ATTACHMENT C

REDACTED

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

REDACTED

REDACTED

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.

REDACTED

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.

REDACTED

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.

REDACTED

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

REDACTED

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°	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 *

⇕ operational

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

Figure 2. DBS Channel Assignments By Orbital Location

REDACTED

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

REDACTED

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

REDACTED

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

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

REDACTED

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.

REDACTED

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.

REDACTED

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.

REDACTED

REDACTED

REDACTED

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

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

REDACTED

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. **Uplinks**

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

REDACTED

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.

REDACTED

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.

REDACTED

3. <u>Satellite Equipment</u>

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

REDACTED

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]

REDACTED

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. **Additional Subscriber Equipment**

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.

REDACTED

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,

REDACTED

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.

REDACTED

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.

REDACTED

REDACTED

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.

REDACTED

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

REDACTED

(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.

REDACTED

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

REDACTED

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

REDACTED

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.

REDACTED

- 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.

REDACTED

REDACTED

"1475" Concept Gain Contours

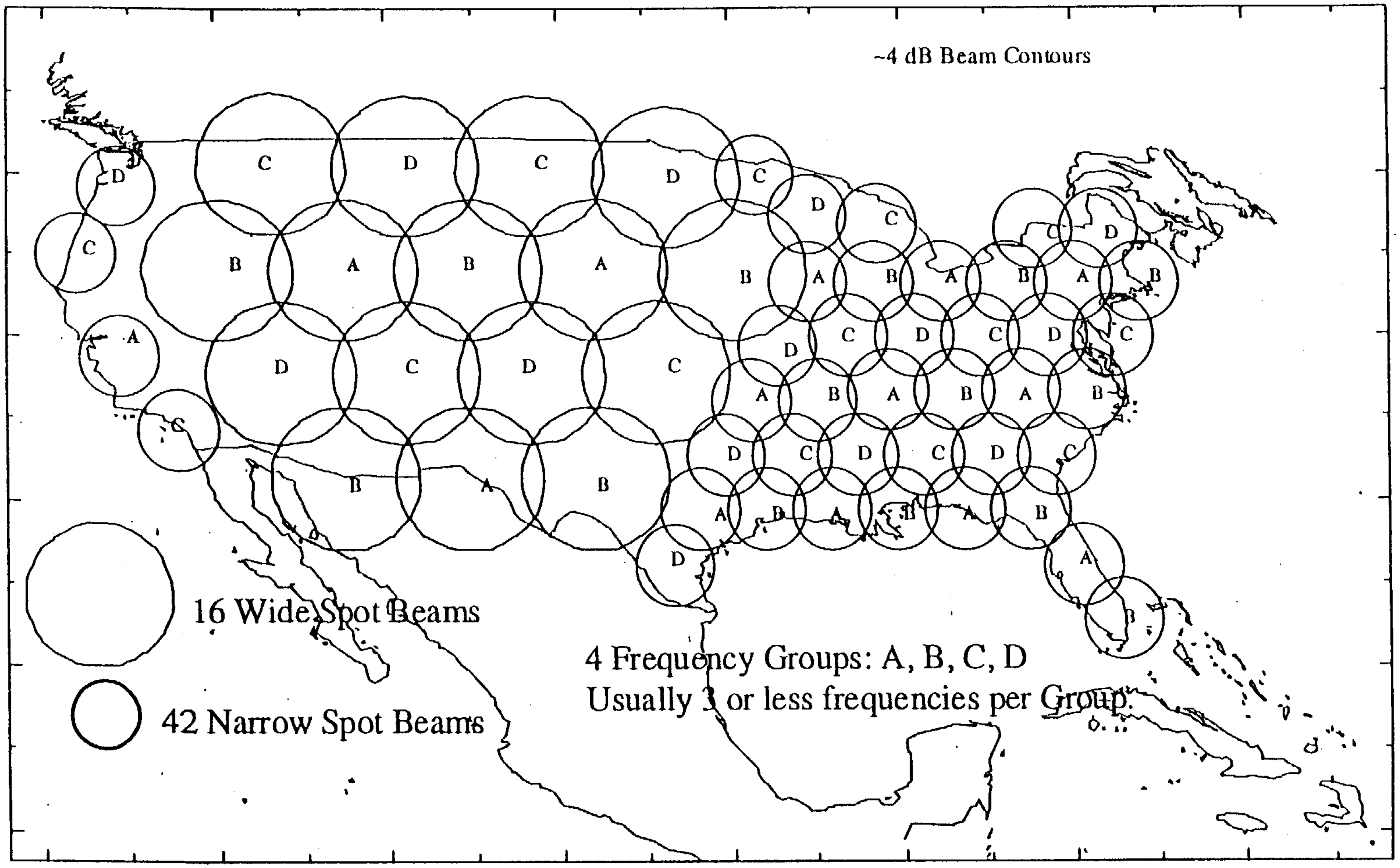
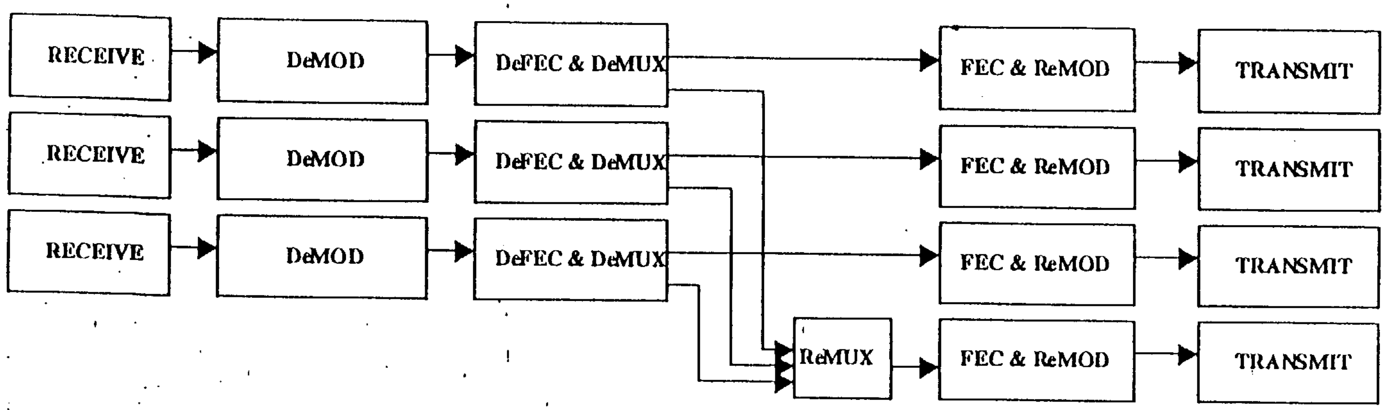


Exhibit C. Spot Beams for the 1475 system

REDACTED

3 Uplinks @ 16QAM Yield 4 Downlinks @ 8PSK



2 Uplinks @ 16QAM Yield 4 Downlinks @ QPSK

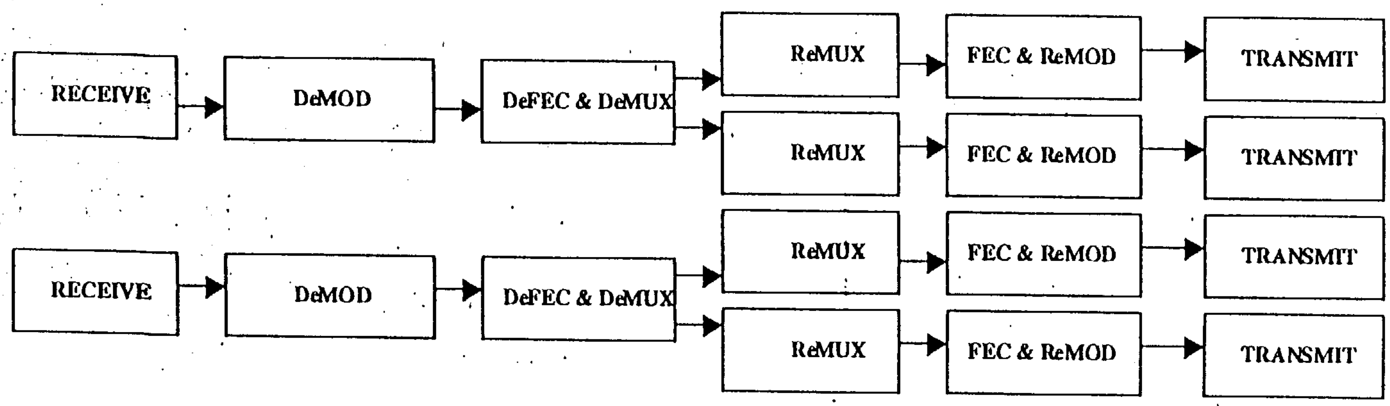


Exhibit D. Satellite Payload Modulation Conversion (assumes use of the same FEC rate)