An Engineering Statement

Prepared on Behalf of the National Association of Broadcasters

Regarding the Technical Aspects of the SDARS Providers XM and Sirius

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Introduction and Summary:

This Engineering Statement was prepared at the request of the National Association of Broadcasters (NAB) regarding certain technical aspects of the two SDARS (Satellite Digital Audio Radio Service) systems provided by XM and Sirius.

There are significant differences in certain technical aspects of the two SDARS systems as deployed by XM and Sirius. The systems as currently deployed are not interoperable. That is to say, an XM receiver cannot receive the Sirius signal and vice versa. Thus, as is true today, if the proposed merger of XM and Sirius were consummated, consumers would still need to purchase a new interoperable receiver in order to receive the signals of both providers.

These differences in system operation, function, and structure make the design and implementation of a single unified and interoperable receiver both complex and expensive. In fact, both XM and Sirius have been working in a joint venture to develop an interoperable radio since 2000. At this time, no interoperable radios have been introduced into commercial production.

The data capacities of both the XM and Sirius systems are filled with programming and significant spare capacity is not available. Expanding the number of program offerings on the XM or Sirius platforms through more aggressive digital compression is possible but would result in unacceptable degradation of audio quality.

SDARS Technical Overview:

The two SDARS systems employ different RF frequencies, bandwidths, transport stream packet structures and, most significantly, different audio codecs. Table 1 shows some of the technical parameters of the two SDARS systems.

As shown in Table 1, the two SDARS providers have deployed significantly different system implementations. These differences contrast sharply, from the Highly-Inclined Elliptical Orbit of the Sirius satellites to the Geostationary approach of the XM satellites, to different frequency allocations of the satellite and terrestrial repeater frequencies and bandwidths, and to the different audio codecs employed by each provider. These differences cannot be easily harmonized without significant disruption to current consumer receivers, the introduction of a new interoperable radio that will work with both systems, or by obsolescing the satellite receivers of one provider and adopting the technical parameters of the other. In the latter case, it is not likely that the satellites currently in use by the providers would be capable of changing bandwidths and bit rates so as to function with the system of the other provider.

Table 1 – Technical Parameter Comparison[1]

Parameter	Sirius	XM
Headquarters	New York, NY	Washington, DC
Number of studios	75	82
# of satellites In operation	3	2
Orbital configuration	Highly-inclined elliptical (HEO)	Geostationary (GEO)
Satellite elevation angle (typ.)	60 degrees	30 degrees
# of terrestrial repeaters	105 (46 markets)	1,700 (70 markets)
Repeater modulation	OFDM	OFDM
Frequency band (MHz)	2320-2332.5 MHz	2332.5-2345 MHz
Audio coding	PAC	MPEG-AAC
Satellite modulation	TDM QPSK	TDM QPSK
Satellite FEC (uplink)	R-S (128,120)	R-S (255, 223)
Downlink carriers per satellite	1	2
Satellite signal BW (per carrier)	4.2 MHz	1.8 MHz
Satellite signal bit rate (per carrier)	4.4 Mbps	2.048 Mbps
Satellite signal bit rate (total)	4.4 Mbps	4.096 Mbps
Repeater signal bandwidth	4.1 MHz	5.2 MHz

RF System Implementations:

The frequency allocations of the satellite and terrestrial repeater components of the SDARS systems are very different between the two providers. Each provider has a total of 12.5 MHz of total system bandwidth in which to provide both satellite and terrestrial signals (see Figure 1).

However, in the case of Sirius two separate 4.2 MHz band segments are used by the satellite transponders with a center 4.1 MHz segment being used for the terrestrial repeater component of the system. This is compared to XM, where the satellite segments are 3.7 MHz on either end of the band with a center 5.1 MHz segment being used for terrestrial repeaters. These differences result in different bandwidths and ultimately bit rates available for the various delivery mechanisms.

[1] See "Application for Minor Modification of Satellite License and for Authority to Launch and Operate Replacement Satellite Digital Audio Radio Service (SDARS) Satellites," filed with the FCC by XM Radio on March 12, 2004, and "Application of Satellite CD Radio, Inc. to Modify Authorization," filed with the FCC by Sirius (then Satellite CD Radio) on December 11, 1998.

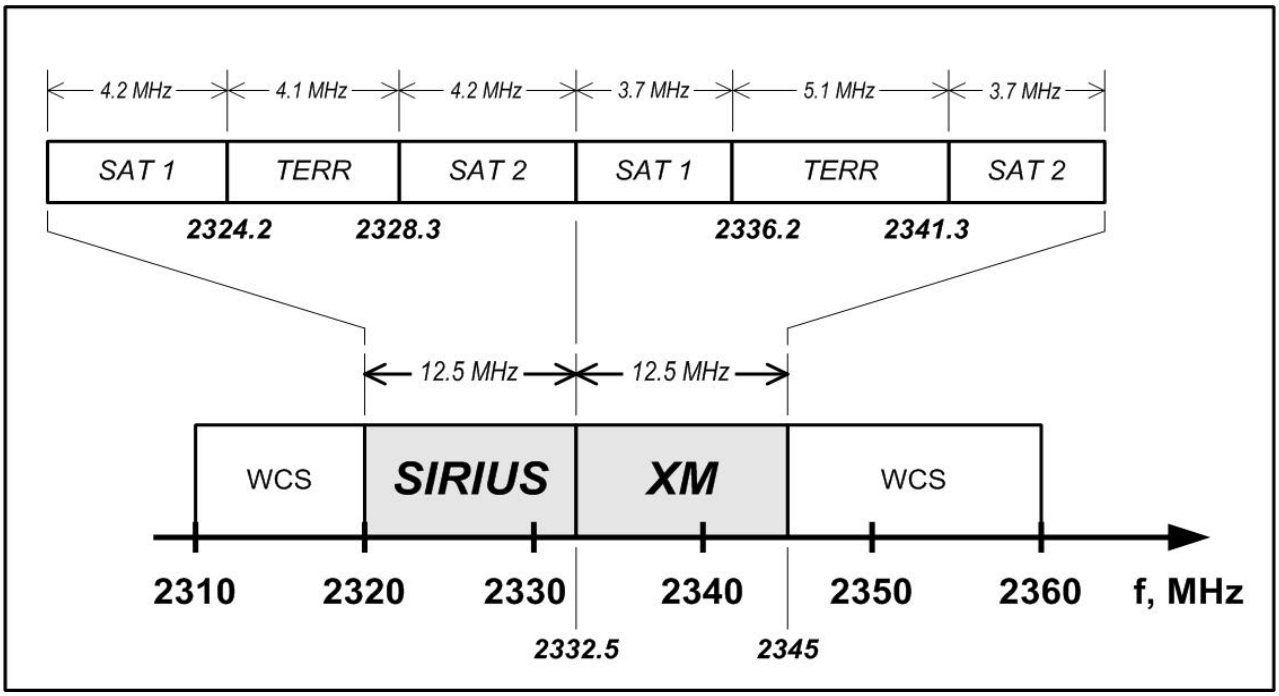


Figure 1 – RF Spectrum Utilization Satellite & Terrestrial Comparison XM & Sirius[2]

Interoperability:

Statements regarding the interoperability of the two SDARS systems seem to have been generally misunderstood by some to imply that the proposed merger would allow consumers to receive the signals of both providers with current radios.[3] This is not the case. In fact, the technical parameters of the two systems are not interoperable in current production satellite radio receivers.

The following statement by Mel Karmazin, CEO of Sirius, was made during testimony before Congress.[4] "But, if our merger is approved, we will offer consumers a much more attractive choice: the best of each service on one radio at a price well below the cost of the two services today." This statement allows an interpretation that the current radio used by an XM or Sirius subscriber would be sufficient to receive both signals. As explained herein, this is not the case. In fact, subscribers would need new interoperable radios in order to receive both signals.

[2] See footnote 1.
[3] For example see testimony of Mr. Mel Karmazin, CEO, Sirius Satellite Radio Before the House Energy and Commerce Committee's Subcommittee on Telecommunications and the Internet, March 7, 2007. Page 6 of prepared Testimony.
[4] Ibid.

New Interoperable Receiver:

FCC rules actually require that both SDARS providers design interoperable receivers, although to date neither SDARS provider has provided such a receiver. In its March 1997 Report and Order on SDARS, the FCC declined to set a specific receiver design but did require the SDARS providers to design receivers that would receive all DARS providers.[5] The FCC R&O stated, "We adopt, however, the principle behind our proposed rule that satellite DARS licensees are required to design a receiver which would accommodate all satellite DARS providers…"

In February 2000, both XM and Sirius entered into a joint venture to develop an interoperable radio. Some three years later in 2003, XM and Sirius formed a joint venture named "Interoperable Technologies, LLC." This joint venture has not yet produced an interoperable radio that is available commercially.

In January 2005, the FCC's International Bureau's Satellite Division asked both XM and Sirius to provide an update regarding the progress on making the interoperable receiver available.[6] On March 14, 2005, both companies replied to the FCC with a joint letter stating that, at that time, the receiver was not yet completed.[7]

The complexity of the design task to produce an interoperable radio is significant. It would need to have wider bandwidth in order to receive both SDARS signals. It would need to have separate TDM-QPSK demodulators with various bandwidths, as well as OFDM demodulators of various bandwidths, as well as various FEC decoders. In addition it would need to have separate transport stream de-multiplexers for both services and two separate audio decoders. Also, there would be some need for software to allow the consumer to navigate the services of both providers. This is indeed a complex design task, and the fact that the joint venture has not produced any commercially available radios may be an indication of the difficulty of the project.

Total Bit Rates and Number of Audio Channels:

As currently deployed, the Sirius system has a total bit rate of approximately 4.4 Mbps (Megabits per second) within the satellite component, and the XM system has a total bit rate of approximately 4.1 Mbps in its satellite component. These total capacities would not change unless the providers alter the current technical operations. The current satellite radio receivers that have been deployed to consumers are designed for these bit rates. Thus, the total capacity of the two systems will not change even if the companies merge.

[5] See "Report and Order Memorandum Opinion and Order and Further Notice of Proposed Rulemaking," IB Docket No. 95-91, Adopted March 3, 1997, at Paragraph 103.
[6] See Letter from Thomas S. Tycz to Lon C. Levin, XM Radio Inc. (January 28,2005); Letter from Thomas S. Tycz to Patrick L. Donnelly, Sirius Satellite Radio Inc. (January 28,2005), IB Docket No. 95-91.
[7] See Letter from William Bailey, XM Radio, Inc. and Patrick L. Donnelly, Sirius Satellite Radio to Thomas S. Tycz (March 14, 2005), IB Docket No. 95-91.

Sirius and XM programs could be inter-mixed on the two services. An example would be providing Howard Stern to XM subscribers if XM were to remove an existing program channel and replace it with Howard Stern. However, with current audio codec technologies as employed by XM and Sirius, additional numbers of audio channels (programs) would not be possible without degrading the audio quality of the existing services. That is, the total number of audio services cannot be increased without lowering the bit rates of current audio services which would likely result in degradation to the audio quality of the service.

Exhaustive testing has been done by various organizations regarding the bit rates needed with various audio codecs to achieve varying levels of audio quality. Tests conducted by National Public Radio (NPR) using a similar audio codec to the one employed by XM show that there is perceptible audio degradation at bit rates lower than about 48 kbps (kilobits per second).[8] And, very good audio quality is achieved with bit rates around 64-96 kbps.

It is important to note that XM and Sirius use completely different audio codecs. The Sirius system utilizes a compression algorithm called PAC while the XM system uses an MPEG-AAC codec. These two audio codecs are not interchangeable. Thus, an interoperable satellite receiver would need to have the circuitry to decode both types of audio codecs, thus increasing the complexity and cost of production.

The current XM system offers approximately 148 channels of programming. XM has not publicly disclosed the exact bit rates of the various program channels. But, it is well known that different program channels utilize different coding bit rates depending upon the type of music, popularity of the channel, if the channel is mostly voices, or other considerations such as day part or time sharing of channels.

The Sirius service offers approximately 123 channels of programming. Again, the exact bit rates of the various program channels are not disclosed. But, similarly to XM, one can surmise that different program channels utilize different coding bit rates depending upon the type of music, popularity of the channel, if the channel is mostly voices, or other considerations such as day part or time sharing of channels. In the absence of full disclosure from the SDARS service providers on bit rate, anecdotal information on the bit rates being used has been widely disseminated within the trade press, satellite radio users groups, and the like. Table 2 is a reasonable estimate of how XM may be allocating their data capacity as a function of program channel/genre type.

[8] See "Perceptual Tests of iBiquity's HD Coder at Multiple Bit Rates" prepared for National Public Radio by Ellyn G. Sheffield, October 14, 2004.

Table 2. XM Estimated Bit Rates per Channel Type

Program channel genre/type	*Average bit rate/channel (kbps)*	*Number of program channels*	*Total bit rate required (kbps)*
Rock Music	40	31	1,240
Hip-Hop/Rap Music	40	13	520
Classical Music	50	7	350
Jazz Music	40	15	600
Country Music	40	10	400
Voice/News/Comedy	16	50	800
Weather/Traffic	4	22	88
Program Data	8	1	8
	TOTAL	**148**	**4,006**

These various bit rates may change dynamically based upon the program content and the need for additional bandwidth for various programs. Thus, in order to allocate enough bandwidth on each providers' satellite system to offer the combined services of 291 program channels, the audio bit rates would need to be significantly reduced. It is very likely that consumers would strongly object to the resulting audio quality. Referring to the audio quality versus bit rate curve from the NPR study in Figure 2, it is clear that as bit rates are reduced below 40 kbps, audio quality rapidly degrades. Thus, even adding just a dozen channels to the SDARS services would not be possible without significant reduction in audio quality.

As Table 2 illustrates, there is likely no excess capacity in the XM system based upon the total system bit rate for XM of approximately 4,096 kbps (4.1 Mbps). These estimates suggest that the total system capacity is being used to supply the current program services. It is believed that the Sirius system would closely resemble the bit rate allocations as noted above. Similar constraints on the total number of program channels also apply to the Sirius system.

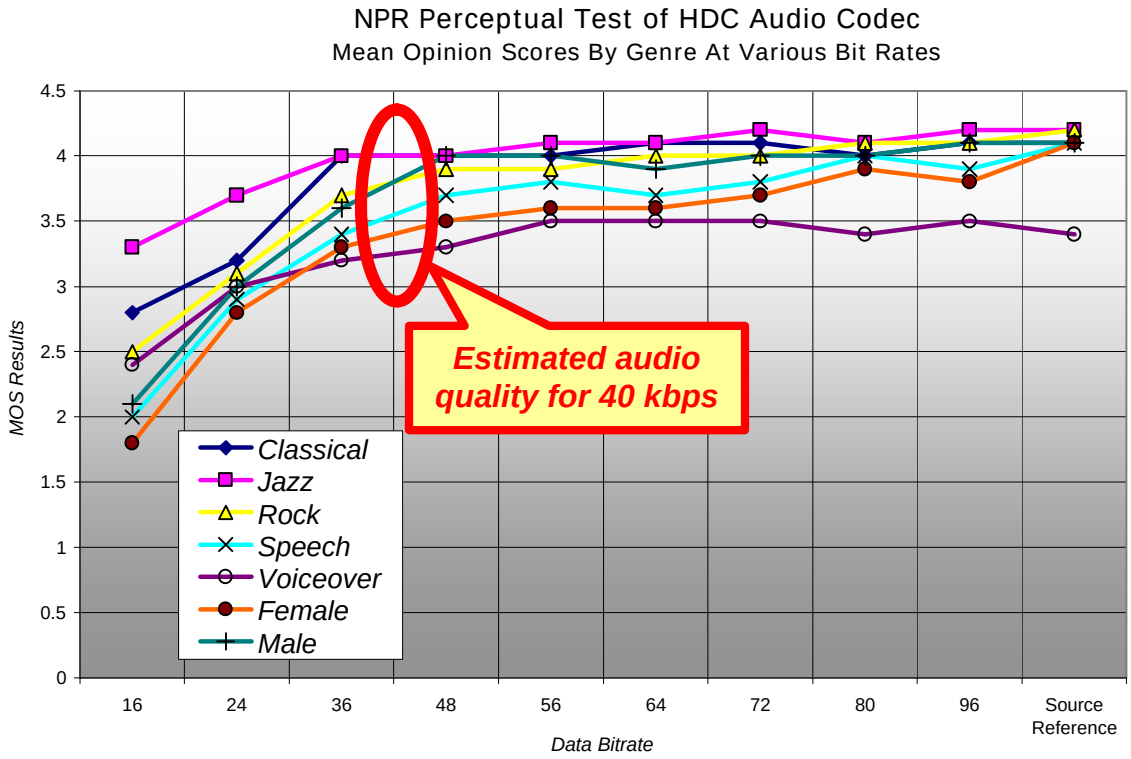


Figure 2. Graphical representation of subjective evaluation results from NPR tests[9]

Conclusions:

It is not possible for the current production satellite receivers to simultaneously receive both the XM and Sirius signals. In order for consumers to simultaneously receive the signals of both providers, they would need new interoperable radios or need to purchase two separate current production receivers.

A merger of XM and Sirius would not change the technical parameters or implementations of their respective SDARS systems. Consumers would still not be able to receive the signals of both SDARS providers without buying a new interoperable radio, or by using two radios simultaneously, one for Sirius, and one for XM.

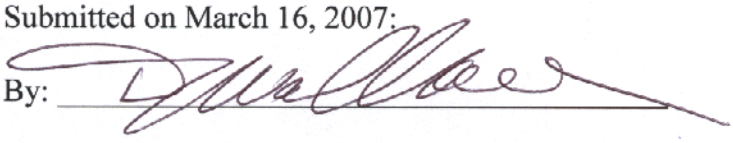
Progress on the design and implementation of a new unified and interoperable radio has been slow and still has not yielded any commercially available receivers. The joint venture of XM and Sirius has been ongoing for over seven years and still has not produced the interoperable radio as required by FCC Rules. This fact may indicate the complexities of design and costs are difficult challenges to resolve. The FCC rules

[9] Ibid.

require that the SDARS licensees deliver designs for interoperable radios. Neither licensee has met the spirit or the letter of this obligation to date. Further, consumers should have access to these radios, regardless of whether the proposed merger is consummated, and such product introductions are nowhere in sight.

Both providers are limited in their ability to add new program channels to their services without removing an equivalent number of existing program channels. Attempts to achieve more program capacity through more aggressive digital compression and fewer bits per program would result in significant audio quality degradations likely to be unacceptable to consumers. The limited bandwidth and bit rate capacity of the systems cannot be overcome without significant changes in the technical parameters of the systems. Thus, adding a new program channel from each provider's lineup will require a trade-off with an existing provider's incumbent program channel likely being removed from the line-up on a one-for-one basis.

Submitted on March 16, 2007:

By: 

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