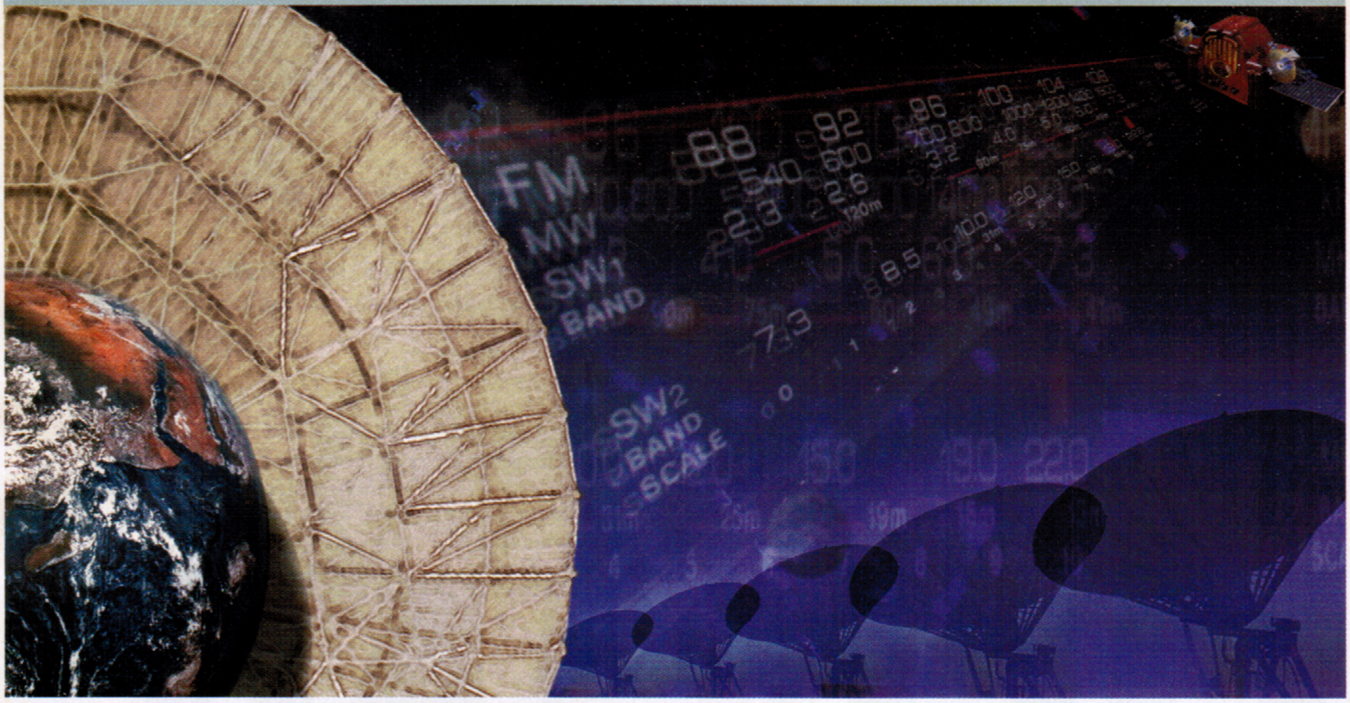


Heavenly music

Digital radio: A handful of satellite start-ups are hoping to deliver global digital audio to the last analogue holdout: radio. Meanwhile, conventional AM and FM broadcasters are responding with their own digital scheme

THE launch of America's first satellite-radio service was not without its hitches. XM Satellite Radio, the first firm to go live in the United States, began broadcasting late last year. But its start had already been postponed following September 11th. Eventually, when Hugh Panera, XM Radio's chief executive, was able to flip the switch, the company's two geostationary satellites began beaming 100 channels of CD-quality music and talk to listeners in San Diego and Dallas—the two first test markets.

But no sooner had the trials started than another problem emerged. The solar arrays on both of XM's Boeing 702 satellites were found to be degrading faster than expected. The estimated 15-year lifespan of the $150m satellites was suddenly cut in half. It is a good thing that XM keeps a spare.

Such technical snags do not trouble Mr Panera. Nor do they bother executives at Sirius Satellite Radio in New York, XM's only American competitor at the moment, which has been equally plagued with high-tech hiccups. If XM and Sirius succeed in rejuvenating the geriatric analogue radio industry with dozens of niche music, news and entertainment channels available to anyone, anywhere, in America's lower 48 states, even the most ardent sceptics will forgive their embarrassing start.

But XM and Sirius are not alone in the heavens. With plans to launch a third satellite within the next year, WorldSpace, based in Washington, DC, will serve South America, Western Europe, Africa and Asia with 40-odd channels in more than 20 languages—including Swahili, Tamil and Thai. WorldSpace plans to equip 30,000 Kenyan schools with receivers in the hope of profiting from a distance-learning initiative. Meanwhile, Global Radio in Luxembourg is aiming to start its satellite service in 2005. It will target Eastern and Western Europe with six "spot" beams from three satellites delivering 150 channels in ten languages.

Even conventional radio operators are diligently preparing for the inevitable shift to digital. In August 2000, a merger of Lucent Digital Radio and USA Digital Radio formed iBiquity Digital in Columbia, Maryland. Robert Struble, the company's chief executive, wants to persuade analogue radio operators to upgrade because he is convinced that flawless sound—packaged with regional news and local personalities—will keep listeners loyal to AM and FM.

It is satellite radio—with its ability to broadcast nationally or even across whole continents—that tantalises media analysts. Most expect satellite radio to aggregate niche markets that would not normally be profitable. That could shake up the antiquated radio world much as cable challenged network television in the 1980s. Mr Panera, who spent a decade with Time Warner Cable and five years at Request TV, an American pay-per-view network, remembers when the television networks scoffed at the introduction of cable. He believes that many of those broadcasters fell behind because they failed to embrace the technology.

Nevertheless, satellite radio cannot depend on the same lures as cable providers, who tempt prospective customers with complimentary receiver boxes and free home set-up. None of the satellite-radio firms will be giving away $229 receivers or doing installation for nothing. Mark Fratrick, a radio analyst with BIA Financial Network, predicts that even after satellite firms smooth out the technical wrinkles, it will still be tough to persuade millions of potential listeners to upgrade. In five to ten years, Mr Fratrick reckons that companies such as XM will win a respectable share of the market. In the meantime, XM and Sirius are going to need all the cash they have got. ▸▸

> "Two companies with a little imagination and a lot of cash snapped up chunks of the spectrum in the newly available S-band."

In 1992, America's Federal Communications Commission (FCC) earmarked a slab of the country's radio spectrum for something called Digital Audio Radio Service. At the time, the technology for compressing packets of digital music and voice—and transmitting them from orbiting satellites 23,000 miles above the equator to cheap little receivers on the ground—was barely on the drawing-board. But two companies with a little imagination and a lot of cash snapped up chunks of the spectrum being offered in the newly available S-band (around 2.3 gigahertz). American Mobile Radio and CD Radio paid the FCC $80m each for the rights to rain digital entertainment from the heavens. American Mobile Radio became XM and CD Radio became Sirius.

Scrunching the sound

All four satellite-radio firms—XM, Sirius, WorldSpace and Global Radio—employ similar technology to deliver their service. Music or spoken programming is first compressed using proprietary algorithms based on the Movie Picture Experts Group Audio Layer-3 (commonly called MP3). This lets broadcasters cram dozens of channels into a thin slice of bandwidth. After scrunching the audio data, operators must also decide on a bit rate—ie, the kilobits per second (kbps) of data that each signal can carry. As with streaming audio over a telephone line to a PC, a low bit rate translates into poor sound. For commercial reasons, XM does not reveal its exact bit rates, but it confirms that it uses higher levels on music channels to ensure CD-like quality. News and talk, however, transmit at much lower bit rates. Ground stations then upload the signal—now packaged as 1s and 0s of digital signalling—to satellites. These bounce the signal earthwards to mobile or (in the case of WorldSpace) stationary receivers.

The amount of processing power and data storage needed to handle 100 channels of compressed audio is staggering. XM's headquarters, which contains 82 studios with all the latest equipment, is networked top-to-bottom with fibre-optic cable to ensure that the gargantuan loads of audio data can zip from servers to studios to satellites effortlessly. When audio is not being beamed out live, it is kept on 400 workstations that together store 1.5m songs or 50 terabytes (ie, 50m megabytes) of data—more than four times that held in the Library of Congress. The firm's operations centre puts the Pentagon's early-warning system to shame, with banks of computers scrutinising the output of each channel, while the positions of the satellites and overall reception are tracked on three massive overhead screens. The military analogy is fitting: XM's senior vice-president of engineering and operations is a retired air-force brigadier-general.

Though the studios are impressive, the most critical component for digital radio is in the receiver. At its core is a set of chips whose job it is to reassemble multiple digital signals arriving at varying times from alternate directions. This chipset then decompresses the stream into clean, crisp audio. More than any other factor, the chipset defines the audio experience. A poorly designed chipset will corrupt the sound with pops, clicks or dead air.

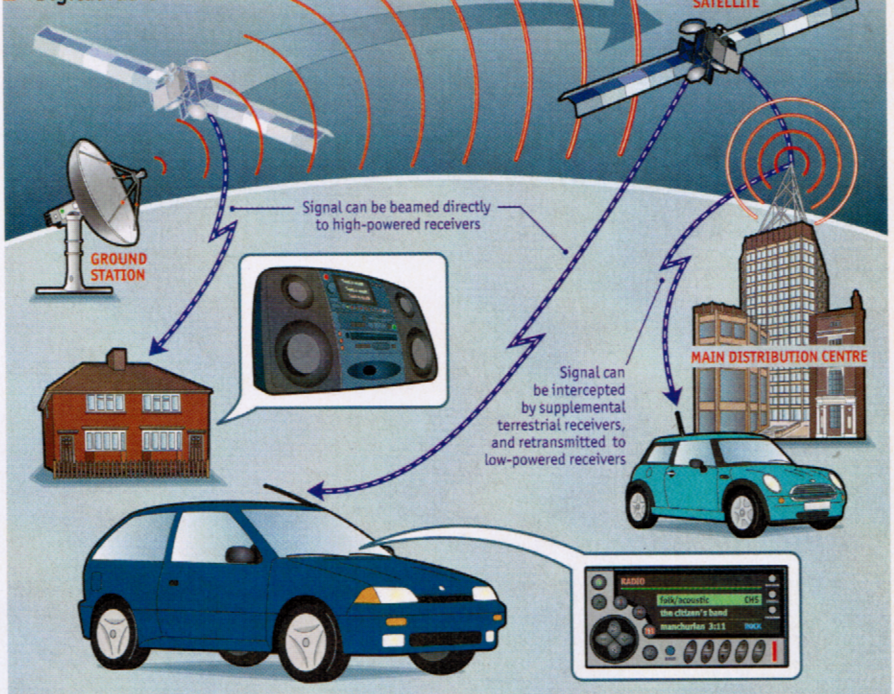
Working with Germany's Fraunhofer Institute (the birthplace of MP3) and STMicroelectronics, XM essentially re-engineered an existing chipset. Supplied by SGS-Thomson, the earlier chipset had been used by WorldSpace since 1997, but could not get mobile reception. Among other things, it lacked a memory "buffer" which banks audio in a separate storage area that can be drawn on if line-of-sight reception is blocked.

A closer look at XM's chipset reveals two unique integrated circuits, each assigned to different tasks. The first scrutinises multiple streams of data arriving from satellites and ground repeaters (which help boost weak signals), then decides how best to reassemble them. The second circuit handles decompression and encryption. Relying on subscription-paying customers, XM, Sirius and Global Radio scramble their signals so that they cannot be heard free of charge. The second circuit also buffers four seconds' worth of incoming data, so that tunnels, underpasses or other blind spots do not hinder reception.

By contrast, the Sirius chipset, which is manufactured by Agere Systems (formerly part of Lucent Technologies), encompasses eight integrated circuits. Pundits surmise that getting such a complex device to work properly has been one of the reasons why Sirius had to delay its launch. Eight months behind schedule, Sirius finally got its system in orbit on February 14th.

Sirius has had other difficulties. Instead of "hovering" two geostationary satellites over the equator due south of its American market like XM, Sirius chose to fly three satellites in an orbit that is 29,000 miles above the earth and inclined at an angle to the equator. This was supposed to make things easier. Each satellite covers the continental United States for only 16 ▸▸

Digital radio



Source: XM Satellite Radio

"Operators of traditional radio stations in America claim not to be worried about the satellite invasion, saying there is plenty of advertising to go round."

hours each day; but with two satellites in sight at any one time, the elliptical orbit places the signal's emitter more directly overhead. In theory, this should improve reception a lot. However, it also requires the Sirius satellites to "hand-off" signals from one to another as they move out of range. Some engineers believe that passing the signal between the satellites, coupled with data arriving from repeater stations on the ground, could create anomalies in reception. To be fair, Sirius argues, with some justification, that its system should eventually provide superior sound. That is because, instead of limiting broadcasts to fixed bit rates, Sirius continually fine-tunes its audio quality—a practice called "statistical multiplexing".

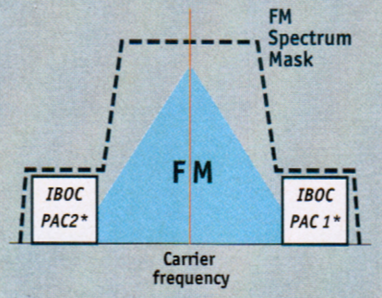
Global Radio has taken yet another approach. Eschewing the "hard-wired" design that is difficult to upgrade, Global Radio has set out to create a software-driven chipset that is based on a generic digital signal processor (DSP). In doing so, Global Radio can upgrade the software or replace the hardware whenever newer and better technology become available, allowing its chipset to improve steadily with time. In addition, being able to buy DSPs off the shelf has saved the company a fortune in not having to create a custom-built chipset from scratch.

The company's co-founder and chief executive, Paul Heinerscheid, talks of adding a GPS (global positioning system) feature to the receivers. With Global Radio's transmissions and GPS signals being neighbours in the radio spectrum, it ought not to be too difficult to make a dual-function chipset for an all-purpose, music-everywhere, never-get-lost gizmo. Global Radio needs $1.3 billion to achieve its ends. Assuming the money can be raised, it is going to take a further two years before it is broadcasting from space.

Room for all?

Operators of traditional radio stations in America claim not to be unduly worried by the satellite invasion—or at least, not by the prospect of competing with hundreds of specialist channels or even a national broadcaster. They point to the 51 different types of radio formats they beam out to 200m potential listeners. With XM and Sirius targeting only 4% of the market between them, radio operators say there are plenty of advertising revenues to go round. But that assumes the 11% annual growth in advertising revenue that the terrestrial stations enjoyed in the latter half of the 1990s will return. It also assumes that satellite radio goes ahead successfully as planned.

Hitching a ride
How analogue FM can carry digital radio



In-Band On-Channel (IBOC) digital broadcasting signals, compressed by Perceptual Audio Coding (PAC), are carried in side-bands
Source: iBiquity

The one thing that gives local broadcasters sleepless nights is the network of repeater stations that the satellite companies are setting up in dozens of cities—to capture the incoming signal from orbit and retransmit it to "dark" areas that are hard to serve by line-of-sight transmission from satellites. The worry is that if satellite radio founders, the 1,500 or so repeaters perched on hill tops and tall buildings could easily be rerigged to broadcast local content. Objectors point to Boston, where XM Radio has set up 66 repeaters, giving it the option of establishing that many independent radio stations should it desire.

In the United States, Edward Fritts, the president of the National Association of Broadcasters, has made this an issue. His comments have roused the fears of local broadcasters, who have demanded a response from the FCC. They are not alone. Protests have also come from big providers of mobile-phone services, including AT&T, WorldCom and BellSouth, who claim that the terrestrial repeaters could interfere with reception of future data services planned for their wireless networks. There have even been grumblings from the Ultra Wide Band (UWB) community—developers of a new wireless broadband technology—who argue that the repeaters could disrupt their own 2.5 gigahertz transmissions.

For the time being, the FCC has sided with XM Radio and Sirius. Last September, the regulatory agency granted both companies temporary licences to operate their repeaters in areas where a satellite signal might be blocked. A final ruling was due as this issue of TQ went to press. Most expect XM Radio and Sirius to get a permanent green light.

In the meantime, radio operators in the AM and FM bands are supporting their own brand of digital broadcasting, from iBiquity Digital. The company's core technology, called In-Band On-Channel (IBOC) broadcasting, lets station owners add a digital signal to the same chunk of spectrum that they already use for their analogue transmissions. With a solution to hand, iBiquity has quelled many of the local broadcasters' fears about satellite radio. If anything, Mr Struble views XM and Sirius as clients rather than competitors. That is because the audio compression technology used by the satellite operators is licensed from iBiquity.

Off to a wrong start

Digital AM and FM is not new. Since the mid-1990s, many broadcasters in Europe, Canada, Asia and Australia have struggled to implement their own versions of digital radio, using a common standard called Eureka 147. This transmits CD-quality audio along with extra data to provide the performer's name and song title, or weather and traffic reports. However, Eureka 147 is rooted in an outmoded compression technology. It also requires radio broadcasters to transmit their digital signals over an entirely separate swathe of frequencies to their analogue signals.

In America, that part of the spectrum is simply not available, having long since been allocated to the armed forces. How about tweaking Eureka 147 to transmit elsewhere on the spectrum? Unfortunately, that is not a realistic option. It would still require broadcasters to pay for two licences—one for analogue and another for digital. That is what makes IBOC so attractive. It lets broadcasters use their existing part of the spectrum for both digital and analogue transmissions.

For that, America's radio broadcasters can thank some extra precautions taken by the FCC. When the regulator apportioned spectrum to radio stations, it added a tiny 200 kilohertz buffer to each slice of assigned frequency—like saddlebags on a horse (see illustration above). An FM station that was assigned the 93.5 megahertz broadcasting frequency actually got an allocation that spanned from 93.3 to 93.7 megahertz. The FCC's intention was to prevent interference from one station affecting others broadcasting on adjacent frequencies. What engineers at iBiquity found was that they could squeeze a compressed digital signal into that buffer and still have 100 kilohertz left

"To station owners, the advantage of IBOC is that it does not require new transmitters or additional licences. Stations can switch in three days."

over to prevent their signal from interfering with a neighbouring station's.

The company has designed a chipset that can not only process the old analogue signal, but also combine it with two new digital streams. Moreover, the digital broadcast was found to consume very little bandwidth, leaving plenty of room for the fat analogue signal to spread its wings. In fact, enough space was found in the saddle-bags to carry additional data. So, apart from hearing local AM and FM with pin-sharp digital reception, listeners can also get stock quotes, news headlines, weather forecasts, or movie times on a display fitted in their car's dashboard. And if digital reception is somehow obstructed, the IBOC chip can switch back to analogue, which tolerates weak or reflected signals.

Field trials of the IBOC hardware in Las Vegas, Washington, DC, and San Francisco have been overwhelmingly successful. The National Radio Systems Committee, a standards body, wrote of one test that "the digital signal remains robust and unimpaired [when] analogue reception is severely compromised."

To station owners, the advantage of IBOC is that it does not require new transmitters or additional licences. Mr Struble estimates that stations can make the switch in three days. The average cost to upgrade a station's broadcasting equipment is a modest $75,000. He argues that, with all other entertainment media having joined the digital bandwagon, it is time for terrestrial radio to climb aboard.

America's first terrestrial digital transmission equipment will be demonstrated in Las Vegas this April. Later this year, stations in Los Angeles, Miami, New York, San Francisco, Chicago and Seattle will start trials by adding digital streams to their analogue broadcasts. The first digital radio receivers will be unveiled to the American public in January 2003. No one expects motorists to replace their existing car radios with satellite receivers overnight. More likely, car radios will evolve over the years to include IBOC circuitry along with such features as navigation and mobile telephony.

Some audiophiles will not wait that long. They will tune in to the Internet instead. At present, there are some 4,000 radio stations offering together more than 100,000 streaming audio channels online. However, the only way to enjoy such programming today is with a PC and a broadband connection such as DSL (digital subscriber line) or cable modem. But what if there was a wireless device that could tune into thousands of Internet stations, but small enough to fit in a mobile receiver? This is what 3COM, a computer network company based in Santa Clara, California, had in mind when it paid $80m for Kerbango, a small company in Cupertino that marketed a portable Internet radio. However, faced with the need for drastic corporate restructuring, 3COM closed Kerbango last year.

For now, Internet radio—and, for that matter, iBiquity's and Eureka 147's terrestrial digital audio as well—are still years away from widespread use. Mr Fratrick at BIA predicts that it will be at least a decade before ground-based digital radio replaces analogue FM. By contrast, he expects XM Radio and Sirius—which have raised $3.5 billion between them from public offerings and private investors—to have little trouble luring gadget-mad consumers and high-mileage motorists to switch to satellite radio.

Tie-ups are the key

To that end, XM Radio has already signed agreements with General Motors (which has a 5.6% stake in the company), Saab, Suzuki and Isuzu. It has also been working with manufacturers of car stereo equipment, including Sony, Pioneer, Alpine and Panasonic. Deals have been concluded with such retailers as Best Buy, Circuit City and Sears. The 2002 Cadillac Seville is the first car to come equipped with an XM receiver. Meanwhile, Sirius is signing up a posse of retailers as well as such radio makers as Kenwood and Clarion, and motor manufacturers such as Ford, Chrysler, Mercedes and Volvo. WorldSpace has done the same with Hitachi, JVC and Sanyo, while Global Radio plans to secure similar relationships.

It is these strategic partnerships that will decide the success of satellite radio. The idea that millions of car owners will toss out a perfectly good radio and spend several hundred dollars for a new one that receives XM or Sirius broadcasts, no matter how pristine the signal, is hardly realistic. But tacking $250 for a satellite radio on to the price of a $30,000 new car is a different matter.

On average, some 14m new cars are bought annually in America, each with a radio installed. Add to that a chunk of the 22m Americans who live so far out in the countryside that they can get fewer than five radio stations, and the potential audience for satellite radio begins to look respectable. XM and Sirius say they need only 2% of that market to break even. Indeed, analysts expect both companies to be in the black by 2005.

But what if America makes the same mess of digital radio as it did with mobile telephones? The hotch-potch of standards for mobiles means consumers have to buy a new phone every time they want to switch contracts or travel abroad. Will motorists have to pull out the receiver in the family saloon when they tire of XM's content and want to switch to Sirius?

Maybe not. XM Radio's 10K filing with America's Securities and Exchange Commission mentions "development of a unified standard for satellite radios". As part of a settlement to end litigation filed by Sirius in 1999, which charged XM with patent infringement, the two firms have decided to share various aspects of their technology—with the intention of developing a radio that will, one day, let listeners buy one receiver that can recognise either signal. Now, if the satellite-radio devotees could only start talking to their terrestrial counterparts, the future could hold the promise of all manner of "narrowcast" radio programming—from classroom exercises to minor league sports events, ethnic news and a million other things that never get the time of day on AM or FM radio. Wishful thinking? Perhaps, but worth the wait all the same. ■

Readers wishing to discuss issues raised in this article are encouraged to post their comments on the online forum at www.economist.com/forums/tq