The proverbial chicken-and-egg quandary "will broadcasters make content before receivers are available or will receivers be made available before content is broadcast?" does not exist - at least as applied to terrestrial digital radio in the U.S. Empirical evidence abounds, such as that of satellite radio in the U.S. and DAB (Digital Audio Broadcasting) in the UK. The experience of these two systems proves that unless there is content available from digital radio broadcasters that is promoted effectively, a particular market will not happen. Consumer electronics OEMs have accepted, even embraced, the reality that without an established base of readily available content, consumers will not invest in digital radio equipment, even if it is affordable and compelling.

There are several ideas, some learned while deploying DAB, which need to be applied to HD Radio broadcasts, speeding mass adoption and time-to-revenue.

**Anoraks' Guide to HD Radio Technology**

Analog broadcasting in the U.S. uses frequency modulation (FM) or amplitude modulation (AM). Both methods modulate the carrier wave's properties with the signal: FM modulates the frequency of the sinusoidal carrier wave while AM modulates the amplitude. After the RF transmission, the message signal is received, demodulated and extracted from the transmitted signal. The current bands for AM and FM are between 540 – 1700 kHz and 88 – 108 MHz, respectively. These bands contain an eclectic mix of talk and musical formats. However, other than for a limited use of RBDS (Radio Broadcast Data System) and other niche data subcarrier services, neither of these frequencies is used to broadcast data.

HD Radio technology does not require a new frequency spectrum since it utilizes the existing AM and FM bands. Within HD Radio broadcasts, there are two forms: hybrid and all digital. The hybrid mode broadcasts the existing analog signal sandwiched between digital information contained in two adjacent sidebands. The all-digital mode removes the analog channel and replaces it with a wholly digital transmission. Extensive digital signal processing is involved with receiving this signal, compared to FM or AM signal extraction.

For the digital sidebands, removal of the adjacent analog channel is necessary (see Figure 1, also only in FM), along with a more complex demodulation scheme involving Orthogonal Frequency Division Multiplexing (OFDM).
In addition to deinterleaving and error correction, the digital stream must be decompressed using iBiquity's HD Radio Codec (HDC). At the same time, the analog signal must be processed in parallel as described earlier. Finally, the digitized analog audio and the digital audio (from the HDC) are blended together to create the desired HD Radio audio (see Figure 2).

Beyond these signal processing issues, one of the primary differences between the analog radio and HD Radio systems is the transmission of data. Similar digital techniques described above (sans HDC) can be used to provide a data signal that can contain a wide variety of information. What type of information can be transmitted and how this affects broadcasters and radio manufacturers alike is critical for the market’s future success.

Data and Audio Processing Ideas for HD Radio Technology
Initially, the idea behind rapid adoption of digital radio around the world was quality. By employing advanced codec technology, digital radio enables CD and higher quality audio even over existing AM and FM bands. However, this belief has waned as more broadcasters focused on the core value proposition of radio: content.

One of the primary innovations enabled by HD Radio technology is the ability to offer more content within the same spectrum used for traditional AM/FM terrestrial radio broadcast. Through the use of what are now called Supplemental Audio Services, broadcasters are able to offer two channels of content (and possibly more), where they were only able to offer one before. This is accomplished by subdividing the available audio bandwidth into different channels, similar to DAB’s multiplex environment. The ability to double available content without doubling broadcasting costs is a key driver for HD Radio technology. Broadcasters can increase listening audience size and associated revenues while offering consumers more choices.

Broadcasters and receiver manufacturers planning to use HD Radio technology and intending to make it a success can learn from DAB by using data capabilities from the outset. There are several applications that can be implemented that should convince consumers to make the shift to HD Radio receivers. For example, program associated data, such as song title or radio station format, needs to be a basic data feature of any HD Radio receiver. As a consequence, receivers will need an LCD that
can, at the very least, support a scrolling capability that will give the user the ability to see the full information regarding the selection being aired. For broadcasters, regular updates of these selections could be shown in the form of electronic program guides (EPG). Already, this capability has been standardized and appeared in DAB products.

Another innovation possibly enabled by EPG mechanisms when matched with storage capabilities, such as when a receiver also has an integrated hard disk drive (HDD), is the ability to time-shift content. At the simplest level, a user could pause a program to answer his or her cell phone; meanwhile, the receiver would record the program in storage so that after the call is completed, the user could continue listening to the program out-of-time.

More advanced receivers could enable users to program them to autonomously record a program broadcast at a time inconvenient for the user so it could be played back at a later time. EPGs with the ability to track individual song listings could enable users to program a receiver to scan the available broadcast channels for a particular song and to store it once the song has been found. Note that program buffering and time-shifting require a receiver with the ability to encode content. Instead of storing the native broadcast signal, the receiver could transcode the signal through acoustical modeling into a more efficient format, such as MP3, to better utilize storage capacity.

Besides time-shifted audio and EPG, traffic information could be sent through the HD Radio transmission. A major principle of terrestrial radio in the U.S. is localism, and its ability to cater to the specific needs of a community. Traffic information is naturally needed in mid-sized to major metropolitan areas. When coupled with a GPS-enabled navigation system, traffic information sent through an HD Radio broadcast could be useful and actionable, allowing the driver to re-route quickly around accidents and construction. Data on this would be updated more quickly than with alternative means. The HD Radio data transmission allows for this, though the application layers still need to be created.

**Mobile TV**

Another innovative use of data sideband channels to present compelling content to users is illustrated by BT LiveTime, a joint venture between British Telecom and UBC Media. BT LiveTime provides headline and video services over the DAB data channel, in addition to multiple audio channels. For devices with limited display capabilities, such as two-line LCDs common in many automotive head unit receivers, headline services enable these receivers to scroll the top news on the LCD without disrupting the audio experience.

Even more compelling is the use of the data channel to broadcast video, enabling mobile television applications. Mobile phone users, for example, will be able to listen to and watch TV while they're on the go.

Non-program associated data, such as pictures and videos, involves the careful consideration of the cost of a display and possibly the need for storage space for such broadcasted files. Nonetheless, the proper application of such data with an eye toward local content could be influential to the rapid adoption of HD Radio technology. Receiver manufacturers will also need to consider safe, effective means of displaying a standardized data format. Broadcasters should evaluate what information to transmit and how to make it concise, while recognizing the additional revenue streams this technology enables.

**Flexible Platform for HD Radio Receivers**

The most exciting and innovative parts of digital radio, such as Supplemental Audio Services and other new data services enabled by the digital sidebands, are only just beginning to be explored.
Because of the inevitable differences in the adoption and implementation of data applications, a flexible platform for the radio must be chosen. In addition, radio manufacturers will want to differentiate the way they implement HD Radio technology from their competitors, adding their own particular value through the special intellectual property that they have. A fixed HD Radio receiver, capable of only doing HD Radio demodulation and decoding, will be detrimental to the receiver manufacturer and incapable of using the beneficial HD Radio data and audio content. As a result, the broadcaster might not be able to transmit different forms of HD Radio data and content, leading to consumers not using HD Radio technology. In addition, compelling products may not be realized, such as those that try to address some of the features above like recording or time-shifting.

It is also important to consider the form factor and target markets for receivers. A programmable architecture provides a foundation from which developers can quickly spin off diverse product families, from automotive headunits to home stereo equipment to handheld devices, while leveraging existing software and hardware investments.

HD Radio is an exciting emerging technology that has distinct digital signal processing needs beyond the current analog radio of today. The added complexity in demodulating and decoding a base audio signal is coupled with the need to address data broadcasting and additional audio content. DAB and satellite provide an example to the HD Radio market of how to effectively merge audio with data, as well as how broadcasters can effectively promote the technology. Beyond content and promotion, success in the HD Radio market will come not only from choosing the correct platform that can handle HD Radio signal processing but one that is flexible enough to take advantage of and exploit both audio and data features.

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Resources:

[Digital Radio Development Bureau](http://www.digitalrdb.gov), a resource for broadcasters, manufacturers, retailers, and advertisers interested in DAB digital radio in the UK.