturers supposedly producing HD Radio sets, which is found on the HD Radio website, those products are not on store shelves. A consumer cannot choose HD Radio when the choice of sets is not present.

An additional complicating factor is the confusion over the term "digital radio" which has made it near impossible for HD Radio to differentiate itself from competitors,

namely satellite radio. Most consumers likely realize the difference between listening to a digital audio stream and listening to over-the-air broadcasting. But, that difference is clouded with satellite radio—a *perceptually* "over-the-air" audio service that is available in cars and other portable devices on receivers that look and operate substantially like terrestrial radio receivers. And, importantly, satellite radio is digitally delivered. When satellite radio beat HD Radio to the market by one year, it gave the satellite radio companies a tremendous "first-mover" marketing advantage to establish in the consumer's mind that satellite radio was "digital" and superior to regular terrestrial radio. When HD Radio came to the market, it was already fighting an uphill battle to convince consumers that its digital product was "digital radio," after that concept had already been usurped by satellite radio.

Proof of this usurpation comes from shoppers who have written about their experiences trying to purchase HD Radio receivers on the aftermarket. Fisher (2007) wrote about radio station personnel who shopped at a Best Buy store incognito and asked about HD Radio, but were taken to the satellite radio section of the store. Ray (2010) found that his automotive dealership could not give him any materials about HD Radio and kept asking him if he meant satellite radio. Although these stories constitute anecdotal evidence, it is evidence from radio professionals who have taken the initiative to ask about a technology on which millions of dollars in promotional advertisements have been spent. When a consumer walks into a store, particularly a store such as Best Buy, which is listed as a retailer where a consumer can purchase an HD Radio set, and the sales professionals do not know about the product, it is difficult to generate any

substantial sales. Especially if a consumer mentioning a general category of product inspires the sales professional to lead the consumer to a competing product.

Programming and Content

Many of the technological innovations that have been brought to the audio marketplace have given choice over programming to the consumer. The idea of "podcasting" to time shift programming to times when someone will find it more convenient is quite popular. Audio file players can be loaded with an individual's favorite music or programming, and most times this entertainment is commercial free.[85] The streaming audio area also can be tailored to the individual's tastes, at least generically. Services like Pandora and iHeartRadio ask for consumer feedback per song and record the data to further tailor the listening experience to the listener's taste, even though the consumer may not have direct control over what plays next.

In radio, programming is used to attract the largest audience possible; however, radio cannot be individually programmed to the tastes of each particular listener. Radio stations conduct market research to determine the most acceptable programming to the target audience the station is attempting to reach. Stations then schedule the overall best liked shows, music, and personalities in hopes of maintaining a large audience. However, a radio programmer cannot possibly do as good a job programming to one particular person as that person can do for himself (or herself). Audio file players give people the chance to program to themselves and time shift programming to their schedules, options that many have found fit their lifestyles better. Rather than simply accepting what is on the radio at any given time, people can use their audio file players to instantly hear something they like. HD Radio, like all radio based service, faces this

[85] Some podcasts may contain commercials within them.

challenge from audio file players, and there is very little it can do to compete with this technology from a consumer choice-of-programming standpoint.

What HD Radio can do is offer consumers more choices of audio programming than is offered on analog radio. HD Radio's subchannel capabilities, offering more than one stream of audio programming on a frequency, were highly touted as being one of the digital service's strengths. Niche formats that struggled to find permanent places on the analog radio dial would now be able to be on the air, thanks to HD Radio, thereby providing more variety in programming, including community service, music, news, and other items of interest in the station's listening area. If one station was a dominant force in a radio format, an HD-2 or HD-3 station could be launched by a competitor. As originally envisioned, HD Radio was supposed to expand the typical programming offerings on radio.

Although there are now several HD-2 and HD-3 stations on the air, many of them are not offering either groundbreaking programming or new programming. Many radio groups have chosen to simulcast AM stations on a HD-2 or HD-3 channel.[86] This program duplication puts the AM stations on a clearer FM-based HD signal, but is not "new" programming that would attract adherents to the technology.

If not simulcasting a sister station property, several station ownership groups have also tried different music and talk-based formats on HD Radio subchannels with no significant breakthroughs in Arbitron ratings and listenership. Granted, some of the formats that have been tried on HD Radio subchannels are considered "niche", with programming that appeals only to a certain segment of the population and is not intended

[86] This arrangement can be found in several cities nationwide. As one example, WPOW-HD in Miami, Florida, also features WPOW-HD2, a simulcast of sister station WQAM-AM, and WPOW-HD3, a simulcast of sister station WSBR-AM (iBiquity, 2013).

to be mass appeal.[87] However, a quick scan of several markets with HD Radio stations demonstrates that mass-appeal music and talk formats do exist on HD Radio subchannels.

Yet, their mere existence has not generated more listeners to HD Radio. One possible explanation is that the subchannel formats, especially music formats, are almost exclusively automated. One song plays after another with little to no human interaction with the music; it is, in essence, a computer-generated playlist that can run endlessly. Fisher (2007) notes that the main difference in the acceptance of digital radio programming in the United Kingdom versus the United States is that broadcasters in the U.K. use their extra channels for new, live programming, whereas U.S. broadcasters run "canned," pre-recorded automated programming.

This programming "excitement" deficiency is even more pronounced when HD Radio programming is compared to the offerings available on satellite radio. Besides being a destination for commercial free music programming, satellite radio has generated excitement for its service by offering several distinctive branded program channels. Many of these channels involve celebrity or musician-endorsed programming. For example, there are commercial-free country music channels available on SiriusXM. In addition to those channels, there is also a channel called "Willie's Roadhouse," associated with country music superstar Willie Nelson (SiriusXM, 2013). Other celebrities associated with satellite radio with their own channels include talk show host Oprah Winfrey, blues legend B.B. King, and rock music star Ozzy Osborne. Satellite radio has capitalized on associations with famous personalities and musicians to enhance

[87] Examples of "niche" formats include foreign language programming, ethnic music, or other music formats without wide appeal.

its image of offering not only more programming variety, but programming approved by some of the target audience's favorite celebrities.

HD Radio has had none of this association. Programming has been left entirely to the individual station ownership groups; very few of these groups have the industry clout to bring aboard extremely famous individuals for additional digital radio programs. If any "stars" are brought on board, they are programmed where they will attract the most listeners—on the main station analog signal, not put on HD-2 or HD-3 subchannels. In short, HD Radio has not gained any discernable notoriety for the additional channels of programming it offers. With little excitement or "buzz" about who or what is on HD subchannel programming, there is little incentive for a consumer to want HD Radio for that reason, especially when the programming that is offered is, as Fisher (2007) writes, "canned." Even with receivers being placed into the market by iBiquity through automobiles, the programming on the overwhelming majority HD-2 and HD-3 channels fails to garner enough listeners to be rated in Arbitron radio ratings.

Return on Investment

The problem of listenership on HD Radio leads to the next area that has limited HD Radio's diffusion: at present, there is no practical return on investment for radio stations to convert existing facilities into hybrid broadcasting HD Radio facilities. After a decade on the market, the conversion of stations to HD has completely stalled, with the number of stations broadcasting in HD shrinking in 2012 (Santhanam et al., 2013). One of the primary reasons for this shrinkage has to be the fact that HD Radio, especially the HD-2 and HD-3 subchannels, represent no practical increased income potential at the present time.

If a station converts to HD broadcasting, more than likely the HD-1 channel is the simulcast of the analog station. Because this programming can be heard with an ordinary analog radio, it is difficult to quantify any additional financial benefit to the station from broadcasting digitally. HD-2 and HD-3 channels, due to low listenership, have proven to be extremely difficult in selling advertising to clients interested in getting their message to the most people in the most cost effective way. After spending thousands of dollars on a conversion to HD Radio, the bottom line benefit of this investment is presently not apparent.

Of course, this idea of stations converting to HD Radio broadcasters before a financial benefit can be ensured, leads us again to the classic issue of "chicken or egg" discussed earlier. Without HD Radio programming being transmitted for listeners, listeners have little incentive to buy HD Radio receivers. Conversely, without demonstrated listeners demanding HD Radio programming, financially-stressed broadcasters have little incentive to spend money for an innovation that has not attracted listeners. The situation becomes more dire when examining the leveraged debt of major broadcasters in the United States, including HD Radio Alliance member and the country's largest individual holder of station licenses, Clear Channel Media + Entertainment. Although several other ownership groups have leveraged debt as part of their financial profile, Clear Channel stands out as the company most in trouble. Due to their 2008 acquisition by Bain Capital and Thomas H. Lee Partners, Clear Channel is roughly $20 billion in debt.[88] With this kind of financial pressure bearing down on the company, Clear Channel has looked to trim costs and find economy-of-scale solutions in

[88] This not only includes the radio division, but also the Clear Channel Outdoor advertising division.

several areas of operation. Investing in a technology that has produced little if any additional revenue for stations that have converted is unlikely.

Where companies have invested heavily and are seeing growing returns (RAB, 2013) is the Internet. The growth of "digital sales" over the past few years has been a boon to radio station owners who are seeing real dollars being generated from station websites and other online activities. Clear Channel has invested heavily in its iHeartRadio product and is seeing growth in users and revenue. Cumulus Media, the nation's second-largest radio ownership group, has found revenue from its station websites along with SweetJack.com, an online couponing site (similar in many ways to Groupon.com). Other station groups have also invested in their online presence to varying degrees of success; in the aggregate, there can be no denying the growth of revenue year-over-year from online advertising and merchandise sales (RAB, 2013).

Not coincidentally, during the same period of time Internet revenue streams have been growing for radio station owners, the number of station conversions to HD Radio has been drastically reduced. Only 17 stations converted to HD Radio broadcasting in 2011; in 2012 HD Radio actually showed negative growth (Santhanam et al., 2013). No further significant gains have been made with HD Radio broadcasters, as more investment is made into online platforms. *Perceptually* to the consumer, online radio offers many of the "benefits" of HD Radio, including digital sound, multiple channels of entertainment, song and data display, and more. Listeners can access stations online from devices many of them already own—an Internet-capable computing device or smartphone. There is no need to buy additional equipment for most; they simply go to a website address or download an app and content can be heard. In summary, HD Radio

has been stifled by the development of online platforms at the expense of its product and content on a local level that receives practically no investment compared to online.

Economic Slowdown in 2008

Similar to the last point, it is important to keep in perspective exactly why the radio industry finds itself choosing which platforms it should invest in and which platforms are on the "back burner." In 2008, the nation experienced an economic scare which, in turn, led to a pullback in many sectors of the economy, including media advertising, the lifeblood of radio, television, and other electronic media. Radio was not turning huge profits prior to the economic collapse, showing stagnant-to-slow growth throughout the middle-2000s. However, the advertising sales numbers for 2009 demonstrated just how severe the advertising drop-off was for radio, with overall sales plunging more than $3 billion. This missing revenue exacerbated the problem many radio station ownership groups faced with their debt. Already saddled with large debt service payments, many groups found themselves with even more pressing problems as advertisers refused to spend precious funds on advertising in an uncertain economic time period.

In this environment, it is natural for companies to slash non-essential items from budgets. Cuts driven by budget issues can include personnel (often the largest expense for any company), new durable goods orders, and investment into projects that it is hoped will benefit the company in the future. After a peak of over 600 HD station conversions in 2006, conversions fell slightly in 2007 and a little more in 2008. But from 2009 forward, the results have been devastating for HD Radio, with the number of stations converting coming to a standstill. It appears that the recession was the trigger point that

forced stations' decisions—either to continue to invest in and promote HD Radio as radio's digital future or promote their own websites as the digital future. The decisions made could not be clearer from the data—radio has chosen the Internet for its digital future, investing in the product throughout the post-recession period and looking to refine ways to reach new audiences with content and advertising on the Internet platform. In many ways, this shift is understandable, because the Internet can reach a worldwide audience and HD Radio, as good as it may be, is still limited by the contours of its broadcast signal. There is simply a larger market to be conquered online than locally.

For HD Radio, this is a devastating development. One of the primary benefits of choosing the IBOC system, mentioned in FCC documentation and support letters from companies asking for IBOC to be chosen, is that programming and content controlled by local stations would be key to the success of any terrestrial digital system. It was thought that local station owners would be able to leverage knowledge of their markets to providing programming that was appropriate and needed. In other words, it was expected that local radio would invest heavily into the IBOC/HD Radio system to provide the content that would drive listeners towards purchasing HD Radios, upgrading to digital on a steady pace, and eventually leading to an all-digital broadcast system with additional, high-quality content to serve local communities in the public interest, convenience, and necessity. Instead, station ownership has demonstrably pulled-back from all but nominal investment in HD Radio, leaving it to languish while the Internet platform has grabbed the lion's share of investment and support.

The "Slow Development" Argument

In enumerating the list of reasons why HD Radio diffusion has slowed, it is also prudent to review a primary argument that is often made about the current status of HD Radio: HD Radio is simply a "slow growing" technology that is taking an unusual amount of time to become part of the marketplace. There is good rationale for this argument, especially when reviewing the history of electronic media in the United States. Cable television began as a way to bring over-the-air television signals to rural and hard-to-reach areas in the 1960s; however, it was not until the late 1970s that cable television subscriptions, along with new channels of entertainment and information, began to blossom. Color television was another innovation that took decades to diffuse through both consumers and industry. After adoption of the RCA Color Compatible system in 1953, it was well over a decade before a network broadcast all primetime shows in color and many more years before even half of the country had a color television set (Sterling & Kitross, 2002). Stating that HD Radio could fall into this category is not without some merit, especially considering these previous experiences with new technology.

In August, 2013, iBiquity's CEO Robert Struble wrote a blog article on the slow growth of HD Radio, posted on the official HD Radio website. He stated:

> The one constant for all successful media transitions has been the passage of time, and that patient strategy is working for HD Radio Technology as well. Back in the mid-2000s, many forward looking broadcasters made a strategic decision to upgrade their stations to digital broadcasts. They were the initial chickens and the eggs have followed over time. (Struble, 2013, para. 4)

Struble continues:

> From 2010 to 2013, we see 50% annual growth, most of it driven by automotive uptake: almost 30% of new cars will ship with HD Radio receivers in 2013 and by next year, there won't be an auto dealer in

> America that does not have HD Radio equipped vehicles on the lot. We forecast similar results for the next several years. It sure looks like that famous inflection point experienced by many successful technologies, where sales trundle along for several years and then break through and head straight north. (Struble, 2013, para. 5)

Struble argues that after several years of poor sales and a "patient strategy," HD Radio is poised to become a "successful" technology due to the increasing sales over the past few years of receivers, most of them in automobiles. Struble references that "famous inflection point experienced by many successful technologies" to indicate that it is his belief that HD Radio is passing that point and will now experience tremendously better growth and acceptance of technology.

Unfortunately, this argument falls flat when reviewing basic diffusion description from Rogers (2003). As previously discussed, Rogers (2003) noted that there is a difference between technology and an innovation, and the two are oftentimes used synonymously in error. Simply because a technology exists does not mean it is an innovation; it is what is done with the technology that creates the innovation. What is being done in the case of HD Radio is that the technology is being placed into cars, but that is all. A piece of equipment or product appearing on one's doorstep or dashboard is not diffusion in any meaningful way because many of the psychological steps critical to the acceptance (and, therefore, the diffusion) of an innovation have been short-circuited. There has been no deliberative process or weighing of options, nor interpersonal channels of persuasion employed, aside from the hope that by using the product that interpersonal channels will be stoked. This strategy is similar to free packets of food or laundry detergent that are sent through the mail by companies to prospective customers. Many customers will accept what is given to them, and some may even try the product sample.

However, *distribution* does not automatically indicate a successful *diffusion* of product. A successful diffusion is marked by use of the technology to create the innovation; HD Radio is pointing to numbers of units sold or distributed and saying that is proof of diffusion of the technology. What Struble fails to mention is the miniscule listenership, as ranked by Arbitron. That evidence suggests that HD Radio stations have very few total listeners, no matter how much hardware has been sold in the marketplace. No matter how many HD Radio sets are placed into the market or into automobiles, unless consumers use the devices, there is no meaningful diffusion. The knowledge-persuasion-decision-implementation-confirmation steps must be undertaken by a consumer for a successful diffusion. If this strategy is accepted "whole cloth," then it would appear that the AM Stereo innovation was also successfully diffused, since it too was built in to many new car and truck radios in the 1980s. Of course, AM Stereo is seen by many as one of the largest technology debacles ever and did not successfully diffuse.

Struble continues his analysis of HD's progress by mentioning a new tactic by station owners: using FM translator stations[89] to broadcast HD Radio subchannels on an analog frequency.

> The HD Radio-on-Translator playbook is fairly straightforward. An FM station upgrades to HD Radio broadcasting. They expand their content offering by programming a new HD2 (or HD3 or HD4) channel. Here's the innovative part: they take the HD2 content and simulcast it on an analog translator, making the digital broadcast simultaneously available to all analog radio receivers already in the market. No more waiting around for more digital radios, because they can also rely on all the analog ones out there and sell ads immediately. In effect, it's like getting another unique analog FM signal for a tiny fraction of the cost of a new station. Get that translator's antenna up high enough, and it's basically a new Class A for the cost of the HD Radio upgrade. (Struble, 2013, para. 9 & 10)

[89] According to the FCC, a translator station is a "low power service on the FM broadcast band (88 to 108 MHz) that complements the primary FM service." (Federal Communications Commission, 2013)

Although the spin from Struble is positive, his description of this arrangement begs a question, "If I can now receive HD Radio subchannel content with a regular analog radio, why does it matter whether I get an HD Radio receiver or not?" The answer may be the often-repeated themes of digital sound, data content delivery, and other features of an HD Radio set. However, the old phrase "content is king" is relevant to this discussion. One of HD Radio's primary selling points has been *more* channels of free over-the-air radio available to listeners. Now, at least some of those channels can be found on in-market FM translator stations, which Struble and iBiquity hope to use to demonstrate that listeners are finding "HD Radio" and liking it. The move to use translators is being driven by station ownership, who view these signals as additional market coverage. They can place content on the signal, sell advertising, and make money, just as they do with full-power stations.

None of this recent translator activity actually *requires* using HD Radio or branding of HD Radio. Station owners can acquire translators and use them to boost their main channel coverage or present other compelling programming. What is stunning is that iBiquity, faced with the reality of low listenership, is now endorsing using an *analog* content platform to simulcast and attempt to boost its *digital* platform to demonstrate to broadcasters that "HD Radio" can make money. If HD Radio was successfully diffusing, as Struble effusively claims, it is difficult to imagine this step back to analog broadcasting of HD Radio content as necessary after a decade on the market. It is, in effect, a self-indictment of just how weak HD Radio listenership is on the digital platform to have to resort to putting content on analog frequencies just to be heard and generate revenue for station ownership.

Is HD Radio a "failed" innovation?

The central question, after careful analysis of the evidence, is this: after a decade on the market, is HD Radio a "failed" innovation; an innovation that has not diffused sufficiently through the population and is unlikely to do so in the current environment? The evidence indicates that the answer is yes: HD Radio is a failed innovation. Even though HD Radio has recently generated some market gains through inclusion in automobile radios, there remains little evidence of popular support and consumer choice for the innovation. Other competitive technologies have dwarfed HD Radio in sales and consumer interest. Confusion among consumers over what "digital radio" is has muddied the marketplace to a great degree and the likelihood of HD Radio breaking through this clutter in the current environment to establish a well-defined brand, after a decade on the market, is unlikely. Despite enthusiastic support from the FCC, and stated support from the radio industry itself, HD Radio has withered under low demand, consumer confusion, poor programming, low return on investment for broadcasters who have converted facilities to HD-capable, competitive pressures from technologies that were not available when it was approved in 2002, and from competitive and financial pressures within the radio industry.

CHAPTER V: DISCUSSION

In this final chapter, a discussion of the preceding analysis of HD Radio in the United States will be undertaken, paying particular attention to the path ahead for this innovation. Although the evidence suggests that HD Radio continues a slow growth pattern, it is an innovation that is not close to being adopted *en masse* by American radio listeners. Changes in the marketplace, whether they be regulatory, price-point adjustments for equipment, or programming choices could make a difference in the rate of adoption and those ideas will be explored. Finally, this chapter concludes with recommendations on a path forward for HD Radio, beyond what it is currently proposing, and statements on the digital future of radio broadcasting in the United States.

The stagnation of the diffusion of HD Radio is likely apparent from a variety of evidence available to the ordinary observer. For example, after a decade on the market if consumers do not know what a product is or how to differentiate it from its competitors, there is a substantial problem. However, the confluence of several factors overwhelming HD Radio makes it a unique story worthy of study. Despite the strong initial support from the FCC and broadcasting industry, HD Radio has had to fight against a rapidly rising tide of innovation in many other areas other than the radio industry itself.

One of the difficult challenges is examining this topic is that there is relatively little research on the topic and little reporting on HD Radio in general. It is not a topic that is top-of-mind to even media and technology writers. There are some reviews of products and various commentary on the state of HD Radio and what should be done with the product. But overall, it is difficult to find all the pieces of the HD Radio puzzle and put them together so the complete story can finally be told.

Knowing what happened to this innovation that held so much promise is important for many reasons. The success of a digital radio system would bring radio in line with all other major electronic media technologies; as it stands, radio remains the last mostly analog-based medium. Hundreds of millions of dollars have been spent pursuing the establishment of IBOC and HD Radio, in research and development, promotion, and equipment purchase. It would be a tremendous "sunk cost" if HD Radio is indeed a failure. Analyzing the multiple factors in the diffusion of HD Radio is also important because it is easy to see this story from a one dimensional point-of-view, rather than the complex system negotiation it was. Winning regulatory approval was a huge step; winning the business of broadcasters and consumers proved difficult. The problems cannot be blamed simply on "bad marketing," "satellite radio," or other easy-to-see mistakes or singular competitors.

The analysis of the evidence finds that HD Radio has stalled and is, at present, a failed innovation. Over 10 years after being introduced to the public, HD Radio has little consumer awareness and little consumer demand; on the broadcaster side, HD Radio has gone from being a primary focus of many large radio broadcasting groups to also-ran status, lagging behind the growing digital market found on the Internet.

For broadcasters, the return on investment calculation is straightforward. Short-term, they can make more money by focusing on Internet products than HD Radio. This is due to the fact that HD Radio receivers have yet to find any meaningful presence in the marketplace. However, for consumers, why they are not buying HD Radio's is an important question, if only because so much money has been used to promote the technology and persuade listeners to switch to HD Radio. Among the many concepts that

diffusion of innovations theory illuminates, the idea of relative advantage is key to understanding the consumer's behavior. Although relatively little has been written by critics reviewing HD Radio receivers, much of what has been written has been middling at best. Whether it is Riismandel (2010) lamenting the way an HD set tunes in stations or Falcone (2006) noting that an HD Radio is only a radio (and not something more spectacular), any research a consumer is likely to do is likely to find these kinds of testimony from experts. These reviews demonstrate that to experts, and likely to consumers, there is no apparent relative advantage to having an HD Radio, especially because most of the same content is already available, in acceptable audio quality, on analog radio equipment they already own. The uninspired programming on the additional available subchannels only exacerbates this perception. The conclusion, drawn by consumers who research HD Radio, must be that it is not worth the extra money to have the same content sent digitally, no matter how much more clear or dynamic the sound may be.

There is also the issue of how much improved the sound can be with HD Radio and whether, practically, that is an advantage. Do consumers actually perceive a *better* sound from HD Radio? *Consumer Reports* (2011) said that HD Radio does indeed live up to its promise of improved sound over FM broadcasts and markedly improves AM broadcasts. However, those tests were conducted in perfect conditions, conditions that many people do not replicate when listening to the radio. Is the sound that much "better" in a noisy room, a wind-blown car, or any other challenging listening environment compared to analog radio? HD Radio also suffers from the digital "cliff effect," meaning consumers do not get "fuzzy" stations if the signal is weak, they get nothing. iBiquity

has built radios that capture the analog signal if the digital signal is lost, but this feature is for the HD-1 channel only. If HD-2 or HD-3 signals are lost, the consumer gets nothing. Again, is this *better* sound than analog radio, which at least can receive and transduce a weak signal into listenable entertainment?

Digital television broadcasting had a large advantage over radio during its transition period. As consumers were told about the switch, they could go down to a local electronics store and see with their eyes the vastly improved picture that 720p or 1080p high-definition television sets could bring to their homes. This clearly observable attribute of digital television sets was a large improvement over the old 480p standard definition sets, and many homes already had a digital television by the time of the changeover in June 2009. The quality difference in picture was obvious. The same type of transition cannot happen in radio because different environments for listening, plus variances in hearing capabilities from person to person, will affect judgments on the value of HD Radio to consumers. If an "audiophile" can hear a difference, that is noteworthy; however, it is the mass of consumers, with various levels of hearing loss or damage at various stages in life, who must always and consistently hear a difference. If they cannot hear the difference, then what is the difference between having an HD Radio and not having one? The technology serves no additional usefulness to the listener if no difference can be observed. Looking at this phenomenon through the lens of the technology acceptance model, it is apparent that consumers have determined that HD Radio is not particularly useful to them at the present time. Among those who are aware of HD Radio, well over 50% of surveyed adults, few have adopted the technology.

In many ways, HD Radio has a difficult, lengthy challenge to gain consumer support because there are many areas where the diffusion process has not come close to occurring despite years-long presence in the electronics market. There can be no trialability and observability steps when receivers are so hard to find; because receivers are difficult to find, few consumers can be found to make a decision for (or against) owning a HD Radio and returning to confirm that decision as they continue to own a receiver. HD Radio, despite claims from iBiquity, is still in its infancy when it comes to consumer knowledge, awareness, and support.

But perhaps the largest challenge iBiquity and HD Radio face are with broadcasters who have stopped converting stations to HD Radio. With only a little over 2,000 stations converted out of the 15,000 stations in the country, HD Radio is not a universally-used technology and, at this point, remains unlikely to get to that point. The costs simply outweigh the benefits for broadcasters who, considering low consumer sales, are sending out broadcasts that so few people receive they barely show up in Arbitron ratings. The lack of a sizable audience makes it impossible to sell advertising, impossible to grow revenues, and extremely difficult to convince other stations that HD Radio broadcasting holds promise for the future.

In the regulatory arena, the FCC has been an early and strong supporter of HD Radio. However, they do not escape some accountability in the HD Radio diffusion failure. It is not so much that the FCC did not support HD Radio; instead, it can be demonstrated that the FCC was so eager to have industry support for the digital radio system that they agreed to the one system that would not upset any current station owner in 2002. When examining the case of HD Radio versus the earlier case of AM Stereo, it

is easy to see why the Commission would want to agree to industry demands for a system that, on the surface, would ensure a degree of smooth transitioning. The FCC bungled AM Stereo so badly that the repercussions of those decisions (such as letting the marketplace decide the AM Stereo standard instead of the Commission) had to have been felt in the case of HD Radio. In giving support to the IBOC system, they waited until the technology had developed sufficiently and as soon as IBOC was feasible, it was approved as the digital standard. There was little consideration of a European Eureka-type system that did not protect existing analog station owners. By deed and intention, the FCC steered the United States broadcasting industry into HD Radio so existing station owners could become digital broadcasters without expanding into a new band or competing with upstart ownership groups for licenses.

In an 2012 article featured in *Radio Ink* magazine, broadcasting law attorney John Garziglia wrote a list of challenges the radio industry faces over than the next 10 years. One of the challenges he focused upon was HD Radio.

> The HD radio system of broadcasting was largely foisted upon the FCC and our industry by major broadcasters in a quest to maintain the status quo. Unfortunately, the status quo as it existed when HD radio standards were adopted may not continue to serve broadcasters in our 21st century. HD radio as presently implemented has significant engineering and consumer usability flaws. Many station owners do not foresee any return on investment from HD radio for years to come, if ever. The coming widespread proliferation of HD receivers in automobiles may finally result in the technology being accepted by our industry and by consumers. Or, HD radio's technical and interface issues may result in such consumer unhappiness that the system is finally interred along with such artifacts as AM stereo and FM quad. (Garziglia, 2012, para 9)

Garziglia's stance on HD Radio being approved by the FCC to maintain the "status quo" in the radio industry has merit. In all reality, broadcasters had very little to risk, aside from money, when it comes to digital broadcasting. It was designed as a

system that preserved the status quo of the industry in the late 1990s. Whether or not the public accepted HD Radio as an innovation, broadcasters maintained their licenses, frequency assignments, and other assets, with digital broadcasting filling a role as an enhancement to their existing service. Every ownership group had an opportunity to add HD Radio broadcasting to their service, but the transition was not forced. From the broadcaster's perspective, it is easy to see the calculation: if HD Radio became extremely popular, broadcasters would be in position to take advantage of this technology and exploit it to maximum advantage. If it languished, or if the public does not warm to HD Radio in any significant way, they could rely entirely on the existing analog signals with no great loss in coverage or revenue. The digital experiment would be written off as a "sunk cost."

The evidence clearly shows that the revolution in digital product offerings, whether it is online streaming, online audio "cloud" storage, personal audio devices, podcasting, or other innovation, has significantly changed the status quo into a hyper-competitive marketplace for audio consumers. At the exact moment as digital terrestrial radio was emerging, with mostly the same programming, formatting, and choices available on the old analog system, consumers were getting (a) more control over choices and (b) greater ease of use of complex personal players that could feed those consumers their favorite audio choices on-demand and commercial-free. HD Radio cannot compete with this on-demand world; instead, it merely extended the tried-and-true one-to-many broadcast in a digital format.

Sticking to the current operating protocol for HD Radio will not lead to significant growth in the sector. As noted previously, stations have stopped converting to

HD Radio, even as receivers in the market are increasing due to inclusion in automobiles. There are several factors that could alter the course for HD Radio, setting it on a path to acceptance in the industry marketplace and renewed interest among consumers.

Factors Affecting the Future

As HD Radio languishes among broadcasters and consumers, outside of automobile inclusion, there is a glimmer of optimism for this innovation. Currently, the innovation has failed to diffuse adequately for aforementioned reasons. However, a change in the environment—regulatory, technical, or consumer-oriented—could alter the future of HD Radio in ways that are not possible now.

Change in the Regulatory Environment

Currently, there is no mandate to change to an all-digital radio system. From the start, one of the reasons that the IBOC system was implemented was to preserve analog broadcasting while allowing consumers to make the gradual transition to the digital system. The FCC has reaffirmed this gradual transition strategy; as recently as 2007, the Commission stated it believes that market forces can propel use of a digital system, rather than a mandate or "regulatory scheme" (Federal Communications Commission, 2007, p.8).

The Commission has also given its full support to the IBOC system and, looking to the future, has expressed its desire to give radio listeners the full benefit of digital audio broadcasting. Therefore, it is not unreasonable to conjecture about a mandate from either the FCC or a change in law on the Congressional level mandating the inclusion of HD Radio tuners in every radio sold in the United States. This idea is not without precedent, with the All Channels Receiver Act mandating UHF tuners in television sets

sold. With this legislation passed, UHF finally began to have a foothold in markets, although it took many years for UHF-capable television sets to penetrate households to a sufficient degree. But, by the time these UHF sets had achieved substantial penetration, the need for a separate tuner was being muted with the emergence of cable television, which allowed UHF and VHF stations to compete on an equal technical basis.

For HD Radio, a tuner mandate would solve the problem of getting capable receivers into consumers' hands, but would likely come with a price increase and take many years to diffuse through the population. Since there are so many working analog radios already on the market, it likely would be decades before a majority of radio receivers were analog and digital broadcast capable.[90]

This is where a second type of mandate could change the regulatory landscape: a mandate that establishes a transition deadline. This type of mandate was seen with the transition to digital television in 2009; the FCC established a "sunsetting" date for analog TV as digital sets came on the market. The public was given this information well in advance of the deadline and they were told they would have to buy a new, digitally-capable television or get a special antenna box that converted digital signals for use by analog-based televisions. Federal money was spent on a coupon program, entitling citizens to a discount on a digital converter box purchase.

HD Radio has never had a sunset date attached to its service. This is partially due to the fact that so many analog receivers are on the market and replacing them all would be a hugely expensive proposal. Additionally, unlike a television, many radios do not have inputs where a converter box could be attached successfully or conveniently to

[90] HD Radio receivers are built to receive both analog and digital broadcasts, but cost significantly more than analog-only models.

prolong the life of the analog set prior to purchasing a digital receiver. Finally, the thought of reducing the number of radios able to access programming content is not something the radio industry would support.

It is clear from the evidence presented that the "gradual transition to digital" hoped for by government and industry is not happening to any meaningful degree at this point. Listeners are still able to hear programming on regular radio and are seemingly content to rely on analog technology, rather than voluntarily purchase a HD set. A combination of a transition deadline and tuner inclusion mandate could get things transitioning at a faster rate—or it could potentially destroy the radio industry with fewer capable receivers in the market and fewer listeners. It is important to note that if this "forced transition" happens, the consumer choice is no longer either having radio or not having radio. The choice is between having radio or using podcasts, online streaming, personal music choices (perhaps converted from CDs), and other means of audio entertainment apart from a radio broadcast. This scenario likely keeps the transition from being mandated; the industry cannot afford to lose more ground to competitors, even if a transition to a digital platform includes all of the benefits touted for HD Radio (better sound, more channels, and textual data service). There is no clear-cut answer in this case, but any shift in how the FCC or Congress approaches digital radio and its problems will yield huge repercussions, positive and negative.

Industry Support

As iBiquity looks to the future and continuing to develop and sell HD Radio transmitters and receiver units, their public face is positive. HD Radio is being installed in several models of cars as either standard equipment or available as an option. Putting

the product into the marketplace and into an area where radio has traditionally been a stronghold is a strategic win for iBiquity as it tries to get potential listeners to hear the digital sound and experience the other features of HD Radio. However, industry support for HD Radio is at a crossroads. From the evidence available, it appears that HD Radio has lost the initial support it received from the radio industry in significant ways.

One way support has waned is in the area of promotion. It appears that a version of the Bass Model has been accepted by broadcasters of the HD Radio Alliance; a realization that more promotional marketing will not have a great persuasive effect in converting new customers. In fact, it is difficult to ascertain how much of an effect all of the initial radio promotion of HD Radio actually had on sales, considering they were so dismal. Promotional figures are difficult to acquire from iBiquity, but it is clear that the days of hundreds of millions of dollars in promotional airtime, given by the HD Radio Alliance to iBiquity to promote HD Radio, are over. The last publicly available figures from 2011 show a promotional airtime donation of $110 million. This is still a sizable lot of airtime, but is a fraction of what was previously given. Even so, the promotional focus has shifted away from using analog radio to promote HD Radio[91].

In short, radio—a mass communication powerhouse with nearly-universal penetration in the market—has failed to sell its own listeners HD Radio. This damning failure has set back terrestrial digital radio tremendously, perhaps mortally wounding the innovation. HD Radio depended upon not only promotional support, but programming support to generate interest and sales. Programming initiatives have been curtailed severely, with most HD-2 and HD-3 stations either being automated programming or

[91] 2011 was the last time the HD Radio Alliance announced the dollar amount of promotional airtime given to promote HD Radio. No further releases are available from the HD Radio Alliance; therefore, the analysis of this line stopped in 2012.

simulcasts of AM sister stations. HD Radio's sales pitch has been that if consumers buy an HD Radio, they will receive "more" stations. The question becomes are those additional stations worth having to the consumer, more than the stations available on satellite radio or the millions of available podcasts that can be downloaded to a personal player. The answer, looking to the evidence, has to be "no." Instead of using additional channels on HD-2 and HD-3 to expand necessary service or heighten competition, radio ownership has allowed these resources to remain underdeveloped.

Support has also waned from the industry as digital revenues have come to mean Internet revenues, not money generated from HD Radio. Radio station digital offerings have centered on website development, online ad sales, and content available through the Internet, rather than digital broadcasting. HD Radio has substantial problems in regards to the return on investment for stations that buy equipment, compared to the return on investment for Internet applications and other website development. Radio companies that have millions, if not billions, of dollars in debt, are not keen on investing more money into a technology that does not promise return in a short time frame. This situation is truly an "Achilles heel" for HD Radio: it needs the radio industry to support programming and promotion initiatives to further its goals, yet cannot yet prove to debt-laden companies that an investment in HD equipment is something that will reap substantial dividends in any sort of defined timeframe.

Alternate Paths for the Future

What can be done in regards to HD Radio for the foreseeable future? If current regulatory and industry conditions do not change, what ideas could make the HD Radio innovation more valuable to broadcasters and consumers? iBiquity's strategy is apparent:

to get HD Radio receivers into automobiles, thereby increasing trialability and observability of the technology and, hopefully, increasing the desire for HD Radio throughout the population. Although this effort has yielded increased sales results for iBiquity, with a wide majority of automobile manufacturers offering HD Radio as standard or an option on many models, it still does not address consumer-based issues that keep HD Radio from being a choice that many American consumers are asking for inside retail stores.

Price-Point Adjustments for Consumers

Perhaps one of the biggest differences between an HD Radio and an ordinary analog radio that a consumer notices is the price difference. An analog radio, new or used, can be bought for little cost. On the low end of the scale, a new analog radio can be bought for around $10; used radios can be found at garage sales and thrift shops for even less.

HD Radio faces a dual problem of both price and perception. New HD Radio receivers are substantially more expensive, with the lowest price consumer model starting at $35 and other models considerably more. Although this is not in and of itself a "deal breaker," what makes the price a stumbling block are two factors the consumer sees. First, the same program content is already available on regular analog radio in an acceptable, even hi-fidelity form (at least on the FM band). Second, as noted by at least one critic (Falcone, 2006), an HD Radio receiver really appears to be only a radio, meaning that its utility, to a consumer's perception, is not any more valuable than the cheap analog radio they already own or could purchase with less money. iBiquity regularly touts the additional features of HD Radio, but to a consumer comparing

alternatives, HD Radio simply does not make the case that its additional expense is worth it.

The only way to really attack this problem is for iBiquity and HD Radio manufacturers to start competing with analog radio receivers for market share. This action would involve cutting prices on HD receivers to compete more favorably with available analog radios. This is not an easy decision and is likely one that would involve a certain amount of loss for iBiquity or its manufacturing partners. However, it is plainly apparent from both consumer awareness (Kassoff, 2012) and sales figures that are primarily driven by inclusion in automobiles (not free-choice purchases in retail stores) that HD Radio is not the choice consumers make when deciding to buy a radio or even a larger audio system. Consumers have shown an appetite for expensive digital devices, but they are not lining up to pay at least three times as much money for a digital version of what they likely already own. A cut in the price point for receivers to a more reasonable amount may make the decision to purchase an HD Radio set easier.

HD Radio Centralization

What was supposed to be one of HD Radio's primary strengths has turned into one of its glaring weaknesses. One of the premises why IBOC was approved by the FCC as the digital standard in the United States was to take advantage of existing broadcasters' strengths in resources, programming expertise, and knowledge of their audiences. This mastery was to help the new digital broadcasting system gain both listeners and a wide variety of programming, far more than what could be offered on ordinary analog radio.

Many years after approval, HD Radio languishes with low audience numbers and, for the most part, uninspired programming choices. Critics have lamented the "canned"

automated programming available on HD Radio; some groups have repurposed other properties to broadcast on HD subchannels (such as AM stations seeking a better sounding FM-based transmission). At present, HD Radio appears to be something the radio industry thought it wanted but, having discovered a number of problems with the innovation, has now cast aside.

As opposed to the lackluster programming choices on HD stations, satellite radio has offered branded, oftentimes celebrity-driven programming that creates buzz. Satellite radio has invested millions of dollars attracting stars, from radio and from Hollywood, to participate in many channels of programming. Some stars, such as Howard Stern, command a premium price, above and beyond the initial subscription price, in order to listen. SiriusXM, the only satellite radio company for the United States, fills its channels with tremendous amounts of new content and has generated a loyal and growing subscriber base.

Although HD Radio cannot follow satellite's model directly, given that it is a terrestrially-based local service at heart, it can begin to clean up shoddy programming that has plagued HD Radio for many years. Local stations, due to smaller staffs and programming resources, simply do not have the manpower or brainpower to effectively program HD stations to compete with local broadcast competitors and outside competitors, such as streaming audio or satellite radio. Local HD stations could be helped tremendously if iBiquity would get into the content business to support its product. As the old saying goes, "content is king."

The content idea is simple and harkens back to the Clear Channel "Format Lab" the company ran in the mid-2000s. iBiquity would set up several "turn-key" formats,

available for local customization. These could be popular or niche-based formats, music-based or talk-based, that iBiquity could license from market to market on a first-come, first-served basis. The formats would be locally customizable, similar to current satellite-delivered radio formats used by terrestrial stations today. Importantly, iBiquity could create media interest in HD Radio by turning the same trick satellite radio used to make headlines—celebrities. In a similar fashion to satellite radio, HD could brand its own channels of content with celebrity endorsers or other well-known businesses (e.g., a "Home Depot" home improvement radio channel; a "Katie Couric" news channel, etc.). Local broadcasters could not possibly create this type of content for their HD Radio channels; it could only come from a centralized source such as iBiquity or another entity set up to deliver content to HD broadcasters.

If this is set up properly, the idea could be a boon to HD Radio for many reasons. Foremost, it would likely arouse curiosity about HD Radio and its features, all available for free once a receiver is purchased. This is an important distinction that must be made for HD Radio: it is delivering premium content like satellite radio, but there is no subscription cost. This "free" enhanced content area is an advantage that HD Radio has not been able to take advantage of because of the completely lackluster programming on HD-2 and HD-3 stations. HD Radio has already tried "more channels" in its marketing efforts and has failed miserably in selling that idea to the public, precisely because those extra channels are not worthwhile to listeners, as evidenced by low listenership audience figures. Celebrity or business-endorsed channels from well-known and popular personalities could deliver a substantial push for consumers to check out HD Radio offerings. If a large business, such as a Home Depot, was to become a "brand-name"

channel on HD Radio, that agreement would likely involve a substantial fee paid to iBiquity for the rights to use that channel and clear it on HD Radio stations from coast-to-coast, leading to income streams to support other iBiquity efforts. Finally, broadcasters would feel supported in their efforts in HD Radio broadcasting. Although the original intent was for local broadcasters to have local control over all these additional HD Radio channels, it has been an overwhelming task for many locals to undertake. Letting iBiquity handle programming, with personalities and features the local station simply cannot do, would allow local broadcasters to continue to focus upon their main analog/HD-1 station while at the same time bringing new and exciting programming to the market.

In considering centralized programming, a question arises: if many complaints about HD Radio center on automated programming, why is the solution out-of-market automated programming? The answer is that not all automated programming is created equally. What many HD Radio subchannels now air is a music playlist with station jingles or other imaging in between the songs or take an existing AM station and place it on an FM HD subchannel. Some HD subchannel stations have on-air personalities, but with low listenership and advertising levels, paying for a separate staff of people for an HD channel is an expensive proposition. Additionally, placing more duties on existing personnel stretches their time and talent. Consequently, the subchannels do not get the same care as the money-making analog station (simulcast on HD-1); that station must remain the primary focus and the additional HD channels are secondary.

Having iBiquity provide content exclusive to HD Radio would not only attract more listeners, but more broadcasters to HD Radio. If HD Radio reaches a point of

market saturation with receivers and begins to generate revenue, eventually the content service may no longer be necessary because many stations would want to control their own stations and localize it further. However, with HD Radio station conversions stalled and consumers still confused about what HD Radio actually is (Kasoff, 2012), having a stable programming platform that could be used in every radio market is an idea that would appeal to broadcasters looking to provide top-level programming with very little money and to listeners that want something above-and-beyond current offerings which have not generated much interest.

Subscription-Based HD Broadcasting

One of the ways HD Radio has sought to differentiate itself from satellite radio has been to promote the fact that HD Radio is available freely over-the-air with no monthly subscription fee for programming. This effort has been muddied at best, considering the widespread confusion over what the term "digital radio" means and the other differences between satellite and HD Radio.

Given that consumers have not responded *en masse* to the offer of "free" additional channels of content, perhaps the opportunity is present to offer subscription based HD Radio channels. Technically, it is possible to offer such a service. A digital signal can be encrypted to prevent unauthorized usage (similar to satellite radio or cable television) and receivers can be updated to include keypads to punch in "unlocking" codes. Not all channels would be locked on HD Radio; likely, "free" service would continue on HD-1. However, the idea of a subscription service for subchannels comes with intriguing possibilities.

By paying a fee, something that listeners do for many other audio services, including satellite radio, premium tiers of Internet streaming services (e.g., Pandora One) and mobile phone-based services like Verizon Rhapsody, iBiquity could begin to compete with other content providers on a national level, rather than leave programming choices exclusively up to local stations or station owners loathe to spend money on HD channels due to minimal return on investment. However, it is also possible that a subscription model would work on a local level. An interesting use of a "subscription" model has already been tried, although not on HD Radio. KQED-FM, a NPR-member station in San Francisco, offered its listeners a choice during one of the many membership "pledge drives" to raise money for the station. These pledge drives often interrupt programming for pleas from station personnel for listeners to call and pledge to donate money. KQED offered listeners a deal: for a $45 donation, listeners would be given access to a "pledge drive-free" internet stream, where no mention of the pledge drive would be heard and programming would be uninterrupted (Phelps, 2011). According to KQED Chief Operating Officer Dan Derheim, "listeners are willing to "pay their way around [pledge drives]" (Phelps, 2011, para 5) and that the station had raised more than $26,000 from the offer.

If this works on the Internet, it can work on the air once enough HD receivers hit the market. For example, a popular radio station on HD-1 could offer its listeners a similar "premium" experience by setting up a commercial-free experience on HD-2 or HD-3 of the same frequency. Alternatively, the station could use national resources from iBiquity to set up a premium content channel that is paid for by ongoing subscription fees. A limiting factor is receiver capability to unlock encrypted signals, but new

receivers can be sold with this "enhancement" built in. Although "free" over-the-air broadcast service is a hallmark of the American broadcasting system, the opportunity for additional stabilizing revenue for HD Radio is enticing.

Renewed Sales Training

One of the most disappointing things about the HD Radio story is the apparent inability of iBiquity and the radio industry to make consumers universally aware of what HD Radio is, what it is not, and why they should care. Part of the problem is down at the individual consumer persuasion level, where HD Radio has taken an obvious "also-ran" status to satellite radio in both growth and consumer interest. As previously noted, satellite radio's head start on HD Radio cemented in the consumer mind that "digital radio" meant satellite, not the terrestrially-based stations broadcasting for generations. It has been difficult to break this perception; Fisher (2007), Ray (2010), and Miller (2013) discuss HD Radio's scarcity at retailers and the utter confusion that ensued when a customer requested to see an HD Radio only to be led to the satellite radio section of the store.

To address this problem, iBiquity must get down to the consumer level in stores. The company lists many major retailers on its website as places a consumer can go to get an HD Radio receiver; the question remains, when the consumer gets to the store, will the store personnel know what HD Radio is? Although its main focus appears to be on getting HD Radio sets into cars, iBiquity must address the individual radio-buying customer experience and ensure that he or she can get the technology properly explained when they go into a partner retailer. As Fisher (2007) noted, a radio executive walking into a Best Buy store, asking to see the HD Radios and being taken to satellite receivers

was devastating. Ray's (2010) experience at a car dealership demonstrates this was not an isolated problem. It is a problem that must be addressed by iBiquity directly with its partner retailers to ensure that sales personnel know the difference between satellite and terrestrial digital radio, what HD Radio can offer that satellite cannot, what programming is available locally on HD Radio, and, perhaps an immersive listening experience demonstration to illuminate the differences between analog and digital radio. As Rogers (2003) writes, much persuasion is on an interpersonal level; diffusion occurs as potential adopters learn more about an innovation through interpersonal channels and make their decision based on these conversations and investigations. What the mass marketing campaigns undertaken by iBiquity have shown is that mass marketing does not do the entire job; there must be consumer persuasion at an individual level. Proper training of sales staff by iBiquity in its partner retail stores is a critical step that must be undertaken to move HD Radio forward.

Final Thoughts

The story of HD Radio, from its beginning to the present day, is one of high expectations but low results. Radio broadcasting in the United States remains primarily an analog medium in a nearly fully digital media world. Even though there has been a digital information revolution in every other media field, radio broadcasting remains firmly planted in a technology that is decades-old with no hardened plans to transition to fully digital on the horizon.

This is not necessarily a bad thing. Radio listeners have complaints, but service and sound never seem to be among the top complaints; content and repetitive programming are usually at the top of that list. There is no groundswell of support or

complaint pushing the United States to digital service; no listeners saying they are fed up with electrical interference on the AM band or FM broadcasts that could sound better if only a digital system was in place. As Kasoff (2012) found in a survey of radio listeners, ages 18 to 64, a clear majority were either totally satisfied or mostly satisfied with current radio. HD Radio's marketing materials for many years claimed "It's Time To Upgrade!", meaning that if a consumer purchased a HD set, there would be some perceivable enhancement to a product that already satisfied the majority of people. Those who investigated HD Radio, including critics, noted that an HD Radio was "just a radio" (Falcone, 2006), not a revolution in radio listening. Rather, it was the same radio stations on a different platform, eventually buttressed by some additional channels of either niche programming or simulcast AM stations.

Innovations such as the portable audio file player and streaming audio have been accepted for their differences and improvements on existing technology. For example, the iPod made storage and instant playback of thousands of a listener's favorite songs possible in a miniature package, superseding the cassette or CD Walkman-type players that were bulky and only hold between 60 to 90 minutes of content. Streaming audio opened up a world of radio stations to people; no longer were they tied to only local radio for "radio." In addition, with the advent of Pandora and other personal audio streams, a user could control the experience to a degree by offering feedback on personal likes and dislikes, all while having access to a music library of millions of available songs. Rather than have to purchase songs on albums or compact discs to have access, now a user could stream a genre of music through Pandora (or other services) and have both familiar and new content streamed directly and personally to themselves.

In the end, the radio industry and iBiquity thought that the "magic" happened simply because an already-popular product would be placed on a new, digital platform. What they missed was the true advancement needed for consumers to make the switch; in other words, what was the relevant advantage of getting an HD Radio over an analog set? iBiquity has attempted to answer that question in its marketing materials by saying "better sound" and "more channels," but has never addressed the content issue, instead relying on local stations and station group owners to provide this key function. With almost unlimited freedom to do whatever they wanted to do with HD Radio, the radio industry did not embrace it fully and it has now withered in abandonment, a technology nearly forgotten as more lucrative Internet offerings provide both revenue and customer satisfaction.

Reflecting on HD Radio, the radio industry should now reexamine its motives for wanting a hybrid digital radio system. The reasons the industry offered in support of IBOC in the early 2000s have now evaporated in reality. While the industry during that time period wrote glowing letters in support of HD Radio, claiming it would bring improvements to local service, better quality, and more content to listeners, the current reality is that HD Radio brings none of those things to listeners and little return to the local broadcasters who offer HD service. Rather than go forward blindly with HD Radio, stumbling along until either a mandate is issued by the FCC for the industry to transition to all digital or so many stations shut down HD operations that the innovation collapses, the time is now for a reassessment of how HD Radio can be repositioned to compete against radio's biggest threats. The FCC relied on the radio industry to lead the charge into the digital broadcasting age; it is time for the radio industry to live up to its

promise—not just to implement the technology, but to provide the leadership, in partnership with iBiquity, to stop the slide of HD Radio into the dustbin of history.

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