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16 The New Technologies of Radio

Terrestrial Digital Audio Broadcasting (DAB) and Satellite Digital Audio Radio Service (DARS)

Ted Carlin

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16.1 THE FOUR-STEP PROCESS OF DIGITAL RADIO CONVERSION

Like broadcast television and home video, the radio industry is contemplating a future dependent upon digital conversion. Many radio professionals and industry

observers believe this transition to be necessary, if not unavoidable. According to Suren Pai, President of Lucent Digital Radio, "Digital itself is inevitable. You see that in every aspect of life, and radio is no exception. The world is going digital. There is no going back" (Merli, 46).

These thoughts are echoed by Feldman in his seminal work on digital media: "The idea of digital revolution is implicitly an image of humankind stepping through a doorway into an unknown and fundamentally changed future. And it is a one-way journey, a doorway through which we can never step back to return to the comfortable media certainties of the past."

For radio, this digital doorway has been open for over 15 years, but primarily in the areas of producing and recording audio. Compact disc, digital audio tape, computer hard drive, and MIDI technologies have been available to radio production staffs since the eighties, consistently replacing analog recording technologies such as LP records, reel-to-reel, and cartridge tape systems. In the Preface to *The Art of Digital Audio*, Watkinson describes the state of this digital conversion a decade ago in 1987:

> Digital audio is still developing, but it has reached a point where there is something solid to discuss. There are products in the marketplace which are dependable work-horses rather than laboratory curiosities. People use them to make a living, recording music with breathtaking clarity. Standards have been agreed for many common areas, and controversy over basic theory has largely ceased.

Digital audio production and recording are still developing. A recent, informal survey, conducted by the author, of local radio stations in Southern Pennsylvania and Northern Maryland found that all 20 medium and small market radio stations, covering various programming formats, had at least partially converted their audio production facilities to digital. Every station broadcast music from a digital platform (compact disc or computer hard drive) and digitally mastered all commercials and promotional announcements (on a computer hard drive, digital audio tape, or mini-disc). Three of these stations no longer used any form of analog tape for their broadcast material.

The decisions to convert analog production equipment to digital versions were made relatively easily. Each station tested various digital equipment models and adopted the equipment that best suited its internal needs. Basically, station personnel evaluated the equipment on price, ease-of-use, and effectiveness, with little help or pressure from outside interests.

Yet, as radio stations continue into the next century to convert their production facilities to digital, transmission to the listener, which is the primary focus of this chapter, is in the midst of receiving a digital makeover. For radio broadcasters, this conversion will be a much more difficult task than was the digital conversion of production facilities. As Sedman points out, this digital transmission conversion will be a four-step process which affects many people:

> Major changes in radio service are very difficult to institute. To be successful, a new service generally requires four levels of adoption: (1) approval by a governing body (such as the Federal Communications Commission (FCC) in the United States); (2) acceptance by broadcast stations; (3) consent from the consumer electronics industry to design and market the new technology; and, (4) adoption by the public.

This process applies not only to radio services, but to all communication technologies, including television. The television industry is currently implementing its second major transmission conversion; the first was the conversion from black and white to NTSC color in the mid-fifties. A brief examination of the current conversion from NTSC color to advanced television (ATV) illustrates how this four-step process works:

16.1.1 Step One: Approval by a Governing Body

The FCC begins a series of policy initiatives for ATV, including the establishment of the Advisory Committee on Advanced Television Service to investigate the policies, standards, and regulations that would facilitate the introduction of digital ATV in the U.S. (FCC, 1987). Following recommendations from the Advisory Committee, the FCC outlines a simulcast strategy for the transition to an ATV standard (FCC, 1990) over a 15 year period (FCC, 1992). The FCC updates this simulcast strategy in 1997 (FCC, 1997a) and issues ATV broadcast licenses in 1998 (FCC, 1998). However, the FCC is allowing the marketplace to decide on a transmission standard.

16.1.2 Step Two: Acceptance by Broadcast Stations

Reluctantly, broadcast stations agree to the ATV conversion. The reluctance comes from the FCC's decision to phase out the current NTSC color system and replace it with a totally new ATV system. This move means that all existing NTSC color TV production, transmission, and reception hardware will have to be replaced with new equipment capable of processing the ATV signal. All of the ABC, CBS, FOX, and NBC affiliates in the top 30 markets have committed to broadcasting an ATV signal by November 1999.

Because the television industry, like the radio industry, must make profits to survive, this ATV conversion, estimated to cost $12 million per station (Dupagne and Seel), forces TV stations to spend large sums of money (solely from existing revenue streams) that drastically erode, or erase, their profit margins. Stations see the long-term potential for an ATV system, but must face the short-term realities of implementing an expensive overhaul of their fully functioning, existing NTSC color system (Fedele).

16.1.3 Step Three: Consent from the Consumer Electronics Manufacturers

Without an ATV transmission standard (the Advanced Television Committee approved 18 variations of ATV), electronics manufacturers are cautiously producing ATV sets that cost thousands of dollars, hoping to capture affluent early adopters of ATV. According to Yang, the TV manufacturers "think digital TV is a gold mine. The new sets, costing $5500 and up, carry cushy premiums, and may also spur sales of DVD players, VCRs, and audio gear. But technical glitches could foil the launch. And confused shoppers may decide to wait — slowing sales of regular TVs as well" (Yang, 146).

The primary reason that an ATV transmission standard has not been selected is the late arrival of computer manufacturers to the debate (Tedesco). Computer monitors do not display digital information in the same method as television sets; computers use the progressive scanning technique, while TV sets use interlace scanning. With the increased popularity of computer use for a variety of video applications, computer manufacturers want the ability to transmit ATV signals via their equipment as well. By making their computers a *TV set* in addition to its current functions, computer manufacturers are hoping to increase their dominance and longevity in the video marketplace (Yang).

16.1.4 Step Four: Adoption by the Public

At some point, consumers will have to purchase ATV sets to replace their current NTSC color sets. To smooth the transition, the FCC has provided an ATV phase-in process that allows all parties to adapt. In addition, consumer electronic manufacturers have promised to provide ATV converters that will extend the usable life of current NTSC color sets. The major stumbling blocks will be consumer awareness and comprehension of the conversion to ATV, the cost of ATV sets, and the ability of cable TV providers to successfully distribute ATV signals over their systems (Dupagne and Seel).

16.2 TERRESTRIAL DAB

The radio industry is not as far along as television in its transition to digital transmission. In fact, there has been little impetus for change until recently. Unlike the proliferation of new and bigger TV sets, accompanied by computer and satellite-delivered video over the past decade, the reception of radio has remained virtually the same since the inception of FM broadcasting. Except for the addition of LCD tuners, radio transmission is still primarily designed for car and clock radios, portable units, and home stereos:

> Consumers are not crying out for new and better radios. Consumers are happy with radio — listenership is growing. It's free, it's portable. What else do they need? Outside of the addition of the FM band, radios themselves have changed very little since the medium's birth in the 1920s. Radios come in all shapes and sizes but essentially remain the same (Miles, 17).

In 1996, two enhancements to radio listening did finally occur: the expansion of the AM frequency band and the proliferation of radio data systems (RDS). The expansion of the AM band from 1605 MHz to 1705 MHz provided more AM channels for listeners to receive. The commitment to RDS by more than 300 radio stations provided listeners with an LCD display of information on their radio (such as song information, weather alerts, and vendor coupons). Both enhancements required consumers to purchase new radios to receive the new services. However, neither enhancement was interesting enough to entice consumers to buy enough new

radio receivers to make the services profitable (Sedman). Little has been said about either service in the last few years.

At about the same time that these enhancements were making their way to the consumer, the radio industry, like television, was attempting to embrace society's discovery and acceptance of digital technology. The radio industry wanted to ensure that their product was going to remain attractive to consumers in the future, so research was begun into the use of digital audio broadcasting (DAB) by existing terrestrial AM and FM radio stations. Three types of terrestrial DAB were to be considered: (1) in-band adjacent-channel [IBAC]; (2) in-band on-channel [IBOC]; and (3) out-of-band (Jurgen).

IBAC systems would allow FM stations to keep their current frequency assignment while broadcasting digitally in their sidebands. No IBAC system has been developed for digital AM broadcasting, and there is concern about potential interference from the DAB signals to existing adjacent FM stations if an IBAC system were implemented in the FM band (Spangler). IBAC has, therefore, been virtually eliminated from consideration in the U.S. as a DAB option.

IBOC systems would also allow AM and FM stations to keep their existing frequency assignments. Stations would be able to simulcast an analog and a DAB broadcast on the same frequency. Analog radio receivers would not become obsolete, but consumers would also have the option of purchasing a DAB receiver to be able to receive the digital version of the broadcast. A successful IBOC system has yet to be successfully tested under real-world conditions, but it is strongly endorsed by existing radio stations and their lobbying group, the National Association of Broadcasters (NAB) (Meadows).

Out-of-band DAB service would require existing radio stations to use a frequency spectrum other than AM or FM to transmit its programming. This dual frequency approach is the one being used by television stations to deliver the ATV programming described above. Stations would continue to transmit their programming on their current frequency while simulcasting a digital version on the new, expanded frequency assignment. At some point, the FCC would phase out the simulcasting and take control of the original AM or FM frequency for reuse by another technology, which would then make existing analog receivers obsolete.

This out-of-band approach is being followed by the radio industry in Europe, Canada, Japan, Mexico, South Africa, and Australia. The only major country that has not adopted this out-of-band transmission method for DAB is the U.S., mainly because of successful lobbying efforts by the NAB to protect existing AM and FM stations. The United Kingdom, for example, is using the Eureka 147 DAB transmission standard to broadcast DAB in the L frequency band (217.5 to 230 MHz).

Eureka 147 allows one radio station to transmit through multiplexing up to six stereo radio services on one frequency. For example, one frequency assignment would be able to deliver six types of country music programming: traditional country, young country, country love songs, women of country, country groups, and top-40 country hits. Because of frequency and interference limitations, this multiple delivery is not possible with current AM and FM frequency assignments. FM stations do have the opportunity, however, to practice a limited version of multiplexing by

broadcasting Muzak and data over their subchannels. More frequency space is needed to provide true stereo multiplexing, hence the move to a new frequency band would be required for this type of DAB.

Using the four-step adoption process, a closer examination of the status of these terrestrial DAB options can be provided.

16.2.1 Step One: Approval by a governing body

There have been no IBAC proposals submitted to the FCC to date.

In October, 1998 the first IBOC proposal was delivered to the FCC by USA Digital Radio (Stimson, 1998b). Until this time, research and testing of IBOC systems were being conducted by the National Radio Systems Committee (NRSC). The NAB and Consumer Electronics Manufacturers Association (CEMA) decided to combine forces to establish the NRSC in 1994 as an independent group to evaluate new radio technology. Two subcommittees were established: one to investigate the possible implementation of RDS, and the other to analyze the feasibility of IBOC DAB. Such a joint effort was designed to speed the process of new radio product development by keeping the program transmitters (NAB radio stations) and program receiver manufacturers (CEMA members) working together through real-world development and testing.

The RDS subcommittee has been working steadily since 1994 on the development of RDS *smart* radios. These RDS systems are in operation and are actively being tested by approximately 60 radio stations.

After failing to successfully test an IBOC DAB system for three years, however, the IBOC DAB subcommittee was disbanded in 1997. Original attempts by the USA Digital Radio (USADR) partnership (CBS, Westinghouse, and Gannett) and AT&T's Lucent Digital Radio to test IBOC systems were simultaneously withdrawn (Spangler).

One year later, following the 1998 NAB Radio Show, the IBOC subcommittee was reconvened after news of significant progress by USADR, Lucent Digital Radio, and a third IBOC proponent, Digital Radio Express (DRE) (Stimson, 1998a). However, citing the need to protect intellectual property, USADR bypassed the NRSC and directly submitted its own petition to the FCC for a rulemaking designed to establish IBOC DAB service in the U.S. Lucent and DRE are still working with the NRSC (Stimson, 1998b). Future IBOC petitions may be forthcoming from the NRSC, Lucent, or DRE.

In his speech to the NAB Radio Convention, FCC Chairman William Kennard described the FCC's role now that they have an IBOC petition to consider:

> But let me be very clear. Here is what we will not do. We will not undermine the technical integrity of the FM band. Our job is to be the guardian of the spectrum, not to degrade it. And we will not do anything to prevent the conversion to digital. Just last week, Michael Jordan of CBS presented me with USA Digital Radio's (USADR) petition to establish an in-band, on-channel digital broadcasting service. While we're considering this petition, we'll also continue to follow the testing and development of in-band digital systems by the National Radio Systems Committee (NRSC) set up by

> the NAB and CEMA. This is a great start, and I will do my part to make sure that local radio is not left on the sidelines of the digital revolution (Kennard, 3).

The FCC's next step is to seek public comment on USADR's petition, and eventually issue a rulemaking. This includes comment, analysis, and IBOC test results performed by all interested parties.

No petitions for out-of-band DAB service have been submitted to the FCC to date. The FCC would probably not authorize out-of-band terrestrial DAB because of the lack of available frequencies within the L band. This frequency spectrum is currently being used by the U.S. government for mobile aeronautical telemetry systems (Spangler). It would be a risky proposition for an entrepreneur to propose a new radio service without first having available frequency spectrum, or worse yet, to propose using one that is already being used by the government.

16.2.2 Step Two: Acceptance by Broadcast Stations

Existing AM and FM stations, through the NAB, have definitively backed the IBOC system approach (Stimson, 1998b) which allows stations to keep their frequency assignments and simulcast a DAB signal with the current analog signal on it. This arrangement would alleviate consumer confusion concerning the location of the DAB channel because all transmissions would be located on the existing frequency. Unlike the upcoming digital television conversion process, the IBOC digital conversion of radio would be fairly seamless from the broadcaster's perspective:

IBOC technology provides a unique opportunity for broadcasters and consumers to convert from analog to digital radio without new frequencies or service disruption. Broadcasters will use their current frequency allocations to transmit simultaneous analog and digital audio, in addition to new mobile data services. Consumers will receive familiar radio stations with superior CD-quality sound along with broadcasted in-vehicle data information (USA Digital Radio, 1490).

The cost of the digital transmission equipment will be the main concern for existing stations. As conglomeration continues within the radio industry, these equipment costs may be more easily absorbed by the resulting large station groups, but burdensome for smaller groups and independents. To convert to IBOC, broadcasters will need to make investments in the following equipment: (1) a transmitter (most FM and about half of all AM stations); (2) studio-to-transmitter link (every AM and FM station); (3) an exciter (every AM and FM station); and, (4) an antenna diplexer (about 100 FM stations) (Merli).

16.2.3 Step Three: Consent from the Consumer Electronics Manufacturers

CEMA, through its participation in the NRSC, has decided to explore the merits of an IBOC system with radio broadcasters. However, in 1997, after broadcasters had failed to produce a working IBOC system, CEMA was endorsing the only existent working DAB system at that time, the out-of-band Eureka 147 system. Logically, CEMA wants to ensure that equipment manufacturers have a viable product to

produce and will support any digital transmission system that makes it to market. Because Eureka 147 has been proven to function in the real-world, equipment manufacturers would understandably feel more at ease supporting it instead of an unproven IBOC system. Such has been the case with the manufacturing of other communication technology equipment, including ATV, AM stereo, and DBS systems:

> There's a lot riding on the outcome of IBOC DAB development. But we've been burned before with technology that wasn't ready for prime time. Remember when the FCC picked Magnavox AM stereo as the US standard? AM stereo never recovered and never had a chance thereafter. If [IBOC] works and proves to be everything US radio needs to take it into the next millennium, I'll be one happy radio guy. The rest of the world may then see the advantages [of IBOC vs. Eureka 147] and climb aboard … if Eureka doesn't grab a strong foothold first. There's a great case to be made for a system that can use existing radios: There are almost more radios in the developed world than there are people (Wire, 2).

16.2.4 Step Four: Adoption by the Public

Similar to ATV, DAB listeners will have to purchase a new radio receiver to receive DAB programming. Like every other new communication product introduction, DAB will likely be adopted earliest by those who can afford to purchase the expensive DAB receivers (Klopfenstein). It is highly unlikely that equipment manufacturers will deviate from past practices of pricing new communication technology high. This pricing strategy continues until a critical mass of adopters is reached, or competition forces prices down. The risk associated with the potential failure of the new technology is the primary factor the new product is priced so highly.

By supporting the IBOC system, broadcasters and equipment manufacturers have decided to lower the risk by keeping radio listeners tuning into the same frequencies. It will be up to the consumer to decide if the quality of the DAB signal is superior enough to the existing analog signal to warrant the purchase of a DAB receiver. According to Klopfenstein (188), "Only when new media provide potential adopters with a service that fills a need at a reasonable cost will they have a chance to be successful."

Because most radio listening occurs in vehicles, automobile and truck manufacturers could be deciding factors in the consumer adoption of DAB. If vehicle manufacturers decide to install DAB receivers in their new vehicles, consumers will have a much greater chance of accessing DAB transmissions than if they are forced to buy a DAB receiver to adapt to their existing vehicle radio (similar to adapting a portable CD player to a car's installed cassette player). It is likely that vehicle manufacturers would first install DAB receivers on the most expensive vehicles, where the costs can be most easily absorbed by the manufacturer and the luxury vehicle buyer.

16.3 SATELLITE DARS

In 1990, Satellite CD Radio, Inc. (CD Radio) filed a petition with the FCC to allocate spectrum for a new satellite-delivered radio service — satellite digital audio radio

service (DARS) — and also applied to provide the service to American consumers. CD Radio wanted to create a totally new audio delivery system that would enable consumers to receive audio programming via satellite anywhere in the continental U.S. In essence, a consumer would purchase a small (size of a silver dollar) antenna and digital radio then receive CD-quality audio that would not fade out anywhere across the country. Consumers would then have two choices for broadcast audio: terrestrial AM and FM stations that are subject to quality and interference limitations, or satellite DARS services that eliminate these difficulties. The NAB, and terrestrial radio stations, were obviously not happy with the request:

> The current number of operating FM and AM stations serving the United States public represents the highest level of audio program diversity available in the world … any continued policy of simply adding more and more stations to the commercial radio environment will ultimately disserve the public interest. (Flint, 29).

A closer examination of satellite DARS using the four-step adoption process will provide a useful analysis of this digital audio option.

16.3.1 Step One: Approval by a Governing Body

In the five years that followed CD Radio's 1990 petition, the FCC was urged to examine the impact of this new digital radio service on existing AM and FM stations. In November 1992, the FCC established a proceeding to allocate satellite DARS spectrum domestically and announced a December 15, 1992 cut-off date for satellite DARS license applications to be considered with CD Radio's. In January 1995, the Commission allocated the 2310-2360 MHz band for satellite DARS on a primary basis.

In June 1995, the FCC requested detailed information on satellite DARS' potential economic impact on terrestrial broadcasters. The Notice asked about the most appropriate service design and regulatory classification, about what public interest obligations to impose, and whether providers should be permitted to offer ancillary services. The Notice proposed three possible licensing options and rules to allow expeditious licensing after an option was chosen. After the Notice was released, Congress directed the Commission to reallocate spectrum at 2305-2320 MHz and 2345-2360 MHz for satellite DARS to be consistent with international allocations, and to award licenses in that portion of the band using competitive bidding (i.e., auction).

In a regulatory move that has angered the NAB and caused concern for most U.S. radio stations, the FCC authorized satellite DARS as a competitor to terrestrial AM and FM stations (FCC, 1997b). Seven years of petitions from the NAB argued that satellite DARS would present "a potential danger to the U.S.' universal, free, local radio service and thus to the public interest it serves. The erosion of audiences and advertising revenues caused by satellite radio would inevitably destroy the ability of many community stations to offer these services" (Flint 29). Despite the petitions' argument, the FCC approved this new digital radio service on March 3, 1997. The FCC's final response to these claims, after analyzing information from both sides of the issues, came out in favor of the development of satellite DARS:

> Given the distinguishing features of satellite DARS — it is a national service, it will require new and relatively costly equipment, and it may be offered via paid subscription — we find that the effect of satellite DARS on terrestrial radio is likely to be significantly smaller than the effect of additional terrestrial radio stations (FCC, 6).

The FCC was even more specific when analyzing the impact of satellite DARS on advertising revenues of existing radio stations:

> While we recognize that satellite DARS has significant competitive advantages in offering advertising to a national audience with satellite DARS receivers, several factors may limit the possible significance to terrestrial radio of such additional competition. First, at this time, only one out of the four satellite DARS applicants has indicated an intention to implement its system on a non-subscription, advertiser-supported basis. Second, a large share of the national radio audience is not likely to have satellite DARS receivers, at least for a significant period of time. Third, national advertising revenue amounts to only 18% of terrestrial radio advertising revenue and is on average less important for small-market stations than for large-market stations. Local advertising revenue is much more important than national advertising revenue for terrestrial radio's viability and prevalence, and, at this time, we have no evidence that satellite DARS would be able to compete for local advertising revenue (FCC, 1997b, 7).

In April 1997 the FCC successfully auctioned two segments of the S frequency band, 2320–2332.5 MHz and 2332.5–2345 MHz, among four applicants: CD Radio, American Mobile Radio Corporation (AMRC), Digital Satellite Broadcasting Corporation, and Primosphere Limited Partnership. The two winners were CD Radio ($83.3 million) and AMRC ($89.8 million) (Holland).

CD Radio and AMRC, which has since changed its name to XM Satellite Radio Inc., are now in the process of implementing their services, with CD Radio hoping to begin service to consumers in 1999 and XM a year later. Because of the long lead time necessary for satellite construction, the FCC proposed that these satellite DARS licensees begin construction of their space stations within one year of the auction, launch and begin operating their first satellite within four years, and begin operating their entire system within six years. The FCC also proposed that licensees file annual reports on the status of their systems, and, because the Communications Act limits broadcast license terms to eight years, the FCC determined that satellite DARS license terms should be eight years. The license term will commence when each service is put into operation, and be subject to renewal or termination after the initial eight-year period (FCC, 1997b).

16.3.2 Step Two: Acceptance by Broadcast Stations

Because satellite DARS will not be implemented by existing broadcast stations, this adoption step is not necessary for satellite DARS to succeed. However, it would be logical to expect continued resistance from existing stations in the form of further FCC petitions, NAB lobbying efforts, and consumer marketing similar to the cable industry's approach to DBS systems.

The main concerns of radio broadcasters, the potential loss of audience ratings and advertising revenues, will certainly be scrutinized as the satellite DARS providers begin operations. A key factor yet to be addressed by those involved is the audience measurement methodology to be used with satellite DARS. Because broadcast stations are the largest clients of the audience measurement services, including Arbitron, will stations ask them to include satellite DARS in their measurements? This information will give stations, and advertisers, a clearer picture of satellite DARS usage, but will stations want this type of view? Broadcast TV stations have been very slow to support the inclusion of accurate cable television ratings with television ratings (Eastman and Ferguson).

16.3.3 Step Three: Consent from the Consumer Electronics Manufacturers

Because of their close ties with the NAB, CEMA has not been a vocal participant in the satellite DARS debate. Both CD Radio and XM have publicly stated that they are close to signing manufacturing agreements with individual equipment manufacturers (Stimson, 1998c). Unlike IBOC DAB, the risk factor associated with satellite DARS is lower because it has been authorized by the FCC.

As with IBOC DAB systems, satellite DARS equipment will come in two stages: new and aftermarket. There were approximately 8 million aftermarket car radios sold in the U.S. in 1997, and XM's CEO Hugh Panero says this shows "a significant turnover of people who don't like their current (car) radio and want to upgrade" (Stimson, 1998c, 14). It is likely that both satellite DARS companies will also produce converters that utilize existing vehicle cassette players, although only CD Radio has specifically stated an intention to do so.

16.3.4 Step Four: Adoption by the public

CD Radio expects to break even at 1 million consumers in its first two years of operation, while XM hopes to be in the black by 2003 with 2 million users (Curran). Services will probably not be launched before the fourth quarter of 2000 or early 2001.

CD Radio has announced contracts with Space Systems/Loral Incorporated to build its fleet of four satellites, and with Lucent Technologies Microelectronics Group to develop and supply the digital transmission technology. XM has announced contracts with Hughes Space and Communications to build its three satellites, and with German-based Fraunhofer to develop its digital technology (Curran).

Both companies are planning to offer 100 channels of CD-quality audio by subscriptions for around $10 a month. In addition, consumers will have to purchase the radio receiver or converter and the receiver antenna. Original estimates by both companies priced a new radio/antenna combination between $400 and $600 (Curran). The $10-a-month fee will provide subscribers with 50 channels of commercial-free music and 50 channels of commercial-supported news/talk/sports. Up-to-date descriptions of each service can be obtained from their WWW sites: http://www.cdradio.com (CD Radio) and http://www.amrc.com (XM Satellite Radio).

As Klopfenstein points out in Chapter 6, any new radio service will have to fulfill consumers' needs at a reasonable price to attract subscribers away from existing services. This is the key to success for any entertainment provider. Successful AM and FM radio programmers have known this for decades: "Ultimately, it's going to be a question of compelling programming. If [competition is] not compelling, they'll siphon only a little off. There's nothing you can do to stave off technology. It's going to be a question of programming — if you're programming a better product than they are" ("Contemplating digital," 117).

And this compelling programming might not be the CD-quality, commercial-free music, according to some FM radio programmers: "If satellite radio is targeting music lovers, it won't get enough audience to survive. Some of those people will probably do it, but not the masses. Call up Sony and ask them how their MiniDisc is going" ("Contemplating digital," 118). Many programmers see personality as the key to every successful radio service, including satellite radio:

> I would try to find the most compelling, unique personalities on the planet, pay them way too much money, and lock them in so they could not be available any other way. That's how you do it. We saw what Rush Limbaugh and his followers have done for AM. There's no reason why a breakthrough personality, or several breakthrough personalities, can't do that for satellite radio. That's the key, as opposed to 200 channels of Montavani ("Contemplating digital," 117).

It would be reasonable to expect that satellite DARS, as well as IBOC DAB, will follow the consumer adoption paths of previous new communication technologies: high-tech affluent early adopters followed by dissatisfied AM and FM users once the price of the equipment falls to a reasonable level. This reasonable level will be determined by the consumer's perception of value for the new service.

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