Before the
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Washington, D.C.

In the Matter of	)	
	)	
ADJUSTMENT OF RATES AND TERMS FOR PREEXISTING SUBSCRIPTION SERVICES AND SATELLITE DIGITAL AUDIO RADIO SERVICES	)	Docket No. 2006-1 CRB DSTRA

REBUTTAL TESTIMONY OF

BRUCE R. ELBERT

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Public Version

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Rebuttal Testimony of BRUCE R. ELBERT

I. INTRODUCTION AND QUALIFICATIONS

My name is Bruce Elbert. I am the President of Application Technology Strategy, Inc., a company I own that assists users and providers of satellite technology. Prior to my current employment, I spent 25 years with Hughes Electronics, the company that invented and built the first geostationary satellite, produced and operated ground electronics and networks that control and employ such satellites, and established DirecTV as the first leading direct-to-home satellite television operator in the US. Although I had no direct role in the project, Hughes was selected during my tenure to design and construct the satellites employed by XM.

As Senior Vice President, Operations, at Hughes, I managed engineering design teams that designed communications satellites and networks for mobile and broadband applications to US and international customers. Between 1984 and 1995, I developed the design and service offering for mobile satellite programs; managed service marketing, operations and engineering of the Galaxy cable-TV satellite network; assisted with DirecTV startup by recommending space segment and control system specifications; and prepared the successful FCC filing for the Spaceway digital broadband satellites. Prior to 1984, my role was to oversee the development of the communications payload and bus for several satellites, including the first Mexican satellites. I also was responsible for the overall design and end-to-end test of two satellites and a complete ground segment for Indonesia with 40 Earth stations to support a nationwide network for television distribution and telephone communications.

In 1987, while at Hughes, I also helped establish Supermarket Radio Network, an innovative satellite-delivered service that was the first to combine multiple radio channels with individual formats with terrestrial repeaters using local FM transmitters. While at Hughes, I was

responsible for system design and end-to-end testing of the Indonesian satellite system Palapa A, overseeing a team of five suppliers and over 100 engineers and technicians. I also represented the company and the United States at two World Radiocommunication Conferences.

Prior to my employment at Hughes, I was Assistant Vice President at Western Union Corporation during the development of their second generation satellite system. My responsibility in 1979-1980 was to develop replacement satellites that would implement new digital communications services for data and video applications.

In the early days of the satellite industry, between 1969 and 1972, I worked for COMSAT, where I helped refine concepts that are the foundation of today's fixed and mobile satellite networks. I served on the engineering team that defined the mobile satellite communications architecture for the Inmarsat satellite system for serving ships and aircraft.

Prior to entering the satellite industry, I was a communications officer in the U.S. Army Signal Corps, leading field units that installed various types of wireless and wired communications for the 4th Infantry Division in Vietnam. Upon my return to the United States, I was assigned as senior radio instructor and team chief at the Army Signal School at Fort Gordon, Georgia.

I am an Adjunct Assistant Professor at the University of Wisconsin-Madison in the College of Engineering distance learning program. I have also been an instructor in the Engineering Extension program at UCLA since 1990, teaching a variety of technical courses regarding satellite communications space and ground systems, equipment and applications.

I am a member of the Institute of Electrical and Electronics Engineers (IEEE) and the American Institute of Aeronautics and Astronautics (AIAA). I am also the editor of the Artech House library concerning Space Technology and Applications. I have led and presented at

numerous technical panels and workshops over the years regarding communications satellites and the applications that they provide.

I received a Master of Science degree from the University of Maryland, College Park, with concentration in communications and computer engineering and a Bachelor of Electrical Engineering degree from the City University of New York. Both degrees include studies in radio frequency antennas and electronic systems. I also obtained a Masters of Business Administration from Pepperdine University.

I have written eight books on communications technologies, including three specifically dealing with satellites and their applications, one of which has a chapter that describes in detail the design and performance of XM and Sirius. I have written many articles and technical papers, and am a frequent contributor to SatMagazine.com, an industry trade publication available over the Internet. I have submitted testimony on satellite technology issues in other legal proceedings. My qualifications are set forth in greater detail in my current CV attached as Appendix A.

II. OVERVIEW OF TESTIMONY

I am submitting this testimony to rebut the claims by XM Satellite Radio and Sirius Satellite Radio (collectively, the "Services") in this proceeding that satellite technology is risky, innovative or heretofore unknown, and to offer my opinions regarding technical and operational aspects of satellite digital audio radio service ("SDARS"). I believe the Services' claims are exaggerated. Specifically, I have reviewed portions of the Services' direct cases in this proceeding, including portions of the written and oral testimony of Anthony Masiello, Terrence Smith, Mel Karmazin, David Frear and Gary Parsons, portions of the depositions of Mr. Karmazin, Mr. Frear and Mr. Parsons, as well as documents produced in discovery to SoundExchange by the Services, and publicly available documents.

III. THE ADVANTAGES OF SATELLITE SYSTEMS

In their written and oral direct testimony, Sirius and XM's witnesses discuss the costs and risks of using satellites. Written Direct Testimony of Gary Parsons, ¶ 5 ("Parsons WDT") ("[M]assive investments would be required to build the business."), ¶ 15 (describing "inherently risky" nature of satellites"); Frear WDT, ¶ 2 (discussing Sirius's "extensive investment"), ¶ 5 ("Satellite businesses are extremely risky."), ¶ 12 ("The costs of bringing this new technology to market are enormous."); Karmazin WDT ¶ 3 (discussing "the extraordinary . . . costs and risks that Sirius has incurred . . . ."); Tr., June 6, 2007 (Karmazin testimony), at 283 (claiming that "there's just lots and lots of risks associated with satellites"); Smith WDT ¶ 7 ("Designing, building and launching a satellite is an enormously lengthy, costly, and risky proposition."); Masiello WDT ¶ 12 (noting "the enormous effort and expense required").

However, this testimony ignores the many significant advantages provided by satellite systems, which outweigh the costs. Indeed, Sirius and XM's own satellite expert Roger Rusch[1] repeatedly told groups to which he lectured that satellite radio broadcasting is "Brilliant." SX Ex. 201 RP at SDARS CRB 3251 (also noting that "[s]atellite broadcasting is cost effective" and that "the business model can work").

A. Satellites Are a Cost Effective and Reliable Way to Broadcast Content Nationwide.

Satellites are the most cost effective way to broadcast content nationwide. Despite the high up-front costs for satellites, numerous companies use satellites as the most cost-effective way to implement their various business models, resulting in an extremely robust satellite communications industry that generates over $90 billion in annual revenue. In fact, currently

[1] The Services ultimately withdrew Mr. Rusch's testimony.

there are more than 230 operating commercial satellites in geostationary orbits alone, with 53 of those satellites focused on the United States.

Both XM and Sirius use satellites with coverage that extends over the entire continental United States. With this coverage, XM and Sirius have access to a base of potential subscribers that is as large as the entire population of the United States. Mr. Rusch admitted as much during his deposition, stating that "potentially you could have runs of millions or even billions of people that are receiving signals from a broadcasting satellite." Rusch Depo. at 36; *see also* Parsons Depo. at 17 (noting that [ ]).

Once launched successfully into orbit, satellites like those used by XM and Sirius have long operating lives, typically lasting 12 to 15 years, although they can last up to 20 years. In addition, the vast majority of a satellite's lifetime cost is expended before launch. Once the satellite is successfully in place, it has everything it needs to operate for the rest of its life. During its life, the satellite is nearly self sufficient, only requiring occasional adjustments and monitoring to insure that it is functioning to specifications. Indeed, Robert Briskman, a former technical executive with Sirius, noted in a document produced by Sirius in discovery in this proceeding that Sirius's satellites "[ ] and [ ]." SIR 17799.[2]

Both XM and Sirius have noted that [ ]. SIR 21798; SIR 21790 (noting "[ ]); XMCRB 130615 (noting the [

[2] Citations to "SIR ___," "SDARS CRB ___" and "XMCRB ____" refer to documents produced by Sirius and XM in discovery in this proceeding.

[redacted]]); SIR 33514 (noting the "[redacted]").

The cost effectiveness of satellites can be further demonstrated as follows. If a satellite system space segment (consisting of two in-orbit satellites and a ground spare) with a 15-year life span costs $800 million and serves 10 million subscribers a year, the cost amounts to 44 cents per subscriber per month.

B. XM and Sirius Benefited from Other Businesses' Experience Using Satellites.

There is nothing new about the Services' use of satellites. Private companies have been launching and using satellites for decades. As will be discussed in more detail below, the technology is proven and well understood, and XM and Sirius were able to leverage these existing technologies in the development of their systems. As XM noted in its own documents, [redacted] *See* SX Ex. 202 RR, at XMCRB 21582.

In fact, XM and Sirius were even able to build upon the experience of another pre-existing satellite radio service – WorldSpace. WorldSpace is capable of providing over 100 channels of music and talk radio programming to listeners with portable receivers in Africa and Asia since it launched its first satellite in October 1998.[3]

XM has explicitly noted its reliance on WorldSpace, stating [redacted]" *See* SX Ex. 202 RR, at XMCRB

[3] There are technical differences between the WorldSpace system and the systems used by XM and Sirius (*e.g.*, WorldSpace uses L-band frequencies rather than the S-band frequencies used by XM and Sirius), but XM and Sirius were able to build upon what WorldSpace had begun.

21583. Gary Parsons, XM's Chairman of the Board, admitted that XM [ ] Parsons Depo. at 22-24, 33, 35. [ ] XMCRB 21409. [ ]. XMCRB 44448-44462, at 44448.

XM and Sirius were able to capitalize on the prior experiences of other satellite services. As will be discussed in more detail below, satellites had been used for decades to transmit all sorts of user content (television signals, audio signals, telephone calls, other types of data). In particular, XM and Sirius were able to build upon the experience of the satellite television industry, including the Dish Network and DirecTV, which use satellites to provide video and audio programming directly to consumers for a monthly fee, a service similar in many ways to that of providing audio content.

In many ways, the SDARS faced an easier problem than the satellite television services, despite Mr. Masiello's claims otherwise. Masiello WDT ¶ 3. Mr. Masiello claimed that XM solved a more difficult technical problem with a smaller receiving antenna. *Id.* Mr. Smith also complained that other services used large and expensive receiving antennas. Smith WDT ¶ 4. But these witnesses ignored several key facts. The satellite television services provided audio-only music channels, just like the SDARS, but they provided video programming as well, which requires the transmission of much more data than just audio. Furthermore, satellite television

uses a different part of the spectrum, the Ku-band rather than the S-band, that has reception problems when there is cloud cover or rain, thereby requiring larger receiving antennas. Finally, as is discussed below, other organizations, including NASA, had previously successfully used satellites to transmit to moving vehicles (cars, planes, and ships), and many services used small, omni-directional antennas to receive information from satellites without having to point a receiving antenna at the satellite

In addition, the satellite television industry had developed business systems to support the management of satellite systems (*e.g.*, systems to initiate service, collect revenue, etc.). Mr. Parsons admitted that XM gained experience in billing, programming, and customer service (along with monetary investments) directly from DirecTV. Parsons WDT ¶ 9.

Because of the leverage from pre-existing satellite services, XM and Sirius could start their services relatively rapidly and garner millions of paying subscribers in one of the shortest periods in history. Although XM's and Sirius's witnesses complained of the amount of time they spent developing their services, Smith WDT ¶ 4 (noting "decade-long gestation period"); Parsons WDT ¶ 5 (discussing the "years of effort" put in by XM); Karmazin WDT ¶¶ 13-22; Tr., June 6, 2007, at 268-70 (Karmazin testimony), DirecTV required even more time to develop its service because it developed its service first.

Moreover, given the number of different satellite manufacturers, satellite businesses can pit companies against one another to compete for the rights to build the satellites. With their recent satellite purchases, both XM and Sirius [ ] XMCRB 98577-79. [

[redacted] SIR 17764-65.

C. For Decades Satellite Businesses Have Been Able to Raise Significant Funds from the Capital Market for the Operation of Their Satellites.

XM's and Sirius's witnesses emphasized the high upfront costs of satellite businesses. *See, e.g.*, Parsons WDT ¶ 13; Frear WDT ¶¶ 8, 14; Masiello WDT ¶ 8; Tr., June 6, 2007 (Karmazin testimony), at 269. Such statements ignore two facts: as discussed above, satellites have long operational lives requiring minimal attention; and satellite businesses have experience raising significant amounts of capital through the markets. As early as the mid-1960s, a satellite company used an IPO to raise hundreds of millions of dollars. By the early 1980s, the major Wall Street investment firms had specialists who maintained contacts with the principal satellite operators and manufacturers. Echostar, Iridium, GlobalStar, and WorldSpace all used the capital markets to raise huge sums of money to finance their initial operations. As large as XM's and Sirius's initial investments were, they are the norm in the satellite industry.

Furthermore, satellite businesses take steps to control and predict these costs. For example, satellites are purchased with so-called "fixed-price" contracts. Under these contracts, the manufacturers bear the risks of any cost increases during the manufacture of the satellites. The contracts also frequently contain liquidated damages clauses whereby the manufacturer must pay the satellite business if the satellite is not delivered on time. Typically, businesses make progress payments under the contract as the satellite is being built, but many withhold a portion of the price until the satellite has been successfully tested and as an incentive for the continued satisfactory performance of the satellite. If the satellite business feels that the manufacturer did not build the satellite to proper specifications, the business can terminate the contract for cause and receive back all monies paid. [redacted]

[redacted] XMCRB 102580-102727 at 102634, 103636, 102697-98.

D. XM and Sirius Have Another Unique Benefit: a Government Created Duopoly.

XM and Sirius have an advantage unique to their satellite systems: a government-created duopoly. The Federal Communications Commission (FCC) auctioned the frequencies used to broadcast satellite radio signals. The predecessors of XM and Sirius successfully bid on these frequencies, and they received *exclusive* licenses to the frequencies in question, thereby forestalling any possible competition by a third satellite radio service. Further, the FCC, along with providing domestic licenses, arranged for international acceptance of the licenses as well.

IV. PRIVATE BUSINESSES HAVE DESIGNED, LAUNCHED, AND OPERATED SATELLITES FOR FORTY YEARS.

Contrary to the testimony of XM's and Sirius's witnesses, XM and Sirius did ***not*** need "to create an entirely new means of providing audio programming." Karmazin WDT ¶ 3; *see also* Parsons WDT ¶ 2 ("We built the new satellite radio industry . . . from scratch . . . ."; Frear WDT ¶ 2 (asserting that Sirius has "create[d] from scratch a new transmission system"); Masiello WDT ¶ 2 (noting that XM "had to design, build and launch virtually from scratch, all aspects of its service infrastructure"); Smith WDT ¶ 4 ("Sirius took on the enormous task of designing and building from scratch a . . . satellite digital audio radio service.").

In fact, XM and Sirius created their systems by building upon existing technologies and designs from the many satellite ventures that existed before. As Mr. Rusch admitted, "many of the practical technical issues were resolved in 1963." Rusch WDT ¶ 11.

While there are no off-the-shelf satellite systems, and each system must be independently tailored to fit specific system requirements, each system builds on previously designed systems.

The satellite industry has time-tested and proven methodologies for designing, verifying, and testing satellite systems, including adaptations made to previously proven designs. Nearly every satellite system – including the geostationary satellites used by XM and the elliptical-orbit satellites used by Sirius – starts with a proven satellite design and is tailored by the manufacturer to meet the specific needs of the operator. The industry standards and methodologies provide assurance that the satellites will operate as planned for many years once in orbit.

Private companies have been designing, launching, and operating satellites for over 40 years, since two private companies, COMSAT and Hughes, launched a satellite in 1965. COMSAT, Intelsat, Western Union, RCA, AT&T, Hughes, NTT, France Telecom, Inmarsat, and News Corp have all employed satellites for decades to provide reliable communications services. More recently, DirecTV and DISH Network demonstrated that they could develop multi-billion dollar businesses based on the direct provision of content (in their case television programming) to consumers via reliable satellite systems.

V. THE SATELLITE INDUSTRY UNDERSTANDS AND MANAGES RISK.

XM's and Sirius's witnesses suggest that the satellite industry is extremely risky. Frear WDT ¶ 5; Smith WDT ¶ 16-17; Masiello WDT ¶ 23; Karmazin WDT ¶ 3. Tr., June 6, 2007, at 283 (Karmazin testimony). But the last 40 years of commercial satellite launch and operation history demonstrate that the business of putting up and operating satellites is straight-forward and reliable. While there are risks, they are well known, and the industry has developed methods for mitigating them.

Contrary to Mr. Masiello's testimony that "[l]aunching satellites is inherently a risky endeavor, even for the most experienced launch companies," the commercial satellite launching industry has an extremely good track record going back decades. Masiello WDT ¶ 23; *see also* Tr., June 5, 2007, at 12-13 (Parsons testimony) (stating that "[l]aunching satellites are a

historically fairly risky venture"). Since 1965, approximately 700 commercial satellites have been launched with a failure rate of only approximately five percent. Satellite launches are said to "fail" when an otherwise working satellite is not delivered within a set radius of its target destination. Thus, after some launch failures, the satellites are still operable and can be moved into the proper orbit, although the expenditure of extra fuel to move the satellite can lower the satellite's life expectancy. Since 1997, 185 geostationary communications satellites, most of which are used for commercial purposes, have been launched with only *eight* failures. Neither XM nor Sirius has had a single launch failure to date.

Mr. Karmazin misstates the case when he claims that "any mistake in trajectory can render a satellite worthless." Karmazin WDT ¶ 28. Launch vehicles routinely deliver satellites to the general vicinity of the desired orbit, and the satellites' on-board propulsion systems are then used to maneuver the satellite into its proper orbit. It is extremely rare for the satellite's initial position to be so far off that the satellite is abandoned. Furthermore, satellite engineers have understood the physics of orbital trajectories for decades, and they have used them to launch rockets successfully onto their desired trajectories countless numbers of times.

As with all types of business ventures, some satellite businesses have failed (*e.g.*, due to poor business models); but many more have succeeded. The satellite television companies are perhaps the closest examples to the SDARS. Both DirecTV and the Dish Network successfully raised large amounts of initial capital and parlayed that capital into thriving subscriber bases. Many other telecommunications business models have succeeded as well. For instance, SES-Global has very successfully operated a satellite system called Astra in Europe. Astra has been in existence for at least 15 years and provides television broadcasting to many European countries, including SkyTV to the United Kingdom. Thuraya, a company based in the United

Arab Emirates, provides mobile satellite communications via handheld phones. The cable television network HBO began by using satellites to deliver pay per view events (and later movies) to individual cable operators, who would then transmit the broadcasts to their own customers via cable.

It is important to understand the difference between the risks associated with new businesses and the risks unique to satellite businesses. Of course, satellite businesses face the same business risks that all start-up businesses face (*e.g.*, poor business models, lack of consumer demand, etc.). XM's and Sirius's witnesses testified about a number of satellite business failures, but these businesses failed because of failures in the business models rather than due to any failure of the satellites. Parsons Depo. at 28-29; Parsons WDT ¶ 5; Smith WDT ¶ 4. Mr. Rusch admitted during his deposition that he could not think of a single satellite operator whose business failed because of a satellite failure, either during launch or in-orbit. Rusch Depo. at 73. Where the businesses failed, the satellites functioned as designed, but the consumers were not sufficiently interested in the product. That is the type of risk faced by any new business, not something unique to the satellite industry.

There are two primary forms of risk unique to satellite businesses: the risk of a launch failure and the risk of an in-orbit failure. As discussed above, the risk of launch failure is approximately five percent. The risk of total satellite loss once the satellite is in orbit is even lower, approximately one percent. The satellite industry has developed a number of different methods for mitigating each type of risk, and two of those methods – insurance and spares – can mitigate both types of risk. Furthermore, I am not aware of a single commercial satellite business that has failed because of a satellite failure, either during launch or in-orbit, precisely because these risks are well understood and businesses can take steps to mitigate them.

A. Satellite Businesses Insure Their Satellites.

First, there is a well-developed insurance industry to cover both types of risk. Satellite businesses have used insurance to mitigate the risks of launching and operating their satellites for at least thirty years, and most major satellite operators purchase such insurance, including, for example, DirecTV, Dish Network, and Intelsat. Indeed, both XM and Sirius have at times purchased launch insurance and in-orbit insurance (also called "life" insurance). *See, e.g.*, SIR 15838; SIR 39547; XMCRB 18681-713; XMCRB 18723-18742.

Launch insurance covers two types of risk related to launching satellites. First, the purchaser receives payments/benefits when the satellite suffers damage or is destroyed during the actual launch (*e.g.*, the launch vehicle or satellite malfunctions). Second, the purchaser also receives benefits when the satellite is delivered into orbit safely, but the satellite does not arrive within a specified distance of its target orbit. In many of these situations, the satellite can be moved into the proper orbit, where it can then function as planned; however, doing so may shorten the satellite's expected life (due to the extra fuel that must be used to move the satellite), and the launch insurance covers this lost life expectancy.

Satellite life insurance is generally significantly cheaper, and the price typically decreases as the satellite ages because the price is percentage of the insured value, which drops as the satellite depreciates each year. Satellites are designed and fueled to function without loss of performance or capacity for many years. While the precise life expectancy of any given satellite varies depending on a variety of factors, satellites generally last between 12 and 15 years, although they can last as long as 20 years. When in-orbit problems arise that disable all or part of the satellite or reduce the life expectancy of a satellite, life insurance covers the value of that lost "life." Life insurance is considered standard practice in the satellite industry, in part because

it provides assurances to investors, and both XM and Sirius have purchased such insurance. SIR 39547; XMCRB 18723-18742.[4]

Mr. Smith, senior vice president for engineering at Sirius, testified that Sirius currently does not carry life insurance for its satellites. Tr., June 7, 2007, at 118 (Smith testimony). Thus, Sirius must have concluded that as a business matter the risk of loss from an in-orbit failure was so low that it did not justify the cost of the insurance.[5] Such a decision can be a reasonable business decision based on the satellite business's specific situation.

B. Satellite Businesses Maintain Spare Satellites.

Satellite businesses acquire spare satellites so that they can maintain their services in the event of a failure of a satellite. Both XM and Sirius included ground spares in their original satellite purchase contracts. Satellite businesses frequently negotiate provisions in their launch contracts that give them priority so that they can launch a spare satellite within a set period if there is a failure in the original launch. For example, XM's contract with Boeing for its first two satellites, Rock and Roll, contained a provision that [ ]. XMCRB 102580-102727, at 102688. In addition, because satellite businesses launch satellites periodically, many have pre-existing contracts for future launches, and if they need to launch a replacement satellite quickly, they can substitute the replacement satellite into a pre-existing

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[4] In fact, XM filed a claim on the life insurance for its first two satellites ("Rock" and "Roll"). Both satellites launched successfully, but they suffered a premature loss of power due to a problem with the solar panels. This problem reduced the expected life of the satellites. Both satellites continued to "[ ]" despite the problems, XMCRB 130615, and both satellites functioned until XM placed replacement satellites in orbit, at which point Rock and Roll were turned off. Moreover, both satellites remain in orbit and can be used as spares if necessary. *See* http://www.tbs-satellite.com/tse/online/sat_xm_1; http://www.tbs-satellite.com/tse/online/sat_xm_2.

[5] *See, e.g.*, http://investor.sirius.com/ReleaseDetail.cfm?ReleaseID=187963 (noting that Sirius's satellite expenses decreased when Sirius decided not to renew its satellite insurance policy in August 2004).

contract to do so. Furthermore, a spare can be launched ahead of the actual need, and the original satellites can be turned off and held as in-orbit spares. If there is ever a catastrophic failure, the business can simply re-activate the spare satellites to maintain the service until a new replacement satellite is launched. In fact, XM currently has its first two satellites, Rock and Roll, in-orbit but turned off, even though they both could provide service for many years. Parsons Depo. 77-78.

C. Satellite Businesses Also Mitigate the Risk of Launch Failure Through Their Choice of Launch Company and Their On Board Systems.

A satellite business also can minimize launch risk through its choice of launch company. Mr. Smith testified that Sirius faced an "enormous hurdle in launching [its] satellites successfully." Smith WDT ¶ 16. However, this statement is an exaggeration. At the time XM and Sirius required launch services, there were at least two different companies capable of meeting their general requirements on a reliable and cost-effective basis, offering at least four different launch vehicles.[6] In selecting a launch vehicle, businesses weigh a number of different factors: the weight and size of the satellite, the orbit required, the availability of launches in the companies' schedules, the companies' recent launch experiences, and the terms of the launch agreement, including in particular the price of the launch.

Mr. Parsons testified that XM performed exactly this type of weighing. He testified that XM chose Sea Launch from among several competing companies based on the combination of attributes offered by Sea Launch, including its low price. Tr., June 5, 2007, at 54-55 (Parsons testimony); Parsons Depo. at 66-69; XMCRB 130649 (comparing [ ]), 130714 (noting

[6] Lockheed Martin, Boeing, which operates Sea Launch and which was used by XM, and International Launching Services ("ILS"), currently launches satellites. ILS, which launches the Proton vehicle used by Sirius, used to be part of Lockheed Martin but is now an independent private company.

that XM received [[redacted]]). Both Mr. Masiello and Mr. Parsons stated in their written direct testimonies that XM chose Sea Launch despite its having launched only "a handful of satellites" prior to launching XM's satellites. Parsons WDT ¶ 15; Masiello WDT ¶ 23. These statements overstate the risks associated with choosing Sea Launch. First, XM clearly felt that any increased risk was more than offset by the cost savings offered by Sea Launch, especially given that the launch itself was insured and XM had a ground spare that could have been launched within six months of any launch failure. Second, XM used the Zenit launch vehicle. Although Sea Launch did have a failure in one of its first launches while using the Zenit vehicle prior to XM's launches, the Zenit vehicle itself had a good launch record during its use by the Soviet Union. DirecTV has also used Sea Launch and the Zenit vehicle.

As Mr. Smith testified, Sirius considered two possible launch vehicles and eventually decided to use the Proton launch vehicle. Smith WDT ¶ 16. The Proton vehicle has been in use for over 40 years and is the most experienced Russian large launch vehicle. In addition, Sirius launched the Proton vehicles carrying its satellites from a site in Kazakhstan where the former Soviet Union launched the Molniya satellites into their highly elliptical orbits, the orbits on which Sirius's orbits were based. By choosing the Proton vehicle and launching from the Kazakh facility, Sirius had access to that accumulated experience.

D. Satellite Businesses Mitigate the Risk of In-Orbit Failure Through Design Methodologies and In-Flight Work-Arounds.

Finally, satellite businesses use a number of proven strategies for minimizing the risk once the satellites are in-orbit. Several of the Services' witnesses testified that satellites are difficult to repair physically once they are in orbit. Smith WDT ¶ 14; Karmazin WDT ¶ 28. As the repair of the Hubble space telescope demonstrated, such repairs are possible, but as a

practical matter, for a private business, such repairs are generally not feasible. Satellite engineers and operators have understood this problem since the first satellites were launched, and consequently, they developed design and testing methodologies that insured that problems were caught, and fixed, prior to launch. For example, a typical satellite undergoes six months of thorough testing, including environmental testing, after assembly and prior to shipment to the launch site. Satellite engineers build on pre-existing satellite designs that have been proven to work in space, and they use as many pre-existing components as they can. Thus, satellite businesses are able to leverage the experience that their satellite manufacturers gained in developing satellites for other customers, and by using known designs and components, the businesses minimize the risk of failure.

Satellite engineers also typically build redundant components directly into the design of the satellite so that if a critical component fails in-orbit, the satellite operators can simply engage the redundant system to continue operating at full efficiency. For example, satellite designers routinely back up receivers, amplifiers, thrusters, solar cells, batteries, and computers with redundant parts. In addition, designers create alternative modes of operation so that if there is a problem with the primary mode, the operators can switch to another mode and keep the satellite functioning. This design methodology is a common-sense adaptation to the difficulties of repairing satellites in-orbit and has been used by satellite engineers since the very first satellites were launched.

In addition, satellite engineers extensively and thoroughly test satellites, and their individual components, on the ground prior to launch. They put the satellites through a rigorous series of tests designed to mimic the harsh realities of operation in space. They even test the satellites and their components in near vacuum to approximate the actual in-orbit conditions.

XM and Sirius followed these industry standard methodologies in the designs of their own satellites. For instance, Mr. Masiello testified about the many precursors to XM's design on which XM relied. Tr., June 6, 2007, at 229-35 (Masiello testimony). An XM document further noted that the "[ ]." *See* SX Ex. 202 RR, at XMCRB 21582. A Sirius document explicitly discussed how Sirius "[ ]." SIR 23508.

Furthermore, having successfully designed, launched, and operated satellites for several years, XM and Sirius can benefit from their own past experience as well, making future development that much easier. For example, in one of its documents, Sirius explicitly noted [ ]. SX Trial Ex. 31 at SIR 25158; *see also* SIR 21833 (noting [ ]); SIR 21801 (noting [ ]).

If a satellite component fails, and there is not a redundant component available, satellite operators also have extensive experience creating in-flight work-arounds to restore functionality. To create a work-around, ground engineers re-route systems or use components in alternative ways that allow the flight engineers to "work around" the failed component. Satellite operators will frequently work with the satellite's manufacturer to test any potential work-arounds thoroughly before attempting them on the actual satellites. In fact, Mr. Rusch testified about one

such work-around from the 1960s during his deposition in this matter. Rusch Depo. at 48-49. Similarly, Sirius developed two work-around solutions [ ]. SIR 7573-75.

VI. XM AND SIRIUS DRAW ON A RICH HISTORY OF SATELLITE TECHNOLOGY.

A. History of Communications Satellites

Although the mere mention of satellites may summon up futuristic images, in fact, satellites are nothing new. They have been around for fifty years, and the technology that underlies them is well-understood and well-executed. In general, there has been a trend where satellites become progressively more powerful, more robust, with more communications capacity, with larger antennas, and with longer lives as each new satellite is designed.[7] Nonetheless, modern satellites also still rely on innovations that were introduced in the very earliest satellites.

In addition, from the very beginning, satellites have been used to provide broadcast content to viewers and listeners. Syncom II, one of the earlier commercial satellites, broadcast live coverage of the 1964 Tokyo Olympics to the United States. Similarly, the first pay-per-view boxing event, the "Thrilla in Manilla" match between Muhammad Ali and Joe Frazier, was broadcast by satellite in 1975, and national cable television stations, including ESPN, HBO, Nickelodeon, and CNN, used satellites as early as 1983 to transmit their content. As the satellite industry developed, services began using satellites to provide content directly to users as well. In addition to the various satellite phone and data services and GPS services that developed, WorldSpace used satellite to provide "radio" channels to listeners, and satellite television services did the same for video channels (along with some music channels as well). Thus, XM's

[7] Similarly, there has been a trend where the receiving antennas become smaller.

and Sirius's use of satellites is not out of the blue; it is merely part of a general trend in using satellites to provide content to consumers.

1. First Satellites

The first satellite, the Russian Sputnik, was launched on October 7, 1957. The United States Army launched the first American satellite, Explorer, on January 31, 1958, and in December 1958, the Army Signal Corps put SCORE, the first radio broadcasting satellite, into orbit to transmit a Christmas message by President Eisenhower.

AT&T designed and built the Telstar satellite, which was the first commercial satellite, launching it with the help of NASA in 1962. Telstar transmitted television signals and relayed telephone calls between the United States and the United Kingdom. Many of the key components of modern communications satellites were included on Telstar, including the traveling-wave tube power amplifier, the use of solar cells to convert solar energy into electricity, and the use of transmit and receive antennas attached to the body of the satellite. XM's and Sirius's satellites make use of each of these innovations, although naturally with some modifications. In 1963, Hughes Aircraft Company pioneered the 24-hour Earth orbit with the small spinning communications satellite, Syncom I.

2. Comsat and Intelsat

The Communications Satellite Act of 1962 created the Communications Satellite Corporation (COMSAT). A successful IPO in 1964 gave COMSAT almost $200 million with which to develop a global satellite network, which became a successful business in only a few years. Rather than using the low Earth orbit (LEO) approach of the AT&T Telstar, COMSAT instead chose the geostationary Earth orbit (GEO) design based on the Hughes Syncom satellite.

COMSAT also fulfilled the mandate of the Act by creating a global alliance called INTELSAT. The INTELSAT system was a quasi-governmental cooperative which had nearly a hundred countries of the world as its members. The first INTELSAT satellite was launched successfully on April 6, 1965 and took up an orbit position over the Atlantic Ocean. COMSAT expanded INTELSAT from this single satellite to a system that covered the globe from orbit locations over the Atlantic, Pacific and Indian Oceans. By providing spare equipment and alternative operating modes, COMSAT could maintain a satellite in working order for a lifetime that extended to seven years or more.

Each successive INTELSAT satellite had more power, more communications capacity, and a longer lifetime than the predecessor. Intelsat IV, first launched on January 25, 1971, had innovations that are key both to direct broadcast satellite ("DBS") television companies and to the Services, including a large solar array capable of more than one kilowatt of DC power output, efficient traveling wave tube amplifiers, dish antennas on board with the ability to direct beams on the Earth, full backup through batteries and redundant power electronics, attitude control to keep beams properly directed, and thermal environment and orbit control to last an extended period in orbit.

The growth of demand for services coupled with increasing use of smaller diameter dishes led INTELSAT contract manufacturers to build larger and more powerful satellites. Intelsat 7, launched in 1992, produces nearly 4,000 watts of solar power and carries equipment to relay 90,000 telephone calls. Space Systems/Loral, the company that developed and manufactured Intelsat 7, went on to [ ]. SIR 221-318, at 232; XMCRB 28768-28842, at 28840.

3. Domestic Satellites

By 1970, the INTELSAT system established itself so well from a performance and reliability standpoint that communications companies recognized that GEO satellites offered the opportunity to extend the coverage of their domestic networks. Also in 1970, the Nixon administration introduced the "Open Skies" policy, which allowed any financially qualified organization to apply for authority to operate a domestic satellite system.

One of the first to file and the first to actually construct a U.S. domestic satellite system was Western Union Telegraph Company. Western Union contracted with Hughes for the design and construction of satellites with the same coverage as those later launched by XM and Sirius. Western Union's first three satellites, dubbed Westar 1, 2 and 3, all had successful launches and lived out their live expectancies of 7 years. Western Union established the practice of launching multiple identical satellites and purchasing additional hardware for use as a ground spare in the event of a launch failure, the same process followed by XM and Sirius to ensure their satellite systems would be technically successful. *See, e.g.*, Karmazin WDT at ¶ 9. Other U.S. companies such as AT&T, RCA, GTE and Southern Pacific Railways, also purchased their own satellites.

One application of the Westar satellites was to relay audio programs for AM and FM radio stations. National Public Radio (NPR) established a nationwide presence using Westar to relay programming from its studio in Washington, D.C. to hundreds of public radio stations throughout the United States. As discussed by Mr. Masiello, ABC Radio Network began with an analog terrestrial network, and transitioned to digital broadcast satellites. *See* Masiello WDT at ¶

4. This is fundamentally the same approach taken at both XM and Sirius. Prior to 1990, many other radio networks also relied on satellites to provide continuous delivery of their services.[8]

B. Comparable Precursor Systems

XM and Sirius were not built on "a new untested technology," nor did they "require[] the development of" a new means of transmitting satellite signals. Karmazin WDT at ¶ 27. Nor did they "open[] new technological avenues in the broadcasting field." Masiello WDT ¶ 3. In fact, there are several examples of precursor satellite systems that included the important technological elements of the SDARS systems and which established relevant business models. Numerous organizations, both private business and governmental entities, were able to use satellites to carry out missions very similar to XM's and Sirius's later goals.

1. Iridium and GlobalStar

Iridium and GlobalStar were important precursors to XM and Sirius. Both these systems provided two-way mobile communications using non-geostationary constellations of moving satellites – akin to Sirius. Iridium and GlobalStar delivered a working mobile telephone service directly to an individual handheld unit slightly larger and heavier than a cellular phone. Motorola proposed the Iridium system concept in 1987, and filed with the FCC in 1990. Loral and Qualcomm followed with GlobalStar. These systems include many important technological innovations subsequently used by XM and Sirius.

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[8] Hughes Aircraft Company moved from being a manufacturer of satellites to being an operator as well. During 1983-84, Hughes successfully launched the Galaxy 1, 2 and 3 satellites, which made Hughes a leader in distributing TV and audio programming to cable TV systems and TV networks. In 1986, Hughes provided satellite delivery for a new service for grocery store chains called Supermarket Radio Network: Supermarket Radio Network originated several radio channels in their Atlanta, Georgia studio and transmitted those channels by satellite to grocery chains. Like XM and Sirius, Supermarket Radio Network used terrestrial repeaters to retransmit the satellite signal to individual grocery stores.

For Iridium and GlobalStar to operate properly, Motorola and Loral/Qualcomm each had to provide all of the elements and integrate them. These efforts took several years and hundreds of engineers. The corresponding effort for either XM or Sirius would be, in my opinion, considerably less.

While the Iridium system employed a different orbital configuration than Sirius, there are nevertheless several similarities between Sirius and Iridium. The Iridium satellites operate in polar orbits, which are inclined by almost 90 degrees. This is greater than the Sirius inclination of 63 degrees, but likewise required corrective motion for adequate solar panel orientation toward the sun, a tool later utilized by Sirius. The Iridium satellites also used their on-board batteries to supplement the solar panels at times of low solar illumination – just as Sirius's satellites would later do.

The orbit of the GlobalStar satellites is inclined by 52 degrees, very similar to the 63 degrees used by Sirius. Space Systems/Loral, which designed both the GlobalStar satellites and the Sirius satellites, in both cases started with a spacecraft bus intended for geostationary orbit and modified it for use in low Earth orbit. Like the Sirius satellites, *see* Smith WDT at ¶ 12, the GlobalStar satellites employ yaw steering.

The satellite control and communications gateway Earth stations of Iridium and GlobalStar both use large dishes that track the satellites continuously as they pass from horizon to horizon. Sirius later adopted the same technique. Tracking moving satellites in orbit is nothing new – this was required for every launch starting with the first satellites in the late 1950s and the need for tracking continues to this day.

The Iridium voice service used a digital audio compression "algorithm" that greatly reduced the quantity of bits needed to provide conduct a conversation. XM and Sirius use a

similar algorithm in order to provide their information services channels, such as channels announcing local weather and traffic for a number of large metropolitan areas, with minimal impact on the greater amount of bandwidth available for music.

The satellite component of Sirius and XM vehicular antennas can be found in the handset and vehicular antennas used with Iridium and GlobalStar devices. The antenna component for terrestrial repeater reception is based on designs for cellular telephones.[9]

2. Satellite Mobile Broadcasting Experiments

The concept of using satellites to broadcast radio signals to moving receivers did not originate with XM or Sirius, but was conceived much earlier as a beneficial use of broadcast satellites. Voice of America, a multimedia broadcasting service in 44 languages from the United States, and a company called TRW investigated satellite radio broadcasting in the 1980s. In 1992, NASA embarked on intensive research, using the S-band, to determine whether radio programming could be transmitted to moving vehicles and portable receivers via satellites.[10] The results of this extensive testing were reported openly to engineers in the general community.

NASA's test program found that expected signal blockages from tree trunks, hills and buildings would cause interruption of reception; based on the NASA tests, it was logical to introduce the same signal over a different, non-blocked path. Radio engineers of normal skill know that there are two ways to provide a different path that would not be blocked by the same obstruction: use a second satellite whose signal is coming from a different direction or use a

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[9] Iridium and GlobalStar both suffered bankruptcies, principally because they failed to acquire enough customers in the first year of operations. *See* SDARS CRB 2340-2348, at 2341-42 (article by Roger Rusch, stating that "[t]he fundamental reason that Iridium failed was that it was too expensive," that "[t]he Iridium defects are not intrinsic to all satellite communication systems . . . ."). Both GlobalStar and Iridium were subsequently taken over by new investors who are continuing to provide voice and data services to several hundred thousand users worldwide. More importantly, the fact that both of these business entered bankruptcy does not diminish from the technological firsts each achieved.

[10] James E. Hollansworth, Utilizing a TDRS Satellite for Direct Broadcast Satellite-Radio Propagation Experiments and Demonstrations, presented to the Third International Mobile Satellite Conference (IMSC 1993).

land-based (terrestrial) signal source that can "fill in" the gaps produced by this kind of blockage (*i.e.*, terrestrial repeaters). Neither of these solutions was new to the satellite industry. AT&T used signals from multiple satellites as early as the 1970s to counter the high noise intensity produced by direct illumination from the sun. Likewise, the GPS system uses multiple satellite signals to deliver reliable data on users' position location. The GlobalStar system also utilizes two satellites for most of its region of coverage. The same principles involved in the use of terrestrial repeaters have long been applied by cellular telephone networks which use hundreds of base stations in major cities. Smith also identifies time and frequency diversity as two additional techniques employed by the Services. *See* Tr., June 7, 2007, at 47-48 (Smith testimony). As I discuss later, both techniques have long been used in digital communications.

3. Satellite DBS TV

XM and Sirius also owe a debt of gratitude to companies that broadcast television programs to homes via satellites, such as DirecTV and DISH Network (so-called direct broadcast satellite, or "DBS," companies). Not only did XM and Sirius build on the satellite technology advances of the DBS systems, but they were able to build on the DBS companies' business models.

While DirecTV is primarily a TV service, it also provided more than 100 audio channels, including stereo sound, via its satellites, ahead of XM and Sirius. While the majority of these were for the sound associated with the picture, there was a package of music channels much like that provided on XM and Sirius. To provide all of these services, DirecTV employs digital compression technology much like that later used by XM and Sirius. DirecTV also pioneered

the use of forward error correction ("FEC")[11] to provide excellent signal quality into a small dish antenna; this was essential to XM and Sirius for much the same reason.

In addition, according to Mr. Parsons, DirecTV invested in XM and contributed its expertise in important areas such as billing, programming, and customer service. Parsons WDT at ¶ 9. Thus, XM took advantage of lessons learned in developing the DBS business model.

The Services claim that they made a significant contribution by integrating all of the elements properly into a working system that served mobile users. But in fact, integrating a number of existing elements is not a unique contribution by the Services, but is a normal aspect any new satellite communications system. DirecTV had to go through the same process and required more time to build its system than did either XM or Sirius.[12] In my opinion, XM and Sirius had a much easier job since DirecTV and WorldSpace had preceded them.

4. WorldSpace SDARS Service

WorldSpace, Inc., implemented the first true satellite digital audio radio broadcasting system, before XM and Sirius. WorldSpace was designed to provide digital satellite audio, data and multimedia services primarily to Africa and Asia. WorldSpace uses two satellites to cover a very large broadcast footprint: over 130 countries including India and China, all of Africa and the Middle East and most of Western Europe. Like XM, WorldSpace utilizes a geostationary orbit. WorldSpace broadcasts 62 channels, of which 30 are WorldSpace-branded stations produced by or for WorldSpace and 32 are provided by third parties.[13]

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[11] FEC is a data encoding and data processing technique that corrects errors caused by noise and other interference that is picked up with the signal.

[12] XM's witness Mr. Masiello acknowledges the innovations of the DBS systems but downplays the challenges DBS operators faced. Masiello WDT at ¶ 3. For instance, he fails to acknowledge that DBS employs the higher Ku-band portion of the spectrum that is subject to heavy fades due to rain attenuation. The S-band spectrum used by XM and Sirius is not affected by rain at all.

[13] About WorldSpace International Satellite Radio Service, http://www.worldspace.com/about/index.html (last visited July 22, 2007).

WorldSpace successfully launched its first satellite, AfriStar, in October 1998, and successfully launched its second satellite, AsiaStar, in March 2000. Each WorldSpace satellite has the capability to transmit more than 100 channels of programming for reception by portable receivers similar in design to those of XM and Sirius. WorldSpace began with a "free-to-air" service but moved toward a paid-subscription business model as practiced by XM and Sirius. The service is available to mobile digital radio receivers as well. Thus, WorldSpace provided a system with all of the essential elements found in XM and Sirius.

The chipset inside the WorldSpace receiver had most of the functions of XM and Sirius. The main difference between the WorldSpace chipset and the XM and Sirius chipsets is the absence of circuitry to coordinate signals from two satellites and a repeater. This is because WorldSpace only operates a single satellite in a given region without terrestrial repeaters. A mobile service from WorldSpace is possible as long as sufficient antenna size is provided and blockage is minimal; for instance on an aircraft, train or vehicle traveling in open country.

The WorldSpace compression algorithm for chipsets was provided by the Fraunhofer Institute, which also provided to XM some of its underlying work done for WorldSpace. Parsons Depo., 33-35. WorldSpace also employed TDM to deliver the many channels to receivers, and included concatenated FEC very similar to what had previously be employed in DirecTV and Dish Networks.[14]

Both XM and Sirius benefited from the advances in satellite broadcasting that WorldSpace pioneered. XM in particular was able to take advantage of lessons learned by WorldSpace, because WorldSpace was an original investor in XM and shared much of its

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[14] Dr. S. Joseph Campanella, Seminar on the WorldSpace Satellite Direct Digital Audio Broadcast System, Address at the IEE Colloquium on Communication Opportunities Offered by Advanced Satellite Systems (July 19, 1998) (Ref. No. 1998/484).

knowledge with XM. Parsons WDT at ¶ 8; Parsons Depo 22:9-24:8. I am also aware that several of the WorldSpace engineering staff were seconded to XM as a means to transfer this know-how.

WorldSpace and AMRC, the predecessor to XM, [[redacted]]. XMCRB 00044448. Alcatel, [[redacted]]. XMCRB 00021409. AMRC also was assisted [[redacted]]. XMCRB 123333-123346, at 123342; Parsons Depo. at 33.

C. Earlier Uses of Elements of Satellites

1. Multiple Signals

XM's and Sirius's witnesses make much of the fact that their companies had to combine the signals from two different satellites and the terrestrial repeaters. Masiello WDT ¶ 25; Smith WDT ¶¶ 8, 24-25. But using multiple signals to overcome barriers (*e.g.*, trees, buildings, or tunnels) that might block a single satellite's signal (so-called signal "diversity") is a well-known technique within the satellite industry. In the late 1970s, as part of an experiment with NASA, the DEA, and the INS, General Electric demonstrated that two satellites could be used to broadcast a signal to an omni-directional antenna mounted on an automobile, thereby countering disruptions to the signal.[15] AT&T also used diversity in the 1970s, receiving signals from multiple satellites in order to counter the high amount of noise created by direct illumination

[15] Axel F. Brisken et al., *Land Mobile Communications and Position Fixing Using Satellites*, Vol. VT-8, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, No. 3, 153 (1979).

from the sun. Similarly, the GPS system uses multiple satellites to increase the reliability of its location determinations, and GlobalStar usually has two satellites transmitting information to provide diversity to its system. NASA conducted additional experiments in the 1990s demonstrating that diversity was required to receive a reliable satellite signal in a moving vehicle.

Indeed, engineers understood the importance of diversity long before those systems. Satellite textbooks first mentioned diversity in 1964, and ocean-going vessels have long used multiple receivers on different frequencies to receive information reliably. Both Services employ time diversity to deal with signal interruption inside a tunnel or overpass. However, the principle of time diversity had been applied in high-frequency radio communications many years before. In addition, portable and vehicular audio CD players employ a form of time diversity very similar to that used by the Services (referred to as anti-skip) so that playout would not be interrupted when the vehicle hits a bump. In the 1960s and 1970s, radio engineers used diversity to overcome signal fading that resulted from various propagation effects, building receivers that combined signals from different incoming paths. In the 1970s and 1980s, military and civilian services commonly used diversity in over-the-horizon tropospheric links, which used the same spectrum frequencies as the SDARS.

Terrestrial repeaters are just another path to increase diversity in locations where satellite signals are likely to be blocked (like urban environments). They function similarly to cellphone towers, broadcasting a stronger signal to a smaller area.

2. Antennas

Witnesses for the Services have claimed that XM's and Sirius's antennas are unique and designed for a unique purpose. Tr., June 4, 2007, at 311 (Parsons testimony); Tr., June 7, 2007,

at 67, 121-124 (Smith testimony). However, XM and Sirius drew significantly on antennas used by other satellite systems.

The small antennas used on vehicles were based on designs similar to that used for the Global Positioning Satellite (GPS) system, which broadcasts positional location data in the L-band spectrum (just below S-band). This was not acknowledged by Sirius's Terrence Smith who asserts that antennas available at the time were "generally large and expensive dishes, which are not practical for use with vehicles." Smith WDT ¶ 4. GPS, which initiated operation in 1985, uses an inclined orbit like Sirius but like Molniya the orbit period is half a day. Since satellites and ground receivers are in motion relative to each other, and multiple satellites are in view at one time, it is necessary to use an omni-directional receiving antenna. Such antennas are compact and simple to construct, and were described in the published engineering literature in the 1960s and 1970s. They were available in marine and handheld receivers on the market in the early 1990s. Both XM and Sirius have benefited from development work and use similar types of antennas for their mobile receivers.

Mr. Karmazin claims that Sirius "developed the world's smallest non-directional satellite antenna to make sure our service could be received in vehicles." Karmazin WDT ¶ 10. But the general class of small receiving antennas existed for mobile satellite communications for many years before either Sirius or XM needed to develop theirs. Like a terrestrial cellular antenna on a cellphone or car, the mobile satellite antenna needs to receive from a radio transmitter that could be located in any direction.

The typical satellite omni-directional antenna was employed for the Inmarsat C service used to transmit and receive low speed data communications. A common design for this is the

quadrifiller helix, which was first published in the open engineering literature in 1974. Inmarsat C and its terminals were in active use as early as 1990.

The satellite portion of SDARS requires the antenna to possess a hemispherical pattern toward the entire sky at one time. This can be done with a variety of simple antenna designs, all of which existed in the engineering literature prior to 1990. In fact, such an antenna could be found in commercial GPS receivers which could "see" the entire sky and are as small as those employed for SDARS reception.

One feature of the SDARS system that required some additional antenna design work was combining the hemispherical coverage technique for satellite reception with a terrestrial type of mobile antenna (like that used on a cellphone) to receive from a terrestrial repeater. In my opinion and based on the designs I have examined, this is not a very difficult design requirement and involves picking appropriate legacy designs for each that can be accommodated in the same physical package. According to the engineering literature, there are a number of alternatives for how this can be accomplished. For example, instead of the quadrifiller helix, the satellite receive antenna could be formed from a compact flat spiral that receives the satellite broadcast and a single vertical monopole inserted in the center to receive the terrestrial repeater broadcasts. The designer only needs to consider the technical requirements for the antenna, and then review the literature to see what existing type of antenna can be applied or adapted to the requirement.

Mr. Smith asserts that one of the main issues that impeded the SDARS was that existing "commercial satellite antennae capable of capturing the relatively weak signal from a satellite were generally large and expensive dishes, which are not practical for use with vehicles." Smith WDT ¶ 4. This is untrue – several satellite systems employed small antennas like those of XM

and Sirius to receive weak satellite signals. Among these are Inmarsat C, GPS, Iridium and GlobalStar.

3. Repeaters

The service reliability of SDARS systems in the US is enhanced through the use of terrestrial repeaters. Contrary to the testimony of the Services' witnesses, Tr., June 4, 2007, at 315-316 (Parsons testimony) ("So the next innovation was, in fact, building a terrestrial-based urban repeater network . . . ."); Tr., June 6, 2007, at 208-210 (Masiello testimony), the use of terrestrial repeaters was not innovative. Terrestrial repeaters are a natural answer to the requirement that satellite broadcasts reach urban areas. Satellite diversity is sufficient in rural or suburban areas, particularly along Interstate highways, where blockage is relatively infrequent. As I discussed above, Supermarket Radio Network and NPR were both using terrestrial repeaters in the 1980s as part of their satellite radio delivery to different locations. Even before that, the US Army employed terrestrial repeaters, called automatic retransmission systems, to extend the range and coverage of tactical VHF radios. This was very effective in South Vietnam in the 1960s, where there was a high degree of signal blockage due to jungles and mountain ranges. Since the 1970s, amateur radio operators have placed such repeaters on hill tops for use in emergency communications when local telephone and cellular services are destroyed by storms, fires or earthquakes.

The terrestrial repeaters used by XM employed existing modulation techniques for broadcasting digital radio signals. Indeed, XM has acknowledged that [ ] *See* SX Ex. 202 RR, at XMCRB 00021582.

4. Business Operations

The business operations of XM and Sirius also imitated those of DirecTV and DISH Network. In addition to the satellites employed by XM and Sirius, both companies acquired ground systems to compress and assemble content in various forms, including music and talk, and transmit it to the respective satellites. The components either are off-the-shelf or modified existing designs and the software that runs the system is similar to that developed for DBS television systems, like DirecTV, that preceded the Services. Indeed, according to Mr. Parsons, DirecTV and others "provided expertise in various elements of the business, such as billing, programming and customer service." Parsons WDT ¶ 9.

5. Chipsets

The SDARS receivers installed or attached to vehicles employ chip sets that were developed according to common practice in the consumer electronics industry. They are not significantly different from their counterparts in DBS systems and cellular telephone networks. A similar design was produced for WorldSpace, which produced a working high power satellite, using L-band rather than S-band (a minor change as far as technology is concerned), low cost receivers and a broadcast of many audio channels on a single radio channel. [[redacted]]. *See* SX Ex. 202 RR, at XMCRB 00021582 ([[redacted]]). Some of [[redacted]]. *See* XMCRB 00044448-44462.

6. Orbits

Despite their claims otherwise, Smith WDT ¶ 7; Masiello WDT ¶ 25, both XM and Sirius used orbits that had been developed first by others. As mentioned above, XM uses a

geostationary orbit. Satellites, and in particular communications satellites similar to XM's and Sirius's, have used geostationary orbits since the mid-1960s. The mechanics and benefits of these orbits are well understood, as XM itself has recognized. *See* SX Ex. 202 RR, at XMCRB 21582 ("[ ].").

Similarly, Sirius's highly elliptical orbit has also been used before – as Mr. Smith admitted on cross-examination. *See* Tr., June 7, 2007, at 91-92 (Smith testimony). Within the satellite industry, such an orbit is referred to as a "Tundra" orbit. The Soviet Union developed the highly elliptical Molniya orbit in the 1960s. The United States military also developed a highly elliptical satellite system in the 1970s to communicate at high latitudes (the Satellite Data System, or SDS), and in the 1980s, a European group developed a project called Archimedes that would have used a highly elliptical orbit combined with several satellites to provide continuous coverage across Europe. Although Archimedes was not implemented, it was reported and its proposed use of the Tundra orbit was well known in the late 1980s. Indeed, Sirius has explicitly acknowledged these predecessors to its own system. *See* SIR 16721 [ ].

Mr. Smith's statements about the "dozens of orbit-specific requirements as well as operational requirements" of which Sirius had to take account ignores the fact that these predecessor systems had to solve the same or similar problems. Smith WDT at 5, ¶ 9. For example, GlobalStar used an inclined low Earth orbit prior to Sirius's launch, and Space Systems/Loral (the company that later built Sirius's satellites) had to design the satellites so that they kept their solar panels aligned with the sun as they moved.

Similarly, Sirius must rotate its satellite antenna reflector as the satellite moves so that it continues to point at the proper locations. However earlier geostationary satellites, like the

Intelsat IV launched in 1971 and Westar 4 in 1982, also had to move their reflectors to compensate for the movement of those satellites. While those satellites moved less than the Sirius satellites, the same mechanisms and control software had to be modified.

7. Mobile Receivers

Satellite communications engineers like those who designed the XM and Sirius systems understand the basic principles of line-of-sight propagation to stationary as well as moving receivers. The satellite link is nearly ideal because it is stable, being only subject to atmospheric effects and to obstacles that may block the path. These principles are covered in text books written more than 15 years ago, including my own.

Research into the effects of obstacles that can block the path, which will occur in the case of SDARS with moving vehicles, was undertaken over the past 20 years by NASA, JPL and others, and reported in the literature. In providing service to moving vehicles, XM and Sirius draw heavily on the experiences of satellite businesses that provided mobile satellite service (MSS), from which it takes the means of serving individual users who are in motion in cars and other forms of transportation. The first MSS satellite operator and service provider was a consortium called Inmarsat, which went into early operation in the late 1970s.

Iridium and GlobalStar were the two low LEO MSS systems that offered two-way voice and data communications services to handheld and vehicular phones. The antennas used in these systems were small so as to have omni-directional directivity. In addition, Motorola, the developer of the Iridium system, produced a variety of small, omni-directional antennas for their mobile devices, which were small and compact like antennas used for Sirius and XM. The first satellite handset, the Motorola 9500, had a quadrifiller helix antenna about the size of a cigar or small tube of toothpaste that was extended above the head of the user. This allowed the phone to

receive the weak satellite signals from any direction in the sky. For vehicular use, Motorola supplied a much smaller "patch" type of antenna that was extremely flat and small, about the size of a silver dollar and one half inch in thickness. Both of these antennas were in commercial production by 1998.

8. Audio Compression

The broadcasting of 100 or more audio channels by a satellite is based on engineering principles understood well before of the development of Sirius and XM. Audio compression has been applied since the 1970s to compress telephone channels, including by the military, which requires that the speech be encrypted as well. Even Mr. Masiello testified that, as early as 1988 at CBS, he "developed . . . expertise in the processing of digital audio signals, and in 'audio compression' technology that could reduce the amount of digital information in a broadcast transmission signal yet still produce clear digital sound quality." Masiello WDT ¶ 7.

In the early 1990s, DirecTV and others employed the new compression standards from the Motion Picture Experts Group (MPEG) to reduce the required number of bits to transfer both sound and picture. The audio portion of MPEG is knows as MPEG Audio Layer 3, which has been abbreviated to the popular consumer form, MP-3.

The other aspect of delivering 100 or more audio programming channels is based on the established principle of time division multiplexing ("TDM"). AT&T and the US Army adopted TDM in the 1960s so that several telephone conversations can be carried by a point-to-point link, which was more efficient than having separate cables or radio transmitters for each conversation. Another well-developed application of TDM prior to 1980 was for multiple channels of telemetry data from satellites. TDM in and of itself does not reduce bandwidth requirements but actually increases the total amount of data transferred.

Mr. Smith states that Sirius "pioneered statistical multiplexing for audio applications." Smith WDT ¶ 20. The technique of statistical multiplexing ("STATMUX") was not new for Sirius but was introduced in the 1980s to compress a TDM data stream by only sending information from active channels. Thus, time is not wasted on periods when no information is coming from one or more of the channel sources, and the ones needing more bits are given faster access to the TDM stream. This technique was also applied in 1970 with audio information for long distance telephone calls, particularly over the oceans, to double the quantity of voice links. DirecTV and DISH networks adopted STATMUX around 1997 for their multi-channel television and audio services to effectively double the capacity of a given satellite. While Mr. Smith acknowledges that STATMUX was common in video, Smith WDT ¶ 20, in fact DirecTV and DISH networks used STATMUX to reduce bandwidth requirements for the audio associated with the video and for the music channels delivered by these systems.

9. High Power Satellites

Satellites in geostationary and geosynchronous orbit, like XM's and Sirius's satellites, need significant power to transmit to small omni-directional antennas located throughout the continental United States. To accomplish this task, XM and Sirius each contracted with leading satellite manufacturers who already had in production spacecraft busses that could meet the Services' power requirements. The XM satellites employed the Boeing 702 vehicle, which was previously purchased by PanAmSat for a high capacity satellite to be used for television and other services.

Sirius chose Space Systems/Loral, which offered the high-powered L-1300 vehicle. One year into its relationship with SS/L, Sirius directed SS/L make a change from a two-satellite GEO system to a three satellite HEO system. SS/L followed normal space systems engineering

practice to modify the satellite for a somewhat different orbit environment. *See* SIR 00007551 at 7562. SS/L had previously accomplished a similar modification of a GEO satellite design for GlobalStar satellites launched prior to the year 2000.

The power systems onboard the XM and Sirius satellites employ standard designs based on nearly four decades of experience by the respective manufacturers. In the case of XM, the B-702 satellite included solar collectors to re-radiate the sun's light onto the main solar panels. At the time XM launched its satellites, solar collectors were already working on Galaxy 11, demonstrating that power could be augmented by increasing the solar intensity using collectors.

VII. CONCLUSION

As described above, the Services' use of satellite technology is neither as risky nor as innovative as some of their witnesses' testimony suggests. To the contrary, satellites are reliable and have been in use for decades.

I declare under penalty of perjury that the foregoing testimony is true and correct to the best of my knowledge and belief.

Bruce R. Elbert

Date: July 24, 2007

Exhibits Sponsored by Bruce R. Elbert

Restricted exhibits, which are identified by the suffix "RR," are not included in the Public Version of SoundExchange's Rebuttal Case

Exhibit No.	Description
SX Exhibit 201 RP	Rusch slideshow presentation (SDARS CRB 00003250 et seq.)
SX Exhibit 202 RR	"XM Satellite Radio Technical Overview" slideshow presentation (XMCRB 0021578 et seq.)

Appendix A to the Written Rebuttal Testimony of Bruce R. Elbert

BRUCE R. ELBERT

Experience:

2000 to date **President, Application Technology Strategy, Inc.**

Founded consulting firm specializing in technical and business aspects of satellite fixed and mobile broadband communications.

Clients include United States Air Force, United States Army, United States Navy, News Corp, DirecTV, Hughes Network Systems, Boeing, EchoStar, ntl (UK), Rockwell Collins, Stratos Global, GlobeCast, AsiaSat, JSAT, and KVH Industries.

Client work involves system design/engineering for space and ground segments, frequency planning and satellite bandwidth assessment, network design for voice/video/data applications, operations and organization management, specification and evaluation of satellite coverage and performance, earth stations and user/subscriber terminals, market assessment and development, contract review and negotiation, frequency coordination and international regulatory support, and technical training; including review and assessment of candidate satellites in terms of technical performance and cost; design of digital content delivery systems for commercial aircraft and retail networks; performance of due-diligence for acquisition of communications microwave component supplier; review and recommendation of payload requirements for replacement Ku-band satellites; and technical expert work in various litigation cases.

1980 to 1999 **Hughes Electronics, Inc., El Segundo, California,**
Senior Vice President, Operations, HSCII

Managed technical and business teams that designed and proposed satellite systems to US and international customers. Led successful campaign for sale of DBS satellites to News Corporation to provide local channels. Developed the architecture for Hughes' geostationary mobile satellites, gateways and handheld devices, which subsequently were purchased by Thuraya. Revenue oversight: approximately $800 million per year; 20 direct reports and indirect responsibility for product design and development by 8,000 person organization.

At Hughes Communications, Inc. (1984-1995): Managed engineering and marketing of the Galaxy cable TV and data communications satellites. Led effort to acquire operating satellites from Western Union and supported the sale/leaseback of Galaxy 2 transponders with First Boston Corp. Contributed to DIRECTV startup; and prepared the successful FCC filing for Spaceway.

Operations director of Hughes ground stations and customer VSAT networks. P&L oversight: approximately $200 million per year; led an organization of over 100 technical and administrative staff.

At Hughes Aircraft Company (1980-1984): Managed the successful campaign for the sale of two satellites and ground facilities to Mexico; led technical management for several satellite programs, including Galaxy, Westar and SBS.

1978 to 1980 **Western Union Corporation, Upper Saddle River, New Jersey, Assistant Vice President, Advanced Westar**

Directed program management and engineering activity for Western Union's second-generation broadband Ku-band digital satellite network (TDRS), contracted at a value of approximately $500 million. Led the evaluation of proposals for the Westar IV and V C-band satellites submitted by three potential suppliers.

1972 to 1978 **Hughes Aircraft Company, El Segundo, California, Senior Project Engineer, Systems Engineering Laboratory**

Directed the communications system design and on-site testing of Indonesia's first nationwide satellite telephone and TV network (Palapa A), contributing to program success in terms of on-time service activation, customer satisfaction and profit. Established Hughes' ITU regulatory support activity, representing the company and the US at two World Radiocommunication Conferences in Geneva. Led test efforts for quality evaluation of FM-TV over satellite links. Designed and tested the first working Ka-band microwave repeater and multi-beam spacecraft antenna under contract from AT&T Bell Laboratories.

1969 to 1972 **Communications Satellite Corporation, Washington, D.C., Member of the Technical Staff, Systems Laboratory**

Participated in new technology development for INTELSAT and system architecture for the first aeronautical mobile satellite application; other project activities included: millimeter wave transmission technology and systems; integration of ground based networks with satellites using TDMA and DAMA access schemes; digital speech and video processing and compression; and terminal design for mobile satellite service.

Military Service:

1965 to 1969 **Captain, U.S. Army Signal Corps**
Radio communications instructor in the officer training program at the Signal School. Prior to this assignment, served two years duty as signal detachment commander, and radio engineering officer with the 4th Infantry Division in the US and Vietnam.

Education: Pepperdine Univ.: MBA (Presidential/Key Executive), 1985
Univ. of Maryland: MSEE, Communications and Computer Engineering, 1972
City College of New York: BEE, 1965

Languages: Fluent Spanish, Conversational French.

Academic History:

2000 to date: **Adjunct Professor, University of Wisconsin – Madison**
Department of Engineering Professional Development, College of Engineering

Faculty in the Master of Engineering in Professional Practice.

1990 to date: **Instructor, University of California at Los Angeles**
Department of Engineering, Information Systems and Technical Management, UCLA Extension

Instructor in Satellite Communications, Information Systems, and Communications Engineering; developed sequence of five short courses in satellite television and radio, mobile and broadband communications engineering and advanced applications; member of the advisory committee for communications engineering; 2006 recipient of the Dean's Distinguished Instructor Award.

Affiliations: IEEE; AFCEA; AIAA; Series Technical Editor of the Artech House Space Technology and Applications Library.

Selected Publications:

Engineering and Professional Books

- *The Satellite Communication Applications Handbook*, 2nd edition, Artech House, 2004
- *The Satellite Communication Ground Segment and Earth Station Handbook*, Artech House, 2001
- *Introduction to Satellite Communication*, 2nd edition, Artech House, 1999
- *Client/Server Computing – Architecture, Applications and Distributed Systems Management*, Artech House, 1994 (co-authored with Bobby Martyna)
- *Networking Strategies for Information Technology*, Artech House, 1992
- *International Telecommunication Management*, Artech House, 1990
- *Private Telecommunication Networks*, Artech House, 1989

Selected Technical Journal and Conference Papers

- Elbert, "Achieving complementarity when integrating satellite, terrestrial and wireless communications," *19th AIAA International Communication Satellite Systems Conference*, Montreal, Canada, 12-15 May, 2002.

- Elbert, "Broadband data communications via satellite – networks and methodology," *24th Pacific Telecommunications Council Conference*, 13-17 January 2002, Honolulu, Hawaii
- Elbert, "Commercial satellite applications: sort term and long term trends," *17th AIAA International Communications Satellite Systems Conference*, 23-27 February 1998, Yokohama, Japan
- Elbert, "Geostationary communications satellites and applications," *The Communications Handbook*, Dr. Jerry D. Gibson, Editor in Chief, IEEE Press, 1996
- Elbert and P.A. Louie, "The economics of mobile service by satellite," *14th AIAA International Communications Satellite Systems Conference*, Washington, D.C., June, 1992
- Elbert, "Next generation C-band satellite systems for cable program distribution," *Cable '88 National Cable Television Association*, May 1, 1988, Los Angeles
- Sanchez-Ruiz, M.E., and Elbert, B.R., "Mexico's First Domestic Satellite," *AIAA International Communications Satellite Systems Conference*, 1984, Orlando
- Sanderson, C.C., and Elbert, B.R., "Communication system design of the Indonesian satellite system," *1976 IEEE Wescon*, September 14-17, Los Angeles
- Kiesling, J.D., Elbert, B.R., Garner, W.B., and Morgan, W.L., "A technique for modeling communications satellites," *COMSAT Technical Review*, Vol. 2, No., 1, Spring 1972

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