DOCKET FILE COPY ORIGINAL

ORIGINAL

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

RECEIVED
SEP 24 1997
FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of	)	
	)	
Routine Licensing of	)	RM-9005
Large Numbers of Small Earth	)	
Stations Operating in the Ka-Band	)	

COMMENTS

THE WIRELESS CABLE ASSOCIATION
INTERNATIONAL, INC.

Paul J. Sinderbrand
William W. Huber
WILKINSON, BARKER, KNAUER & QUINN, LLP
2300 N Street, N.W.
Washington, D.C. 20037-1128
(202) 783-4141

Its Attorneys

September 24, 1997

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Wireless Cable Association International, Inc. ("WCA"), the trade association of the wireless cable industry, objects to the proposal of Teledesic Corporation in this proceeding on the grounds that it would be premature for the Commission to initiate a rulemaking to allow blanket licensing of ubiquitous, non-fixed earth stations in the absence of a showing by Teledesic that terrestrial fixed users of the 18 GHz band will not be effectively precluded from expanding point-to-point microwave operations in the future.

Wireless cable operators frequently use point-to-point microwave links in the 18 GHz band to relay program material to their transmitters for distribution to subscribers. The continued availability of spectrum in the 18 GHz bands is critical for wireless cable operators, particularly as additional sources of programming and new services are being introduced which must be relayed to wireless cable transmitter sites.

Teledesic has advanced no technical information that might allay the concerns of the wireless cable industry and other terrestrial users that blanket licensing will, in effect, foreclose the routine licensing of future fixed service operations in the 18 GHz band. Requiring fixed users to protect unlicensed Teledesic earth stations that appear to be prone to interference will effectively preclude fixed terrestrial use of the 18 GHz band. As such, the Commission must reject Teledesic's request and refrain from blanket licensing of earth stations in the 18 GHz band until adequate technical showings are presented by Teledesic to demonstrate that band sharing and coordination can be achieved in a practical manner.

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

In the Matter of	)	
	)	
Routine Licensing of	)	RM-9005
Large Numbers of Small Earth	)	
Stations Operating in the Ka-Band	)	

COMMENTS

The Wireless Cable Association International, Inc. ("WCA"), by its attorneys and pursuant to the Commission's September 5, 1997 *Public Notice* inviting additional public comment on the captioned matter,[1] hereby submits its views on the proposals advanced to date in this proceeding.

Lockheed Martin Corporation, AT&T Corp., Hughes Communications, Inc., Loral Space & Communications, Ltd. and GE American Communications, Inc. (collectively, the "Lockheed Group") commenced this matter with a December 23, 1996 Petition for Rulemaking (the "Petition") which urges the Commission to adopt rules that would allow the blanket licensing of large numbers of Geostationary Orbit/Fixed Satellite Service ("GSO/FSS") satellite earth stations operating in the 19.7-20.2 GHz, 28.35-28.6 GHz and 29.25-30.0 GHz frequency bands.[2] The Petition also suggests that a separate proceeding be initiated at an indeterminate point in the

---

1/ *See "Commission Requests Comment to Refresh Record on Proposals for Blanket Licensing of Satellite Earth Stations Operating in the 17.7-20.2 and 27.5-30.0 GHz Frequency Bands and Sharing Between Terrestrial and Satellite Services in the 17.7-19.7 GHz Frequency Bands," Public Notice,* IN Report No. 97-27 (rel. Sept. 5, 1997).

2/ *See* Petition for Rulemaking of the Lockheed Group, RM-9005 (filed Dec. 23, 1996) (hereinafter cited as the "Petition").

future to develop of sharing criteria and licensing and registration procedures to offer protection for GSO/FSS earth stations and terrestrial Fixed Service ("FS") facilities in the 17.7-18.8 GHz bands.[3] Commenting on that proposal, Teledesic Corporation ("Teledesic") submitted brief comments urging the Commission to consider blanket licensing for FSS earth stations in the 17.7-19.7 GHz bands at this time. As is described more fully below, WCA objects to Teledesic's proposal on the grounds that it would be premature for the Commission to initiate a rulemaking to allow blanket licensing of small, ubiquitous interference-prone earth stations in the absence of at least a minimal showing by Teledesic that terrestrial fixed users of the 18 GHz band will not be effectively precluded from expanding terrestrial fixed point-to-point microwave operations in the future.

I. Statement of Interest and Summary.

WCA is the principal trade association of the wireless cable industry. Its membership includes virtually every wireless cable operator in the United States, the licensees of many of the Multipoint Distribution Service ("MDS") stations and Instructional Television Fixed Service ("ITFS") stations that lease transmission capacity to wireless cable operators, producers of video programming, and manufacturers of wireless cable transmission and reception equipment. Wireless cable operators frequently use point-to-point microwave links in the 18 GHz band to relay program material to their transmitters for distribution to subscribers. The continued availability of spectrum in the 18 GHz bands is critical for wireless cable operators, particularly as additional sources of programming and new services are being introduced which must be

---

[3] *See* Petition, at 7.

relayed to wireless cable transmitter sites.[4] As such, WCA's membership has a vital interest in the Commission's rules governing the use of the 18 GHz band for terrestrial fixed point-to-point microwave services.

WCA is gravely concerned that hasty consideration of Teledesic's suggestion may hobble the future growth of wireless cable. As the Commission has recently stated, "Protection from interference is a fundamental Commission function that must be considered when introducing new technologies into spectrum allocations currently in use."[5] The concerns underlying that statement are certainly present here, where Teledesic's proposed blanket licensing of small, interference-prone satellite earth stations would very likely have a serious negative impact on 18 GHz fixed service users. Teledesic has provided no technical information that allays the concerns of the wireless cable industry and other terrestrial users that blanket licensing will, in effect, foreclose the routine licensing of future fixed service operations in the 18 GHz band. Requiring fixed users to protect unlicensed Teledesic earth stations that appear to be prone to

---

[4] As the Commission is well aware, a group consisting of over 110 participants in the wireless cable industry and the educational community recently filed a Petition for Rulemaking proposing technical rules designed to ease the deployment of a cellularized transmission architecture. *See* Petition for Rulemaking, RM-9060 (filed Mar. 14, 1997). *See also* "Pleading Cycle Established For Comments On Petition For Rulemaking To Amend Parts 21 And 74 Of The Commission's Rules To Enhance The Ability Of Multipoint Distribution Service And Instructional Television Fixed Service Licensees To Engage In Fixed Two-Way Transmissions," *Public Notice*, RM-9060, DA 97-637 (rel. March 31, 1997). Once that proposal is adopted, demand by wireless cable operators and ITFS licensees for point-to-point microwave links in the 18 GHz band can be expected to increase. Point-to-point microwave facilities in the 18 GHz band are well suited to the relatively short transport distances of 15 miles or less that will separate the multiple, closely-spaced transmitter and repeater facilities to be employed by wireless cable systems using cellularized topologies.

[5] *Advanced Television Systems and Their Impact Upon the Existing Broadcast Service*, 11 FCC Rcd 6235, 6254 (1996).

interference will effectively preclude fixed terrestrial use of the 18 GHz band. As such, the Commission must reject Teledesic's request and refrain from blanket licensing of earth stations in the 18 GHz band until adequate technical showings are presented to demonstrate that band sharing and coordination can be achieved in a practical manner.

II. Teledesic Has Made No Showing To Assuage Concerns That Its Proposal To Deploy Ubiquitous Earth Stations Under A Blanket License Will Effectively Freeze Future Use the 18 GHz Bands By Terrestrial Users.

While Teledesic suggests that sharing and coordination is possible among terrestrial and satellite uses in the 18 GHz band, it has advanced no band sharing criteria or other technical support for that claim. After reviewing Teledesic's proposal, WCA's Engineering Committee has concluded that, if Teledesic's blanket licensing proposal is adopted, that action would be tantamount to a reallocation of the 18 GHz band to the detriment of future terrestrial fixed uses.[6/] Generally, it is very difficult to provide reasonable interference protection to small aperture earth stations.[7/] According to information downloaded from Teledesic's Web site, Teledesic intends to deploy in an ubiquitous manner both fixed-site and transportable earth stations with diameters as small as 16 cm.[8/] Teledesic has provided no information on the discrimination characteristics of those earth stations, nor has it indicated what steps, if any, it intends to take to reduce interference on its part.

6/ *See* WCA Engineering Committee Comments On 18 GHz Issues, appended hereto as Exhibit A, at 1.

7/ *See id.*

8/ *See* http://www.teledesic.com/overview/system.html, at Section 5. For the Commission's convenience, a copy of that information is attached hereto as Exhibit B.

WCA believes that coordination will be virtually impossible under a blanket licensing scheme, given Teledesic's stated intention to use transportable earth stations to provide "location-insensitive" broadband services.[9] WCA's Engineering Committee has noted that, even should acceptable interference criteria be developed, blanket licensing will give not provided adequate notice of the placement of earth stations, making it "impossible for a fixed service to design a non-interfering system with any certainty of success."[10] As a result, the adoption of Teledesic's proposal would, in effect, be tantamount to a reallocation of the 18 GHz band to satellite use and would freeze out further terrestrial fixed service use of these vital frequencies.[11]

Even the Lockheed Group, the proponent of the Petition, has recognized that inter-service coordination in the 18 GHz band is a special case that warrants careful deliberation in a separate proceeding. In the Petition, the Lockheed Group pointed out that the development of sharing criteria between the GSO/FSS and terrestrial fixed service uses in the 18 GHz band is necessary in order to "provide a reasonable level of interference protection to the FSS Ka-Band transceivers and allow for efficient implementation of the 'first-come, first-served' principle that applies to co-primary FS and FSS sharing."[12] The Lockheed Group also suggested that "the licensing and registration process for GSO/FSS earth stations using the 17.7-18.8 GHz needs to

---

[9] *See* WCA Engineering Committee Comments On 18 GHz Issues, Exhibit A, at 1.

[10] *See id.*

[11] *See id.*

[12] Petition for Rulemaking of the Lockheed Group, RM 9005, 7 n. 1 (filed Dec. 23, 1996).

be further developed to afford the GSO/FSS earth stations an appropriate level of protection."[13/] As a result, the Lockheed Group did not seek to include the 18 GHz band within the scope of its Petition.[14/] WCA agrees with the Lockheed Group's view that the 18 GHz band sharing presents unique issues, and urges the Commission not to include this band in the proposed rulemaking proceeding unless band sharing criteria are proposed by satellite interests that demonstrate that coordination is possible among incumbent terrestrial fixed and FSS users in this band.

While Teledesic has suggested that band sharing and coordination is possible in the 18 GHz, there is no evidence that this situation is any different from that of the 38 GHz band. Earlier this year in comments filed with the Commission in the 38 GHz proceeding, Teledesic noted the conflicts between an NGSO FSS applicant and the incumbent terrestrial fixed services posed a conflict of incompatible services; this incompatibility, Teledesic urged, requires the adoption of a band segmentation plan in the 38 GHz band.[15/] In light of its conclusion that satellite and terrestrial fixed uses are incompatible in the 38 GHz band, WCA is at a loss to

---

[13/] *Id.* at 7.

[14/] However, in its Reply, the Lockheed Group offered lukewarm support for Teledesic's proposal, reiterating its view that inter-service sharing in the 18 GHz band poses "different, and potentially protracted, issues" which should be handled by establishing industry working groups to consider these matters. Reply of Lockheed Group, RM 9005, at 3 (filed Mar. 5, 1997).

[15/] *See* Comments of Teledesic Corporation, in *Allocation and Designation of Spectrum for Fixed Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz, and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations,* IB Docket No. 97-95 (filed May 5, 1997).

understand how Teledesic can suggest that band sharing and coordination can be realistically achieved between incumbent users and satellite interests in the 18 GHz band.

Similarly those examples cited by Teledesic as precedent in support of its view that sharing and coordination is possible among satellite and terrestrial fixed services serve only to heighten incumbents' fears that no realistic sharing can be achieved among terrestrial fixed and satellite users in the 18 GHz bands.[16/] The establishment of the Radiodetermination Satellite Service ("RDSS") is hardly a model of band sharing.[17/] There Geostar Corporation had proposed the reallocation of four spectrum bands to permit the licensing of its proposed radiodetermination and associated message transfer services.[18/] As here, one of those bands (2483.5-2500 MHz) was employed by existing broadcast and private radio users.[19/] Rather than mandate sharing and coordination among the existing and potential users, the Commission reallocated that band to the RDSS and permitted existing licensees to remain on a

---

16/ *See* Teledesic Comments, at 4-5.

17/ *See Amendment of the Commission's Rules to Allocate Spectrum for, and to Establish Other Rules and Policies Pertaining to, a Radiodetermination Satellite Service*, 104 F.C.C. 2d 650 (1986) (the "*RDSS Second R&O*") *cited in* Teledesic Comments, at n. 7.

18/ *See Amendment of the Commission's Rules to Allocate Spectrum for, and to Establish Other Rules and Policies Pertaining to, a Radiodetermination Satellite Service*, Gen Docket Nos. 84-689 and 84-690, FCC 83-319 (rel. Sept. 7, 1984).

19/ *See RDSS Second R&O*, at 666.

"grandfathered" basis.[20] The imposition of a similar freeze on future terrestrial use of the 18 GHz bands is just the situation that the wireless cable industry cannot abide.[21]

III. Teledesic's Proposal Fails To Satisfy the Standards For Rulemaking Petitions And Should Be Dismissed.

The Commission should dismiss as premature Teledesic's proposal pursuant to Section 1.401(e) of the Commission's Rules.[22] In cases such as this, where technical standards have not yet been developed in support of a proposal, the Commission has dismissed without prejudice the proposal.[23] In the absence of any suggestion that a workable band sharing and coordination

---

[20] *See Amendment of the Commission's Rules to Allocate Spectrum for, and to Establish Other Rules and Policies Pertaining to, a Radiodetermination Satellite Service*, 58 RR 2d 1416, 1421 (1985).

[21] While Teledesic has also cited Specialized Mobile Radio ("SMR") Service as an example supporting the use of blanket licensing where inter-service sharing exists and coordination is required, WCA is unaware of an inter-service sharing applicable for SMR. *See* Teledesic Comments, at n. 7.

[22] *See* 47 C.F.R. § 1.401(e).

[23] *See e.g., Amendment of Part 97 of the Commission's Rules to Authorize Time Division Multiplex Emissions in the Amateur* Service, 7 FCC Rcd 6547 (1992) (petition for rulemaking denied as premature because protocol standards for use of TDMA technology in amateur service had not yet been developed). Indeed, the situation faced by the wireless cable industry, where demand for 18 GHz point-to-point links will greatly increase with distributed transmission architectures, poses a similar situation to that line of cases in which the Commission has dismissed as premature rulemaking petitions where the existing service has not had sufficient opportunity to develop and fully exploit its spectrum allocation. *See e.g., Amendment of the Commission's Rules to Provide Ancillary Services in the 849-896 MHz Bands*, 8 FCC Rcd 3920 (1993) (petition for rulemaking proposing ancillary use of Air-Ground Service bands deemed premature where service found to be in its initial growth stage and adoption of proposal "could adversely affect implementation of Air-Ground Service."); *Amendment of Part 2 and 94 of the Commission's Rules to Allocate Spectrum in the 896-901 MHz and 935-940 MHz Frequency Bands for Multiple Address System and Point-to-Point Operations,* 4 FCC Rcd 4979 (1989) (rulemaking petition proposing reallocation of spectrum from SMR use dismissed as premature where all channels not yet available for SMR licensing).

regime can be established, the Commission should deem premature Teledesic's proposal and should defer consideration of that scheme for blanket licensing of earth stations in the 18 GHz band until band sharing criteria can be developed and proposed.

Similarly, the Commission may refrain from considering Teledesic's proposal as it fails to comply with the substantive requirements for a petition of rulemaking. Section 1.401(c) of the Commission's Rules is clear in requiring that a petition for rulemaking "shall set forth the text or substance of the proposed rule, amendment, or rule to be repealed, together with all facts, views, arguments and data deemed to support the action requested, and shall indicate how the interests of the petitioner will be affected."[24/] Teledesic has included no facts or data to support its suggestion that coordination can be achieved among the terrestrial and satellite services sharing the 18 GHz bands. Nor have either Teledesic or the Lockheed Group proffered the text of a proposed rule governing sharing between incumbent fixed and FSS users in the 18 GHz bands.

IV. Conclusion.

In conclusion, WCA strongly believes that it is premature to issue a notice of proposed rulemaking on Teledesic's proposal for sharing of the 18 GHz in the absence of sufficient technical information to support Teledesic's band sharing plan. For the reasons stated herein,

---

[24/] 47 C.F.R. § 1.401(c). The Commission has consistently denied rulemaking petitions where the dictates of Section 1.401(c) have not been met. *See e.g., Cable Television Syndicated Exclusivity and Carriage of Sports Telecasts,* 56 RR 2d 625 (1984); *Margaret Bohannon-Kaplan,* 7 FCC Rcd 2241 (1992).

the Commission should refrain from initiating a rulemaking proceeding on this proposal until sufficient technical information is made available to support consideration of Teledesic's plan.

Respectfully submitted,

THE WIRELESS CABLE ASSOCIATION
INTERNATIONAL, INC.

By: ______________________
Paul J. Sinderbrand
William W. Huber

WILKINSON, BARKER, KNAUER & QUINN, LLP
2300 N Street, N.W.
Washington, D.C. 20037-1128
(202) 783-4141

Its Attorneys

September 24, 1997

EXHIBIT A

WIRELESS CABLE ASSOCIATION
ENGINEERING COMMITTEE

COMMENTS ON 18 GHZ ISSUES

INTRODUCTION

The Engineering Committee (the "Committee") of the Wireless Cable Association ("WCA") has reviewed the Petition for Rulemaking filed by Lockheed Martin Corporation, AT&T Corp., Hughes Communications, Inc., Loral Space & Communications, Ltd., and GE American Communications, Inc. ("Petitioners") concerning routine "blanket" licensing of GSO/FSS earth stations operating in the 19.7-2.2 GHZ, the 28.35-28.6 GHz, and the 29.5-30.0 GHz bands. In addition, the Committee reviewed the comments of Teledesic Corporation ("Teledesic") urging the Commission to adopt rules that would allow the "blanket" licensing of satellite earth stations operating in the 17.7-20.2 GHZ ("18 GHz") band.

POSSIBLE IMPACT ON WIRELESS CABLE USE OF 17.7-20.2 GHZ BAND

With the advent of digital wireless cable transmissions, many operators are now, or soon will be, implementing distributed transmission systems. These systems, which will employ multiple, closely spaced transmitter and repeater sites, need an ability to transport the originating programming to these various sites. To date, one of the best and most cost effective methods for such signal transport is fixed terrestrial microwave. Given the relatively short transport distances, generally less than 15 miles, the 18 GHz band has proven excellent for such signal transport.

If the Commission were to move forward on the Teledesic proposals, the continued use of fixed services in the 18 GHz may be greatly compromised. With no technical proposals forwarded, it is difficult to provide specific analyses of the impact; however, some issues can be raised. Generally, using other satellite services as a guide, it will be very difficult for a 18 GHz fixed service user to provide reasonable interference protection to any small aperture satellite user. By example, in the 4 GHz band the Commission has recognized this issue and does not provide protection to receive only satellite earth stations with an antenna size of less than 4.5 M in diameter. The effect of "blanket" licensing would be to preclude large areas surrounding such a site from fixed service. In addition, should acceptable interference criteria be developed, lacking public notice of the placement of such sites, it would be impossible for a fixed service user to design a non-interfering system with any certainty of success. If adopted, Teledesic's proposals would, in effect, be tantamount to a reallocation of the 18 GHz band to the detriment of any future fixed uses.

CONCLUSION

Without a thorough technical proposal, it is impossible to provide a thorough response to the proposals advanced in the Petition of Rulemaking or Teledesic's comments with respect to the 18 GHz band; however, the impact on terrestrial fixed users can be expected to be great. As such, the Committee urges the Commission to refrain from initiating a rulemaking proceeding with respect to blanket licensing of earth stations in the 18 GHz band until a technical proposal is advanced.

By: ______________________
T. Lauriston Hardin, P.E.
Chairman

Date: September 22, 1997

EXHIBIT B

Teledesic

TECHNICAL DETAILS OF THE TELEDESIC NETWORK

1. CAPABILITIES

The Teledesic Network uses a constellation of 840 operational interlinked low-Earth orbit satellites and up to four operational spares per orbital plane to provide global access to a broad range of voice, data and video communication capabilities. Through its global partnerships, the Network provides switched digital connections between users of the Network and, via gateways, to users on other networks. A variety of terminals accommodate "on-demand" channel rates from 16 Kbps up to 2.048 Mbps ("E1"), and for special applications up to 1.24416 Gbps ("OC-24"). This allows a flexible, efficient match between system resources and the requirements of users' diverse applications.

The Teledesic Network provides a quality of service comparable to today's modern terrestrial communication systems, including fiber-like delays, bit error rates less than 10^{-10}, and a link availability of 99.9% over most of the United States. The 16 Kbps basic channel rate supports low-delay voice coding that meets "network quality" standards.

The initial Teledesic constellation will support a peak capacity of 1,000,000 full-duplex E-1 connections, and a sustained capacity sufficient to support millions of simultaneous users. The actual user capacity will depend on the average channel rate and occupancy. The system design allows graceful evolution to constellations with much higher capacity without altering the system architecture, spectrum plan or user terminals. The network capacity estimates assume a realistic, non-uniform distribution pattern of users over the Earth's land masses.

The system provides 24 hour seamless coverage to over 95% of the Earth's surface and almost 100% of the Earth's population.

2. THE CONSTELLATION OVERVIEW

The Teledesic constellation design supports the network requirements for quality, capacity and integrity. To provide high-quality, high-speed wireless channels at the intended peak user density levels requires substantial bandwidth. The only feasible frequency band internationally allocated to Fixed Satellite Service that meets Teledesic's requirements is the Ka band. High rain attenuation, terrain blocking, and other terrestrial systems in this band make it difficult for earth terminals to communicate reliably with a satellite at a low elevation angle. The Teledesic constellation uses a high elevation mask angle to mitigate these problems. A low orbit altitude is used to meet the requirements for low end-to-end delay and reliable communication links that use low power and small antennas. The combination of low altitude and high elevation mask angle results in a small coverage area per satellite and a large number of satellites for global coverage. A high degree of coverage redundancy and the use of on-orbit spares support the network reliability requirements.

3. The Network

End users will be served by one or more local service providers in the United States and in each host country. Terminals at gateway and user sites communicate directly with Teledesic's satellite-based network and through gateway switches, to terminals on other networks. Figure 1 is an overview of Teledesic's Network.

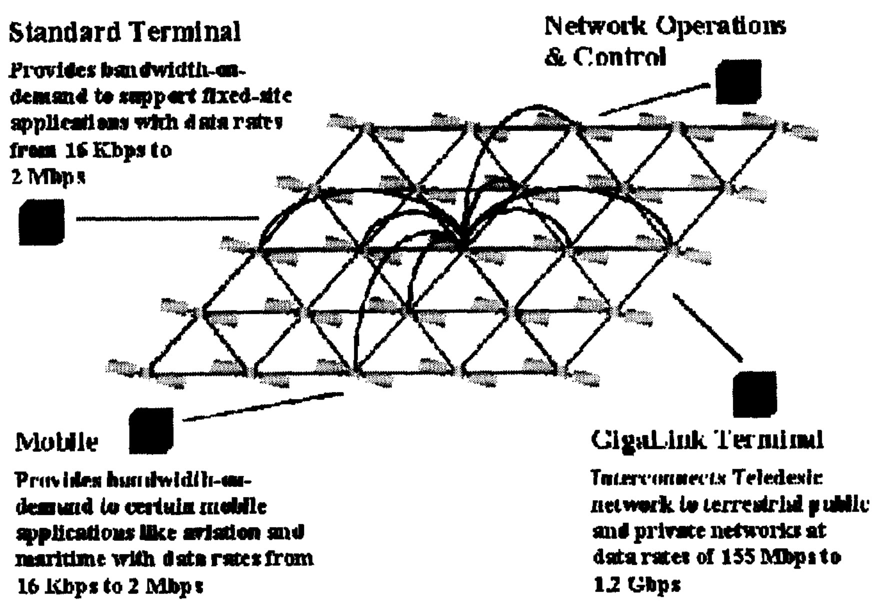

Figure 1 – The Teledesic Network

The network uses fast packet switching technology based on the Asynchronous Transfer Mode ("ATM") technology now being used in Local Area Networks ("LAN"), Wide Area Networks ("WAN"), and the Broadband Integrated Services Digital Network ("B-ISDN"). All communication is treated identically within the network as streams of short fixed-length packets. Each packet contains a header that includes address and sequence information, an error-control section used to verify the integrity of the header, and a payload section that carries the digitally-encoded voice or data. Conversion to and from the packet format takes place in the terminals. The fast packet switch network combines the advantages of a circuit-switched network (low delay 'digital pipes'), and a packet-switched network (efficient handling of multi-rate and bursty data). Fast packet switching technology is ideally suited for the dynamic nature of a LEO network.

Each satellite in the constellation is a node in the fast packet switch network, and has intersatellite communication links with eight adjacent satellites. Each satellite is normally linked with four satellites within the same plane (two in front and two behind) and with one in each of the two adjacent planes on both sides. This interconnection arrangement forms a non-hierarchical "geodesic," or mesh, network and provides a robust network configuration that is tolerant to faults and local congestion.

4. Adaptive Routing

The topology of a LEO-based network is dynamic. Each satellite keeps the same position relative to other satellites in its orbital plane. Its position and propagation delay relative to earth terminals and to satellites in other planes change continuously and predictably. In addition to changes in network topology, as traffic flows through the network, queues of packets accumulate in the satellites, changing the waiting time before transmission to the next satellite. All of these factors affect the packet routing choice made by the fast packet switch in each satellite. These decisions are made continuously within each node using Teledesic's distributed adaptive routing algorithm. This algorithm uses information transmitted throughout the network by each satellite to "learn" the current status of the network in order to select the path of least delay to a packet's destination. The algorithm also controls the connection and disconnection of intersatellite links.

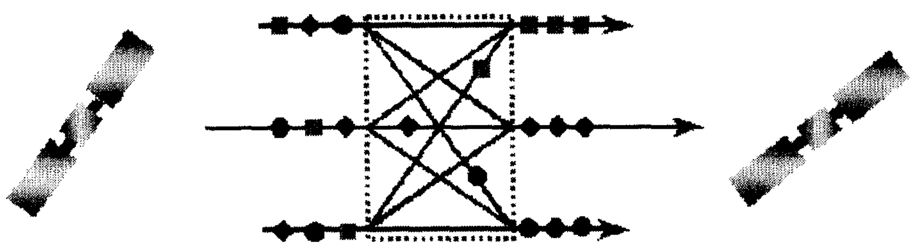

Figure 2 – Teledesic's Distributed Adaptive Routing Algorithm

The network uses a "connectionless" protocol. Packets of the same connection may follow different paths through the network. Each node independently routes the packet along the path that currently offers the least expected delay to its destination (see Figure 2). The required packets are buffered, and if necessary resequenced, at the destination terminal to eliminate the effect of timing variations. Teledesic has performed extensive and detailed simulation of the network and adaptive routing algorithm to verify that they meet Teledesic's network delay and delay variability requirements.

5. Communications Links and Terminals

All of the Teledesic communications links transport data and voice as fixed-length (512) bit packets. The basic unit of channel capacity is the "basic channel", which supports a 16 Kbps payload data rate and an associated 2 Kbps "D-channel" for signaling and control. Basic channels can be aggregated to support higher data rates. For example, eight basic channels can be aggregated to support the equivalent of an 2B + D ISDN link, or 97 channels can be aggregated to support an equivalent T-1 (1.544 Mbps) connection. A Teledesic terminal can support multiple simultaneous network connections. In addition, the two directions of a network connection can operate at different rates.

The links are encrypted to guard against eavesdropping. Terminals perform the encryption/decryption and conversion to and from the packet format. The uplinks use dynamic power control of the RF transmitters so that the minimum amount of power is used to carry out the desired communication. Minimum transmitter power is used for clear sky conditions. The transmitter power is increased to compensate for rain.

The Teledesic Network accommodates a wide variety of terminals and data rates. Standard Terminals will include both fixed-site and transportable configurations that operate at multiples of the 16 Kbps basic channel payload rate up to 2.048 Mbps (the equivalent of 128 basic channels). These terminals can use antennas with diameters from 16 cm to 1.8 m as determined by the terminal's maximum transmit channel rate, climatic region, and availability requirements. Their average transmit power varies from less than 0.01 W to 4.7 W depending on antenna diameter, transmit channel rate, and climatic conditions. All data rates, up to the full 2.048 Mbps, can be supported with an average transmit power of 0.3 W by suitable choice of antenna size.

Within its service area, each satellite can support a combination of terminals with a total throughput equivalent to over 125,000 simultaneous basic channels.

The Network also supports a smaller number of fixed-site GigaLink Terminals that operate at the OC-3 rate ("155.52 Mbps") and multiples of this rate up to OC-24 ("1.24416 Gbps"). Antennas for these terminals can range in size from 28 cm to 1.6 m as determined by the terminal's maximum channel rate, climatic region and availability requirements. Transmit power will range from 1 W to 49 W depending on antenna diameter, data rate, and climatic conditions. Antenna site-diversity can be used to reduce the probability of rain outage in situations where this is a problem.

GigaLink Terminals provide gateway connections to public networks and to Teledesic support and data base systems including Network Operations and Control Centers ("NOCCs") and Constellation Operations Control Centers ("COCCs"), as well as to privately owned networks and high-rate terminals. A satellite can support up to sixteen GigaLink terminals within its service area.

Intersatellite Links ("ISLs") interconnect a satellite with eight satellites in the same and adjacent planes. Each ISL operates at 155.52 Mbps, and multiples of this rate up to 1.24416 Gbps depending upon the instantaneous capacity requirement.

6. Earth-Fixed Cells

One benefit of a small satellite footprint is that each satellite can serve its entire coverage area with a number of high-gain scanning beams, each illuminating a single small cell at a time. Small cells allow efficient reuse of spectrum, high channel density, and low transmitter power. However, if this small cell pattern swept the Earth's surface at the velocity of the satellite (approximately 25,000 km per hour), a terminal would be served by the same cell for only a few seconds before a channel reassignment or "hand-off" to the next cell would be necessary. As in the case of terrestrial cellular systems, frequent hand-offs result in inefficient channel utilization, high processing costs, and lower system capacity. The Teledesic Network uses an Earth-fixed cell design to minimize the hand-off problem.

The Teledesic system maps the Earth's surface into a fixed grid of approximately 20,000 "supercells," each consisting of nine cells (see Figure 3). Each supercell is a square 160 km on each side. Supercells are arranged in bands parallel to the Equator. There are approximately 250 supercells in the band at the Equator, and the number per band decreases with increasing latitude. Since the number of supercells per band is not constant, the "north-south" supercell borders in adjacent bands are not aligned.

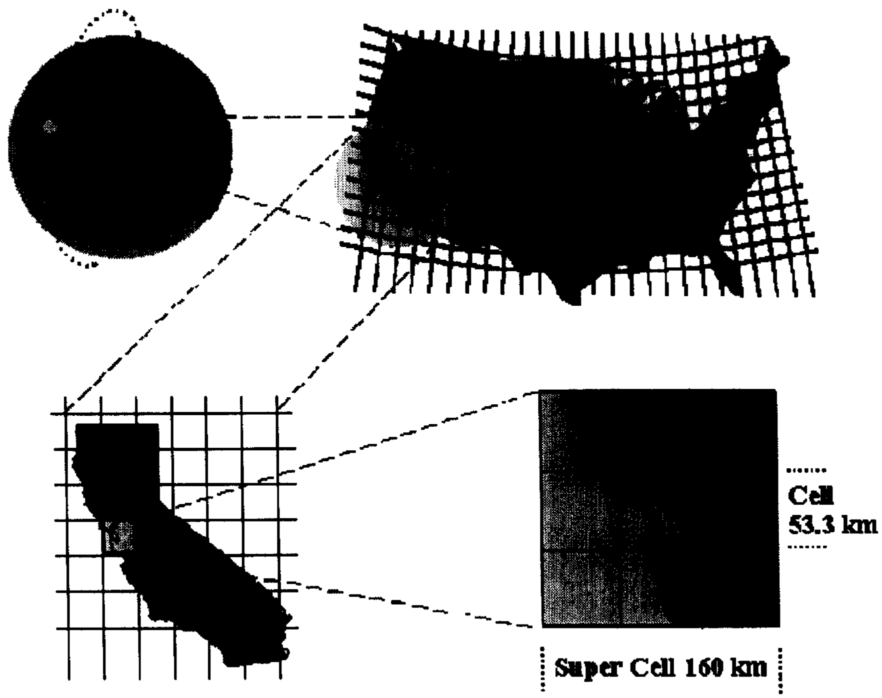

Figure 3 – Teledesic's Earth-Fixed Cells

A satellite footprint encompasses a maximum of 64 supercells, or 576 cells. The actual number of cells for which a satellite is responsible varies by satellite with its orbital position and its distance from adjacent satellites. In general, the satellite closest to the center of a supercell has coverage responsibility. As a satellite passes over, it steers its antenna beams to the fixed cell locations within its footprint. This beam steering compensates for the satellite's motion as well as the Earth's rotation. (An analogy is the tread of a bulldozer that remains in contact with the same point while the bulldozer passes over). This concept is illustrated in Figure 4.

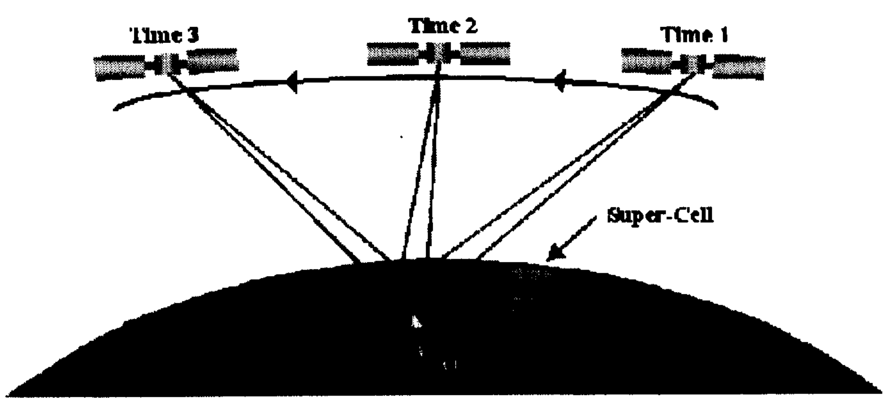

Figure 4 – Illustration of Beam Steering to an Earth-Fixed Cell

Channel resources (frequencies and time slots) are associated with each cell and are managed by the current "serving" satellite. As long as a terminal remains within the same Earth-fixed cell, it maintains the same channel assignment for the duration of a call, regardless of how many satellites and beams are involved. Channel reassignments become the exception rather than the normal case, thus eliminating much of the frequency management and hand-off overhead.

A database contained in each satellite defines the type of service allowed within each Earth-fixed cell. Small fixed cells allow Teledesic to avoid interference to or from specific geographic areas and to contour service areas to national boundaries. This would be difficult to accomplish with large cells or cells that move with the satellite.

7. MUTIPLE ACCESS METHOD

The Teledesic Network uses a combination of multiple access methods to ensure efficient use of the spectrum. Each cell within a supercell is assigned to one of nine equal time slots. All communication takes place between the satellite and the terminals in that cell during its assigned time slot (see Figure 5). Within each cell's time slot, the full frequency allocation is available to support communication channels. The cells are scanned in a regular cycle by the satellite's transmit and receive beams, resulting in time division multiple access ("TDMA") among the cells in a supercell. Since propagation delay varies with path length, satellite transmissions are timed to ensure that cell N (N=1, 2, 3,...9) of all supercells receive transmissions at the same time. Terminal transmissions to a satellite are also timed to ensure that transmissions from the same numbered cell in all supercells in its coverage area reach that satellite at the same time. Physical separation (space division multiple access or 'SDMA') and a checkerboard pattern of left and right circular polarization eliminate interference between cells scanned at the same time in adjacent supercells. Guard time intervals eliminate overlap between signals received from time-consecutive cells.

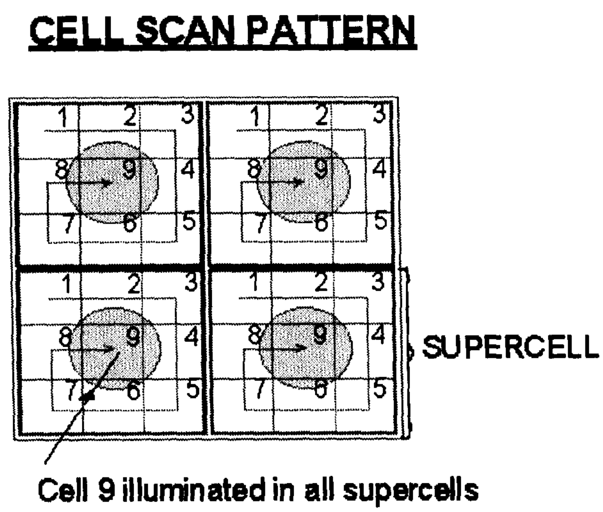

Figure 5 – Teledesic's Cell Scan Pattern

Within each cell's time slot, terminals use Frequency Division Multiple Access ("FDMA") on the uplink and Asynchronous Time Division Multiple Access ("ATDMA") on the downlink. On the uplink, each active terminal is assigned one or more frequency slots for the call's duration and can send one packet per slot each scan period (23.111 msec). The number of slots assigned to a terminal determines its maximum available transmission rate. One slot corresponds to a Standard Terminal's 16 Kbps basic channel with its associated 2 Kbps signaling and control channel. A total of 1800 slots per cell scan interval are available for Standard Terminals (see Figure 6).

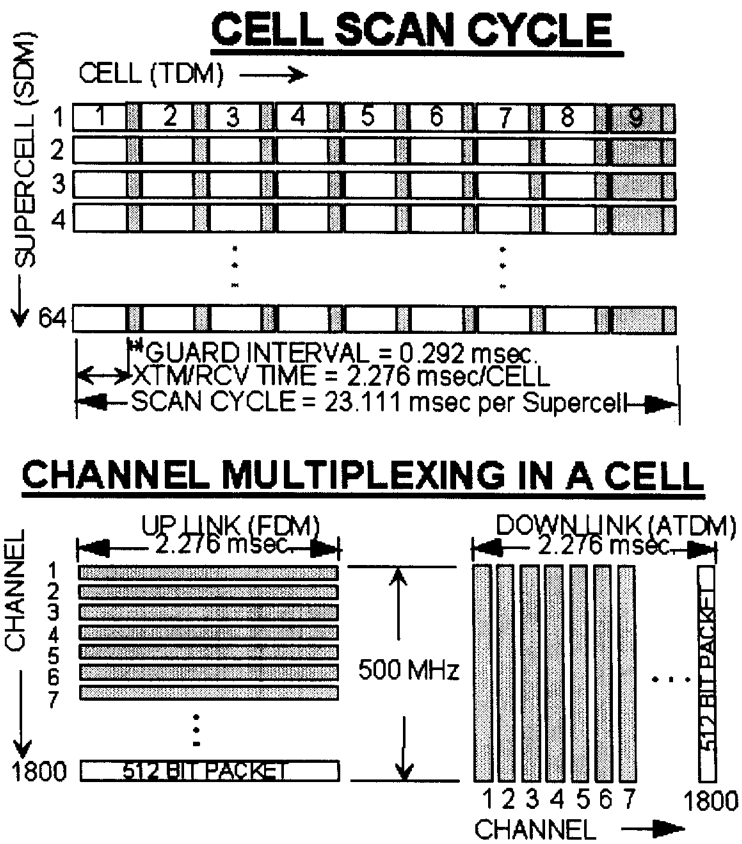

Figure 6 – Teledesic's Standard Terminal Multiple Access Method

The terminal downlink uses the packet's header rather than a fixed assignment of time slots to address terminals. During each cell's scan interval the satellite transmits a series of packets addressed to terminals within that cell. Packets are delimited by a unique bit pattern, and a terminal selects those addressed to it by examining each packet's address field. A Standard Terminal operating at 16 Kbps requires one packet per scan interval. The downlink capacity is 1800 packets per cell per scan interval. The satellite transmits only as long as it takes to send the packets queued for a cell.

The combination of Earth-fixed cells and multiple access methods results in very efficient use of spectrum. The Teledesic system will reuse its requested spectrum over 350 times in the continental U.S. and 20,000 times across the Earth's surface.

8. SYSTEM CONTROL

The network control hierarchy is distributed among the network elements. Terminals and other network elements use a packet-based protocol for signaling and control messages (similar to the ISDN D-channel and CCITT Signaling System No. 7). The network handles these "control" packets in the same manner as normal information packets.

The highest levels of network control reside in distributed, ground-based systems that are connected via GigaLink Terminals to the satellite network. Database systems provide terminal/user feature and service profiles, authentication and encryption keys, call routing data, and other administrative data. Administrative systems, from "network-level" to local "in-country" systems, provide secure access to various levels of the database and billing systems.

High-level call control functions reside in feature processors and gateway switches. The feature processor controls intra-network calls as well as the initial setup of inter-network calls which involve a gateway. Only control and signaling packets are passed to the feature processor; user packets are transmitted through the network over the path of least delay. A gateway switch controls calls that are connected through that switch.

The satellite-based switch node includes some mid-level call control functions in addition to its packet routing function. It manages the assignment, supervision, and release of all channels in its coverage area and the "hand-off" of channels to other satellites. It also monitors channel signal quality and initiates uplink power control when required.

Terminals control some low-level call control functions similar to those of a cellular or ISDN functional signaling terminal. These functions include user authentication, location registration, link encryption, monitoring and reporting of channel quality, channel assignments and hand-offs, and D-channel signaling.

9. Satellite and Launch Overview

The Teledesic satellite is specifically designed to take advantage of the economies that result from high volume production and launch. All satellites are identical and use technologies and components that allow a high degree of automation for both production and test. To minimize launch cost and the deployment interval, the satellites are designed to be compatible with over twenty existing international launch systems, and to be stacked so that multiple satellites can be launched on a single vehicle. Individual satellites, the constellation as a whole, and the COCCs are designed to operate with a high degree of autonomy.

The initial constellation includes a number of active on-orbit spares that can be used to "repair" the Network immediately if a satellite is removed from service temporarily or permanently. Routine periodic launches will be used to maintain an appropriate level of spares in each orbit plane. Launch vehicles and satellites that have reached the end of their useful life are deorbited. They disintegrate harmlessly on re-entry, and will not create space debris.

VISUALIZATIONS OF THE TELEDESIC NETWORK

HOME PAGE OVERVIEW