Attachment B

To Pegasus Communications Corporation's Petition To Deny

Affidavit and Report of Roger J. Rusch

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In re Consolidated Application of **EchoStar Communications Corporation,** **General Motors Corporation,** **Hughes Electronics Corporation,** Transferors, and **EchoStar Communications Corporation,** Transferee, For Authority to Transfer Control.	**CS Docket No. 01-348**

AFFIDAVIT OF ROGER J. RUSCH

STATE OF CALIFORNIA)
) SS:
COUNTY OF LOS ANGELES)

ROGER J. RUSCH, being duly sworn, deposes and says:

1. I have been asked by Pegasus Communications Corporation ("Pegasus") to address various arguments asserted by the transfer applicants in this proceeding about why the pending transfer of control is necessary in order to allow New EchoStar to provide local-into-local service to 100 DMAs and to provide additional services, including satellite broadband, to its DBS customers.

2. The attached report contains the results of my analysis and the bases for my conclusions that the transfer applicants' contentions about their need for the combined spectrum of both entities is misplaced, and that both EchoStar and DIRECTV are capable of providing a full array of competitive services on their own.

I declare under penalty of perjury that the foregoing statements are true and correct.

Roger J. Rusch

Subscribed and sworn before me
this 31 day of January, 2002.

Notary Public

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FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In re Consolidated Application of **EchoStar Communications Corporation,** **General Motors Corporation,** **Hughes Electronics Corporation,** Transferors, and **EchoStar Communications Corporation,** Transferee, For Authority to Transfer Control.	)	**CS Docket No. 01-348**

REPORT OF ROGER J. RUSCH

1. I am the President of TelAstra, Inc., a technical and management-consulting firm located in Palos Verdes, California. I have been a graduate scientist and professional telecommunications engineer since 1962. I have been active in the design of communications and broadcasting satellite systems since 1965 starting with INTELSAT III at TRW, INTELSAT IV at Hughes Aircraft Company, and INTELSAT V at Ford Aerospace. I have held primary design responsibility for a wide variety of communication satellites and was elected as a founding director of the Direct Broadcasting Satellite Association in 1984. I was a member of the US delegation to the ITU World Radiocommunications Conferences in 1992 and 1995 that dealt with all aspects of radio frequency spectrum allocation. I have lectured extensively in the United States, Europe, and Japan on the business and financial aspects of communication satellites. A short version of my resume is attached to this Affidavit as **Exhibit A**. A list of my technical publications is attached to this Affidavit as **Exhibit B**.

2. I was retained by Pegasus Communications Corporation to undertake an analysis of domestic Direct Broadcasting Satellite (DBS) systems in connection with the proposed merger of EchoStar and DIRECTV. I analyzed the ability of satellite carriers, using currently available technology, to offer re-broadcast of all high-power television broadcast stations in the Continental United States (CONUS). I reviewed documents submitted to the FCC as well as publicly available data regarding the characteristics of

other satellites that are being designed or have been successfully launched. These documents are identified in footnotes.

3. I have concluded that EchoStar and DIRECTV each has sufficient spectrum today to provide a bundle of services (including, but not limited to, local television signals) to compete with state-of-the-art digital cable systems.

A. Background on DBS Spectrum

4. Both DIRECTV and EchoStar operate in a designated frequency band that is reserved for direct-to-home broadcasting by treaty under the auspices of the International Telecommunications Union (ITU). The Broadcast Satellite Service (BSS) frequencies are limited in number, but may be re-used by satellites operating in different locations within the geostationary arc. The treaty carefully apportions these special frequencies and orbital locations to ensure that each signatory country has access to a share of these resources, which are both highly valued and strictly limited. They are highly valued because their technical profile and regulatory treatment make them far superior to other satellite spectrum for the provision of television broadcast services. They are strictly limited because the technical profile – which makes them capable of providing reliable service to extremely small receiving dishes – requires far greater spacing between satellites than is common in other satellite bands. The unique technical and regulatory profile of BSS results naturally in extremely high and, in some cases, preclusive barriers to entry for new providers. In other satellite bands, a country can "stake out" new satellite orbital slots and frequencies to accommodate new entrants simply by registering its intent to use them with the ITU, followed by actual launch of a satellite to perfect the rights. This procedure doesn't apply to the BSS bands. The slots and frequencies assigned to a country, including the United States, are determined in the treaty and subject to change only by multilateral international agreement, resulting in an amendment to the treaty.

5. According to the BSS plan, the United States is allotted frequencies in only three orbit locations capable of providing service to all of the continental United States ("CONUS"): 101ºWest Longitude (WL), 110ºWL, and 119ºWL. The FCC awards and administers licenses for use of these orbital slots.

B. DBS Frequencies Allocated to DIRECTV and EchoStar

6. DIRECTV and EchoStar are the two dominant DBS providers in the United States and collectively control the entire spectrum at these three locations. Both are licensed to operate in the BSS band, which consists of 500 MHz of broadcast spectrum from 12.2 to 12.7 GHz, which is a part of the electromagnetic spectrum known as the "Ku-band." The 500 MHz of spectrum is divided into 16 sub-bands, each of which is about 27 MHz wide with a 2 MHz guard-band. Electromagnetic waves propagate in three dimensions so that it is possible to transmit two independent sets of information or two "senses of polarization" on the complex waveform. Consequently, the spectrum may effectively be used twice, once with Right Hand Circular Polarization (RHCP) and once with Left Hand

Circular Polarization (LHCP). As a result, 32 frequency blocks are available for DBS broadcasts at each orbital location.

7. DIRECTV is licensed to use 46 full CONUS frequency blocks, including the entire spectrum at 101ºWL (32 frequency blocks), part of the spectrum at 110ºWL (3 frequency blocks), and part of the spectrum at 119ºWL (11 frequency blocks). EchoStar is licensed to use 50 full CONUS frequency blocks, including part of the spectrum at 110ºWL (29 frequency blocks) and part of the spectrum at 119ºWL (21 frequency blocks). EchoStar also controls additional spectrum at 61.5ºWL, which may be used to provide DBS service to areas east of the Rocky Mountains, and at 148ºWL and 175ºWL, which may be used to provide DBS service to areas west of the Rocky Mountains. **Figure 1** shows the present DBS orbital assignments and frequency blocks.

Permittees/ Licensees	Total	175°	166°	157°	148°	**119°**	**110°**	**101°**	61.5°
DIRECTV	46					**11⇳**	**3⇳**	**32⇳**	
EchoStar	107	22			24	**21⇳**	**29⇳**		11⇳
R/L DBS	11								11 *
Dominion	8								8⇳
Unassigned	84	10	32	32	8	**0**	**0**	**0**	2 *

<u>KEY</u>: ⇳ = operational; * = used by EchoStar pursuant to a grant of Special Temporary Authority.

Figure 1: DBS Frequency Block Assignments by Orbital Location

8. In addition to the Ku-band frequency blocks, EchoStar and Hughes Electronics (DIRECTV's corporate parent) have vast amounts of satellite spectrum in other frequency bands which can be used for supplemental broadcasting service and two-way broadband services.

C. Existing DBS Satellites Operated By EchoStar and DIRECTV

9. EchoStar and DIRECTV currently operate twelve satellites at five orbital slots, not including the slot at 175ºW. Typically, each satellite is designed to carry 16 high power (120 watt) Ku-band "transponders," which may, in turn, be paired to produce the equivalent of 8 240-watt transponders. A transponder is a device which takes the signal received from an Earth uplink station on the uplink frequency, here at 17.3 to 17.8 GHz, filters it, converts it to the appropriate downlink frequency, here at 12.2 to 12.7 GHz, amplifies it, and transmits it back to receiving Earth stations. In the satellites that are currently in use by DIRECTV and EchoStar, each transponder may be used to retransmit

12 or more television signals for a total of 384 (32 frequency blocks x 12 signals) television signals at each full CONUS orbital location.[1]

10. The original satellites utilized by DIRECTV and EchoStar at 101ºWL, 110ºWL, and 119ºWL transmit each cable or television broadcast signal throughout the CONUS. Consequently, the signal of a local broadcast station with viewers residing solely in the Washington, D.C. metropolitan area is transmitted nationwide. However, under the Satellite Home Viewer Improvement Act of 1999, neither DIRECTV nor EchoStar has the necessary copyright license to provide that station to subscribers nationwide. As a result, DIRECTV and EchoStar must block or black out reception of that television signal in geographic areas outside of Washington. Such nationwide broadcasts of television stations are particularly inefficient in that they waste both spectrum and power. Because the signal is transmitted nationwide, the satellite carrier is prevented from using the same frequency to transmit the signal of a different local station due to the resulting interference between the two signals. DIRECTV and EchoStar's existing satellites have been transmitting an average of 10-12 television signals on each frequency block. In this configuration, each slot is capable of transmitting between 320 and 384 television signals. It is immaterial whether the signals are nationwide cable channels or local television stations.

II. Providing Local-Into-Local Service

A. Spot Beam Satellites

11. To facilitate the carriage of local television broadcasts, DIRECTV and EchoStar have begun deployment of satellites with multiple "spot beams" to retransmit local television stations too much smaller geographic areas. Because the television signal is transmitted only to a small area, the same frequency may be re-used in other geographic areas without the interference that would result if two signals were transmitted nationally on the same frequency. There are two advantages to the spot beam technique. First, the frequencies can be reused, *i.e.*, used to transmit other signals in other beams. This means that a single satellite can supply a large number of local television channels with relatively little spectrum usage. Second, the satellite transmitter power can be greatly reduced because the energy is spread over a much smaller area. Coverage is limited to the immediate area surrounding the local stations.

12. Spot beams are especially useful for local television retransmission because multiple local television stations can be transmitted by reusing the same frequency to transmit different local stations to distinct geographic markets. Spot beam satellites that are being

[1] The Joint Engineering Statement (p. 13) submitted by the transfer applicants in this proceeding indicates that using existing hardware, and without a degradation in service quality, both EchoStar and DIRECTV expect transmit 12 television signals on each frequency block. The transfer applicants state: "Four to five years ago, compression ratios of 6-8 were achievable and the future outlook using existing hardware is only expected to achieve ratios of about 12:1 with acceptable service quality."

designed today for this service could reuse the same spectrum 8-12 times. This means that 8-12 local television programs can be provided as an alternative to a single national broadcast. Consequently, all of the eligible local television stations in the CONUS[2] could be broadcast by using 16 frequency blocks or less. This result is calculated as follows: First, assuming (as indicated in the transfer applicants' Joint Engineering Statement)[3] that 12 television signals can be transmitted on each frequency block, then 16 frequency blocks could transmit 192 signals (16 x 12). Second, applying a re-use rate of 8 means that, with spot beams, 1,536 (192 x 8) television signals could be transmitted on 16 frequency blocks. Applying a re-use rate of 12 means that, with spot beams, 2,304 (192 x 12) television signals could be transmitted on 16 frequency blocks. Thus, EchoStar, which controls 50 full CONUS frequency blocks, would only need to dedicate 32% (16/50) of its full CONUS DBS spectrum to provide local-into-local service throughout the CONUS. DIRECTV, which controls 46 full CONUS frequency blocks, would only need to dedicate approximately 35% of its full CONUS DBS spectrum to provide local-into-local service throughout the CONUS. However, if the re-use rate were closer to 12 than 8, then fewer than 16 frequency blocks would be needed. Thus, spot beams make additional spectrum available for nationwide service. These conclusions are not merely an exercise in arithmetic; we have prepared complete preliminary designs of the satellites to demonstrate that the approach is practical.

13. As noted above, the next generation of DBS satellites, which use spot beams to provide local-into-local service, is already being deployed[4]. These include DIRECTV 4S, DIRECTV 7S, EchoStar 7[5], EchoStar 8, and EchoStar 9. Each of these satellites uses smaller beams that cover a portion of the United States, about the size of the State of Colorado. For the DIRECTV system, DIRECTV 4S, which was launched November 26, 2001, is intended to be the primary spot beam satellite at 101ºW[6]. DIRECTV 4S is designed to use six spot beam frequency blocks to provide local television service in 41 DMAs with more than 500 TV stations. According to its FCC filing[7]:

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2 For purposes of my analysis, I have assumed that approximately 1,475 local television broadcast stations may be eligible for carriage under the Satellite Home Viewer Improvement Act of 1999 if EchoStar and DIRECTV were to provide service in all 210 DMAs.

3 *See* footnote 1.

4 "Ariane 4 Launch Closes Slowest Year Since 1993" by Peter B. de Selding, Space News, December 3, 2001, page 3.

5 EchoStar Satellite Corporation Application for Authority to Make Minor Modification to Direct Broadcast Satellite Authorization, Launch and Operating Authority for EchoStar 7, FCC filing DBS 88-01, DBS 88-02, SAT-A/O 20010810-00073, August 10, 2001.

6 Arianespace e.space, No 170, November 2001, Flight 146 DIRECTV-4S Main Payload Characteristics. Page 3.

7 FCC APPLICATION FOR AUTHORITY TO LAUNCH AND OPERATE DIRECTV 4S (USABBS-13) , File number S2430, SAT-LOA-20010518-0045, Submitted May 18, 2001.

> "The DIRECTV 4S satellite payload uses 26 separate spot beams on six frequencies (channels) to provide up to 44 RF transponders to selected geographic regions. Depending on the particular characteristics of the region, the power in the spot beam transponders varies from 30 Watts to 88 Watts."

14. After the 4S satellite was launched the press reported[8]:

> "DIRECTV fleet to use highly focused spot beam technology that will provide DIRECTV with the capacity to deliver more than 300 additional local channels to its 41 local channel markets."

15. Less public information is available about the other spot beam satellites, but a press release sheds some light on the capability of DIRECTV 7S[9]:

> "DIRECTV-7S will generate more than 13kW of total satellite power at the beginning of its life and is designed to operate from orbital locations at 101 degrees West longitude, the primary orbital slot for DIRECTV, or 119 degrees West longitude.
>
> "In one operating mode, the new satellite will be capable of providing up to 54 transponders for high-quality local and national digital video service broadcast into 27 beams. In its other configuration, the satellite will be capable of providing up to 44 transponders broadcast into 30 beams."

16. DIRECTV 4S has 26 spot beams for broadcasting local TV into 41 Designated Market Areas (DMAs).[10] DIRECTV 7S satellite is designed with 29 additional spot beams to provide service to a larger number of DMAs. Consequently, the two satellites should provide service to at least 86 DMAs ((26+29)*41/26 = 86), and probably the 100 DMAs that the New EchoStar proposes to serve after the merger, because a number of the spot beams will cover more than one DMA.

17. Based on the foregoing, it is my opinion that EchoStar and DIRECTV erroneously assert that the merger is necessary to permit them to serve 100 DMAs. From the public data

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[8] "DIRECTV Launch Key To Delivering Local Channels", Communications Today, November 27, 2001.

[9] SPACE SYSTEMS/LORAL AWARDED CONTRACT TO BUILD HIGH-POWER SPOT BEAM SATELLITE FOR DIRECTV, DIRECTV-7S will provide More Capacity for Additional Local Channels and In-Orbit Redundancy, Press Release, NEW YORK - September 6, 2001 - Space Systems/Loral (SS/L)

[10] *See In re DIRECTV Enterprises, Inc.*, Application for Authority to Launch and Operate DIRECTV 4S (USABBS-13), SAT-LOA-200110518-00045 at 6-7 and Appendix A, p.1 (May 18, 2001).

available, it appears that each of them, on their own, could serve the 100 DMAs that the transfer applicants propose to serve post-merger with their own existing and planned facilities.

18. The transfer applicants' individual ability to provide this level (or more) of local-into-local service is illustrated by **Figure 2**. The estimated number of local television channels eligible for carriage under SHVIA is based on published lists of channels in each DMA. The number of frequency blocks required by a spot beam satellite assumes 12 channels per frequency block and 8 times frequency reuse. The total frequency blocks are 46 full CONUS blocks for DIRECTV and 50 for EchoStar. The estimate of 16 non-local frequency blocks before SHVIA is based on 160 local channels using 10 channels per frequency block. I understand that a higher number of channels per frequency block has been implemented since January 1, 2002.

# of the Largest DMAs Served	Approximate # of Local TV Stations Entitled to SHVIA Carriage	Approximate # of Frequency Blocks Required	Remaining Non-local Frequency Blocks, DIRECTV	Remaining Non-local Frequency Blocks, EchoStar	Approximate Non-local frequency blocks, pre-SHVIA, DIRECTV	Approximate Non-local frequency blocks, pre-SHVIA, EchoStar
1-50	610	7	39	43	30	34
1-100	983	11	35	39	30	34
1-150	1277	14	32	36	30	34
1-210	1475	16	30	34	30	34

Figure 2: Frequency Blocks Required for Local-into-Local Service

19. As illustrated in **Figure 2**, the demands of local-into-local coverage on BSS spectrum are not of a nature that would preclude either EchoStar or DIRECTV, on their own, from serving the proposed 100 DMAs today. As compared to service to the top 50 DMAs, service to the next 50 DMAs requires only an incremental four frequency blocks. If both DirecTV and Echostar separately launch spot beam satellites designed to provide local television service to the top 100 DMAs, each would still have more frequencies available for non-local (national) services than it did when fewer than 50 local markets were served without spot beams. Moreover, as discussed in the following Section, each could provide full local-into-local service to all 210 DMAs.

B. <u>Full Local-Into-Local Service To All The DMAs</u>

20. Beyond the 100 DMAs that the New EchoStar proposes to serve, either entity could ultimately serve 150 or all-210 DMAs. It would be entirely feasible to retransmit all of the local television broadcasts with a single satellite. My firm designed such a system for the US Department of Justice in connection with *Satellite Broadcasting & Communications Ass'n of America v. FCC and National Ass'n of Broadcasters*, Civil

Action No. 00-1571-A (E.D. Va.).[11] In that scenario, we assumed that it would be necessary to preserve transmission of all of the cable channels and all of the local stations. We used 12 of the available 32 frequency blocks for local-into-local service, leaving the remaining 20 frequency blocks for cable channels. Then, we assigned, on a single satellite using 58 spot beams, the 12 frequency blocks to obtain 112 usable downlink frequency blocks. This system could transmit 1,792 local television channels (112 frequency blocks x 16 channels per frequency block) serving all 210 DMAs.

21. The system discussed in the preceding paragraph differs from the current practices of EchoStar and DIRECTV in two respects: (1) It uses the more efficient 8PSK modulation technique, which is incompatible with the applicants' existing QPSK receivers; and (2) It specifies one satellite with 58 spot beams, which is more than the applicants have used to date.

22. Using current design practices, EchoStar and DIRECTV each could support full CONUS local-into-local coverage of all 210 DMAs using a total of 16 frequency blocks divided between two satellites, while retaining their existing QPSK set-top boxes. One such system would use two satellites located at two orbital positions. Each satellite would have 29 spot beams carrying approximately one-half of the local television signals, plus a CONUS-coverage antenna for national signals.[12] These satellites would utilize only technology already launched or under construction by the applicants. Only about one-third of each applicant's total spectrum would be devoted to local-into-local service.[13]

C. <u>Estimates Of Cost And Schedule For Full Local-Into-Local Service</u>

23. Implementation of full local-into-local service would require two or three years for design, construction and launch of appropriate new satellites. The new satellites would cost approximately $250 million each (satellite, launch vehicle and insurance). In addition, there would be a need for four to six additional uplink Earth stations that should cost approximately $30 million in total capital costs.

24. It is conceivable that some of the spot beam satellites currently under construction could be modified for full local-into-local service. Modification would cost far less time and expense than the construction of new satellites. We would estimate that these modifications would require no more than 18 months and cost $10-20 million.

25. From the discussion above one can conclude that there is no spectrum limitation that restricts complete local-into-local service. There is ample spectrum for each of the DBS

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11 *Satellite Broadcasting & Communications Ass'n of America v. FCC and Nat'l Ass'n of Broadcasters,* Civil Action No. 00-1571-A, Declaration of Roger J. Rusch (redacted), dated May 23, 2001 (E.D.Va.). See **Exhibit C.**

12 Alternatively, CONUS coverage could be provided by a third satellite, including one that is already in service.

13 *See* ¶ 11, *supra*. Note that EchoStar's Dish 500 systems can receive all 50 of EchoStar's full-CONUS frequency blocks.

carriers to re-broadcast all of the local television stations. Using only the technology and frequency planning techniques employed on the current generation of DBS spot beam satellites, it would be a relatively simple matter for either EchoStar or DIRECTV to provide local-into-local service to 100 DMAs or all 210 DMAs. However, there are significant costs for collecting local programming and relaying it to the uplink stations. There is no technical reason that DirecTV and Echostar could not co-locate most or all of their regional uplink centers and share the costs of local signal collection and relay.

26. In sum, the fact that EchoStar and DIRECTV are not serving more local markets today is not attributable to spectrum or other technological constraints.

III. Cable Channels and "Advanced" Services

27. As explained above, spot beam satellites reduce the number of frequency blocks needed for local-into-local service and, thereby, increase the number of frequency blocks available for national programming and other services.

28. Thus, in addition to providing local-into-local service throughout the CONUS, each entity has sufficient capacity to carry all available cable channels (*e.g.*, CNN, HBO, etc.), as well as pay-per-view, video-on-demand, information-on-demand, music, and other services at a level competitive with digital cable.

IV. Broadband Internet Service

29. According to the International Telecommunication Union Radio Regulations, the DBS spectrum is allocated for Broadcast Satellite Service (BSS) and it has coordination priority over other services.[14] The satellites are designed distinctively for a one-way service. For example, there are a limited number of small spot beams for uplink access. The subscribers can receive signals from the satellites, but cannot send return signals to the satellite. In fact, a two-way service operating in the BSS bands could cause significant interference to other BSS services and would require judicious coordination, which is impractical for services provided via ubiquitously deployed consumer terminals.

30. As noted, the BSS frequencies are uniquely optimized for high-quality, high-capacity television service. They are not technically suitable for two-way broadband communications. Use of the rare and specialized BSS spectrum for broadband services, which can be provided far more effectively in several other satellite bands that are optimized for two-way data communications and which can accommodate far more satellites, would be spectrally inefficient and operationally cumbersome. Broadband services can be provided far more effectively in several other satellite bands that are optimized for two-way data communications and which can accommodate far more

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[14] "In the band 11.7 – 12.5 GHz in Regions 1 and 3, the fixed, fixed-satellite, mobile, except aeronautical mobile, and broadcasting services, in accordance with their respective allocations, shall not cause harmful interference to broadcasting-satellite stations . . . ." Footnote S5-487 to the Final Acts of the World Radiocommunication Conference (WRC-95).

satellites. Both Hughes and Echostar have launched competing broadband satellite platforms that use non-BSS satellites for communication. Consequently, the antenna and user terminal differs from a simple satellite television receiver. The broadband service is entirely distinct from the DBS service. Hughes' DIRECWAY service is operated not by DIRECTV, but by Hughes Network Systems. EchoStar holds a controlling interest in the competing StarBand platform. Both services use Ku-band FSS satellites, and are similar in price and performance. Today, broadband satellite services are not provided in the BSS bands.

31. In addition to this Ku-band two-way service, both EchoStar and Hughes Electronics are investing in dedicated broadband services in Ka-band. Hughes Network Systems sponsors the Spaceway project. EchoStar is an investor in WildBlue and is constructing EchoStar 9 that carries Ka-band transponders. It has also acquired a controlling interest in Visionstar and ordered a Ka band satellite from Lockheed Martin.

32. It is clear that both EchoStar and DIRECTV – as stand-alone entities – have access to sufficient spectrum (both in the Ku FSS and Ka FSS bands) to provide competitive satellite broadband services.

33. The advantage of combining the DBS service with broadband services is that there is an established customer base that already uses satellite services. This could be a powerful factor for EchoStar and DIRECTV in maintaining and expanding their respective broadband satellite businesses.

V. Expanded Use of the Spectrum

34. Both EchoStar and DIRECTV could make even greater use of the ample spectrum that each currently possesses with certain technological improvements.

A. Turbo Coding

35. One method of increasing channel capacity or throughput is called turbo coding. This method is currently being used on some satellite services to improve the signal robustness (lowering the required Eb/No) substantially, by as much as a factor of two. This could double the effective channel capacity.[15]

B. 8PSK Modulation

36. Another method to expand capacity is higher order modulation. Higher-order modulation makes possible transmission at higher data rates using the same frequency bandwidth. This is the same technique that has been used to transmit higher data rates over telephone lines and cable television. In 1980 a telephone line could only carry data at about 600

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[15] Technical Description of Turbo Products Code, Version 3.1, June 1998, Efficient Channel Coding, Inc. WWW.eccincorp.com. and Innovations for Maximizing Bandwidth, by Steven Packer, Comtech EF Data Corporation, Satellites and the Internet Conference, San Diego, Dec. 7, 2001.

bps. Over the years the data rate grew in steps to 1200, 2400, 4800, 9600, 14400 bps, 28.8 kbps, and 53 kbps. Each step involved the use of better modulation techniques.

37. At present most of the DBS modulation is called Quaternary Phase Shift Keying (QPSK or 4PSK), but 8PSK could be used. 8PSK has been used on INTELSAT and FSS networks for 20 years, but it was not originally selected for the DBS services because it requires higher transmitter power. Today, satellite electrical subsystems and antenna gain are much more powerful. 8PSK would increase the transmission data rate and therefore the number of channels carried in each frequency by about 35%.

C. Compression

38. One of the most effective methods to increase the number of channels is compression. Since the television signals are converted to digital bits of information it is possible to process the minute dots (pixels) that make up a television picture. Such processing can eliminate redundant information and reduce the required data rates. For the past decade the Motion Picture Experts Group (MPEG) has been developing standards for digital compression of video signals.[16]

39. A typical MPEG-2 compressed satellite television program can be broadcast at data rates of about 3 Mbps and less for some types of programming. Consequently, 10 or more television channels can be broadcast in each frequency block. Compression algorithms have been improving along with the ongoing improvements in computational processing power. We can expect superb quality pictures at lower data rates in the near future, and continued improvements going forward, without any changes to consumer equipment. For even greater gains, the recently adopted MPEG-4 standard can provide a reduction in data rates by a factor of two or three as compared to MPEG-2. Use of MPEG-4 would require upgrade of transmission equipment and a new class of set-top boxes, but the changes could be implemented incrementally. That is, one transponder could be upgraded to MPEG-4 and used to transmit certain non-core advanced services. Consumers wishing to access those services could install new set top boxes capable of receiving both MPEG-2 and MPEG-4. Over time, more transponders can be transitioned and more advanced boxes can be deployed. This practice of staged migration is a widely used technique for upgrading networks. It is employed by cellular telephone service providers who incrementally migrate to advanced transmission technologies and deploy dual mode or tri-mode phones. Similarly, cable television systems have added digital tiers to analog systems and are deploying dual mode analog/digital set top boxes only to customers subscribing to a digital tier.

[16] *See* **Understanding MPEG-2 Digital Video Compression,** by Mark Long, 1996, WWW.mlesat.com/article7.html; **DVB, North American MPEG-2 Information,** November 16, 2001, WWW.coolstf.com/mpeg/.

D. <u>Personal Video Recorders</u>

40. A profound change is occurring in the communications and broadcasting business with the incorporation of mass data storage devices into user terminals. Innovation with satellite data delivery and terminal storage is initiating a revolution. Broadcast services will be transformed into pseudo-interactive communications. TiVo is already an example of a storage solution that records television broadcasts.

41. Currently, pay-per-view movies and theatrical events are transmitted on dedicated transponders as required. With new mass data storage devices, many of these productions could be downloaded in advance and released on demand by means of controlled access features. By equipping set-top boxes with technology that permits customers to capture programming and watch it on their own schedule, both companies can avoid repetitive programming, thereby freeing up a substantial amount of spectrum. This is a key feature of EchoStar's deal with Vivendi. For example, rather than repeatedly cycling pay per view movies on multiple channels with staggered start times so that viewers can access convenient start times, a single movie can be transmitted once and stored on the viewer's set top box so that it is always available on demand. For example, according to DIRECTV's online program guide on January 30^{th} (**Figure 3)**, Echostar offered 48 screenings of the pay per view movie "Rush Hour 2". This was accomplished by cycling the movie continuously on four channels in two-hour blocks, with a start time every half-hour. With PVRs, DIRECTV could have transmitted the movie once, for a 48:1 spectrum savings, and viewers could have any start time they want. In fact, DIRECTV could have transmitted the movie once at the beginning of the one-month pay-per-view window, and recovered four entire channels for the remainder of the month. This is just one example of an advanced service that results in an enormous reduction in necessary spectrum.

42. Since the demands on spectrum are low, both EchoStar and DIRECTV can provide these services on their own.

Figure 3: DIRECTV online program guide on January 30th

VI. Cost And Schedules For New Services

43. Expanding local-into-local service and developing new technology to maximize the efficient use of spectrum will require time and money. This is the case whether the DBS platforms merge or not. Many of the gains are proportional to the investment, but many are not. Some improvements, such as more efficient MPEG-4 encoders, are simple and relatively inexpensive to implement. Others, such as optimizing spot beam satellites to cover more local-into-local markets, require little or no incremental cost if planned from the beginning. However, other gains will require new satellite and ground station facilities and changes to the customer's equipment.

44. For local-into-local service, new user antennas may be required with feeds that can detect signals from two or more satellites. In some cases, the current antenna will be re-pointed

to another satellite. The cost of this hardware is only a few dollars because the production volume is high, but service calls are relatively expensive. However, achieving the promised efficiencies of the merged platform would require even more extensive changes. Making the asserted spectrum gains available to all subscribers would require that every subscriber be provided with a dish and set top boxes that are capable of receiving programming from all three DBS orbital slots. Today, only a tiny fraction of DBS customers have such equipment.

45. Many of the planned improvements will require modifications to the set-top box. Once again, the cost of the hardware can be relatively modest. The differential cost between two alternative indoor units is negligible. Fortunately, most subscribers can change their own set-top boxes.

46. New EchoStar would need to integrate its customer base on a common platform, because EchoStar and DIRECTV use different compression standards. This means providing new set-top boxes for those users that would change from the EchoStar signal format to the DIRECTV format (7 million users) or vice versa (11 million users). Furthermore, many of the users would require new antennas for local-into-local service, depending on how the system is configured.

47. Any system that upgrades its service must change out facilities and equipment. Both EchoStar and DIRECTV have indicated that they expect to offer new services. Many of these services will require upgrades to the user equipment. However, I am not aware of any new services that a merged company could offer that either could not provide alone.

48. Whether EchoStar and DIRECTV merge or pursue upgrades individually, the costs are significant. It is not obvious that there are any additional upgrade cost efficiencies for a merged company. The costs and processes are essentially the same.

49. Consequently, there is not likely to be a measurable difference in the completion time and the costs involved if EchoStar and DIRECTV pursue upgrades individually or as a merged entity.

VII. <u>Other Wireless Services Would Not Be Viable Competition</u>

50. Although a number of alternative wireless broadcast and broadband services have been discussed, none has emerged as a serious competitor to Ku-band DBS, especially in rural regions. MMDS has a limited deployment today and would require an enormous investment to serve the entire continental United States. The situation is much the same for LMDS, but the deployment is almost nonexistent because the propagation losses are more severe at Ka-band.

51. C-Band was used for broadcasting services to rural regions 20 years ago and at one time there were approximately 3 million users. After the introduction of DIRECTV and EchoStar services, the number of users has continued to dwindle and there are only approximately 700,000 remaining.

52. MVDDS, which has not yet been finally allocated by the FCC and for which no licenses have been issued, is an unproved technology. It is likely to be implemented in a way that will lead to significant operational constraints, including highly directional transmitters that are limited to southern propagation, and low power transmission, resulting in small service areas. There are no operating MVDDS services.

53. It would not be practical for a new entity to compete with New EchoStar by using the "wing slots" at 61.5ºWL and 148ºWL. Satellites positioned at these orbit locations cannot provide service to the entire CONUS. **Figure 4** shows that a satellite at 101º can cover almost the entire CONUS with user elevation angles above 30º. Moreover, DBS service provided exclusively from wing slots is at a decisive disadvantage as compared to service provided from full-CONUS slots for a number of reasons. First, if an entity were to provide DBS service using only wing slots, it would need to duplicate all national programming at both slots. Thus, it would need twice as many transponders, and twice as many satellites, as a full CONUS provider to offer the same number of national channels. Moreover, the risk of satellite failure requires that DBS satellites used to provide core-programming services be backed up with redundant on-orbit capacity. A provider using the wing slots would have to provide redundant backup at both locations. Together, these two factors mean a provider would have to launch a minimum of four satellites, two into each of two orbital slots, to provide the same channel lineup and same reliability that a full CONUS provider could offer from two satellites located in one slot. A wing slot provider could never match the channel capacity provided by EchoStar and DIRECTV individually today. The severe disadvantages of operating from the wing slots are further compounded by the fact that EchoStar is already far and away the largest licensee of spectrum at the wing slots, and the only licensee that currently has satellites in the wing slots. Any new entrant providing service from the wing slots would face a competitor that has all three of the full CONUS slots, plus as much or more wing slot spectrum as the new entrant. The wing slots are best suited for the purpose for which EchoStar uses them today. It provides services of interest to limited geographic areas. This service does not benefit from a national footprint. It also delivers specialized, niche services (including business video services that do not serve consumers at all) that are not of general interest.

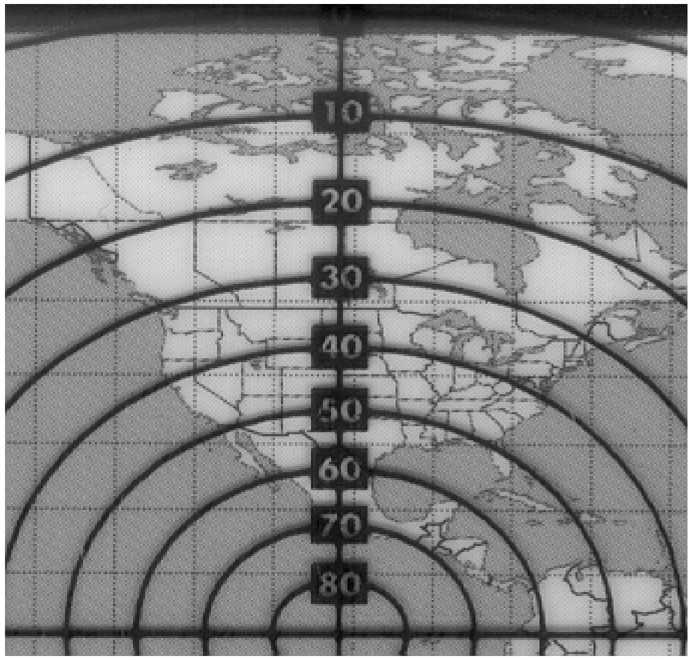

Figure 4. Satellite Service from 101º WL

54. The wing slots would provide service from much lower elevation angles over much of the CONUS. **Figure 5** and **Figure 6** show the elevation angles from 61.5º WL and 148º WL. Clearly, the elevation angles would fall below 20º over large portions of CONUS. There would be a higher risk of rain fades due to lower elevation angles. Consequently, providing a full CONUS service using only wing slots would require double the number of satellites. Moreover, they would require twice as many uplink facilities. Although these slots could be useful for local-into-local service and 148ºWL could provide service to Alaska and Hawaii, the wing slots are not well suited to a national multi-channel service carrying cable programming. Operating a satellite broadcast service from only wing slots promotes spectrum inefficiency, inasmuch as all national programming must be duplicated at each wing slot. These slots are better situated for supplementing full-CONUS coverage, as EchoStar does today.

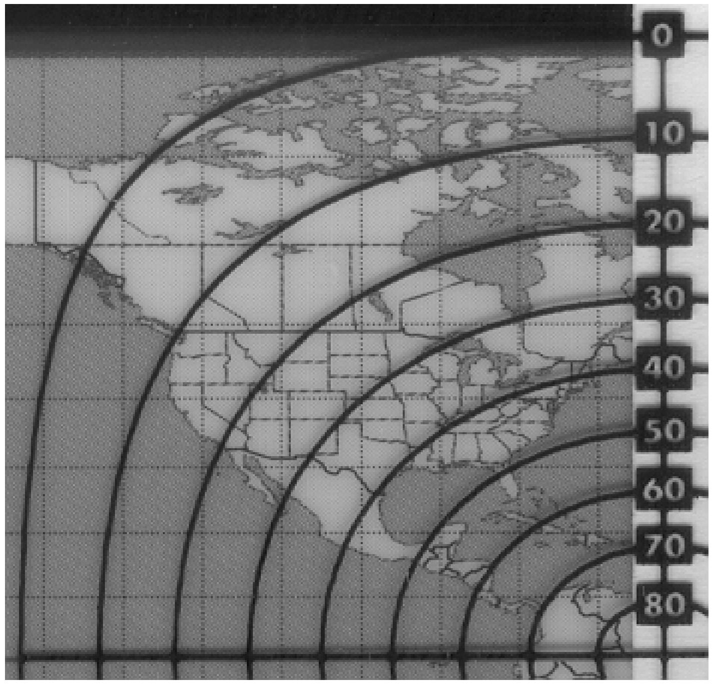

Figure 5: Satellite Service from 61.5ºWL

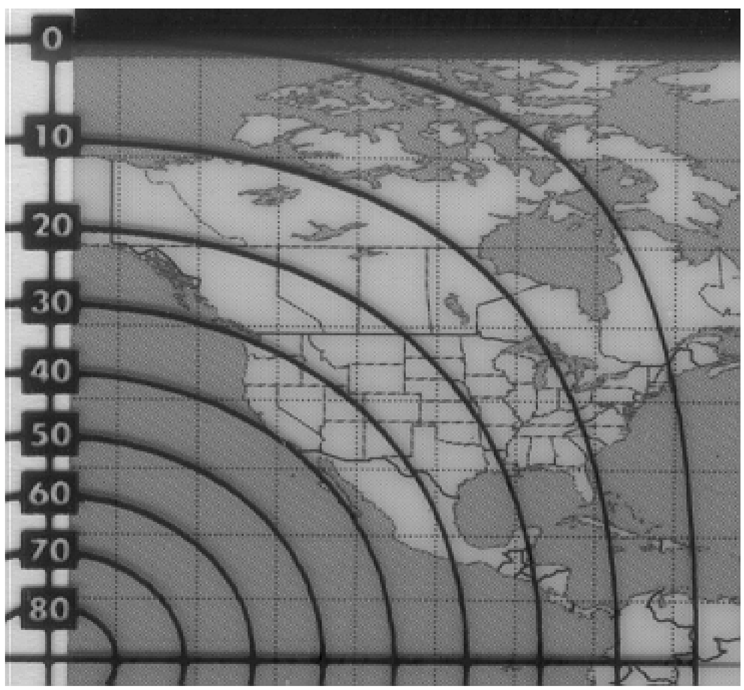

Figure 6: Satellite Service from 148ºWL

Exhibit A

Resume

Roger J. Rusch, President, TelAstra, Inc. and the TA Group (5 years)
TelAstra is an objective technical and management-consulting firm dedicated to universal communications service. The company counsels service operators, system producers, and investors in business and financial aspects of the telecommunications industry. Mr. Rusch is a pioneer in the satellite communications industry with 40 years of contributions to space technology. He has been responsible for the management of all aspects of satellite manufacturing including design, systems engineering, production, testing, and business development. He has held senior positions at Hughes Space and Communications Group (6 years), Space Systems / Loral (then Ford Aerospace, 10 years), and TRW (15 years). Some highlights of his experience include:

- Managed the construction and launch of INTELSAT IV satellites, including the satellite that was used to relay the first television pictures of President Nixon's visit to China in 1972.

- First program manager and Technical Director for the highly reliable INTELSAT V series of satellites. These pioneering satellites produced six spot beams and provided four times frequency reuse. Fifteen satellites were built and the first in the series was launched in 1980. They were the workhorses of the fleet for more than 15 years.

- He served as a founding Director of the Direct Broadcasting Satellite Association from 1984 to 1985. He also designed TV broadcasting satellites for DBSC, one of the original winners of an FCC license.

- Director of Systems Engineering and Integration for the TRW Federal Systems Division which managed the NASA programs including TDRSS.

- Publisher of COMMUNICATIONS SATELLITE DATABASES for the past 16 years. These data provide comprehensive records of the cost, schedule, technical, and operational performance of all the communications satellites, under contract, built or launched.

- Prepared business and financial studies of satellite systems including Investing in Mobile Satellite Services, Investing in Broadband Satellite Services, Investing in DARS, Investing in Launch Vehicle Services. More than 200 copies of these reports have been sold to members of the space community.

- Recipient of several patents for inventions in the field of space communications. The patents for Odyssey were sold to ICO Global for US $150 million.

- Expert witness for the US Department of Justice. The issue was whether a DBS system can be built, using currently available technology, that would enable satellite carriers to offer re-broadcast of all high-power television broadcast stations in the Continental

United States (CONUS) that may be eligible for carriage under the Satellite Home Viewer Improvement Act.

- Participant in advisory panels including the National Academy of Sciences, keynote speaker for several major industry conferences, author of numerous papers on satellite communications, and regular columnist for PBI Media.

- Director on the Board of COM DEV International, a Canadian company.

Mr. Rusch received the Bachelor of Science degree in Physics from Iowa State University and two Master of Science degrees in mechanical and electrical engineering from the University of Southern California.

Exhibit B

Roger Rusch Professional Papers (1990 to present)

1. "Success Factors For Broadband Satellite Systems," 7th Ka-band Utilization Conference, Santa Margherite Ligure, Genoa, Italy, Sept. 28, 2001.

2. Communications Satellite Databases, Parts I: Prices, Schedules, Mass, Power, 16th edition for the year 2001, privately published annually by TelAstra, Inc., April 2001.

3. Communications Satellite Databases, Parts II: Subsystems and Anomalies, and 15th edition for the year 2001, privately published annually by TelAstra, Inc., April 2001.

4. Communications Satellite Databases, Parts III: Launch Vehicles, 12th edition for the year 2001, privately published annually by TelAstra, Inc., May 2001.

5. "Providing In-Flight Broadband Services," 19th AIAA ICSSC, Toulouse, France, April 17-20, 2001.

6. "Satellite Niche Businesses," Satellite News, April 16, 2001.

7. "Transformation through Innovation," Satellite 2001 Daily, Day Three, March 29, 2001, Page 34.

8. "Will It Be A Hit or A Miss?," Satellite News, March 19, 2001.

9. "Specific Predictions for 2001 and beyond," Satellite News, February 19, 2001.

10. "Just Wait, Satellites Will Find Place in Broadband," Office.com February 16, 2001.

11. "Next Generation Telecom Strategy, Mobile Systems (MSS, In-Flight, DARS)," ESTEC, Noordwijk, The Netherlands, 7 February 2001.

12. Inmarsat Sales & Marketing Conference, "State of the Satellite Industry," Dubai, U.A.E., 3-4 February 2001.

13. "2001: A Year to Remember," Satellite News, January 15, 2001.

14. "Study of the Next Generation of Mobile Satellite Services," January 16, 2001.

15. "Financial and Business Evaluation of the New MultiMedia Satellite Systems," January 15, 2001.

16. "Study of the Next Generation of Digital Audio Broadcasting Satellites," January 14, 2001.

17. "Lessons Learned from Iridium, ICO, and Globalstar – Part 6," Mobile Satellite News, December 2000.

18. “Investing in Satellite Communications,” Earth Space Review, Vol. 9, No. 3, fall, 2000.

19. “Lessons Learned from Iridium, ICO, and Globalstar – Part 5,” Mobile Satellite News, November 2000.

20. Internet Via Satellite, Workshop, “Investing in Broadband Satellite Services,” San Diego, California, November 8, 2000.

21. APSCC 2000 Conference “What is the financial justification for Broadband Satellite Services?,” Hotel Lotte, Seoul, Korea, 8 November 2000.

22. “Lessons Learned from Iridium, ICO, and Globalstar – Part 4,” Mobile Satellite News, October 2000.

23. “What on Earth is going on with satellite communications?,” Office.com, October 2, 2000.

24. 7th Satel Conseil Symposium, “Overview of the Past 2 Years”, Maison de la Chimie, Paris, September 5-7, 2000

25. “Lessons Learned from Iridium, ICO, and Globalstar – Part 3,” Mobile Satellite News, September 2000.

26. “Lessons Learned from Iridium, ICO, and Globalstar – Part 2,” Mobile Satellite News, August 2000.

27. “Lessons Learned from Iridium, ICO, and Globalstar – Part 1,” Mobile Satellite News, July 2000.

28. “Enterprise Value and Hot Spot Capability,” Mobile Satellite News, June 2000.

29. “What can we learn from the Big LEOs?,” 5th Space and Finance Conference, WorldSat 2000, Marriott East Side Hotel, New York City, June 16, 2000.

30. “Forcing Mobile Satellites to Provide Data Services,” Mobile Satellite News, May 2000.

31. “Examining the Current Status of the Commercial Satellite Industry,” Next Generation Broadband Satellite Systems 2000, Paris, 10-12 May 2000.

32. Next Generation Broadband Satellite Systems 2000 Workshop, “Making the Business Case for Broadband Satellite Systems,” Paris, May 9, 2000.

33. “Making the Business Case for Investing in Broadband Satellite Systems,” Workshop presented for ACT Satellites and the Internet v.4, April 25, 2000.

34. “Excellence Awards and Human Folly,” Mobile Satellite News, April 2000.

35. “Estimating the Demand for Launch Services,” 18th AIAA ICSSC, Oakland, CA, April 10-14, 2000.

36. “10 Steps To Save Globalstar,” Commentary, Space News, March 27, 2000, Vol. 11, No. 12. Page 15.

37. “Introducing new satellite services,” Mobile Satellite News, March 2000.

38. “Trends and Opportunities in the World of Satellite Communications,” HTSI Strategic Planning Meeting, Columbia, MD, March 22, 2000.

39. Investing in Mobile Satellite Services, A Complete Multi-Client Report, privately published by TelAstra, Inc., February 2000.

40. “Assessment of Alternatives for the US Navy MUOS”, Aerospace Corp., El Segundo, February 14, 2000.

41. “Trends and Opportunities in the World of Satellite Communications,” Norwegian SatCom Conference, Oslo, February 3, 2000 (videoconference).

42. “Growth Statistics,” Satellite 2000, Washington Convention Center, February 2, 2000.

43. Satellite 2000, “View of the Experts MSS & Broadband,” Washington Convention Center, Feb. 1, 2000.

44. “Will LEO Constellations Survive?,” Launchspace magazine, February, 2000.

45. “Investing in Satellite Communications, Exploring the Business Case,” AIC Workshop, Millennium Chelsea, London, November 3, 1999.

46. “Exposing the myths of LEO, MEO, and GEO satellite constellations,” Space Technology, Volume 19, Number 1, Fall, 1999.

47. “The Case for Providing Satellite Services in Ka-band,” 5th Ka-band Utilization Conference, Grande Albergo Capotaormina, Taormina, Italy, October 19, 1999.

48. NASA Launch Demand Study, October 15, 1999.

49. Study of Next Generation: Audio Broadcasting Satellites for the European Space Agency, November 15, 1999.

50. Study of Next Generation: Non-Geostationary Ku-Band FSS Systems for the European Space Agency, November 15, 1999.

51. Study of Next Generation Mobile Satellites for the European Space Agency, November 1999.

52. “Current Trends in Broadband and Narrowband Satellite Communications,” NERA, Oslo, Norway, October 4, 1999

53. “Alternatives for the Next Generation of MSS,” IMSC #5, Ottawa, Canada, June 17, 1999.

54. “Appraisal of Tangible & In-kind Assets for Andesat S.A.,” Miami Radisson Mart Plaza, November 13, 1998.

55. Financial and Business Evaluation of the New Multimedia Satellite Systems, Part 2, A Complete Multiclient Report, privately published by TelAstra, Inc., September 1998.

56. “Evaluation of the New Broadband Satellite Systems,” Study Report for the European Space Agency, June 1998.

57. “Key Regulatory & Licensing Issues: Challenges & Obstacles Up Ahead,” Third Annual Space & Satellite Finance: Worldsat 98, Plaza Hotel, New York, May 20, 1998.

58. “Evaluation of the New Multimedia Satellite Systems,” 17th AIAA International Communications Satellite Systems Conference, Yokahama, Japan, February 26, 1998.

59. “Satellite Communications Growth Statistics,” Satellite 98, Sheraton Washington Hotel, Washington, DC, February 19, 1998.

60. Financial and Business Evaluation of the New Multimedia Satellite Systems, A Complete Multiclient Report, privately published by TelAstra, Inc., August 1997.

61. “Antennas for the next generation of mobile satellite services,” 10th IEE International Conference on Antennas and Propagation, Edinburgh, Scotland, April 14-17, 1997.

62. “Future Application of mm Waves for Space Communications,” Keynote Address, International Conference on mm & Sub-mm Waves and Application III, Denver, August, 1996.

63. “Personal Communications Via Satellite,” Keynote Address, International Conference on GaAs MANTECH, San Diego, April, 1996.

64. “Selecting the Best Constellation for Mobile Satellite Services,” 16th AIAA International Communications Satellite Systems Conference, Washington, February, 1996.

65. “The Market and Proposed Systems for Satellite Communications,” Applied Microwaves and Wireless, Fall 1995.

66. “Moving Cellular Communications into Space,” Keynote Address, 1995 IEEE MTT-S International Microwave Symposium, Orlando, Florida, May 15-19, 1995.

67. “Status Report on the Odyssey Satellite System,” 15th AIAA International Communication Satellite Systems Conference, San Diego, CA, March 1994.

68. “Odyssey, An Optimized Personal Communications Satellite System,” 44th Annual IAF Congress, Graz, Austria, October 1993.

69. “Comparison of Personal Communications Satellite Systems,” Satellite XII, Washington, March 1993.

70. “Odyssey, A Constellation for Personal Communications,” 14th AIAA International Communications Satellite Systems Conference, Washington, March 1992.

71. “Design and Price of Audio Broadcasting Satellites,” Symposium on Digital Audio Broadcasting, Washington, March 1990.

 Exhibit C

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF VIRGINIA
Alexandria Division

SATELLITE BROADCASTING & COMMUNICATIONS ASSOCIATION OF AMERICA, et al.	)
Plaintiffs,	)
v.	) Civil Action No. 00-1571-A
FEDERAL COMMUNICATIONS COMMISSION, et al.,	)
Defendants,	)
and	)
NATIONAL ASSOCIATION OF BROADCASTERS, et al.	)
Defendant-Intervenors.	)

DECLARATION OF ROGER J. RUSCH

ROGER J. RUSCH declares and states as follows:

1. I am the President of TelAstra, Inc., a technical and management-consulting firm located in Palos Verdes, California. I have been a graduate scientist and professional telecommunications engineer since 1962. I have been active in the design of communications and broadcasting satellite systems since 1965 starting with INTELSAT III at TRW, INTELSAT IV at Hughes Aircraft Company, and INTELSAT V at Ford Aerospace. I have held primary design responsibility for a wide variety of communication satellites and was elected as a founding director of the Direct Broadcasting Satellite Association in 1984. I was

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a member of the US delegation to the ITU World Radiocommunications Conferences in 1992 and 1995 that dealt with all aspects of radio frequency spectrum allocation. I have lectured extensively in the United States, Europe, and Japan on the business and financial aspects of communication satellites. A short version of my resume is attached to this Declaration as **Exhibit A**.

2. I was retained by the United States Department of Justice to undertake an analysis of Direct Broadcasting Satellite (DBS) systems. The question was could a DBS system be built, using currently available technology, that would enable satellite carriers to offer re-broadcast of all high-power television broadcast stations in the Continental United States (CONUS) that may be eligible for carriage under the Satellite Home Viewer Improvement Act.

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For the reasons set out below, I have concluded that such a system is not only possible, but also could be operated using only 12 DBS frequencies, which is less than the number currently utilized by DirecTV and Echostar for local television broadcasts.

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I. BACKGROUND

A. DBS Frequencies Allocated To DirecTV and Echostar

3. The Federal Communications Commission (FCC) has designated several orbital slots for DBS service. The most desirable orbital locations are at 101ºWest Longitude (WL), 110ºWL, and 119ºWL. Satellites at these orbital locations are capable of providing DBS service to the entire CONUS.

4. DirecTV and Echostar are the two dominant DBS providers in the United States and collectively control all of the spectrum at these three locations. Both are licensed to operate in the 500 MHz of broadcast spectrum from 12.2 to 12.7 GHz, which is a part of the electromagnetic spectrum known as the "Ku band." The 500 MHz of spectrum is divided into 16 sub-bands, each of which is about 27 MHz wide with a 2 MHz guard-band. Electromagnetic waves propagate in three dimensions so that it is possible to transmit two independent sets of information or two "senses of polarization" on the complex waveform. Consequently, the spectrum may effectively be used twice, once with Right Hand Circular Polarization (RHCP) and once with Left Hand Circular Polarization (LHCP). As a result, 32 frequencies are available for DBS broadcasts at each orbital location.

5. As shown in **Figure 1**, DBS signals are uplinked from ground to satellite at 17.3 to 17.8 GHz and subsequently downlinked from satellite to subscribers at 12.2 to 12.7 GHz.

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LHCP Uplink	LHCP Downlink	Transponder Frequency	RHCP Downlink	RHCP Uplink
	12.224	1		17.324
17.339		2	12.239	
	12.253	3		17.353
17.368		4	12.268	
	12.282	5		17.382
17.397		6	12.297	
	12.311	7		17.411
17.426		8	12.326	
	12.341	9		17.441
17.455		10	12.355	
	12.37	11		17.47
17.484		12	12.384	
	12.399	13		17.499
17.514		14	12.414	
	12.428	15		17.528
17.543		16	12.443	
	12.457	17		17.557
17.572		18	12.472	
	12.486	19		17.586
17.601		20	12.501	
	12.516	21		17.616
17.63		22	12.53	
	12.545	23		17.645
17.659		24	12.559	
	12.574	25		17.674
17.688		26	12.588	
	12.603	27		17.703
17.718		28	12.618	
	12.632	29		17.732
17.747		30	12.647	
	12.661	31		17.761
17.776		32	12.676	
16	16	32	16	16

Figure 1. DBS Channel Plan

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6. DirecTV is licensed to use 46 full CONUS frequencies, including the entire spectrum at 101ºWL (32 frequencies), part of the spectrum at 110ºWL (3 frequencies), and part of the spectrum at 119ºWL (11 frequencies). Echostar is licensed to use 50 full CONUS frequencies, including 29 frequencies at 110ºWL and 21 frequencies at 119ºWL. Echostar also controls additional spectrum at 61.5ºWL, which may be used to provide DBS service to areas east of the Rocky Mountains, and at 148ºWL and 175ºWL, which may be used to provide DBS service to areas west of the Rocky Mountains. **Figure 2** shows the present orbital assignments and frequencies.

Permittees/ Licensees	TOTAL	175°	166°	157°	148°	[redacted]	[redacted]	[redacted]	61.5°
DirecTV	46					[redacted]	[redacted]	[redacted]	
EchoStar	107	22			24	[redacted]	[redacted]	[redacted]	11⇳
R/L DBS	11					[redacted]	[redacted]	[redacted]	11 *
Dominion	8					[redacted]	[redacted]	[redacted]	8⇳
Unassigned	84	10	32	32	8	[redacted]	[redacted]	[redacted]	2 *

⇳ operational

* used by EchoStar pursuant to a grant of Special Temporary Authority

Figure 2. DBS Channel Assignments By Orbital Location

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B. Existing DBS Satellites Operated By Echostar and DirecTV

7. Echostar and DirecTV currently operate eleven satellites. The manufacturer, location, and launch date of each are shown in **Figures 3 and 4** below.

Program	No.	Launch Date	Location
DirecTV	1*	15 Dec 93	109.8°W
DirecTV	2*	3 Aug-94	100.8°W
DirecTV	3*	10 Jun 95	100.8°W
DirecTV	6**	8 Mar 97	118.5°W
DirecTV	1R*	10 Oct 00	100.8°W

* Built by Boeing Space Systems (Hughes)

** Built by Space Systems/Loral, also called Tempo 2. See Deposition of David W. Baylor, Executive Vice President of DirecTV ("Baylor Dep."), at 41-42.

Figure 3. DirecTV satellites

Program	No.	Launch Date	Location
Echostar	1	28 Dec 95	147°W
Echostar	2	11 Sept 96	118°W
Echostar	3	4 Oct 97	61.5°W
Echostar	4	7 May 98	119°W
Echostar	5	23 Sept 99	110°W
Echostar	6	14 Jul 00	119°W

Figure 4. Echostar satellites all built by Lockheed Martin

8. Each satellite is designed to carry 16 Ku-band high power (120 watt) "transponders", which may, in turn, be paired to produce the equivalent of 8 transponders at 240 watts. A

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transponder is a device which takes the signal received from an Earth uplink station at 17.3 to 17.8 GHz, filters it, converts it to the appropriate downlink frequency at 12.2 to 12.7 GHz, amplifies it, and transmits it back to a receiving Earth station. In the satellites that are currently in use by DirecTV and Echostar, each transponder may be used to retransmit 10 to 11 television transmissions for a total of 320 to 352 television channels at each orbit location.

9. The existing satellites utilized by DirecTV and Echostar at 101ºWL, 110ºWL, and 119ºWL transmit each cable or television broadcast signal throughout the CONUS. Consequently, the signal of a local broadcast station with viewers residing solely in the Washington, D.C. metropolitan area is transmitted nationwide. However, reception of the television signal may be blocked or blacked out in every geographic area outside of Washington. Such nationwide broadcasts are particularly inefficient when used for carriage of local broadcast television channels that are intended for a viewing audience located within a single Designated Market Area (DMA). Because the signal is transmitted nationwide, the satellite carrier is prevented from using the same frequency to transmit the signal of a different local station due to the resulting interference between the two signals. Therefore, DirecTV and Echostar's existing satellites are transmitting an average of 10 to 11 television signals on

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each frequency. It is immaterial whether the signals are nationwide cable channels or local television stations.

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III. TECHNICAL FEASIBILITY OF CARRYING ALL ELIGIBLE LOCAL BROADCAST STATIONS

19. Based on my analysis of the available data, I have concluded that it is technically feasible to construct and operate a Direct Broadcasting Satellite (DBS) system with the capacity to re-broadcast all high-power television broadcast stations that may be eligible for carriage under the Satellite Home Viewer Improvement Act (SHVIA). This can be achieved using technology that is currently available and already in use on other satellites. Moreover, such a system could be constructed and operated using as few as 12 DBS frequencies.[1]

20. The design of such a system would build on the approach used by both DirecTV and Echostar to provide local-to-local service by means of spot beams. The capacity to retransmit 1,475 local television broadcast channels could be achieved in a number of different ways using varying combinations of satellites and frequencies. One example of a method that could be used to carry all 1,475 stations is described below (the "1475 System") and would require the use of only 12 DBS frequencies at a single orbital location for local-to-local service. **REDACTED**

[1] For purposes of my analysis, I have assumed that approximately 1,475 local television broadcast stations may be eligible for carriage under SHVIA if DirecTV and Echostar were to utilize the license created by SHVIA in all 210 DMAs.

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A. The 1475 System

1. Downlinks

21. A single satellite using 58 downlink beams would be capable of handling more than the approximately 1,475 local television stations that are potentially eligible for carriage under SHVIA.

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There would be 38 narrow beams in the eastern portion of the CONUS, 16 larger beams in the West, and four additional narrow spot beams in the densely populated areas of the West Coast.

22. The System would require the use of 12 DBS frequencies. The System would provide for use of one, two, or three frequencies per downlink beam with occasional uses of four frequencies. The number of frequencies used per beam averages about two. The actual number of frequencies assigned to each beam is a matter of detailed assignment based on the number of TV stations located in each beam and the need to avoid interference.

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25. with 112 downlink frequencies in the design, the System has the capacity to carry 1,792 television channels (112 frequencies x 16 channels per frequency), which is 317 channels more than the 1,475 channels required to provide local television service throughout the United States. The excess capacity provides an ample margin over and above the channels needed to account for any "mismatch" where it is not possible to exactly match the need (i.e., where the 16 television stations per frequency are not all needed in a given beam). In DMA's where only 12 (rather than 16) channels are needed, the user terminals could be QPSK rather than 8PSK.

26. The 1475 System is designed to avoid interference by providing adequate isolation between beams using the same frequencies. This is achieved by avoiding use of the same set of frequencies in adjacent beams and by ensuring that beams using the same frequencies are spaced apart by approximately the width of a beam. To maintain the appropriate spacing to allow reuse of the beam, the distance between the center points of each of the narrow beams using the same set of frequencies (e.g. beams using Frequency Set "A") would be approximately two times the diameter of the narrow beams. Similarly, the distance between the center

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points of each of the larger beams using the same set of frequencies would be approximately two times the diameter of the larger beams. A geographical representation of the beam layout of the 1475 System and the frequencies used in each beam is contained in **Exhibit C**. The overlap shown between each of the beams on **Exhibit C** is intended to reflect that the individual beams tend to decrease in intensity in a gradual rather than an abrupt manner. The depiction in **Exhibit C** is not intended to alter the spacing requirements of the design that are discussed above.

27. In areas in the central and western portions of the country, there are a limited number of small beams that would use the same set of frequencies as larger beams that are nearby. See **Exhibit C**. In these instances, the distance between the center point of a smaller beam and the center point of a larger beam using the same set of frequencies is less than twice the diameter of the larger beam. In these circumstances, adequate isolation of the signals may be achieved by an accepted technique known as "signal nulling" or "signal cancellation." This technique involves deliberate (directional) coupling of a small part of the signal from the interfering beam into a beam location where the interference would otherwise occur. Since the same signal appears in two beams, a user on Earth receives the same signal from two sources. By adjusting the phase properly on the

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satellite, the two interfering signals arrive out of phase by 180 degrees, cancel each other out, and thereby avoid any interference with the television signals that are intended to reach the user. This technique involves little cost and may be used as often as necessary to reduce interference.

2. <u>Uplinks</u>

28. In a "bent pipe" satellite system,

REDACTED there is no onboard processing of signals on the satellite. Consequently, a bent pipe satellite would normally require 112 uplinks to handle 112 downlinks. With 12 DBS frequencies allocated to the system, it would be necessary to reuse each of the 12 frequencies 9.33 times to create 112 uplinks (12 frequencies X 9.33 reuses = 112 uplinks). Reusing the same frequency more than 9 times would require 10 separate uplink centers. Such a system would clearly be feasible and would require no onboard processing of the television signals on the satellite.

29. To limit the number of uplink centers and the associated expense of those centers, the System could be designed to utilize satellite on-board processing. The use of onboard processing would have significant advantages. First, the uplinked signals do not suffer from any "mismatch" associated with the downlink signals. Therefore, it would not be necessary to provide for the type of margin discussed above. In effect, it

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would only be necessary to provide capacity for the 1,475 television signals that would actually be used rather than the 1,792 signals used for purposes of the downlink beams. Second, use of onboard processing would permit the use of increased bits/Hz modulation methods over that used for the satellite downlinks. Use of 16PSK (or 16QAM, a variation) rather than 8PSK modulation in the uplinks would allow approximately 33% more data to be transmitted in the same bandwidth over that provided by 8PSK at the same FEC rate. Thus, the Uplink can handle 21 television channels per frequency (1.33 x 16 = 21).

30. At 21 television channels per uplink frequency, 71 uplink frequencies would be required to uplink data for the approximately 1,475 eligible local television channels (71 uplink frequencies x 21 channels per frequency = 1,491 channels). With 12 DBS frequencies allocated to the System, it would be necessary to reuse each frequency six times using onboard processing, which would only require six widely separated uplink centers.

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uplink centers should require only maintenance level staffing, since it is feasible to use automated transmission of data that was assembled by the existing ground stations.

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3. Satellite Equipment

31. The satellite will use on-board processing to convert from 16QAM in the uplinks to 8PSK and/or QPSK in the downlinks. This type of on-board processing is a well-established technology. Several commercial communications satellites, including Motorola's Iridium, Hughes Electronics' Spaceway, and Lockheed Martin and TRW's Astrolink, use onboard processing. INTELSAT signatories routinely use 16QAM uplink and downlink terminal-processing equipment for high data rate transmission today. **Exhibit D** illustrates the basic concept.

32. The 1475 satellite power, mass, and size are comparable to other satellites being built. Major satellite manufacturers are building relatively large satellites today. Boeing Space Systems (Hughes) has orders for about 12 large, high-power HS-702 satellites. Space Systems / Loral, Lockheed Martin, and other satellite manufacturers have also developed large satellite platforms that can take advantage of the latest generation of large launch vehicles.

33. The proposed satellite antennas (the largest of which is approximately 6 meters in diameter) are practicable as evidenced by the fact that other large antennas of similar size have been built and launched. TDRSS launched two 4.88-meter (16-foot) Ku-band antennas on each satellite starting in 1983. Both MSAT and AMSC-1 use two graphite antenna reflectors that are 4.9

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by 6.7 meters (16 x 22 feet). New launch vehicles like the Ariane 5 and Atlas 5 support fairings with diameters greater than 5 meters that would support sufficiently large, rigid, folded reflectors.

34. The satellite payload would utilize 75 high power amplifiers to transmit programming to the users. As **Figure 6** reflects, a number of satellites are being built with 75 or more transponders:

Program	Supplier	Transponders	Power, W
Anik F-1	Boeing SS	84	15,000
NSS F-8	Boeing SS	88	14,000
iPDataStar	SS/Loral	100	14,000
REDACTED			
1475 Example	TBD	75	8,793

* includes both spot beam and national beam transponders

Figure 6. Comparison of Current Large Satellites

35. The transponder amplifiers boost the signal strength so that it can be received by the end users. The transponder power required for the 1475 System is less than other systems for several reasons. First, the beams used are smaller and therefore provide more gain. Consequently, less RF power is needed for each beam in order to achieve the same power flux density (which is measured in Watts per square meter) on the ground. The smaller spot beams used on the 1475 System provide four to ten

times more antenna gain (+6 dB to +10 dB)[3]

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The mass per traveling wave tube amplifier is less for the same reasons. Second, by using a larger number of smaller spot beams, capacity can be focused where it is needed. It is not necessary to transmit as much power into areas with few local television stations, and use of a tightly focused spot beam design results in fewer television stations being broadcast into the wrong DMAs. Matching of capacity to demand substantially reduces the total transmitted power needed.

4. <u>Additional Subscriber Equipment</u>

36. Neither DirecTV nor Echostar would have to replace all existing set top boxes to use 8PSK modulation. However, in those areas where 8PSK modulation is used for local service, subscribers who wish to receive local broadcast television stations would need a modified demodulator or set top box with the capacity to process both the existing QPSK signals as well as the new 8PSK modulation formats. REDACTED

[3] Decibel or dB is a logarithmic measure of relative signal strength.

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37. There would be no plausible business or technical reason for abruptly changing all existing set top boxes. Instead, new set top boxes could and would be phased in over a period of years. Consumers routinely purchase and/or upgrade electronic equipment, such as set top boxes, when they first obtain service or when they wish to take advantage of new features,

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38. REDACTED

DirecTV and Echostar could begin using set top boxes that are compatible with 8PSK modulation at the same time that they begin development of a new satellite.

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. In some markets substantial numbers of set top boxes would have to be replaced to utilize 8PSK. In those cases DirecTV could elect to provide local service using the 1475 System to transmit some of the stations in a particular market using QPSK modulation (rather than 8PSK) supplemented by carriage of other stations in the same market on a CONUS beam.

B. Alternative Systems

39. There are undoubtedly many alternative approaches that would allow carriage of all local broadcast stations in the nation through the use of additional satellites or more than twelve assigned frequencies.

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40. The 1475 System could likewise be altered to limit its capacity in a manner that would enable it to be used to supplement local television service provided through other satellites. For example, the 1475 System could be modified to eliminate the use of 8PSK in downlinked transmissions, thereby obviating the need for any change in set top boxes.

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Even with those changes, the System would have the capacity to carry 1,114 television channels using only 12 frequencies. The remaining 361 television stations could easily be accommodated through the use of a different spot beam satellite, REDACTED

C. <u>Ongoing Improvements in Compression Technology</u>

41. The satellites described above are based on technological systems that are already in use. It is inevitable that more efficient systems will be developed in coming years. In particular, there is every reason to believe that further advances will be made in compression technology.

42. The Motion Picture Experts Group (MPEG) has been developing compression standards for more than ten years. The common goal of MPEG compression is to reduce the number of pixels

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(PIcture ELements or data points) required by a factor of 52. MPEG-2, which was introduced in 1995, allows for better picture quality (studio and HDTV) as well as for multiple channels at different bit rates to be multiplexed into a single data stream.

REDACTED

43. MPEG-4, which is currently under development, is expected to provide a reduction in data rate by a factor of 3 compared to MPEG-2.

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MPEG4 is already being used on a limited scale with examples available on the Internet. Microsoft has developed an MPEG-4 CODEC (COder-DECoder or Compression-DECompression software) that it distributes for free on its web site under the name "Windows Media Tools." A French engineer has developed another free version of this software called Div-X. There is also a very real prospect that the new standard will be implemented for streaming video in the next few years. It is reasonable and indeed, highly probable, that similar improvements will be made in compression technology used in digital television transmissions. This would

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allow a dramatic increase in television channel carriage capacity.

IV. Summary and Conclusions

44. Building a satellite system to deliver all eligible local broadcast television channels into each DMA is technically feasible. A DBS system that would enable satellite carriers to broadcast the signals of all local broadcast stations potentially eligible for carriage under SHVIA could be built and operated using only 12 DBS frequencies. With the 1475 system described above, most subscribers electing to receive local television service would require an upgraded set-top box that is compatible with 8PSK modulation. An alternative system could be designed to deliver the vast majority of local television stations without any modifications to subscribers' set-top boxes. Such a system would also require only 12 frequencies. Both systems would be practical to build and based on straightforward and currently available technology.

I declare under penalty of perjury that the foregoing is true and correct.

Dated: May 23, 2001

ROGER J. RUSCH

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Exhibit A Resume

Roger J. Rusch, President, TelAstra, Inc. and the TA Group (5 years)

TelAstra is an objective technical and management-consulting firm dedicated to universal communications service. The company counsels service operators, system producers, and investors in business and financial aspects of the telecommunications industry. Mr. Rusch is a pioneer in the satellite communications industry with 39 years of contributions to space technology. He has been responsible for the management of all aspects of satellite manufacturing including design, systems engineering, production, testing, and business development. He has held senior positions at Hughes Space and Communications Group (6 years), Space Systems / Loral (Ford Aerospace, 10 years), and TRW (15 years).

- Managed the construction and launch of INTELSAT IV satellites, including the satellite that was used to relay the first television pictures of President Nixon's visit to China in 1972.
- First program manager and Technical Director for the highly reliable INTELSAT V series of satellites. These satellites were first launched in 1980 and were the workhorses of the fleet for more than 15 years.
- He served as a founding Director of the Direct Broadcasting Satellite Association from 1984 to 1985. He also designed TV broadcasting satellites for DBSC, one of the original winners of an FCC license.
- Director of Systems Engineering and Integration for the TRW Federal Systems Division which managed the NASA programs including TDRSS.
- Publisher of COMMUNICATIONS SATELLITE DATA BASES for the past 15 years. These data provide comprehensive records of the cost, schedule, technical, and operational performance of all the communications satellites, under contract, built or launched.
- Prepared business and financial studies of satellite systems including Investing in Mobile Satellite Services, Investing in Broadband Satellite Services, Investing in DARS, Investing in Launch Vehicle Services. More than 200 copies of these reports have been sold to members of the space community.

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- Recipient of several patents for inventions in the field of space communications. The patents for Odyssey were sold to ICO Global for US$150 M.
- Participant in advisory panels including the National Academy of Sciences, keynote speaker for several major industry conferences, author of numerous papers on satellite communications, and regular columnist for PBI Media.
- Director on the Board of COM DEV International, a Canadian company.

Mr. Rusch received the Bachelor of Science degree in Physics from Iowa State University and two Master of Science degrees in mechanical and electrical engineering from the University of Southern California.

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"1475" Concept Gain Contours

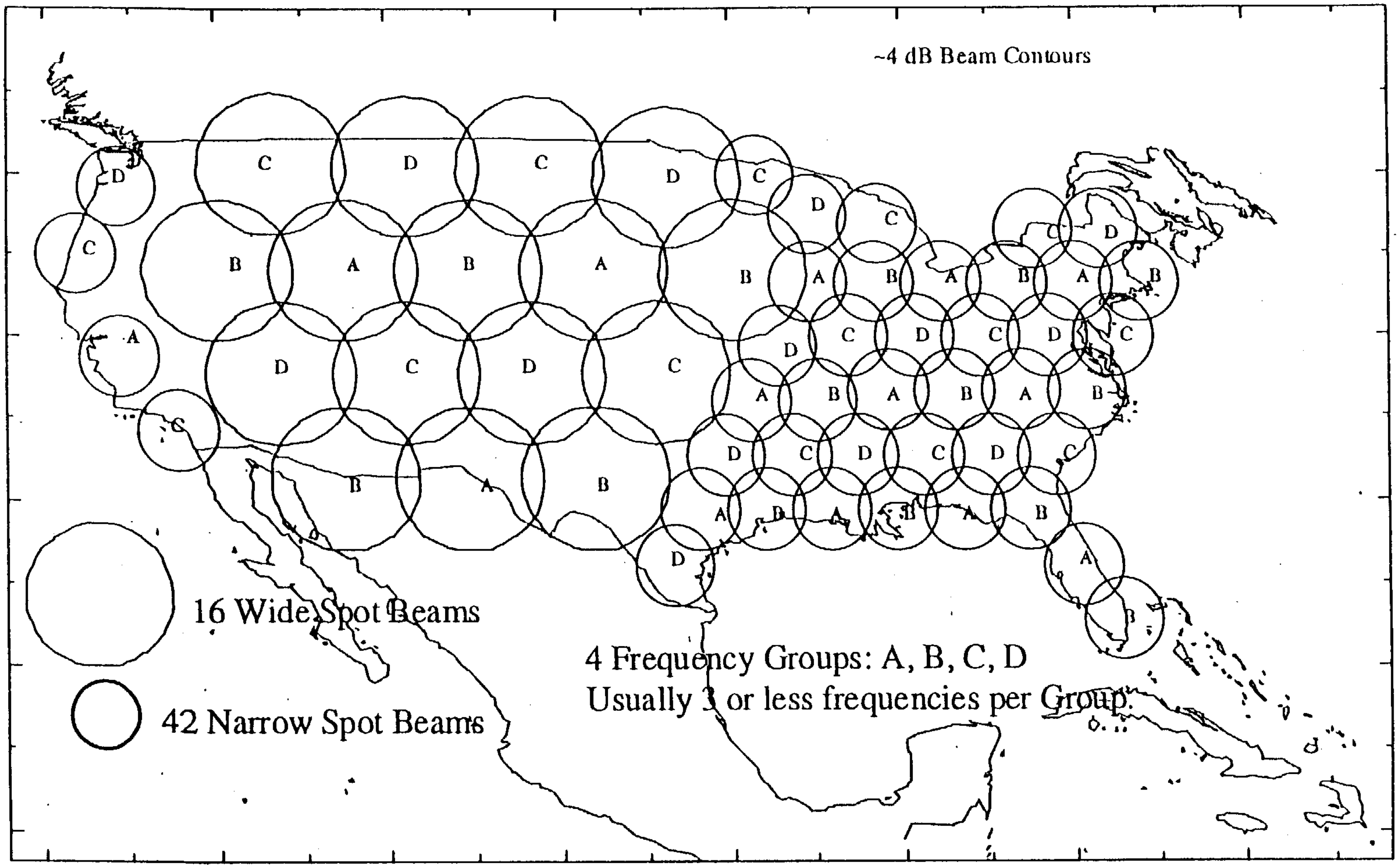

Exhibit C. Spot Beams for the 1475 system

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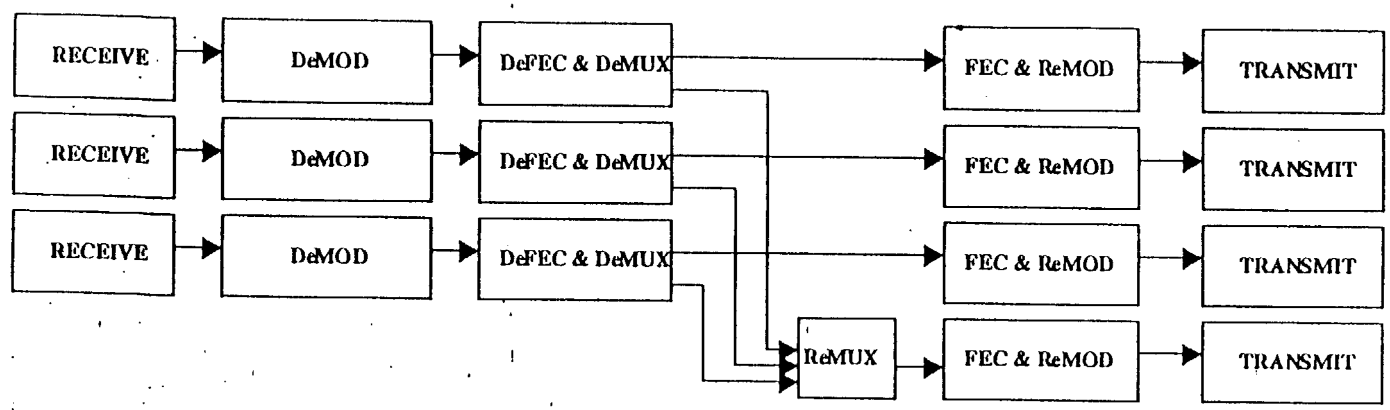
3 Uplinks @ 16QAM Yield 4 Downlinks @ 8PSK



2 Uplinks @ 16QAM Yield 4 Downlinks @ QPSK

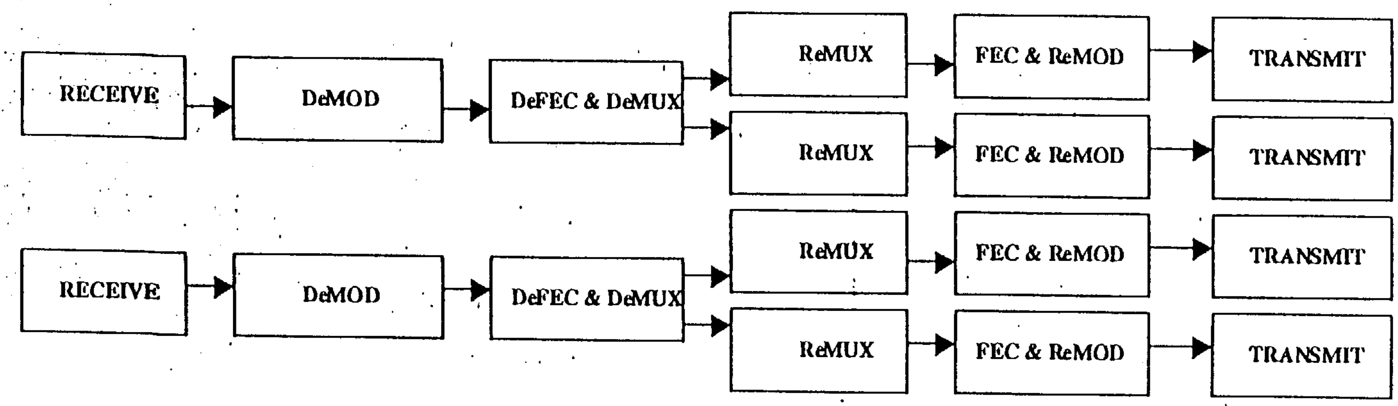


Exhibit D. Satellite Payload Modulation Conversion (assumes use of the same FEC rate)