BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

Washington D.C. 20554

LETTER OF INTENT

OF

New Spectrum Satellite, Ltd

CORRECTED TECHNICAL NARRATIVE

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May 26, 2020

Executive Summary

New Spectrum Satellite, Ltd ("NSS") hereby files this Amended Letter of Intent to participate in the Commission's most recent processing round for NGSO Fixed Satellite Service systems, *Public Notice*, DA 20-325 (March 24, 2020) for operation in the United States for its Non-Geostationary Satellite Orbit (NGSO) System, File No. SAT-PDR-20170726-00111, *Public Notice,* Report No. SAT-01351 (released October 12, 2018).[1] This Amendment was necessitated the reallocation of portions of the C-band downlink spectrum to terrestrial services[2]. NSS is also taking this opportunity to update the design of its NGSO satellite system -- named there "Virtual Geo™" -- to conform better to spectrum allocations for NGSO and to improve system performance and efficiency, and hereby amends its earlier Petition for Declaratory Ruling filed on July 26, 2017. While continuing the earlier constellation design and user link services, an important part of this update is the movement of all feeder links from the C and Ku bands described in the earlier Petition to the Ka band, in response to the FCC's reallocation of the 300 MHz of the C-band downlink spectrum. In updating its system design, NSS also applied some system changes to improve the performance of the system, such as a more flexible channel mapping scheme and larger satellite antennas for better beam focus, emission control, and frequency reuse. We anticipate that none of these changes causes

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[1] The *Public Notice* that established the processing round for its original application indicated that Virtual Geo will be afforded an opportunity "to amend or supplement this application, if necessary, to conform to any requirements or policies that may be subsequently adopted concerning NGSO-like satellite operation in these bands." *Public Notice*, DA 17-524, 32 FCC Rcd 4180 (May 26, 2017) at pp. 4-5. This Amendment reflects changes to the C-band allocations in the United States, although even if deemed a "major amendment," this Application would still be considered as part of the processing round established for the NSS and other applications consistent with the March 24, 2020 *Public Notice*.

[2] *Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, FCC 20-22, 35 FCC Rcd 2343 (released March 3, 2020), 85 Fed Red 22804 (April 23, 2020).

increased interference to any of the protected systems operating in the requested bands, and should in fact decrease interference by substituting narrower beams and more efficient channel allocations.

In light of the expectation that the Commission may be revisiting inter-system sharing,[3], and to clarify a multiple-entry feature of the Virtual Geo architecture, it is important to differentiate *between* the Virtual Geo framework, which consists of multiple simultaneously operating and independent systems capable of reusing the full spectrum allocated to the projected services, *and* the proposed system employing that framework consisting of 15 satellites and for which this Petition is intended. To clarify this seeming confusion we have encountered previously between the larger Virtual Geo framework and the constellation of satellites and services NSS will build and deploy, which we had also called "Virtual Geo™", NSS has changed the name of the satellite system under application from the "Virtual Geo™ System" to the "Pleiades™ System". The "Virtual Geo™" name is retained to be used to identify the multiple entry NGSO orbital framework that "Pleiades™" will employ with its fifteen satellites. As a multiple system entry framework, the Virtual Geo framework is suitable for deployment of a number of other NGSO systems in a coordinated GSO-like framework without the crossing interference internal to other types of NGSO systems or among those systems that those designs experience. Using the Virtual Geo system sharing framework for multiple system entry would simplify the task of coordinating the NGSO systems using Virtual

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[3] *Public Notice*, Petition for Rulemaking Filed, RM-11855, Report No. 3148, released, May 14, 2020.

Geo's straightforward slotting scheme.[4,5] As amended, the NSS system will efficiently provide global satellite services using a highly-elliptical orbit, and thus well serve the public interest. In addition, as demonstrated in the Application and below, NSS is legally and technically qualified for the requested authorization. NSS thus requests prompt grant of its application.

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[4] Virtual Geosatellite, LLC intends on making the Virtual Geo framework available internationally on reasonable and non-discriminatory terms.

[5] The Virtual Geo architecture is capable of replicating a Pleiades-like system 30 times on a worldwide scale.

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1 Letter of Intent Narrative Description

New Spectrum Satellite, Ltd. ("NSS"), pursuant to Sections 308 and 309 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 308 and 309 (1996), Parts 1 and 25 of the Commission's Rules, and the Commission's *Public Notice* (DA 17-524, released May 26, 2017), hereby seeks authority to operate within the United States a state-of-the-art system of fifteen (15) non-geostationary satellites in sub-geosynchronous inclined elliptical orbits that will be licensed by Canada. NSS's proposed system, called "Pleiades." Pleiades will provide fixed-satellite services to all of the world's populated land masses through a combination of user and gateway links in the Ku- and Ka-bands,[6] as well as through inter-satellite links in the optical frequencies.

Pleiades is the first of a new class of constellation systems that are virtually geo-synchronous. Unlike geostationary systems or so-called "quasi-geostationary" systems in which the individual satellites attempt to follow the Earth, all of the satellites in a virtual geostationary system, as a whole, follow the Earth in fixed geosynchronous ground tracks. It is this feature which gives this constellation type the name "virtual geo."

Virtual Geo satellites are separated from the geostationary arc by at least 40 degrees at all times within the system's service areas. This key feature of the virtual geostationary concept means that Pleiades not only fully protects current geostationary FSS networks, it leaves them an effectively unfettered opportunity to evolve their technologies to meet future service requirements.

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[6] The *Public Notice* invited additional applications in the 12.75-13.25 GHz, 13.85-14.0 GHz, 18.6-18.8 GHz, 19.3-20.2 GHz, and 29.1-29.5 GHz bands. NSS is seeking authority in this application for these bands, but will operate in additional bands, including the C-band, outside of the United States. NSS will operate in these additional bands within the United States only if such usage is authorized by the Commission. *See* n. 2, *supra*.

1.1 Introduction

This application and its appendices contain all of the information required for a space station authorization as specified in Part 25 of the Commission's Rules. In accordance with the Commission's rules, the information provided throughout this application includes references to the specific subsections of Section 25.114 of the Commission's Rules to which the submitted information pertains.

1.1.1 Name and Address of Applicant (47 C.F.R. § 25.114(c)(1))

The applicant for the authority to launch and operate the proposed satellite system is:

New Spectrum Satellite, Ltd.
925 Boulevard de Maisonneuve, Suite 247
Montreal, Québec H3A 0A5
Canada

In the US:
c/o Virtual Geosatellite, LLC
P.O. Box 40246
Washington, DC 20016
(202) 466-4488

1.2 Correspondence (47 C.F.R. § 25.114(c)(2))

Correspondence and communications concerning this application should be addressed to the following:

Dr. David Castiel
President and CEO
Virtual Geosatellite, LLC
P.O. Box 40246
Washington, DC 20016
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<u>With copies to</u>:

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1.3 1.3 Type of Authorization Requested (47 C.F.R. § 25.114(c)(3))

In this Application, NSS requests authorization to provide service in the United States using a constellation of nongeostationary satellites that will be licensed by Canada.

2 Overview of Pleaides and the "Virtual Geostationary Orbit" Concept

NSS intends to deploy and operate the Pleiades System -- a system of 15 non-geostationary satellites in a coordinated set of inclined highly elliptical orbits -- to provide high capacity digital two-way fixed satellite services connecting customer fixed earth stations to gateway fixed earth stations interconnected with the terrestrial digital network and to other user terminals. As mentioned, the Pleiades satellite system of fifteen (15) non-geostationary satellites in sub-geosynchronous inclined elliptical orbits uses an NGSO multiple entry framework known as "Virtual Geo." The Commission previously reviewed and authorized a system of this orbital design for NSS's affiliate, Virtual Geosatellite, LLC.[7]

NSS's proposed Pleiades satellite system presented here will provide fixed-satellite services to major markets around the world using a total of nine "active arcs" satellite operational locations distributed around the world (explained further below). It employs user links operating in Ku band and gateway links in the Ka-band. It also employs optical inter-satellite links.

1.4.1 The Virtual Geo Framework

To describe the Pleiades System adequately it is first necessary to describe the Virtual Geo constellation framework the Pleiades System uses. This non-geostationary (NGSO) framework is capable of supporting many satellite systems on a coordinated

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[7] Virtual Geosatellite, LLC, 21 FCC Rcd 14687 (2006). Virtual Geosatellite subsequently surrendered that authorization due to adverse economic conditions at that time. *See,* Letter from Stephen D. Baruch to Marlene H. Dortch, dated February 5, 2007.

multiple system entry basis using essentially the same sharing approach as is used in geostationary orbits, that of assigning slots to satellites, which in this framework will continually maintain a designated angular separation from other satellites deployed within the same framework. Furthermore, operating satellite locations within the Virtual Geo framework are at latitudes always above 43 degrees latitude North or South compared to the geostationary (GSO) deployment around the equator at zero degrees latitude. As a result, the satellites in the Virtual Geo framework always maintain an operations angular separation from the Geo arc of around 39 degrees or more. Figure 1 illustrates the Virtual Geo framework as seen from space, relative to the GSO satellite framework. Figure 2 to Figure 4 illustrate a Cartesian view of the populated framework, showing the Northern (Aurora) and Southern (Australis) active arcs, and the ground tracks of Aurora satellites.

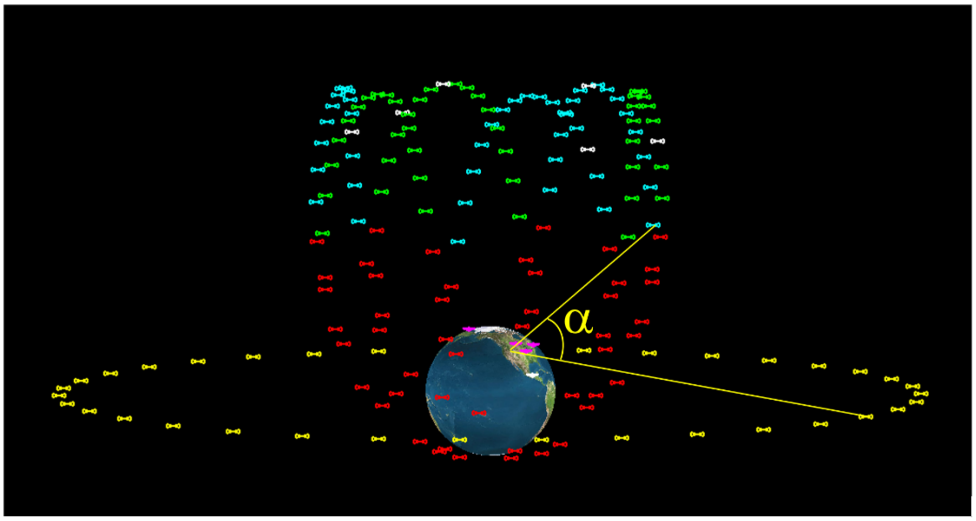

Figure 1, A snapshot view of the Virtual Geo framework from space, positions to scale, shown populated with a large number of satellite systems sharing the framework. A system might only use one or two satellites per active arc or lobe shown. The Blue and green lobes are active arcs and are geostationary. Red satellites here are inactive and in transit between active arcs, only the blue or green satellites shown are active and radiate. This also illustrates the substantial angular separation “α" between the closest active framework satellites and any GSO satellite (α > 39°).

Southern active arc satellites in the framework, not shown here to simplify the illustration, are similar, except the active satellites operate to the South of the Earth by equal distances.

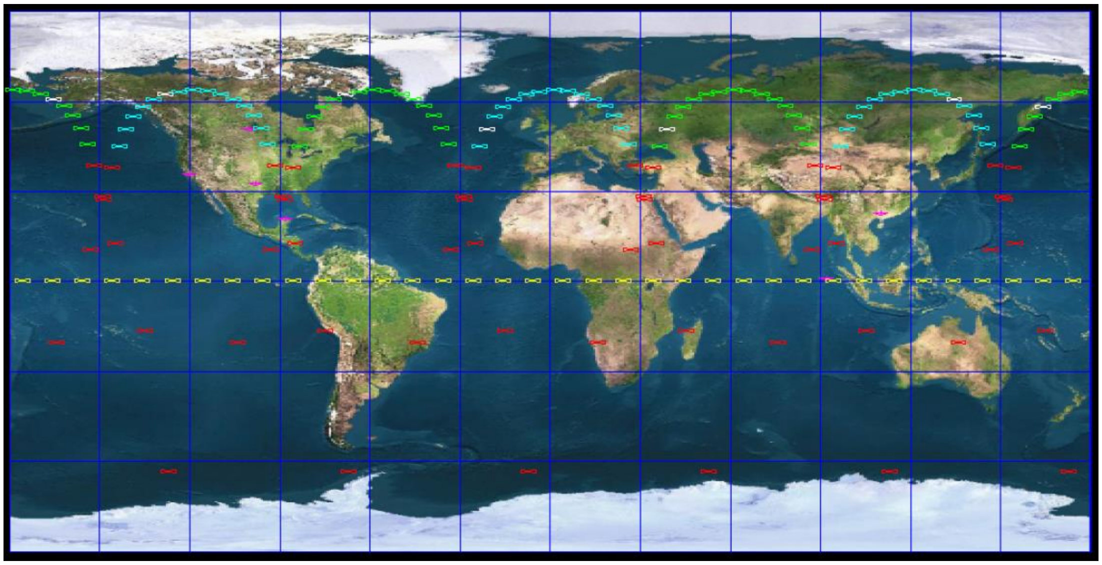

Figure 2, Northern Active Arcs active satellite positions shown in green (Aurora I) and blue (Aurora II) highlighting the multiple entry feature of the Virtual Geo Framework. Red satellites are inactive, and yellow satellites are GSO satellites. As time passes Pleiades satellites, here shown equally spaced in time, move in formation slowly through active arcs, all the while maintaining a minimum satellite-satellite separation. They then transit rapidly to succeeding active arcs. Satellites remain in a given active arc for 4 hours and 48 minutes before going passive and transiting to the next arc.

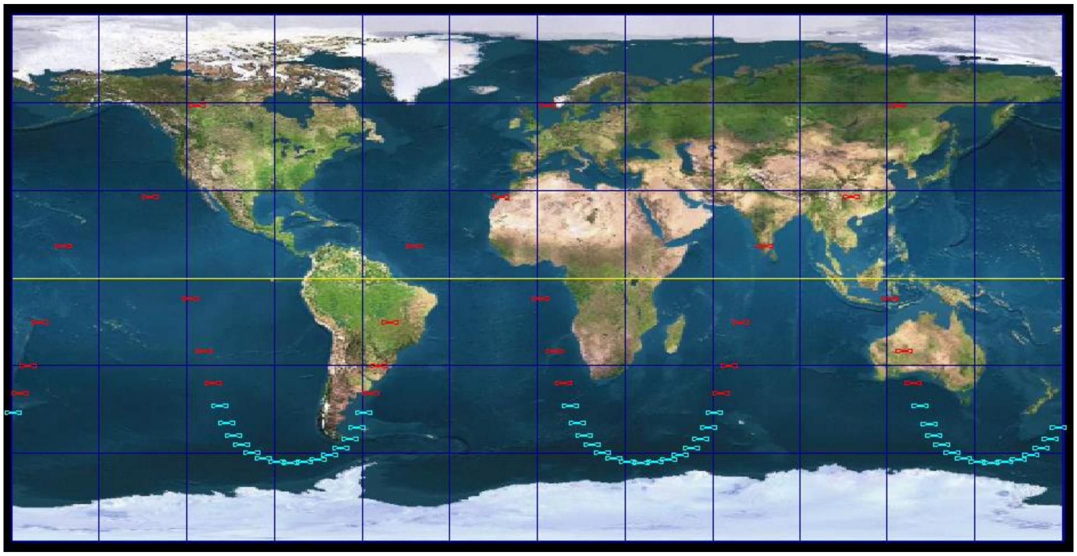

Figure 3, Pleiades Australis I active arcs. Australis II, not shown, lies between the Australis I active arcs in the same manner as the Aurora I and II active arcs to the North. Blue satellite positions are active, red are inactive and in transit between active arcs.

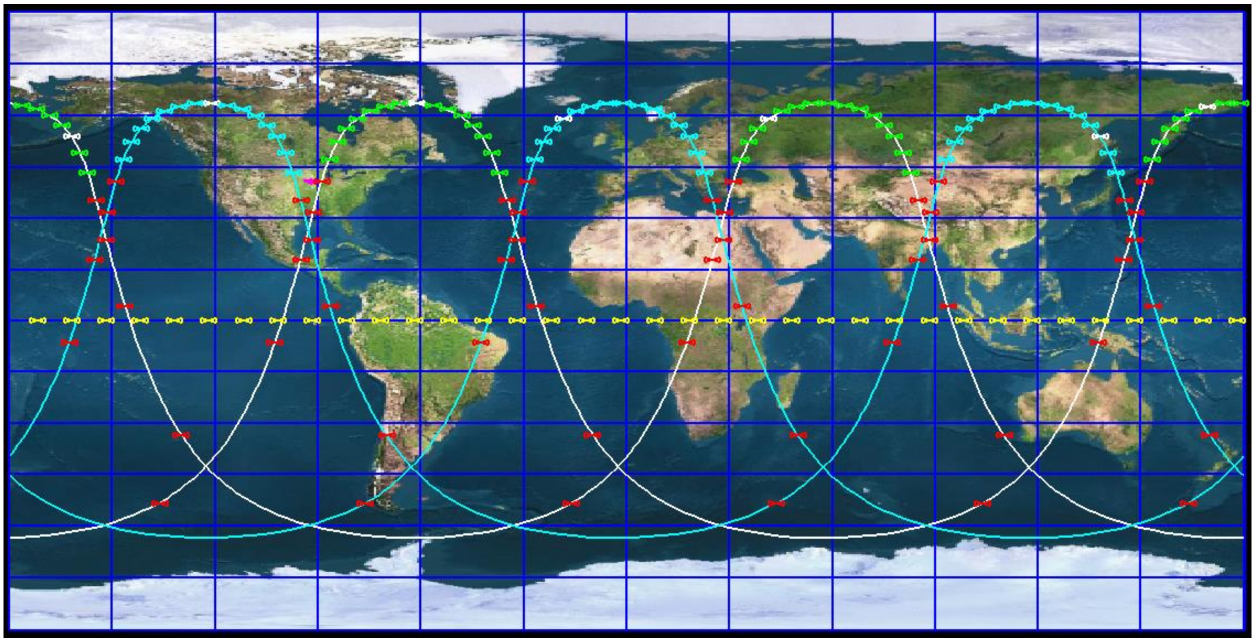

Figure 4, The ground tracks for the above illustrated Northern Virtual Geo framework, shown in blue and white for the 2 Northern ground tracks. Southern ground tracks are similar but inverted by latitude and displaced 20.3 degrees East. As before, active satellites are blue or green depending on the ground track, inactive satellites are red. All satellites shown are evenly spaced in time. Note the relatively even geographic satellite spacing within the active arc and the rapid satellite acceleration outside of them

2.1 Virtual Geo Framework Characteristics

The higher latitudes of the Virtual Geo framework satellite active arcs yield a minimum angular separation “α” of 39 degrees between a line connecting a ground station with a Virtual Geo framework satellite and the line from the same ground station to any location on the GSO arc (shown in Figure 1). This large minimum separation angle helps minimize interference from satellites in the Virtual Geo framework into GSO systems and thereby facilitates using GSO-allocated frequencies while minimizing any interference to GSO systems.

The core of the Virtual Geo framework is the inclined elliptical orbit used by all satellites sharing the framework. This orbit has an apogee of 26,679 kilometers and a perigee of 1,125 kilometer, arguments of perigee of 270 or 90 degrees, a period of 8 hours, an eccentricity of 0.63, and an inclination of 63.435 degrees.[8] These features yield repeating ground tracks, a frozen argument of perigee, and apogees either at the northern or southern ends of the orbits. Satellites only radiate above approximately 17,142 kilometers in geocentric altitude. The portions of the orbits/ground tracks in which satellites radiate are termed “active arcs.” The defined active arc also includes a 3-minute added margin at each end of the active arc for handover from an active-arc-departing satellite or after handing off to another active-arc-arriving satellite and for satellite housekeeping. The right ascension of the ascending node at epoch (RAAN) and mean anomaly for each satellite are chosen to place satellites in one of the four designated ground tracks.

The four allowed ground tracks separate the active arcs so that they do not cross. All active arcs are either well to the North or well to the South of the equator. With the objective of creating geographically frozen active arcs through which successive satellites pass, the Virtual Geo framework is therefore inherently ground track-oriented rather than orbit-oriented.

Table 1 shows the longitudes of the various Virtual Geo framework active arcs.

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[8] Details of Pleiades orbital parameters are given in Section 4.1 below.

Table 1, Pleiades Geo Ground Tracks and Active Arcs. Each column is a ground track. Successive rows are the Active Arcs that are visited in time sequence by the satellites within a ground track.

Aurora I™ Northern Hemisphere	Aurora II™ Northern Hemisphere	Australis I™ Southern Hemisphere
210.8-261.8 W. North America	270.8-321.8 E. North America	130.5 – 181.5 Australia-NZ
90.8-141.8 East Asia	150.8-201.8 Pacific	10.5 - 61.5 Africa
330.8-21.8 Europe	30.8-81.8 West Asia	250.5 – 301.5 South America

Each satellite is in traffic service for 4 hours and 48 minutes in each active arc between its western arrival and eastern departure of the arc. Hence satellite handoffs within an active arc happen only once per 4 hours and 48 minutes. On departing the active arc, the satellite becomes inactive, and transits to the next active arc in the ground track in 3 hours and 12 minutes[9]. Since the orbits have an approximate 8-hour period, a satellite will pass through apogee three times per 24-hour period. During this period the earth rotates, placing a different part of the earth under the orbit apogee. The satellite therefore passes through 3 active arcs in its ground track per day, each displaced from the

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[9] Satellites are allocated a maximum 3-minute window before going live with user traffic to wake up and interact with TT&C. Likewise, satellites are allocated a maximum 3-minute window after dropping traffic to interact with TT&C before going quiescent until the next active arc.

next on the earth by 120 degrees of longitude. It returns to its first active arc 24 hours later.

Since ground tracks are geographically fixed, it also follows that satellites sharing the ground track follow the same fixed track in space as seen from any fixed spot on the earth's surface, hence emulating the geostationary satellites paths around the earth. This greatly simplifies satellite tracking in that the ground station need only track a single curved line segment through its sky; all satellites transiting the active arc serving its area will follow that same path.

Elevation angles from North America always remain quite high to active Pleiades satellites. Figure 5 through Figure 9 illustrate elevation angles from Eastern, central, and western locations in North America. These charts also demonstrate the large separation angles at all times between satellites in the active arcs shown in blue or green and the geostationary satellites in yellow. These figures are sky charts, so are properly read as if placed over the head. The bottom is South, the left edge is East, and the right Edge is West. The center is straight up. Successive circles are 10 degrees apart.

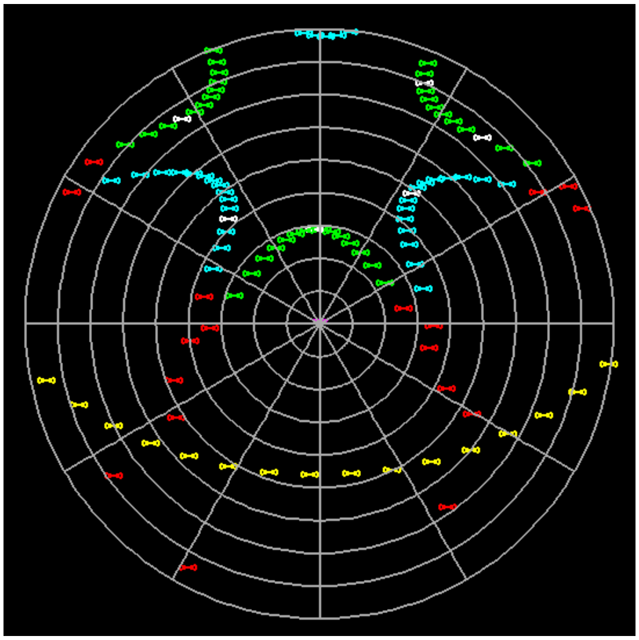

Figure 5, View of the active arcs seen from 40N 77W. Blue and green satellites are active in the active arcs, red satellites are inactive, and yellow are geostationary satellites along the geostationary arc.

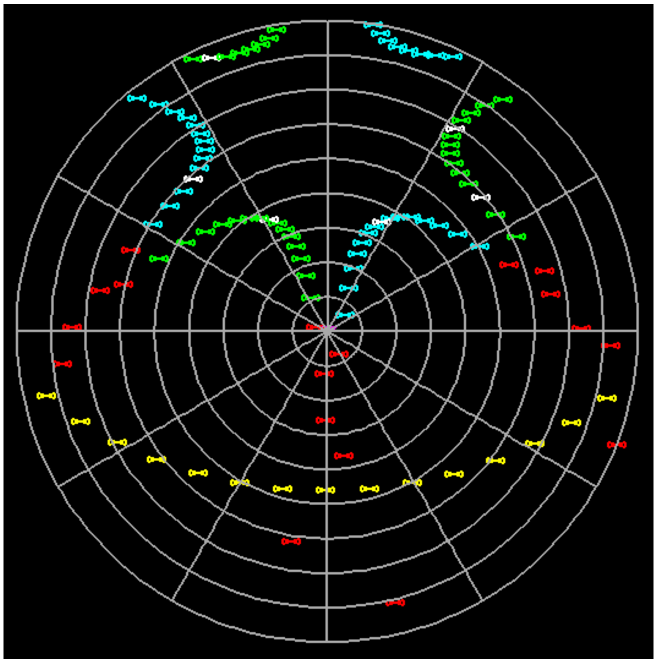

Figure 6, Active arcs seen from 40N 94W

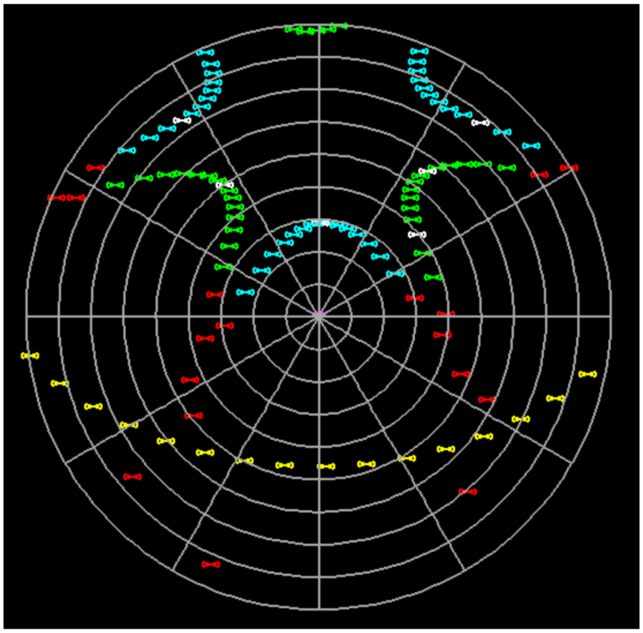

Figure 7, Active Arcs seen from 40N 122W.

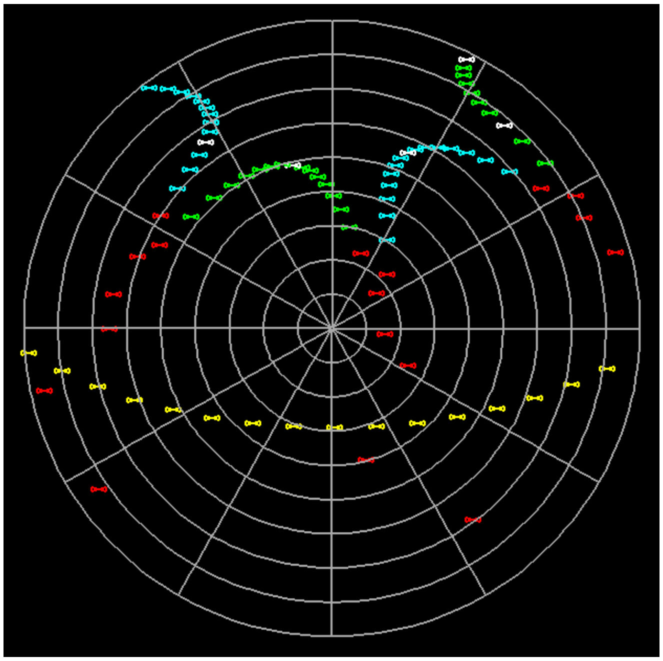

Figure 8, Active arcs seen from Miami FL

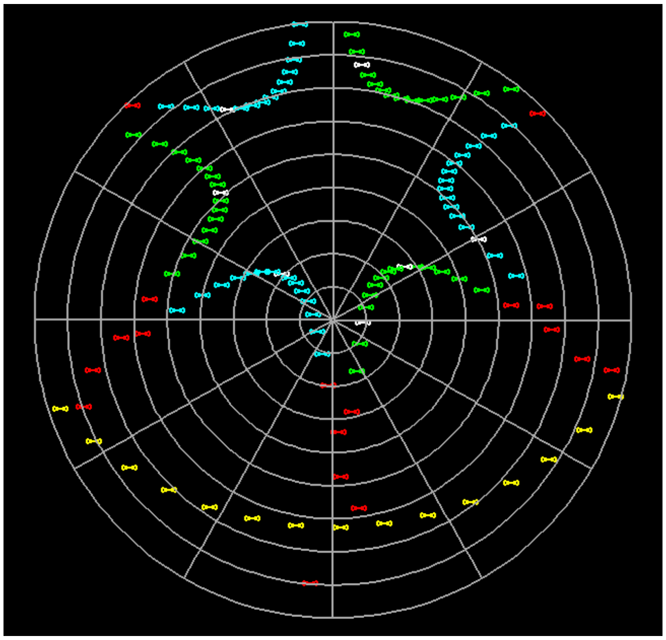

Figure 9, Active Arcs seen from Anchorage AK. Alaska is served by two active arcs, including the WNA and Pacific Arcs

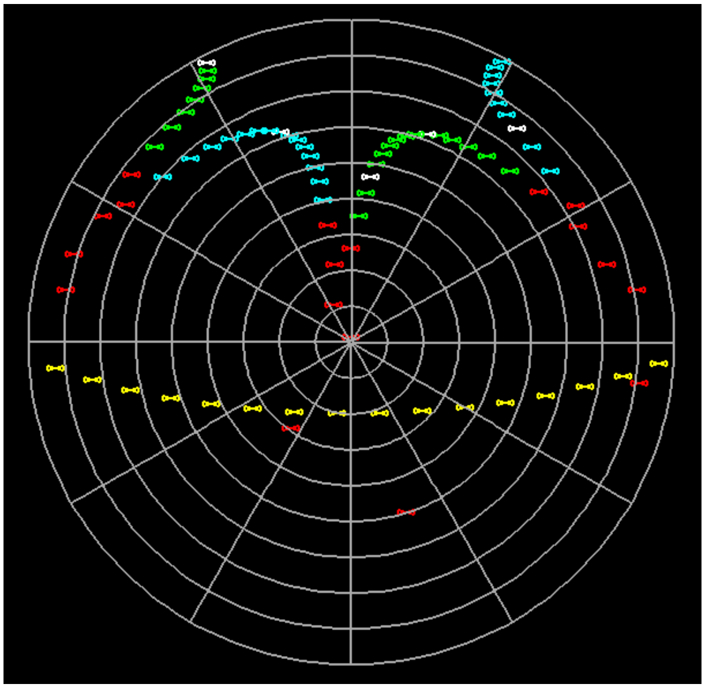

Figure 10, Active arcs seen from the island of Hawaii. Hawaii can be served by two active arcs, including the WNA and Pacific Arcs.

2.2 Further Virtual Geo Framework Advantages

While in an active arc, satellites using the Virtual Geo framework, such as the Pleiades satellites, are between 17,142 and 26,679 kilometers in altitude. Their apogee or maximum altitude however is only 75 percent of that of GSO satellites, and most times in the active arc are at an even smaller percentage of GSO altitude. Average latency is about 68% of that of geostationary satellites.

Since active arcs are at medium latitudes, they offer higher elevation angles to gateways than those to the GSO satellites from important temperate latitude markets. Satellites in the northern active arcs serve locations all the way to the North Pole with high elevation angles. Likewise, satellites in southern active arcs serve locations all the way to the South Pole with high elevation angles.

A system deploying into the Virtual Geo framework can deploy one ground track at a time and begin full time fully capable competitive service to large geographic areas —several national markets in each of three active arcs — with the first deployment. It can therefore begin earning revenue from this first deployment. This facilitates further system build-out by enabling earnings from early deployments to help fund further deployments, reducing financing burdens.

Furthermore, each satellite serves three active arcs, hence three markets in turn. Investment cost amortization is distributed over three markets. If a satellite fails, its loss results in a 20 percent loss of coverage time in each active arc in which it flew. Eighty percent of the time service will remain at full capability from the other four satellites in the ground track. The movement of satellites from active arc to active arc also simplifies satellite sparing and makes it more efficient. For example, it would be sufficient for the system to maintain one in-space spare for each ground track, rather than the more intensive sparing common for GSO satellites. A low earth orbit for a spare satellite enables it to be made available for any of multiple operational planes by exploiting the shorter LEO orbital period and other LEO orbital differences for timing a spare satellite orbit-raising maneuver to the needed Virtual Geo orbit.

Finally, all Virtual Geo framework satellites fly in highly elliptical orbits, with an apogee of 26,679 kilometers and a perigee of 1125 kilometers. With this type of orbit, retro-burns at apogee are feasible and economical for dropping a satellite’s perigee, in stages if desired, to cause end-of-life satellites to drop into the atmosphere for a disposal re-entry. Optionally, other burns can be used to reduce apogees or change the argument of perigee as part of orbit adjustment to optimize reentry timing and location. In all ground track cases retro burns can be timed to cause reentry in distant high latitude ocean areas safely away from any land areas. NSS will dispose of satellites through controlled reentry.

3 Pleiades Services to be Provided (47 C.F.R. § 25.114(c)(7))

Pleiades will provide state-of-the-art, affordable, digital fixed-satellite services directly to users throughout its global service area. Pleiades will be capable of accommodating very small earth terminals (on the order of 45 centimeters or 18 inches in diameter). Pleiades's gateway terminals will be larger, but may also be located on the premises of service providers or at the headquarters of corporate customers.

4 Pleiades System Description (47 C.F.R. §§ 25.114 (c)(4) – (c) (13) and 25.114 (d))

4.1 Orbit and Ground Track Details

The Pleiades system will deploy 5 satellites equally spaced in time in each of the two Virtual Geo framework northern ground tracks, Aurora I and Aurora II, and 5 more in Australis I, one of the two possible southern Virtual Geo framework ground tracks (the one illustrated in Figure 3). There are therefore a total of 15 deployed Pleiades satellites sharing the 9 active arcs. Of the fifteen satellites, there is an active satellite in each active arc at all times for a total of 9 active satellites (there are some 3-minute intervals when the incoming and outgoing satellite overlap in an active arc for handover processing).

Apart from the active satellites in a ground track — those in the three active arcs — there are generally two more Pleiades satellites in transit per ground track in non-radiating status. As a Pleiades satellite departs an active arc, another enters it and accepts handover from the departing satellite. So, considering the Virtual Geo framework active arcs shown in Figure 2 and Figure 3, only one green or one blue satellite per active arc would be a Pleiades satellite. Remaining green or blue satellites sharing the same active arcs could belong to other prospective future licensed systems, or possibly to future Pleiades expansion. Table 2 gives the orbital parameters for the Pleiades satellites and identifies the Virtual Geo framework ground track in which they operate.

The controlling factor for the orbit definition is the frozen ground track and frozen active arcs. As necessary the semi-major axes and the arguments of perigee of the respective orbits will be refined in on-going development, deployment, and operation to maintain and ensure these features. Satellite mean anomalies will be managed to maintain equal separations in time among all satellites in a ground track and alternating arrivals into the active arcs between neighboring northern active arcs (*i.e.* those belonging to the two different ground tracks in the northern hemisphere).

Table 2, Pleiades satellite orbital parameters

Ground Track → Orbit Parameter ↓	Aurora I™ Sats n=1-5	Aurora II™ Sats n=1-5	Australis I™ Sats n=1-5	Spare Satellites
Semimajor Axis	20281	20281	20281	7285
Eccentricity	0.63	0.63	0.63	0.05346
Inclination	63.435	63.435	63.435	63.435
Right Ascension of the Ascending Node	306.5 18.5 90.5 162.5 234.5	42.5 114.5 186.5 258.5 330.5	286.5 358.5 70.5 142.5 214.5	0 180 30
Argument of Perigee	270 270 270 270 270	270 270 270 270 270	90 90 90 90 90	270 270 90
Mean Anomaly	0 144 288 72 216	252 36 180 324 108	0 144 288 72 216	0 0 0

Epoch date: January 1, 2020

Table 3, Pleiades Orbit Tolerances

Orbital Element	**Tolerance**
Semi-major axis	200 meters
Apogee	500meters*
Perigee	500 meters*
Inclination	0.1 degree
Longitude of the Ascending Node**	0.2 degree
Mean Anomaly	0.2 degree

* Subject to constraint on semi-major axis

** Pleiades controls longitude of the Ascending node rather than right ascension of the ascending node, since the Virtual Geo framework is frozen-ground-track oriented rather than orbit-inertial-frame oriented. This optimizes satellite tracking, active arc placement, and active arc sharing.

Note that in Schedule S the Active Arc Begin Angle and Active Arc End Angle are the same, since the satellites in Northern active arcs begin operation upon passing 43 degrees Northbound, and end operation upon passing 43 degrees latitude Southbound Likewise satellites in Southern active arcs begin operation upon passing 43 degrees latitude Southbound and cease operations upon passing 43 degrees latitude Northbound.

4.2 Pleiades Minimum Elevation Angles in U.S. Service

Pleiades earth stations normally use the best active arc in view. The earth station will track the satellite in the active arc during its active arc pass. Table 4 shows the minimum encountered elevation angles to Pleiades satellites in the best active arc in view for various U.S. locations. The great majority of time elevation angles are higher than shown here. Pleiades provides fixed satellite service on a continuous basis to all 50 states, Puerto Rico and the U.S. Virgin Islands.

Table 4, Minimum elevation angles seen during an entire pass, site to satellite in best active arc

Place	Min elevation angle during a pass, Best active arc
Miami FL	38
San Diego CA	54
Hawaii	26
Prudhoe Bay AK	42
Brownsville TX	32
Bangor ME	61
Seattle WA	64
St Croix, USVI	35
Minot ND	46

4.3 Pleiades Satellite Payload and Channel Mapping

The Pleiades satellites will be 3-axis stabilized solar powered platforms stabilized to maintain accurate beam pointing at all times they are active. Three kilowatts of user link transmit power is available for allocation among user downlink signals. One hundred watts of RF power is available at Ka band for feeder link downlinks. Satellites go quiescent on departing an active arc until entering another active arc, when after a brief housekeeping transaction with TT&C, take over traffic from the same active arc's departing satellite. Satellites become active above 17,142 kilometers geocentric altitude.

4.3.1 Satellite Spectrum and Channel Mapping

NSS proposes to operate the Pleiades System in Ku- and lower Ka-band spectrum for user links and in Ka-band spectrum for feeder links[10]. Pleiades will now use the following spectrum:

Table 5, Pleiades spectrum

	User Terminal Frequency Bands		Gateway Terminal Frequency Bands	
	Uplink	Downlink	Uplink	Downlink
Frequency Bands	14.0-14.5 GHz 17.8-18.1 GHz	11.2-12.7 GHz	27.5 -29.1 GHz 29.5-29.9GHz	18.1-19.3 GHz 19.7-20.2 GHz
Total Bandwidth	800 MHz	1,500 MHz	2,000 MHz	1,700 MHz

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[10] NSS' earlier filing with the FCC for landing rights proposed using C-band spectrum along with Ku and lower Ka band spectrum for feeder links. NSS has moved all feeder link spectrum to Ka band as a consequence of the Commission's reallocation of C-band downlink spectrum in the contiguous United States.

Uplink and downlink spectra are divided into successive 25 MHz system channels for purposes of allocating traffic to system channels and managing system channels to beams and geographic locations. The satellite maps each 25-Megahertz system channel among uplink, downlink, and crosslink beams independently as managed by the Pleiades Network Control Center and Gateways in response to traffic demand so as best to allocate capacity to beams. This also means that the satellite emits in each beam only that power to handle the traffic load in that beam at that time. This reduces interference potentials and increases satellite efficiency. The overall satellite payload architecture is illustrated in Figure 14.

Pleiades uses a 1-in-7 frequency reuse scheme in the satellite's user or service beams, including reusing a given band on the opposite circular polarization. With 313 beams this results in a potential frequency reuse of 39 times per satellite. Each active satellite reuses the same spectrum again with the same reuse factor, or a total of 351 times over the constellation of nine simultaneously active Pleiades satellites. This is of course a structural maximum determined by the system architecture, where the actual frequency reuse achieved at any given time, as for any other system, will depend on system build-out, loading and load distribution. Available satellite RF power may limit total simultaneous frequency reuse. Pleiades satellites can simultaneously support as many as 70 fully loaded beams, for 10 times frequency reuse per satellite under this boundary scenario. With light beam loading the satellite can power all beams. As a practical matter traffic will likely be distributed over a range of beams, with variations in loading beam to beam. Therefore, actual frequency reuse will be intermediate and is scenario dependent.

Each Gateway reuses the same spectrum for accessing satellites, resulting in two-fold frequency reuse (right and left circular polarization) per Gateway times the number of Gateways deployed worldwide, which could easily number several dozen with buildout over the various service regions. Pleiades foresees as many as 10-12 Gateways serving North America. Moreover, flexible mapping of spectrum to beams in response to traffic ensures Pleiades makes the most efficient use of spectrum

Feeder uplink system channels can be mapped to user downlink channels to a maximum of 375 MHz spectrum per user link beam, and user uplink channels can be mapped to feeder downlink channels to a maximum of 200 MHz spectrum per user link beam. As necessary multiple 25 MHz beams can be combined as a group, creating a single band equal to the multiple of 25 MHz system channels, up to 100 MHz, to a single system path to support higher throughput user channels. Beams in areas with lower demand will not be assigned a full allocation of system channels, allowing unnecessary channels there to be diverted to other beams with demand. This distributed mapping will change as traffic loading changes. This further improves spectrum allocation efficiency.

The number of user link beams a particular Pleiades Gateway will handle at any given time is responsively controlled by the NCC and will depend on beam loading and NCC assignments to that Gateway in response to traffic demand, network management, and any projected NGSO spectrum sharing encounters.

One or more user channels -- the channel bandwidth occupied by individual user terminals -- are mapped into system channels for system routing. Gateways manage the mapping of user channels to 25 MHz system channels or larger system channel groups as necessary to respond to demand.

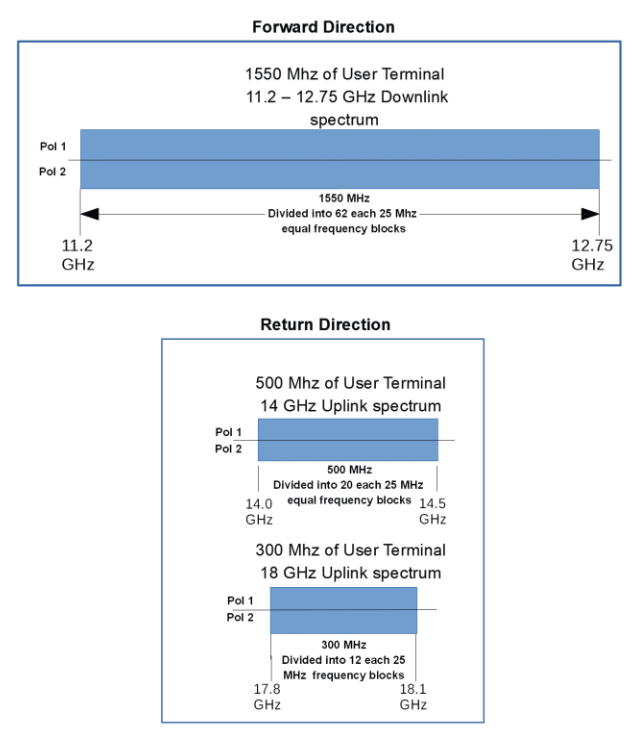

Figure 11, Pleiades user link spectrum

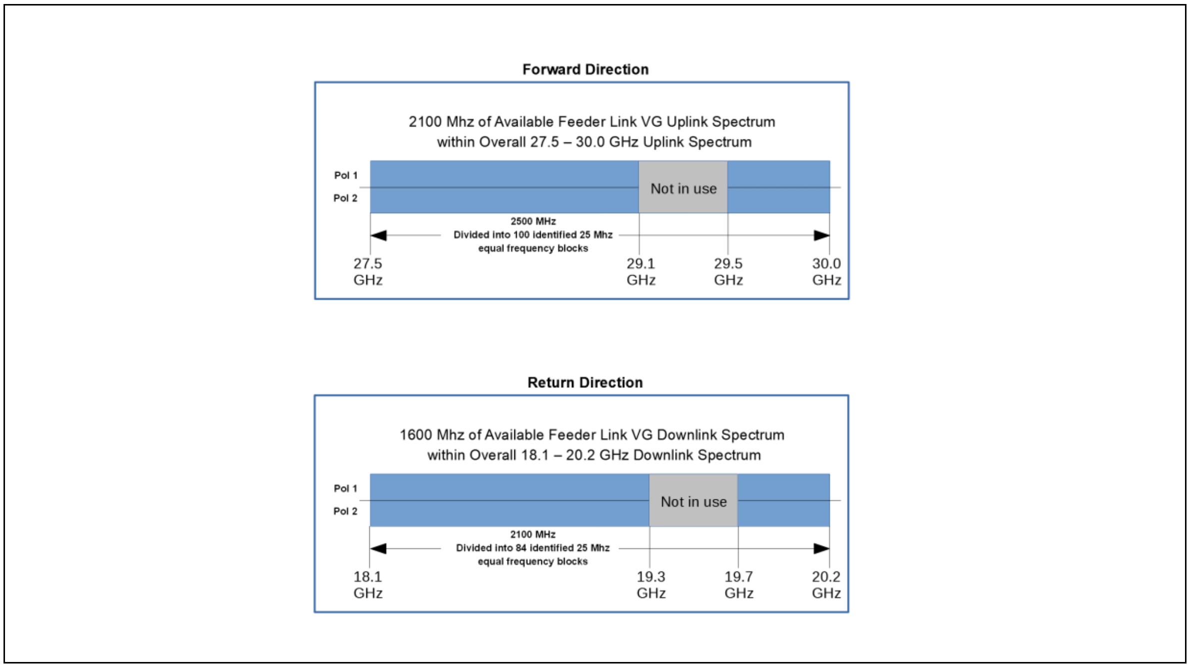

Figure 12, Pleiades feeder link spectrum

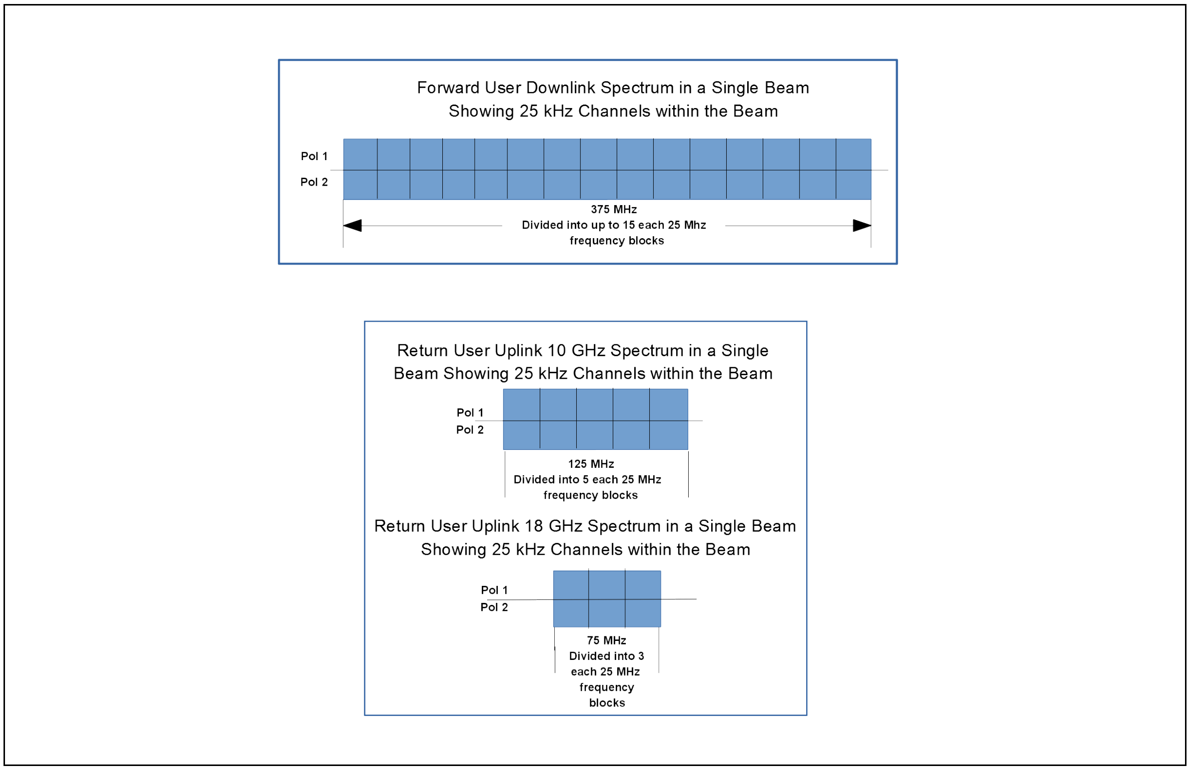

Figure 13, Dividing per-beam user link spectrum into system channels for mapping to feeder links.

Table 6, Channel identities, characteristics, and applications (next 5 pages). As noted in the preceding figures, some of the identified and numbered feeder link channels will not be in use.

Receive Channels	**Frequency**	**BW**	**Use**		**Transmit channels**	**Frequency**	**BW**	**Use**
RU01	14,012.5	25.0	User Link		TU01	11,212.5	25.0	User Link
RU02	14,037.5	25.0	User Link		TU02	11,237.5	25.0	User Link
RU03	14,062.5	25.0	User Link		TU03	11,262.5	25.0	User Link
RU04	14,087.5	25.0	User Link		TU04	11,287.5	25.0	User Link
RU05	14,112.5	25.0	User Link		TU05	11,312.5	25.0	User Link
RU06	14,137.5	25.0	User Link		TU06	11,337.5	25.0	User Link
RU07	14,162.5	25.0	User Link		TU07	11,362.5	25.0	User Link
RU08	14,187.5	25.0	User Link		TU08	11,387.5	25.0	User Link
RU09	14,212.5	25.0	User Link		TU09	11,412.5	25.0	User Link
RU010	14,237.5	25.0	User Link		TU10	11,437.5	25.0	User Link
RU11	14,262.5	25.0	User Link		TU11	11,462.5	25.0	User Link
RU12	14,287.5	25.0	User Link		TU12	11,487.5	25.0	User Link
RU13	14,312.5	25.0	User Link		TU13	11,512.5	25.0	User Link
RU14	14,337.5	25.0	User Link		TU14	11,537.5	25.0	User Link
RU15	14,362.5	25.0	User Link		TU15	11,562.5	25.0	User Link
RU16	14,387.5	25.0	User Link		TU16	11,587.5	25.0	User Link
RU17	14,412.5	25.0	User Link		TU17	11,612.5	25.0	User Link
RU18	14,437.5	25.0	User Link		TU18	11,637.5	25.0	User Link
RU19	14,462.5	25.0	User Link		TU19	11,662.5	25.0	User Link
RU20	14,487.5	25.0	User Link		TU20	11,687.5	25.0	User Link
RU21	17,812.5	25.0	User Link		TU21	11,712.5	25.0	User Link
RU22	17,837.5	25.0	User Link		TU22	11,737.5	25.0	User Link
RU23	17,862.5	25.0	User Link		TU23	11,762.5	25.0	User Link
RU24	17,887.5	25.0	User Link		TU24	11,787.5	25.0	User Link
RU25	17,912.5	25.0	User Link		TU25	11,812.5	25.0	User Link
RU26	17,937.5	25.0	User Link		TU26	11,837.5	25.0	User Link
RU27	17,962.5	25.0	User Link		TU27	11,862.5	25.0	User Link
RU28	17,987.5	25.0	User Link		TU28	11,887.5	25.0	User Link
RU29	18,012.5	25.0	User Link		TU29	11,912.5	25.0	User Link
RU30	18,037.5	25.0	User Link		TU30	11,937.5	25.0	User Link

Receive Channels	**Frequency**	**BW**	**Use**		**Transmit channels**	**Frequency**	**BW**	**Use**
RU31	18,062.5	25.0	User Link		TU31	11,962.5	25.0	User Link
RU32	18,087.5	25.0	User Link		TU32	11,987.5	25.0	User Link
					TU33	12,012.5	25.0	User Link
					TU34	12,037.5	25.0	User Link
RF01	27,515.0	20.0	Feeder link		TU35	12,062.5	25.0	User Link
RF02	27,537.5	25.0	Feeder link		TU36	12,087.5	25.0	User Link
RF03	27,562.5	25.0	Feeder link		TU37	12,112.5	25.0	User Link
RF04	27,587.5	25.0	Feeder link		TU38	12,137.5	25.0	User Link
RF05	27,612.5	25.0	Feeder link		TU39	12,162.5	25.0	User Link
RF06	27,637.5	25.0	Feeder link		TU40	12,187.5	25.0	User Link
RF07	27,662.5	25.0	Feeder link		TU41	12,212.5	25.0	User Link
RF08	27,687.5	25.0	Feeder link		TU42	12,237.5	25.0	User Link
RF09	27,712.5	25.0	Feeder link		TU43	12,262.5	25.0	User Link
RF10	27,737.5	25.0	Feeder link		TU44	12,287.5	25.0	User Link
RF11	27,762.5	25.0	Feeder link		TU45	12,312.5	25.0	User Link
RF12	27,787.5	25.0	Feeder link		TU46	12,337.5	25.0	User Link
RF13	27,812.5	25.0	Feeder link		TU47	12,362.5	25.0	User Link
RF14	27,837.5	25.0	Feeder link		TU48	12,387.5	25.0	User Link
RF15	27,862.5	25.0	Feeder link		TU49	12,412.5	25.0	User Link
RF16	27,887.5	25.0	Feeder link		TU50	12,437.5	25.0	User Link
RF17	27,912.5	25.0	Feeder link		TU51	12,462.5	25.0	User Link
RF18	27,937.5	25.0	Feeder link		TU52	12,487.5	25.0	User Link
RF19	27,962.5	25.0	Feeder link		TU53	12,512.5	25.0	User Link
RF20	27,987.5	25.0	Feeder link		TU54	12,537.5	25.0	User Link
RF21	28,012.5	25.0	Feeder link		TU55	12,562.5	25.0	User Link
RF22	28,037.5	25.0	Feeder link		TU56	12,587.5	25.0	User Link
RF23	28,062.5	25.0	Feeder link		TU57	12,612.5	25.0	User Link
RF24	28,087.5	25.0	Feeder link		TU58	12,637.5	25.0	User Link
RF25	28,112.5	25.0	Feeder link		TU59	12,662.5	25.0	User Link
RF26	28,137.5	25.0	Feeder link		TU60	12,687.5	25.0	User Link
RF27	28,162.5	25.0	Feeder link					
RF28	28,187.5	25.0	Feeder link					
RF29	28,212.5	25.0	Feeder link		TF01	18,115.0	20.0	Feeder Link

Receive Channels	**Frequency**	**BW**	**Use**		**Transmit channels**	**Frequency**	**BW**	**Use**
RF30	28,237.5	25.0	Feeder link		TF02	18,137.5	25.0	Feeder Link
RF31	28,262.5	25.0	Feeder link		TF03	18,162.5	25.0	Feeder Link
RF32	28,287.5	25.0	Feeder link		TF04	18,187.5	25.0	Feeder Link
RF33	28,312.5	25.0	Feeder link		TF05	18,212.5	25.0	Feeder Link
RF34	28,337.5	25.0	Feeder link		TF06	18,237.5	25.0	Feeder Link
RF35	28,362.5	25.0	Feeder link		TF07	18,262.5	25.0	Feeder Link
RF36	28,387.5	25.0	Feeder link		TF08	18,287.5	25.0	Feeder Link
RF37	28,412.5	25.0	Feeder link		TF09	18,312.5	25.0	Feeder Link
RF38	28,437.5	25.0	Feeder link		TF10	18,337.5	25.0	Feeder Link
RF39	28,462.5	25.0	Feeder link		TF11	18,362.5	25.0	Feeder Link
RF40	28,487.5	25.0	Feeder link		TF12	18,387.5	25.0	Feeder Link
RF41	28,512.5	25.0	Feeder link		TF13	18,412.5	25.0	Feeder Link
RF42	28,537.5	25.0	Feeder link		TF14	18,437.5	25.0	Feeder Link
RF43	28,562.5	25.0	Feeder link		TF15	18,462.5	25.0	Feeder Link
RF44	28,587.5	25.0	Feeder link		TF16	18,487.5	25.0	Feeder Link
RF45	28,612.5	25.0	Feeder link		TF17	18,512.5	25.0	Feeder Link
RF46	28,637.5	25.0	Feeder link		TF18	18,537.5	25.0	Feeder Link
RF47	28,662.5	25.0	Feeder link		TF19	18,562.5	25.0	Feeder Link
RF48	28,687.5	25.0	Feeder link		TF20	18,587.5	25.0	Feeder Link
RF49	28,712.5	25.0	Feeder link		TF21	18,612.5	25.0	Feeder Link
RF50	28,737.5	25.0	Feeder link		TF22	18,637.5	25.0	Feeder Link
RF51	28,762.5	25.0	Feeder link		TF23	18,662.5	25.0	Feeder Link
RF52	28,787.5	25.0	Feeder link		TF24	18,687.5	25.0	Feeder Link
RF53	28,812.5	25.0	Feeder link		TF25	18,712.5	25.0	Feeder Link
RF54	28,837.5	25.0	Feeder link		TF26	18,737.5	25.0	Feeder Link
RF55	28,862.5	25.0	Feeder link		TF27	18,762.5	25.0	Feeder Link
RF56	28,887.5	25.0	Feeder link		TF28	18,787.5	25.0	Feeder Link
RF57	28,912.5	25.0	Feeder link		TF29	18,812.5	25.0	Feeder Link
RF58	28,937.5	25.0	Feeder link		TF30	18,837.5	25.0	Feeder Link
RF59	28,962.5	25.0	Feeder link		TF31	18,862.5	25.0	Feeder Link
RF60	28,987.5	25.0	Feeder link		TF32	18,887.5	25.0	Feeder Link
RF61	29,012.5	25.0	Feeder link		TF33	18,912.5	25.0	Feeder Link
RF62	29,037.5	25.0	Feeder link		TF34	18,937.5	25.0	Feeder Link

Receive Channels	**Frequency**	**BW**	**Use**		**Transmit channels**	**Frequency**	**BW**	**Use**
RF63	29,062.5	25.0	Feeder link		TF35	18,962.5	25.0	Feeder Link
RF64	29,087.5	25.0	Feeder link		TF36	18,987.5	25.0	Feeder Link
					TF37	19,012.5	25.0	Feeder Link
RG01	29,512.5	25.0	Feeder link		TF38	19,037.5	25.0	Feeder Link
RG02	29,537.5	25.0	Feeder link		TF39	19,062.5	25.0	Feeder Link
RG03	29,562.5	25.0	Feeder link		TF40	19,087.5	25.0	Feeder Link
RG04	29,587.5	25.0	Feeder link		TF41	19,112.5	25.0	Feeder Link
RG05	29,612.5	25.0	Feeder link		TF42	19,137.5	25.0	Feeder Link
RG06	29,637.5	25.0	Feeder link		TF43	19,162.5	25.0	Feeder Link
RG07	29,662.5	25.0	Feeder link		TF44	19,187.5	25.0	Feeder Link
RG08	29,687.5	25.0	Feeder link		TF45	19,212.5	25.0	Feeder Link
RG09	29,712.5	25.0	Feeder link		TF46	19,237.5	25.0	Feeder Link
RG10	29,737.5	25.0	Feeder link		TF47	19,262.5	25.0	Feeder Link
RG11	29,762.5	25.0	Feeder link		TF48	19,287.5	25.0	Feeder Link
RG12	29,787.5	25.0	Feeder link					
RG13	29,812.5	25.0	Feeder link		TF65	19,712.5	25.0	Feeder Link
RG14	29,837.5	25.0	Feeder link		TF66	19,737.5	25.0	Feeder Link
RG15	29,862.5	25.0	Feeder link		TF67	19,762.5	25.0	Feeder Link
RG16	29,887.5	25.0	Feeder link		TF68	19,787.5	25.0	Feeder Link
RG17	29,912.5	25.0	Feeder link		TF69	19,812.5	25.0	Feeder Link
RG18	29,937.5	25.0	Feeder link		TF70	19,837.5	25.0	Feeder Link
RG19	29,962.5	25.0	Feeder link		TF71	19,862.5	25.0	Feeder Link
RG20	29,985.0	20.0	Feeder link		TF72	19,887.5	25.0	Feeder Link
					TF73	19,912.5	25.0	Feeder Link
					TF74	19,937.5	25.0	Feeder Link
RS01	14382.8125	15.625	User Link		TF75	19,962.5	25.0	Feeder Link
RS02	14398.4375	15.625	User Link		TF76	19,987.5	25.0	Feeder Link
RS03	14414.0625	15.625	User Link		TF77	20,012.5	25.0	Feeder Link
RS04	14429.6875	15.625	User Link		TF78	20,037.5	25.0	Feeder Link
RS05	14445.3125	15.625	User Link		TF79	20,062.5	25.0	Feeder Link
RS06	14460.9375	15.625	User Link		TF80	20,087.5	25.0	Feeder Link
RS07	14476.5625	15.625	User Link		TF81	20,112.5	25.0	Feeder Link
RS08	14492.1850	15.625	User Link		TF82	20,137.5	25.0	Feeder Link

Receive Channels	**Frequency**	**BW**	**Use**		**Transmit channels**	**Frequency**	**BW**	**Use**
	14492.1850	15.62	TT&C*		TF83	20,162.5	25.0	Feeder Link
					TF84	20,185.0	20.0	Feeder Link
RT28-L	27,502.5	5.0	TT&C		TT18	18,102.5	5.0	TT&C
RT28-U	29,997.5	5.0	TT&C		TT21	21,197.5	5.0	TT&C

Each major service area will be served by as many as 12 gateways to fully exploit satellite coverage, provide sufficient regional capacity, and reuse spectrum effectively.[11] Each gateway will reuse the same gateway Ka band spectrum. Gateways are sited to ensure a high RF isolation among them.

As needed, the satellite is also capable of mapping user link channels to user link channels and uplink or downlink channels to crosslink channels.

4.4 Pleiades Satellite Payload

The Pleiades satellite uses an intermediate-frequency (IF)-switching payload; a programmable and responsive IF switch interconnects channels among the various external receive to transmit links (user receive and transmit, feeder receive and transmit, crosslink receive and transmit) as needed to create the necessary connectivity to support the present demand. Switching is controlled by the payload processor, which is in turn controlled by instructions via TT&C from the SCC in coordination with the relevant NCCs for the active arc.

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[11] The number of Gateways will be determined by the number of active beams in service and actual and anticipated traffic loading. The number will increase as active beams and anticipated traffic demand increases.

Pleiades satellites use 1.5-meter-diameter 313-beam user link phased array antennas, transmit and receive, to serve terrestrial markets. These beams use a 1-in-7 frequency/phase reuse scheme to maintain isolation among neighboring beams. Likewise, the satellites use 2-meter feeder link multi-beam antennas to serve the terrestrial gateway nodes transmit and receive, which are entry points to terrestrial networks. These feeder link satellite antennas create a beam to serve each Gateway with high isolation among the various feeder link beams.

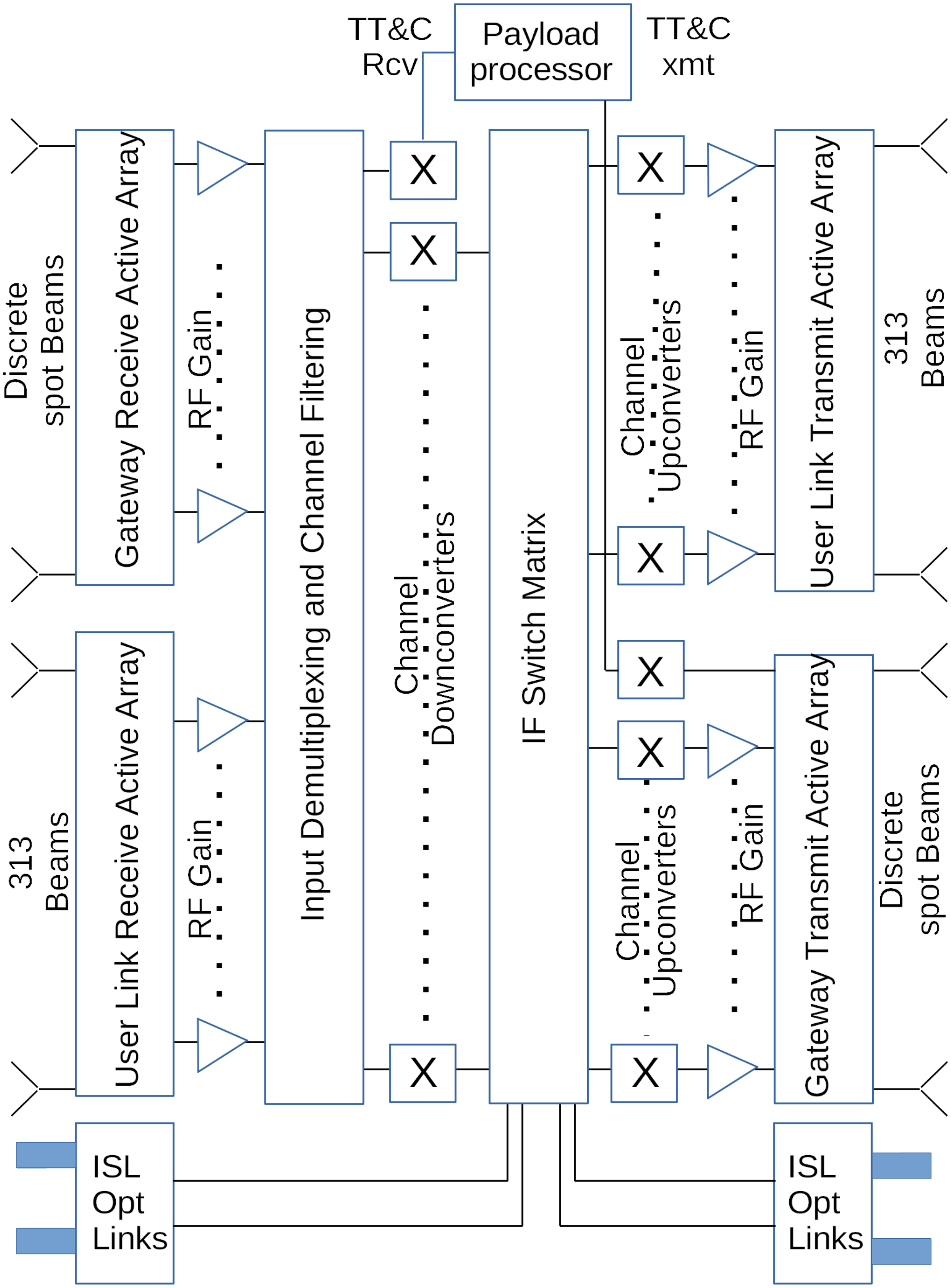

Figure 14, Pleiades satellite payload simplified block diagram

4.4.1 Illustrative Satellite Antenna Patterns

As NGSO satellites, Pleiades satellites are in constant motion relative to the earth-fixed frame of reference. However, while in an active arc the satellites maintain pointing to a defined service area for that arc. Nevertheless, the perspective to that service area from the satellite changes with satellite position and altitude. It is not possible therefore to present a definitive antenna pattern as painted on the ground. Included here are some representative antenna patterns as projected on the earth over North America.

As mentioned, the user link satellite antennas are capable of projecting as many as 313 beams in the form of a hex-pack into a service area. There are always two satellites actively serving North America, one in the WNA active arc and one in the ENA active arc, Hence at all times there will be an overlay of two hex packs of beams over North America, one optimized for Eastern area service and one optimized for Western area service. The following figures show several examples of these beam-packs. There will also be one at all times over other Northern hemisphere areas such as the Pacific, Europe, West Asia and East Asia.

The user beam hex pack centers are kept aimed at a fixed ground target during transit. They are also fixed rotationally with respect to the velocity vector of the earth's surface at the target point. This arrangement minimizes the need for beam handoffs.

Transmit and receive beam packs are congruent. All satellites use the same antenna designs and beam configurations. Antenna beam footprints will move somewhat during active arc passage, including some expansion and contraction. Figure 15 and

Figure 16 illustrate the beam packs from the WNA and ENA satellites. The large outer circle represents an outer envelope of the beams and is not an actual beam. The next two figures show beam contours from nadir pointing beams for user- and feeder-link antennas, respectively. Figure 17 shows the array of beams in service in the North Pacific active arc, another active arc in the ground track serving Eastern North America (see

Table 1).

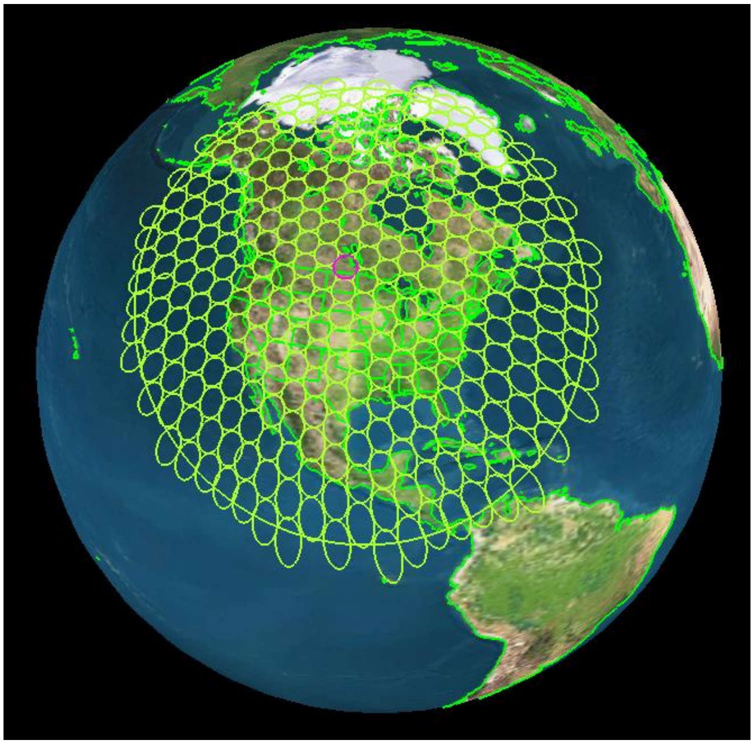

Figure 15, Beam pack of WNA satellite at nominal operational altitude over North America.

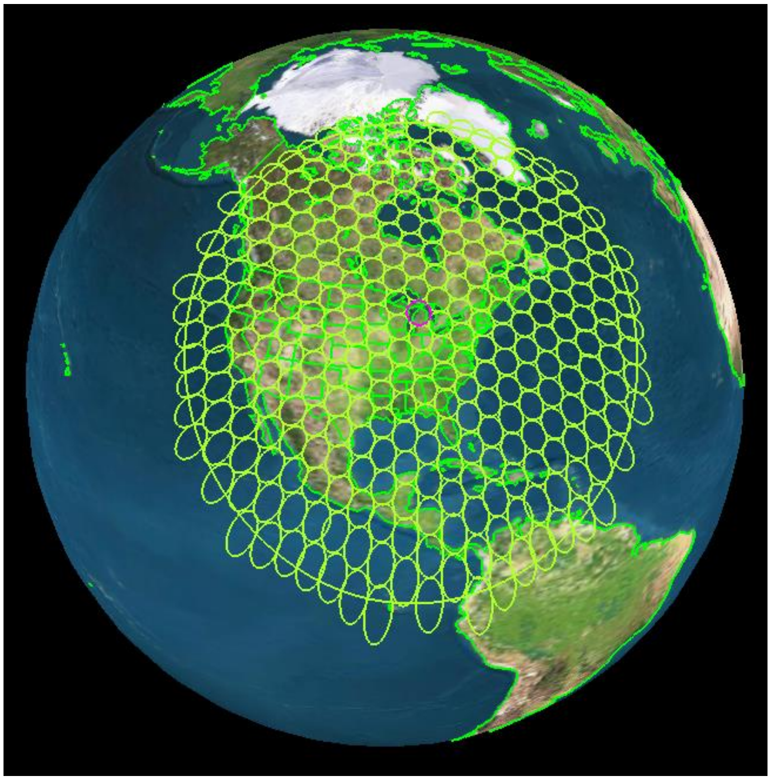

Figure 16, Beam Pack of ENA satellite at nominal altitude over North America

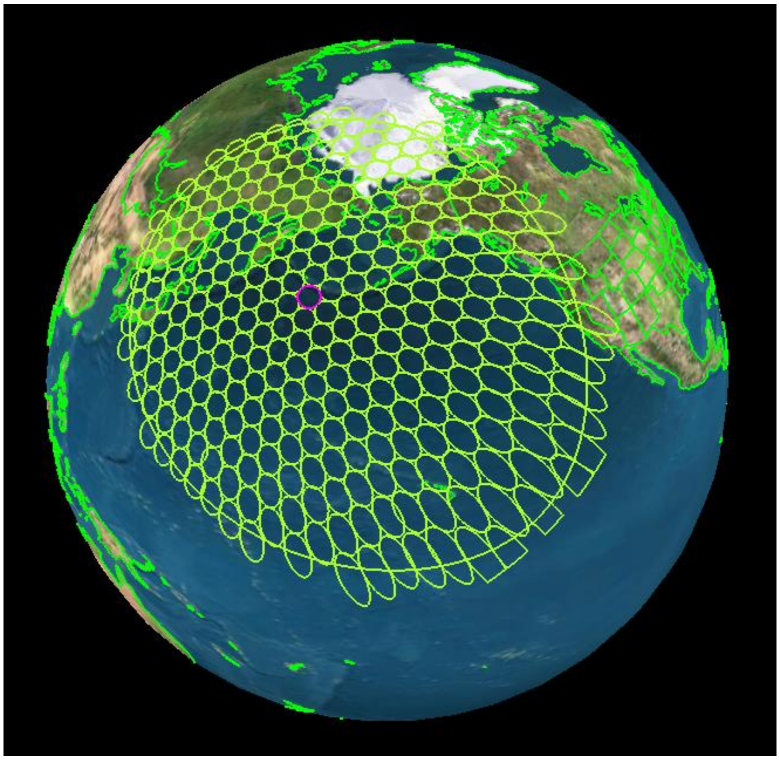

Figure 17, Beam array from the N Pacific active arc, nominal case

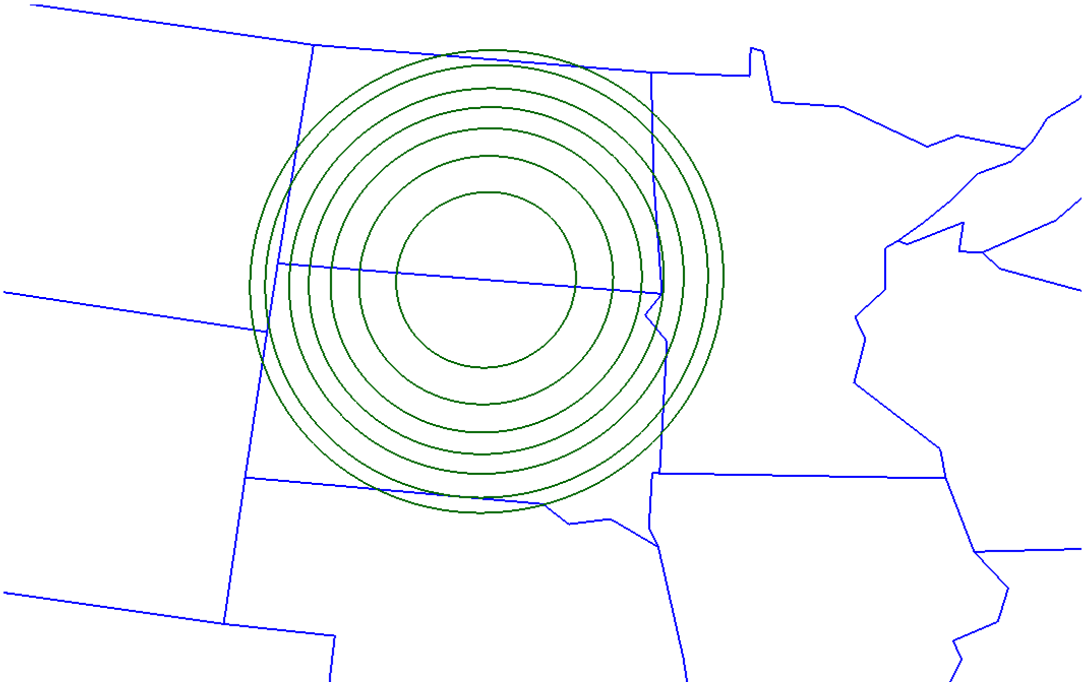

Figure 18, Contours of a single nadir pointing user link downlink 11.9 GHz beam, showing -2, -4, -6, -8, -10, -15, -20 dB contours from peak. Uplink user beams are congruent with this.

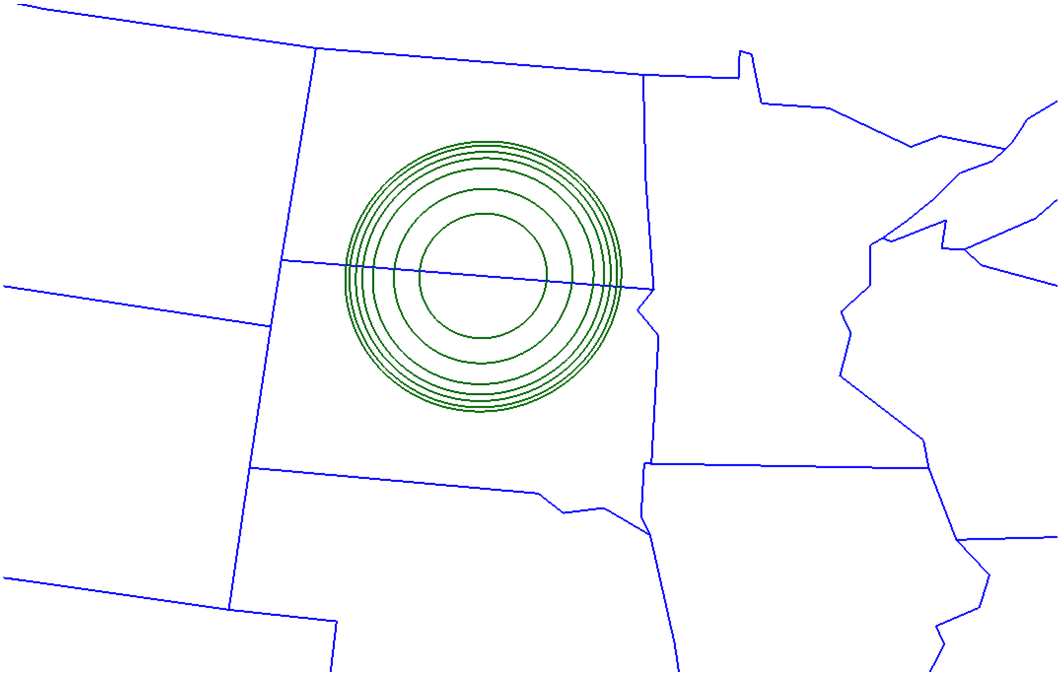

Figure 19, Representative single feeder link nadir pointing downlink 19 GHz beam contours, showing -2, -4, -6, -8, -10, -15, and -20 dB contours from peak. Uplink Feeder29 GHz link beams are congruent with this.

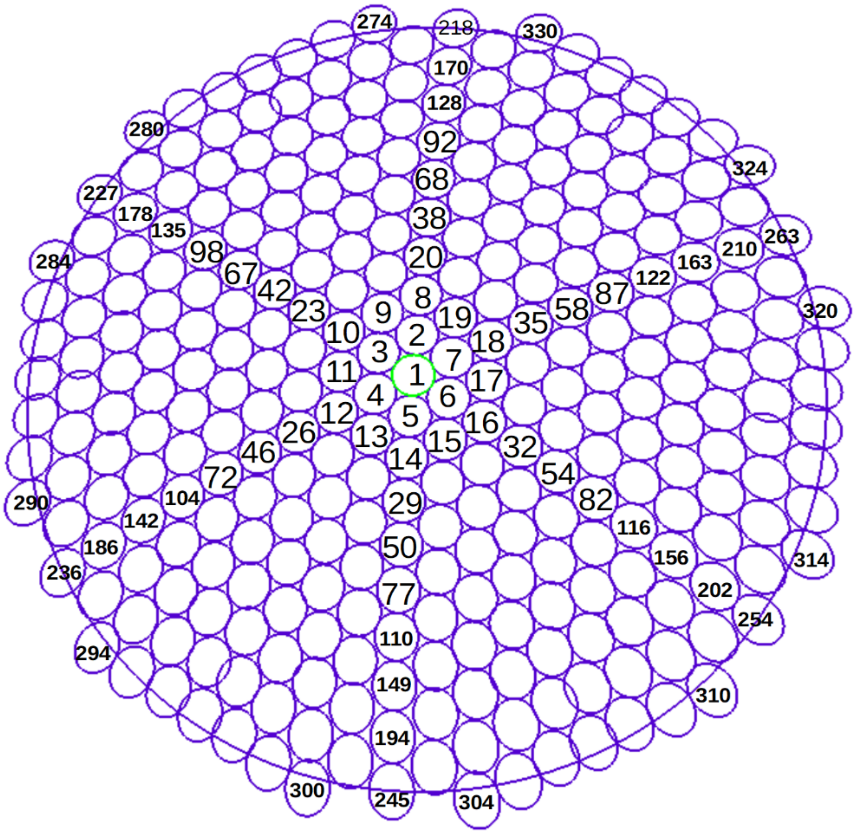

Figure 20, The 313 Pleiades user beams.

Pleiades satellite user beams are numbered #1 as the center beam shown blue above, #2 is the beam directly above, #3-7 counterclockwise around beam 1 from #2, #8 above #2, then counting up counterclockwise outside #2-7 to #19. And so on for each ring proceeding out from the center. Beam numbers for the principle axes are shown in the figure above. To find a beam number not shown, go to the number less than and closest to the sought number and count up to the desired number proceeding counterclockwise around that ring.

4.5 Pleiades Satellite Beam Details

Table 7 presents the beam identities, frequencies and polarizations, and beam use for all satellite beams.

Table 7, Pleiades beam characteristics

Beam ID	Frequencies	Polarization	Application
Receive Beams			
SR01	14000–14125	RHC	Service
SR02	14000–14125	L	Service
SR03	14125–14250	R	Service
SR04	14125–14250	L	Service
SR05	14250–14375	R	Service
SR06	14250–14375	L	Service
SR07	14375–14500	R	Service
SR11	17800–17875	R	Service
SR12	17800–17875	L	Service
SR13	17875–17950	R	Service
SR14	17875–17950	L	Service
SR15	17950–18025	R	Service
SR16	17950–18025	R	Service
SR17	18025–18100	R	Service
OR18	18025–18100	L	OWPC
SR21	14375.000–14390.625	L	Service
SR22	14390.625–14406.250	L	Service
SR23	14406.250–14421.875	L	Service
SR24	14421.875–14437.500	L	Service
SR25	14437.500–14453.125	L	Service
SR26	14453.125–14468.750	L	Service
SR27	14468.750–14484.375	L	Service
OR28	14484.375–14500.000	L	OWPC
FR31	27500–29100	R	Feeder Links
FR32	27500–29100	L	Feeder Links

Beam ID	Frequencies	Polarization	Application
FR33	29100–30000	R	Feeder Links
FR34	29100–30000	L	Feeder Links
Transmit Beams			
ST01	11200–11575	R	Service
ST02	11200–11575	L	Service
ST03	11575–11950	R	Service
ST04	11575–11950	L	Service
ST05	11950–12325	R	Service
ST06	11950–12325	L	Service
ST07	12325–12700	L	Service
ST11	12325.000–12371.875	R	Service
ST12	12371.875–12418.750	R	Service
ST13	12418.750–12465.625	R	Service
ST14	12465.625–12512.500	R	Service
ST15	12512.500–12559.375	R	Service
ST16	12559.375–12606.250	R	Service
ST17	12606.250–12653.125	R	Service
OT18	12653.125–12700.000	R	OWPC
FT51	18100–19300	R	Feeder Links
FT52	18100–19300	L	Feeder Links
FT53	19300–20200	R	Feeder Links
FT54	19300–20200	L	Feeder Links

4.6 Pleiades Ground Facilities

The Pleiades terrestrial component includes

- User Terminals (UT) of several types, providing data services to users anywhere in the service area, interconnecting through the satellite serving their respective areas to a Gateway serving that area. User Terminals can also interconnect through one or more satellites directly with other user terminals in the system, either those in the same area served by the same satellite or to terminals served by another satellite via satellite crosslinks,

- Gateways (GW) as the connection point between the satellites in a service area and the ground networks in that area,

- Network Control Centers (NCC) for managing the operation of the network, subscriber management, and the allocation of resources among network elements,

- System Control Center (SCC), an NCC with overall system monitoring, management, and control responsibility, and

- Telemetry, Tracking and Command (TT&C) facilities for managing the satellite bus including attitude and maneuver, deployments and activation, power and thermal management, end-of-life disposal and other functions having to do with spacecraft bus operation and bus-to-payload interfaces. TT&C facilities will generally be collocated with the primary and secondary SCCs.

4.6.1 Pleiades User Terminals

Pleiades User Terminals will exist initially in three varieties, distinguished by the size of their antennas and their supported data rates. Most subscribers, including the home and small business subscriber markets, will use the subscriber terminal employing a 0.45-meter antenna. This terminal will sustain nominally 27 megabits per second for forward throughput and 24 megabits per second of return (user to Gateway) throughput.

The 1-meter subscriber terminal will provide throughputs of 79 megabits per second forward and 35 megabits per second return. The 2-meter subscriber terminal will support over 150 megabits per second forward and 63 megabits per second return.

All user terminals use electronically steered antennas to track the satellite over its pass, and to switch instantaneously from a setting to a rising satellite.

4.6.2 Pleiades Gateways

Gateways are the ground network entry point for traffic passing over Pleiades satellites. Starting with two, the number of gateways serving North America could grow to as many as ten, of which half would be located in the United States at various scattered locations across the country. Gateways will handle traffic to and from the satellites. Gateways can handle from 8 fully loaded to as many as 160 minimally loaded beams on a satellite in the forward direction, and from 16 fully loaded to as many as 120 minimally loaded beams on a satellite in the return direction. As traffic loading increases, the number of beams handled by a Gateway will decrease and the number of deployed Gateways over the service area will increase.

Gateways handle real-time traffic, allocating spectrum per user connection as appropriate for the beam and the service involved. Gateways coordinate with NCCs for spectrum, beam, and subscriber management.

Gateways will each use three tracking 9.1-meter Ka-band narrow-beam antennas for feeder link uplinks and downlinks. This enables Gateways to handover from setting to rising satellite seamlessly with an available spare, or to use the third antenna in a second active arc, depending on Gateway location. Many Gateway locations will also employ and interconnect to a site-diversity location at a distance of 10 to 20 miles from the main location having another one or two antennas with baseband conversion equipment for mitigating rain losses when they occur.

4.6.3 Pleiades Network Control Centers

There is generally one NCC per service area, which could be a geographic or national area. NSS plans to deploy one NCC to the United States for national network control (the US-NCC). The US NCC would coordinate with the SCC for national-level resource allocations, intersystem coordination, and trans-national operations. Since the NCC responsibility spans the Eastern and Western active arcs, the US-NCC will be located centrally in the United States, prospectively in Sioux Falls, South Dakota or in that vicinity.

4.6.4 Pleiades System Control Center

As a Canadian system, the Pleiades System Control Center will be in Central Canada, prospectively in Calgary, Alberta. The SCC there will also host a Canadian NCC and the Pleiades TT&C facility.

4.6.5 TT&C

TT&C for the Pleiades system will be handled through the Canadian SCC from Canada.

4.7 Pleiades Services

The Pleiades System offers high speed two-way digital connectivity from remote locations through its satellites to gateway facilities with access to various terrestrial networks such as the internet or to private networks. Pleiades also offers direct terminal-to-terminal connectivity for non-public networks and potentially lower latency by avoiding gateway and terrestrial network delays. These connections can be routed as necessary over inter-satellite links. As discussed, user terminal types are characterized by their antenna size and throughput.

4.7.1 Link Budgets

Table 8 through Table 10 present link budgets for the Pleiades System.

Table 8, Forward Link Budget

Pleiades Link Budget
Gateway-to-User (28/12 GHz)

Link Parameters		**Clear Sky nominal location, apogee, elev angle = 25° to UT, 20° to GW**		
Link Geometry:				
GW range to satellite	(km)	29403	29403	29403
UT range to satellite	(km)	28594	28594	28594
Uplink (per carrier):				
Carrier Frequency	(MHz)	28300	28300	28300
Tx E/S Antenna Diameter	(m)	**9.1**	9.1	9.1
Tx E/S Power to Antenna terminals	(W)	**0.050**	0.034	0.025
Tx E/S PSD to Antenna - per 4 kHz	(dBW/4kHz)	-47.9	-54.3	-58.6
Tx E/S PSD to Antenna - per Hz	(dBW/Hz)	-83.9	-90.3	-94.6
antenna efficiency		0.6	0.6	0.6
Tx E/S Antenna Gain (60% eff.)	(dB)	66.3	66.3	66.3
Tx E/S EIRP per Carrier	(dBW)	53.3	51.6	50.3
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	210.8	210.8	210.8
Spreading Loss	(dB)	160.4	160.4	160.4
Satellite:				
Total Power Flux at Satellite	(dBW/m2)	-107.5	-109.3	-110.6
Satellite Rx Gain towards Tx E/S (beam edge	(dBi)	**54.5**	54.5	54.5
Diameter of Rcv antenna	m	2.0	2.0	2.0
antenna efficiency		0.8	0.8	0.8
Received Signal Power	(dBW)	-103.5	-105.3	-106.6
Satellite Receive System Noise Temperature	(K)	**600**	600	600
Satellite G/T towards Tx E/S (beam edge)	(dB/K)	26.7	26.7	26.7
(C/T) Thermal Uplink	(dBW/K)	-131.3	-133.1	-134.4
Net Satellite Channel Gain	(dB)	**105.0**	105.0	105.0
Satellite Tx Power	(Watts)	**1.41**	0.94	0.69
Satellite Tx Gain towards Rx E/S	(dBi)	**44.0**	44.0	44.0
Satellite Tx EIRP towards Rx E/S	(dBW)	45.5	43.7	42.4
Downlink (per carrier):				
Carrier Frequency	(MHz)	11950	11950	11950
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	203.1	203.1	203.1
Spreading Loss	(dB)	160.1	160.1	160.1
PFlux at Earth's Surface	(dBW/m2)	-115.1	-116.9	-118.2
Rx E/S Antenna Diameter	(m)	**0.45**	**1.00**	**2.00**
Rx E/S Antenna efficiency		**0.80**	0.80	0.80
Rx E/S Antenna Gain	(dB)	34.0	41.0	47.0
Squint loss	(dB)	1.0	1.0	1.0
Rx E/S G/T	(dB/K)	12.6	19.6	25.6
Received Signal Power	(dBW)	-125.1	-119.9	-115.2
System (LNA+Sky) Noise Temp.	(K)	110	110	110
(C/T) Thermal Downlink	(dBW/K)	-145.5	-140.3	-135.6
Total Link:				
Information Bit Rate	(kbps)	27,471	79,116	158,232
Symbol rate	ksps	10,417	30,000	60,000
FEC Rate	(fraction)	**0.667**	0.667	0.667
Modulation Type (QPSK, 8PSK, 16APSK, 32/	(? PSK)	**16APSK**	16APSK	16APSK
Rx filter "alpha" factor	(%)	**20.0**	20.0	20.0
Carrier Noise Bandwidth	(kHz)	**12,500**	36,000	72,000
(C/N) - Thermal Uplink	(dB)	26.33	19.98	15.65
(C/N) - Thermal Uplink	(dB)	26.33	19.98	15.65
(C/N) - Thermal Downlink	(dB)	12.13	12.71	14.40
(C/N) - Thermal Downlink	(dB)	12.13	12.71	14.40
(C/I) - Other satellites	(dB)	25.00	25.00	25.00
(C/I) - Cross-Polar Interference	(dB)	25.00	25.00	25.00
(C/I) - Multi-Beam Effects	(dB)	25.00	25.00	25.00
(C/I) - interchannel interference	(dB)	25.00	25.00	25.00
(C/N+I) - Total Actual	(dB)	11.2	11.2	11.2
(Es/No) - Total Actual	(dB)	12.0	12.0	12.0
Desired BER		QEF	QEF	QEF
Es/No required, coded	(dB)	8.97	8.97	8.97
implementation margin	(dB)	1.0	1.0	1.0
Excess Margin	(dB)	2.0	2.0	2.0

Table 9, Return Link Budget, 14 GHz uplink

Pleiades Link Budget
User-to-Gateway (14/19 GHz)

Link Parameters		**Clear Sky nominal location, apogee, elev angle = 25° to UT, 20° to GW**		
Link Geometry:				
GW slant range to satellite	(km)	29,403	29,403	29,403
UT slant range to satellite	(km)	28,594	28,594	28,594
Uplink (per carrier):				
Carrier Frequency	(MHz)	14,250	14,250	14,250
Tx E/S Antenna Diameter	(m)	**0.45**	**1.00**	**2.00**
Tx antenna efficiency		0.80	0.80	0.80
Tx E/S Power to Antenna	(W)	**5.551**	1.183	0.734
Tx E/S PSD to Antenna - per 4 kHz	(dBW/4kHz)	-27.0	-36.6	-39.9
Tx E/S PSD to Antenna - per Hz	(dBW/Hz)	-63.0	-72.6	-75.9
Tx E/S Antenna Gain	(dB)	35.6	42.5	48.5
Tx E/S EIRP per Carrier	(dBW)	43.0	43.2	47.2
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	204.6	204.6	204.6
Spreading Loss	(dB)	160.1	160.1	160.1
Satellite:				
Total power flux at Satellite	(dBW/m2)	-117.6	-117.4	-113.4
Satellite Rx Gain towards Tx E/S (beam edge	(dBi)	44.0	44.0	44.0
Effective Aperture of Receive Antenna	(dB-m2)	-0.5	-0.5	-0.5
Received Signal Power	(dBW)	-118.1	-117.9	-114.0
Received Signal Power	(dBW)	-118.1	-117.9	-114.0
Satellite Receive System Noise Temperature	(K)	600	600	600
Satellite G/T towards Tx E/S	(dB/K)	16.2	16.2	16.2
(C/T) Thermal Uplink	(dBW/K)	-145.9	-145.7	-141.7
Satellite Channel Gain	(dB)	98.0	98.0	98.0
Satellite Tx Power	(Watts)	0.010	0.010	0.025
Satellite Tx Gain towards Rx E/S	(dBi)	51.0	51.0	51.0
Satellite Tx EIRP towards Rx E/S	(dBW)	30.9	31.1	35.1
Downlink (per carrier):				
Carrier Frequency	(MHz)	19,000	19,000	19,000
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	207.4	207.4	207.4
Spreading Loss	(dB)	160.4	160.4	160.4
Power flux at Earth's Surface	(dBW/m2)	-130.0	-129.7	-125.8
Rx E/S Antenna Diameter	(m)	9.10	9.10	9.10
Rx E/S Antenna Gain (60% eff.)	(dB)	62.9	62.9	62.9
Rx E/S G/T	(dB/K)	42.5	42.5	42.5
Received Signal Power	(dBW)	-114.0	-113.8	-109.9
System (LNA+Sky) Noise Temp.	(K)	110	110	110
(C/T) Thermal Downlink	(dBW/K)	-134.5	-134.2	-130.3
Total Link:				
Information Bit Rate (before channel coding)	(kbps)	24,241	35,651	63,293
Symbol rate	ksps	**9,192**	18,000	24,000
FEC Rate	(fraction)	**0.667**	0.667	0.667
Modulation Type	(? PSK)	**16APSK**	8PSK	16APSK
Rx filter "alpha" factor	(%)	0.20	0.20	0.20
Carrier Noise Bandwidth	(kHz)	**11,030**	21,600	28,800
(C/N) - Thermal Uplink	(dB)	12.3	9.6	12.3
(C/N) - Thermal Uplink	(dB)	12.3	9.6	12.3
(C/N) - Thermal Downlink	(dB)	23.7	21.0	23.7
(C/N) - Thermal Downlink	(dB)	23.7	21.0	23.7
(C/I) - Other System Noise	(dB)	22.0	22.0	22.0
(C/I) - Cross-Polar Interference	(dB)	25.0	25.0	25.0
(C/I) - Multi-Beam Effects	(dB)	25.0	25.0	25.0
(C/N+I) - Total Actual	(dB)	11.2	8.8	11.2
(Es/No) - Total Actual	(dB)	12.0	9.6	12.0
Es/No required, coded	(dB)	8.97	6.62	8.97
implementation margin	(dB)	1.0	1.0	1.0
Excess Margin	(dB)	2.0	2.0	2.0

Table 10, Return link budget, 18 GHz uplink

Pleiades Link Budget

User-to-Gateway (18/19 GHz)

Link Parameters		Clear Sky nominal location, apogee, elev angle = 25° to UT, 20° to GW		
Link Geometry:				
GW slant range to satellite	(km)	29,403	29,403	29,403
UT slant range to satellite	(km)	28,594	28,594	28,594
Uplink (per carrier):				
Carrier Frequency	(MHz)	17,950	17,950	17,950
Tx E/S Antenna Diameter	(m)	**0.45**	**1.00**	**2.00**
Tx antenna efficiency		0.80	0.80	0.80
Tx E/S Power to Antenna	(W)	**5.552**	0.789	0.489
Tx E/S PSD to Antenna - per 4 kHz	(dBW/4kHz)	-27.0	-36.6	-39.9
Tx E/S PSD to Antenna - per Hz	(dBW/Hz)	-63.0	-72.6	-75.9
Tx E/S Antenna Gain	(dB)	37.6	44.5	50.5
Tx E/S EIRP per Carrier	(dBW)	45.0	43.5	47.4
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	206.6	206.6	206.6
Spreading Loss	(dB)	160.1	160.1	160.1
Satellite:				
Total power flux at Satellite	(dBW/m2)	-115.6	-117.1	-113.2
Satellite Rx Gain towards Tx E/S (beam edge	(dBi)	44.0	44.0	44.0
Effective Aperture of Receive Antenna	(dB-m2)	-2.5	-2.5	-2.5
Received Signal Power	(dBW)	-118.1	-119.7	-115.7
Received Signal Power	(dBW)	-118.1	-119.7	-115.7
Satellite Receive System Noise Temperature	(K)	600	600	600
Satellite G/T towards Tx E/S	(dB/K)	16.2	16.2	16.2
(C/T) Thermal Uplink	(dBW/K)	-145.9	-147.4	-143.5
Satellite Channel Gain	(dB)	98.0	98.0	98.0
Satellite Tx Power	(Watts)	0.010	0.007	0.017
Satellite Tx Gain towards Rx E/S	(dBi)	51.0	51.0	51.0
Satellite Tx EIRP towards Rx E/S	(dBW)	30.9	29.4	33.3
Downlink (per carrier):				
Carrier Frequency	(MHz)	19,000	19,000	19,000
Atmospheric and Other Losses	(dB)	0.5	0.5	0.5
Free Space Loss	(dB)	207.4	207.4	207.4
Spreading Loss	(dB)	160.4	160.4	160.4
Power flux at Earth's Surface	(dBW/m2)	-130.0	-131.5	-127.6
Rx E/S Antenna Diameter	(m)	9.10	9.10	9.10
Rx E/S Antenna Gain (60% eff.)	(dB)	62.9	62.9	62.9
Rx E/S G/T	(dB/K)	42.5	42.5	42.5
Received Signal Power	(dBW)	-114.0	-115.6	-111.6
System (LNA+Sky) Noise Temp.	(K)	110	110	110
(C/T) Thermal Downlink	(dBW/K)	-134.5	-136.0	-132.1
Total Link:				
Information Bit Rate (before channel coding)	(kbps)	24,241	23,768	42,195
Symbol rate	ksps	**9,192**	12,000	16,000
FEC Rate	(fraction)	**0.667**	0.667	0.667
Modulation Type	(? PSK)	**16APSK**	8PSK	16APSK
Rx filter "alpha" factor	(%)	0.20	0.20	0.20
Carrier Noise Bandwidth	(kHz)	**11,030**	14,400	19,200
(C/N) - Thermal Uplink	(dB)	12.3	9.6	12.3
(C/N) - Thermal Uplink	(dB)	12.3	9.6	12.3
(C/N) - Thermal Downlink	(dB)	23.7	21.0	23.7
(C/N) - Thermal Downlink	(dB)	23.7	21.0	23.7
(C/I) - Other System Noise	(dB)	22.0	22.0	22.0
(C/I) - Cross-Polar Interference	(dB)	25.0	25.0	25.0
(C/I) - Multi-Beam Effects	(dB)	25.0	25.0	25.0
(C/N+I) - Total Actual	(dB)	11.2	8.8	11.2
(Es/No) - Total Actual	(dB)	12.0	9.6	12.0
Es/No required, coded	(dB)	8.97	6.62	8.97
implementation margin	(dB)	1.0	1.0	1.0
Excess Margin	(dB)	2.0	2.0	2.0

4.7.2 System Capacity

The Pleiades system provides simultaneous service in nine regional service areas around the world. Each active satellite provides a fully loaded total outbound (gateway-to-user) transmission capacity of 70 Gbps and a fully loaded total inbound (user-to-gateway) transmission capacity of 54 Gbps using an expected mix of terminal types (92 percent weighted to the smallest terminal size).

Capacity over North America is the sum of the two active arcs there, the WNA and ENA active arcs, yielding a total North American forward fully loaded capacity of 140 Gbps and a return fully loaded capacity of 108 Gbps. NSS anticipates using modern adaptive Shannon-efficient modulation and satellite path-adapted multiple access protocols to provide optimum channel performance.

4.7.3 System Power Control and Rate Adaption

Correct setting of the uplink carrier power levels of both the user and gateway terminals is essential to maintaining reliable channel connectivity. Measurement by the gateway terminals of the fading on the beacon downlink signal is essential to allow the gateway to distinguish between uplink and downlink fades on the inbound links, and hence to the proper implementation of uplink power control for the user terminals. It is also used to determine fading on the satellite-gateway path and hence derive uplink power control information for the gateway terminal transmissions. The system will also apply modulation, coding, and protocol adaption to the channel to assist in combatting fades.

4.7.4 Order Wire and Payload Control Channels

Some of the communications capacity between the gateways and the user terminals will be set aside for Order wire and Payload Control (OWPC) channels. Current estimates suggest that an allocation of three megabits per second per user beam in both the outbound and inbound directions is appropriate, but further system development may result in changes to these allocations.

The OWPC channels will operate over channels RT28-L and RT28-U on the uplinks and TT19-U and TT19-L on the downlinks.

The OWPC channels will operate with transmit power spectral densities that do not exceed those of the communications traffic channels, and as such do not cause any additional interference. These OWPC links are made more robust by the use of a high level of error correction coding.

4.7.5 Beacon Signals

The Pleiades beacons provide power and frequency reference signals to user terminals. The beacon signals, which operate in the user terminal downlink bands of 11.2-12.7 GHz, will operate at a PFD level that is no higher than the user traffic channels.

On-board generated downlink beacons are used to ensure optimum tracking of the active Pleiades satellites by the user and gateway earth stations, and for uplink power control. The beacons consist of a carrier modulated with data and multiplied by pseudo-random noise bit sequences for signal spreading purposes.

The beacons are located within the user terminal downlink spectrum in order to minimize the cost of the beacon receiver functions in the user terminals. Gateways will also use these same downlink beacons via special beacon receivers even though the beacons operate within the user terminal downlink frequency band. Four beacons are provided with opposite circular polarizations and in different halves of the user downlink frequency band to minimize cost impact to user terminals. These beacons will be located at the extreme ends of the user terminal downlink frequency band as follows:

Beacons 1 & 2:	Center frequency 11.2001 GHz in LHC and RHC polarizations
Beacons 3 & 4:	Center frequency 12.6999 GHz in LHC and RHC polarizations

All Pleiades satellites will operate with beacons transmitting at the same frequencies as those given above. The angular spacing between the sequential Pleiades satellites in the same orbit plane will be used to distinguish between the “rising” and “setting” satellites.

The exact frequencies of these beacons may be changed after coordination with other users of the spectrum.

4.7.6 TT&C Links

Pleiades satellite TT&C is handled through the Canadian SCC/NCC facility in Calgary, Alberta.

4.7.7 Frequency Tolerance

The local oscillator frequency stability in the Pleiades satellite communications payload will determine the accuracy of the frequency conversion between uplink and downlink transmissions. This frequency conversion error shall not exceed ±5 in 10^6 under all circumstances.

4.7.8 Cessation of Emissions

All carriers in the Pleiades satellite system, both those transmitted from gateway terminals as well as those from user terminals, will be able to be individually turned on and off through the system management functions controlled by the SCC. The SCC will be in constant contact with all NCCs, including that in the United States, to coordinate any need to cease emissions.

5 The Public Interest in Granting Pleiades License to Operate in the United States (47 C.F.R. § 25.114(d)(6) and § 25.137(a))

The grant of NSS' instant Petition for a Declaratory Ruling for the Pleiades system will promote the public interest in several distinct ways.

NSS observes that the United States has a national interest in promoting broad band telecommunications access both domestically and internationally. Such policies not only benefit U.S. companies by helping them sustain their global leadership in telecommunications, they also contribute substantially to the growth and strength of the global economy. Broadband satellite communications historically have proceeded through exploitation of the geostationary plane and associated frequencies. Both that plane and those frequencies are increasingly congested. The national interest, accordingly, lies in the promotion of technologies and orbital architectures that can efficiently convey broadband services and use spectrum which has been allocated for FSS services without interfering with existing geostationary satellites. NSS' proposed Pleiades system using the Virtual Geo framework, with the its inherent large angular separation from satellites in the geostationary arc and its ability to slot-manage multiple NGSO systems, offers an efficient and robust way forward to greatly expand access to space and space spectrum on a minimum interference basis.

The Virtual Geo framework, which Pleiades employs, offers an exceptionally benign means of sharing spectrum with geostationary satellite services, while offering a multiple entry management approach that replicates the simplicity of the geostationary arc. This opening of a substantial additional space sharing "real estate" will greatly facilitate the expansion of satellite-based wide area services from that of the geostationary arc, helping to relieve the contention there for slots in space. Due to its inherent large angular separation from the GSO arc, the Virtual Geo framework enables reuse of the substantial spectrum already dedicated to the GSO arc while minimizing interference to and from it. The Pleiades System described here is a forerunner exemplar of such efficient space systems, offering wide area high speed satellite-based user and network interconnectivity.

Through its services, Pleiades will offer a significant expansion of the availability of satellite-based access to terrestrial networks, which is proving of increasing importance as emphasis increases on remote work and virtual collaboration.

Because of the unique slotting feature within the Virtual Geo framework, the number of virtual geostationary systems that can potentially operate on a co-frequency basis using existing angular coordination rules largely exceeds that possible using low-Earth NGSO satellite systems of other types. Pleiades thus opens a gate to a larger opportunity for NGSO systems to coexist with GSO systems than otherwise possible.

Pleiades makes efficient use of allocated spectrum by reusing it many times across satellite user beams—10 to 39 times per satellite and potentially up to 351 times over the constellation of active satellites—and full feeder link reuse across each Gateway. As part of its frequency reuse scheme, Pleiades uses the same frequency bands in all service and feeder links twice, once on each of two orthogonal circular polarizations.

NSS is prepared to undertake a comprehensive coordination with other licensed NGSO systems as they develop. The Pleiades System will be a “good neighbor,” sharing responsibly while using spectrum efficiently.

Section 25.137(a) of the Commission's Rules, following the *DISCO* decisions, establishes a presumption that granting applications to provide service in the United States via satellites licensed by countries that are members of the World Trade Organization ("WTO") will enhance competition and therefore is in the public interest.[12] The NSS satellites in the Pleiades constellation will be operated under authority of Canada, which is a member of the WTO, and thus presumptively further the public interest.

In sum, the Pleiades system proposed herein by NSS offers a high degree of public interest benefits with regard to its ability to operate co-frequency benignly with geostationary systems in a framework offering further opportunities to do so. Pleiades will also satisfy the exponentially growing demand for state-of-the-art, affordable satellite services. The Commission should, on these bases, find that grant of NSS' application to operate Pleiades in the United States is consistent with the public interest.

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[12] *See In re Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, Report and Order, 12 FCC Rcd. 24094, 24112 (1997) ("*DISCO II Order*").

6 U.S. and International Interference Coordination

NSS will comply with all applicable domestic and international requirements in coordinating the proposed system. Such coordination will be undertaken under the auspices of the Canadian government, as the licensing Administration. As described above, the angular separation from the Geostationary arc should make coordination with Geostationary satellites relatively easy.

With regard to coordination with NGSO systems, the Pleiades satellite is a virtual-geostationary system which means that the active Pleiades satellites always appear in the same portion of the sky as seen from the Earth. This is very different from the types of NGSO systems that are proposed to operate in circular orbits, particularly those in Low Earth Orbit (“LEO”). These LEO NGSOs must operate almost from horizon to horizon, as viewed from their earth stations, in order to ensure full-time service with a manageable and affordable number of satellites in the constellation. With larger numbers their active arcs could be reduced allowing higher elevation angles but reducing system efficiency. Roaming all over the sky, new techniques must be devised to deal with NGSO crossing interference as Pleiades does for the GEOs and for other Virtual Geo framework systems. We will address these issues in the coordination discussions with the NGSO operators.

This fundamental advantage of a virtual geo system compared to a circular orbiting NGSO system gives rise to a situation where many virtual geo systems of various kinds can operate co-frequency and co-coverage. In this approach, the different virtual geo systems are designed so that each one operates with its active satellites in a part of the sky separated in angle, as viewed by their earth stations, from the others, as shown in Figure 5 through Figure 10 above. There are many possibilities to explore with such a sharing approach between NGSO and virtual geo systems.

Clearly the issue of sharing between NGSO systems is a complex one, and NSS is committed to work with the Commission and other licensees to ensure that viable sharing schemes are established. But given the uncertainty as to how many or which of the proposed systems will be authorized and launched, any attempt to speculate on the details of such sharing would be premature at this point in time.

6.1 Inter-Satellite Links

Due to the extremely narrow beamwidth of optical ISL transmit and receive antennas, there should be no sharing problems associated with Pleiades's use of the optical ISL frequencies.

NSS is committed to working with the Commission and other optical ISL users to develop any sharing conditions that might be necessary for the implementation of the Pleiades optical ISLs.

6.2 Fixed Service

The orbit parameters of the Pleiades system have been deliberately selected to ensure that the active Pleiades satellite operates only at high elevation angles as viewed from the Pleiades earth stations. Not only does this provide excellent link quality in the Pleiades system, with low probabilities of signal blockage and reduced signal attenuation due to rain, it also makes the Pleiades system an excellent sharing partner with co-frequency terrestrial Fixed Services ("FS"). The gain of the transmitting and receiving

Pleiades earth stations is very low in directions towards terrestrial FS transmitters and receivers and so the interference coupling, in both directions, is correspondingly reduced. This advantage is shown in Figure 21 where the additional FS interference protection is calculated as a function of the minimum operational elevation angle of the Pleiades earth stations, relative to the 5° elevation case which is the typical minimum elevation angles of some GSO and circular orbiting NGSO systems.

Figure 21, Interference Protection with Respect to FS Systems as a Function of the Minimum Operational Angle of Separation between the Active Pleiades Satellite and the GSO Arc

Anywhere within US continental territory the minimum operational elevation angle is 32° in Southern Texas while the minimum elevation angle is 28º in Hawaii. This corresponds to a worst-case improvement factor of 20 dB in the continental United States and an 18 dB improvement factor in Hawaii.

In the United States, frequency overlap with the FS occurs only within the 11.2-11.7 GHz and 12.2-12.7 GHz downlink bands of the Pleiades system. The 11.7-12.2 GHz downlink band is not used by the FS in the USA. Of these shared bands, only the

11.2-11.7 GHz and 12.2-12.7 GHz bands are proposed for use by user terminals in the Pleiades system. In the event that particular user terminals are found to be in locations where FS interference is a concern, downlink transmissions destined for these terminals will take place only in the unshared 11.7-12.2 GHz band. The Pleiades RNCC will establish a database of any user terminals affected by interference in this way and assign appropriate frequencies for their use.

Finally, it is expected that interference from terrestrial FS transmitters into the Pleiades satellite receivers will not be a problem, again due to the high elevation angles from the Pleiades beam coverage areas to the active Pleiades satellites.

6.3 Ka Downlinks

The 17.8-20.2 GHz frequency band is proposed by most applicants for NGSO systems. NSS will coordinate with those to ensure proper operation and optimum resource utilization. NSS is committed to work with the Commission and with potential BSS operators in this band to ensure that mutually satisfactory sharing conditions are implemented to adequately protect both systems.

6.4 Earth Exploration-Satellite and Space Research Services

The Pleiades satellite system avoids using the 13.75-13.8 GHz band which is used by NASA for the TDRSS operations. Therefore no interference to this service will occur.

6.5 Radio Astronomy Service

The Radio Astronomy Service ("RAS") has existing operations in the 10.6-10.7 GHz band which is immediately adjacent to the proposed Pleiades gateway downlink band. Interference protection of the RAS will be achieved by a combination of the above:

- The downlink EIRP spectral density in the adjacent 10.7-11.2 GHz gateway downlink band is already 9 dB lower than that proposed in the user terminal downlink band 11.2-12.7 GHz, because of the use of large gateway receive earth station antennas. The beam peak in-band PFD in the adjacent 10.7-11.2 GHz band is defined in Section 3.6.2 above.
- The gateway downlink spot beams will be directed only towards the gateway downlink sites. Depending on the eventual selection of these gateway sites, this may give additional attenuation of the downlink signals due to the roll-off of the Pleiades satellite transmit beam gain.
- The Pleiades downlink transmissions will be adequately filtered to further reduce the out-of-band emissions in the 10.6-10.7 GHz band and provide the additional signal attenuation required to adequately protect the RAS in this band.

NSS is committed to work with the Commission and with the RAS community to ensure that the RAS sites that use the 10.6-10.7 GHz frequency band are adequately protected.

7 Non-Common Carrier Status

NSS elects under Section 25.114(c)(11) of the Commission's rules to provide all capacity on its proposed Pleiades system on a non-common carrier basis. NSS will tailor services to meet the needs of individual customers.

8 Schedule of Implementation

NSS' proposed scheduling milestones for the deployment of the Pleiades system are shown with schedule dates referenced to the date of final Commission approval of the instant application:

Milestone	**Month after approval**
ISED Approval	0
Complete CDR	18
Contract for construction	24
Complete construction Pleiades Satellite A1	48
Complete construction Pleiades Satellite A2	50
Complete construction Pleiades Satellite A3	52
Launch Pleiades Satellites A1-A2	53
Complete construction Pleiades Satellite A4	54
Complete construction Pleiades Satellite A5	55
Complete construction Pleiades Spare SA1	56
Launch Pleiades Satellites A3-A4	57
Launch Pleiades Satellites A5-SA1	59
Complete construction Pleiades Satellite B1	59
Commence AURORA I™ Service	60
Complete construction Pleiades Satellite B2	60
Complete construction Pleiades Satellite B3	61
Complete construction Pleiades Satellite B4	62
Launch Pleiades Satellites B1-B2	63
Complete construction Pleiades Satellite B5	63
Complete construction Pleiades Spare SB1	64
Launch Pleiades Satellites B3-B4	65
Complete construction Pleiades Satellite C1	65
Complete construction Pleiades Satellite C2	66
Launch Pleiades Satellites B5-SB1	67
Complete construction Pleiades Satellite C3	67
Commence AURORA II™ Service	68
Complete construction Pleiades Satellite C4	68
Launch Pleiades Satellites C1-C2	69

Milestone	**Month after approval**
Complete construction Pleiades Satellite C5	69
Complete construction Pleiades Spare SC1	70
Launch Pleiades Satellites C3-C4	71
Launch Pleiades Satellites C5-SC1	73
Commence AUSTRALIS™ Service	74
Complete Worldwide Pleiades Service	74

Note that service from the sub-constellations is independent from each other.

9 Legal Qualifications

NSS is legally qualified to be licensed by the Commission, as demonstrated in the FCC Form 312 separately filed electronically with the Commission.

10 Orbital Debris Information (47 C.F.R. §§ 25.114(d) (14))

Responsibility for orbital debris mitigation will lie with Canada, as the licensing Administration for the Pleiades system. Nevertheless, NSS is providing the information below to demonstrate that it will comply with the Commission's orbital debris mitigation requirements.

10.1 Spacecraft Hardware Design:

NSS has assessed and will continue to assess the degree to which debris will be released during the course of normal operations, and will continue to take steps to ensure that the spacecraft design is such that no debris is released during normal operations.

NSS has not yet engaged a spacecraft house to design in detail the Pleiades spacecraft. However, the Pleiades design team under NSS's leadership will employ standard industry practices to ensure that all system space operations will minimize contributions to orbital debris, including measures to estimate and limit the probability of collision with known objects during the in-orbit lifetime of the system's spacecraft. These practices will include the elimination of any object in the design that would be released in normal operations, including deployment, operation, and retirement. The orbital debris mitigation plan that NSS implements will also consider, and to the extent practicable, limit the probability that collisions with items smaller than one centimeter in diameter could cause a loss of control, and thereby prevent intended means of post-mission disposal.

All spacecraft will use redundant control, sensor, and thruster subsystems. Power subsystems will use a design approach that at the minimum permits fallback to partial power in the event of the failure of any one element in the subsystem or on the power buses. The communications payload will also feature electronic sparing (most amplifiers and control devices) or a fail-soft design (such as, it is expected, within the antenna, RF power amplifiers, and beam forming assemblies). Spacecraft control systems will be mounted within the satellite so as to shield them with structure and other masses, such as batteries and fuel tanks. Fuel tank design and location will take small debris damage failure modes into consideration. No electronic housing surface will form any portion of the satellite exterior surface. Instead, outer structural surfaces, standing off from any electronics modules, will act as a shielding layer to isolate the latter from small debris penetration. The satellite and its launch adaptors will use non debris-generating release mechanisms, and will minimize or if possible eliminate pyrotechnic devices for that purpose.

NSS will use qualified launch vehicles adhering to U.S. policy for minimizing the generation of debris.

In short, NSS has assessed and limited the amount of debris that would be released in a planned manner during normal operations, and has assessed and limited the probability of the space stations of the Pleiades system becoming a source of debris following collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. No debris is planned to be released during the course of normal operations.

The Pleiades satellites will carry the necessary fuel and kick motor to execute a reentry maneuver. Pleiades satellites will not normally use these motors for normal station keeping or attitude control. The considerations described above with regard to steps taken regarding placement of components and shielding to limit the effects of collisions with debris or meteoroids smaller than one centimeter in diameter were analyzed with respect to this sub-system, and similar practices will be followed.

10.2 Minimizing Accidental Explosions:

NSS has been assessing and will continue to assess the design of its spacecraft to ensure its design is such as to minimize the possibility of accidental explosions over the course of the satellites' lifetimes and subsequent disposal. NSS has made this assessment by means of a failure-mode verification analysis.

The Pleiades satellites will contain means to safe the satellites at end of life, including fully discharging the batteries, disconnecting power sources from their loads, and releasing all unused fuel, prior to placing them in any final storage regime. NSS will take steps to ensure that kinetic energy stored in momentum wheels is limited at end of life.

These measures will in any case be available should they be needed. However, NSS now plans on reentering its satellites at end of life, and therefore would not normally need to employ all the above measures prior to reentry.

NSS will ensure that its launch partners also follow these guidelines to ensure that upper stages and related components are safed after use. Where possible, NSS will assess mission profiles to determine if a practical means exists for controlled reentry of upper stages after use, rather than abandoning them in transfer orbit. The elliptical orbits of

Pleiades satellites, with their relatively low apogees, may offer practical options of this nature.

Debris will not be generated from the conversion of energy sources on board the spacecraft into chemical, pressure or kinetic energy that fragments the spacecraft.

10.3 Safe Flight Profiles:

NSS also evaluated and limited the probability of its satellites becoming a source of debris as the result of collision with large debris and with satellites of other known and relevant NGSO constellations (those operating within the same altitude regime as the Pleiades satellites) with the following results. Supporting calculations are given in Figures 9.4-1 and 9.4-2. NSS used current satellite tracking data as its data source for the cited constellations.

a. **Globalstar**. Globalstar operates its satellites with an inclination of 52 degrees at an altitude of 1414 kilometers. Pleiades satellites are always above Globalstar’s altitude.

b. **GPS**. Pleiades satellites pass through the GPS satellite orbital altitude of 20,200 kilometers as they rise above and later fall below that altitude. NSS assessed the probability of collision with a GPS satellite using conservative (large) figures for the area of a GPS satellite and a Pleiades satellite. Calculations revealed an overall probability of one collision between any Pleiades satellite and any GPS satellite over the 15-year lifetime of the Pleiades satellites to be around 7 in 100 million.

c. **Galileo**. Galileo will operate its satellites in circular orbits at an inclination of 56 degrees and an altitude of 23,222 kilometers. This orbit remains outside the space occupied by the Pleiades satellites, which do not rise to this altitude until attaining a declination of 56.5 degrees. Similarly, when Pleiades satellites have a declination of 56 degrees or less, they have an altitude of 22,974 kilometers or less, or some 248 kilometers below the altitude of Galileo satellites. Consequently, with nominal stationkeeping tolerances, Galileo and Pleiades satellites should never intersect.

NSS nonetheless evaluated the probability of collision between Galileo and Pleiades satellites assuming an intersection, and found the probability of collision to be approximately $8x10^{-8}$, or a little less than one in 10 million, that any Pleiades satellite would collide with any Galileo satellite over the lifetime of the Pleiades satellites (assuming complete overlap of Galileo and Pleiades lifetimes).

d. **Glonass**. Likewise NSS evaluated the probability of collision with a satellite in the GLONASS constellation and obtained a chance of around 2.4 in 100 million. GLONASS has fewer satellites than GPS at this time.

e. **Molniya and similar**. An evaluation of collision probability at any time among any of the Molniya and any Pleiades satellite resulted in a figure of 1 in a million. There are presently 30 Molniya satellites, according to tracking data.

The higher probability of collision results from the lower altitude of encounter (resulting in a smaller uncertainty zone within which to collide),

> the number of Molniya satellites, and the obliquity (fine intersection included angle) of the intersection of the orbits, which results in a larger intersection area.
>
> The probability of collision with any satellite of any further N-satellite constellation of a Molniya type would generally follow the probability of N/30*10-6*(area of new satellite)/(area assumed for Molniya).

Many LEO constellations, such as Iridium, Orbcomm, and others, operate below the minimum altitude for Pleiades satellites and are therefore of no factor, since Pleiades satellites never go there. Likewise, Pleiades satellites do not approach GEO altitude, and so pose no threat to GEO satellites.

In general, NSS finds that there is a vanishingly small probability of collision with other constellations within the Pleiades operating envelop. These probabilities are much smaller than the permitted 0.001 probability cited by NASA guidelines for strikes with large debris.[13]

Nonetheless, NSS will maintain a watch on all satellites in intersecting orbits for any impending near approach, and will implement drift maneuvers to ensure safe passage when warranted.

NSS plans on maintaining its satellites in orbit to the following tolerances:

Orbital Element	**Tolerance**
Semi-major axis	200 meters
Apogee	500meters*
Perigee	500 meters*
Inclination	0.1 degree

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[13] Procedures for Limiting Orbital Debris, NSS 1740.14, August 1995, page 5-1.

Longitude of the Ascending Node**	0.2 degree
Mean Anomaly	0.2 degree

NOTES:

* Subject to constraint on semi-major axis

** Rather than providing tolerance information on the Right Ascension of the Ascending Node, NSS has instead provided tolerance information for the Longitude of the Ascending Node, and urges acceptance of this substitution for the following reasons: RAAN refers to the location where an orbit passes the equator going northward expressed in terms of its location in reference to the backdrop of the stars. Longitude of the Ascending Node expresses the same thing (location of the northward equator crossing) in terms of earth's longitude where it occurs. The two can be related by the position of the Greenwich meridian in relation to the stars at the time of measurement. The plane of an orbit tends to remain relatively stationary with respect to the stars in many cases (the satellite once in orbit is unaware that the earth rotates, and the stellar reference frame is a much more inertial, or non-rotating, one), so RAAN is often used in the satellite industry, even though RAAN typically drifts with time due to perturbations from the earth's equatorial bulge, for example. However, in the Pleiades system case, the orbits are deliberately designed to maintain a constant longitude of the ascending node over the long term, in order to maintain a frozen ground track. But NSS does not strive to maintain a frozen RAAN. As a result, designating the LAN of the orbit is more meaningful in the Pleiades system's case than designating the RAAN of the orbit. NSS would control the orbit to maintain the LAN tolerances, which is equivalent to maintaining tolerances on the ground track location. Each Pleiades orbit contains only one satellite. These tolerances together with orbit maintenance enable burns no more frequent than at estimated two-week intervals. They will in turn permit maintenance of accurate satellite positioning to a degree consistent with a deployment of additional interleaved satellites within the Pleiades orbits at some future date.

10.4 Satellite Post-Mission Disposal:

At the end of the mission lifetime for its satellites (mission lifetime is targeted for a minimum of 12 years), NSS will deorbit the satellites using a series of maneuver burns. Pleiades satellites' elliptical orbits with LEO perigees give an opportunity to reenter the satellites with a practical amount of fuel, and permit a controlled reentry, by using an apogee maneuver to drop the perigee to an altitude within the atmosphere, where local reentry can be guaranteed. The two northern Pleiades tracks have perigees in the Southern Hemisphere in three locations each. In the case of each of the two tracks, a perigee is available where the satellite can be reentered to fall safely in the far southern

Pacific Ocean. A fuel Mass fraction (*i.e.*, the ratio of the needed fuel weight to the total satellite launch mass) of around 0.042 (*i.e.*, approximately 127.26 kilograms) is sufficient for this maneuver, yielding a ΔV of around 128 meters per second to drop the perigee as described. Figures 9.4-3 through 9.4-9 illustrate the parameters used to evaluate these options together with maps depicting breakup and impact zones.

In the case of the Pleiades track containing the southern active arcs, the northern perigees occur over land and do not permit safe disposal off-shore. However, a small maneuver at apogee to drop the perigee by 10 kilometers starts an eastward drift in the ground track of the relevant satellite. Such a maneuver requires 1.15 meters/second of velocity change, corresponding to a mass fraction of 4/100 of a percent.

At such a time that the orbit apogee has drifted to the appropriate location, a second apogee retro-burn will drop the perigee so that the orbit intersects the earth at the desired reentry point. This reentry burn requires a 203-meters/second velocity change at apogee, using a fuel mass fraction of 6.6 percent including the small first burn above to drift the orbit to the appropriate location for initiating reentry.

Note that all reentries are controlled reentries, timed to ensure that satellite debris falls safely offshore into deep water greater than 200 nautical miles away from any populated areas. Since all reentries are therefore controlled, they do not fall under the requirements of Guideline 7.1 *Limit the risk of human casualty* in NSS 1740.14, which requires that for uncontrolled reentry, total satellite debris area surviving reentry shall not exceed 8 square meters. NSS notes that casualty risk assessments for the controlled-atmospheric-re-entry case do not call for an estimate of the probability of human casualty resulting from surviving components/fragments of the satellite; such estimates are required only in casualty risk assessments done for the uncontrolled re-entry case. *See Re-Entry Notice, supra.*

NSS will provide appropriate notifications to maritime and aviation interests before a planned reentry to minimize the risks to such interests operating in these areas.

Pleiades satellites will carry the necessary fuel and kick motor to execute this maneuver. Pleiades satellites will not normally use these motors for normal station keeping or attitude control.

NSS presently plans to have Pleiades satellites use a separate fuel supply for thrusting (with options for cross connection as a redundancy and safety measure in the event it uses similar fuels for both purposes). This design approach minimizes gauging uncertainty in allowing adequate fuel for the reentry maneuver. It also reduces the likelihood of reentry fuel loss during normal on-orbit operations. NSS will compensate for any uncertainty in fuel gauging arising out of satellite launch and operations.

NSS will not be its own prime contractor for construction of its Pleiades system. To the extent that it can, NSS will request that its contractor, pursuant to NASA Safety Standard 1740.14, prepare two debris assessment reports during program development. The initial report would be prepared at PDR, and a final assessment will be prepared 45 days prior to CDR. The purpose of the report submitted at PDR would be to identify debris issues early in the development cycle. The report submitted prior to CDR will document the position of the program relative to the guidelines to limit orbital debris generation.

Table 11, Data used for calculating probability of impact.

Constellation	**Glonass**	**GPS**	**Molniya**	**Galileo**
Altitude	19200	20200		23222
Max degrees, orbit inclination	64.7	55	63.435	56
lat of intersection	47.9	50.1	15	
Number of satellites in constellation	11	32	30	30
Size of satellite				
Max dimension	30	30	30	20
dimension orthog 1	3	3	3	3
dimension orthog 2	2	2	2	2
Avg area of satellite	75	75	75	50
Size of Virgo satellite				
Max dimension	40	40	40	40
dimension orthog 1	4	4	4	4
dimension orthog 2	3	3	3	3
Avg area of intersecting satellite	140	140	140	140
2-D convolved area sq m	490	490	490	420
eccentricity	0	0	0.75	0
sma	25510	26559	26559	29994
semiminor axis			17567.13	

Table 12, Calculations supporting probability of satellite impact. Note that normally Galileo does not intersect the Pleiades orbits, missing by around 250 kilometers. Calculations here are for the case of an intersection due to deviations from nominal orbit parameters, and assume in the Galileo case that the orbits intersect for the lifetime of the satellites.

	Glonass	**GPS**	**Molniya**	**Galileo**
intersecting latitude	47.9	50.1	16	56
altitude from center of earth at intersection	25510	26559	8820	29994
radius of annulus North of earth at stated lat	17102.58305	17036.26076	8478.328158	16772.43195
Width of anulus = max intersection dim	70	70	70	60
area of annulus of all possible orbit intersctn pts	7522108897	7492938833	3728963484	6323057878
intersection area	490	490	490	420
orbit inclination	64.7	55	63.435	56
ratio of intersecting area to annulus area	6.51413E-08	6.53949E-08	1.31404E-07	6.64236E-08
Number of intersections per orbit	2	2	2	2
P(orbits intersect)	1.30283E-07	1.3079E-07	2.62808E-07	1.32847E-07
circumference of orbit, meters	160284057.2	166875118.6	139454873.9	119976000
area of target orbit (intersctn dim*circumf) m^2	11219884003	11681258300	9761841171	7198560000
intersection included angle, deg	40	40	5	45
corrected target intersctn area due to obliquity of intersection	762.3046752	762.3046752	5622.11949	593.9696962
Intersection area to orbit area ratio	6.79423E-08	6.52588E-08	5.75928E-07	8.25123E-08
P(orbits intersect & tgt sat at intersctn | V sat at intrsctn)	8.8517E-15	8.53518E-15	1.51358E-13	1.09615E-14
Number of Virgo revs per day	3	3	3	3
Number of Virgo sats	15	15	15	15
Number of target sats	11	32	30	30
Number of years of Virgo life	15	15	15	15
total probability of collision, any Virgo sat with any Target sat	2.39892E-08	6.72914E-08	1.11873E-06	8.10193E-08

Table 13, Data used for calculating the probability of large debris impact. Debris Flux taken from Figure 5-1 of NSS 1740-14 following instructions there.

altitude upper limit	Flux, impacts/ m^2/yr	times	Fraction of orbit duration within zone	Product of duration and flux
		10:22:00 PM		
1160	1.80E-06	10:24:15 PM	0.009375	1.69E-08
1320	1.00E-06	10:27:08 PM	0.011979	1.20E-08
1570	1.50E-06	10:29:41 PM	0.010677	1.60E-08
1630	9.00E-07	10:30:11 PM	0.002083	1.87E-09
1730	5.60E-06	10:31:00 PM	0.003385	1.90E-08
1880	2.30E-07	10:32:07 PM	0.004622	1.06E-09
2000	1.20E-07	10:32:57 PM	0.003515	4.22E-10
2110	6.00E-08	10:33:41 PM	0.003060	1.84E-10
2220	3.00E-08	10:34:22 PM	0.002865	8.59E-11
2330	1.50E-08	10:35:03 PM	0.002799	4.20E-11
2440	7.50E-09	10:35:42 PM	0.002734	2.05E-11
2550	3.75E-09	10:36:21 PM	0.002669	1.00E-11
2660	1.88E-09	10:36:57 PM	0.002539	4.76E-12
2770	9.38E-10	10:37:34 PM	0.002540	2.38E-12
2880	4.69E-10	10:38:09 PM	0.002474	1.16E-12
2990	2.34E-10	10:38:45 PM	0.002474	5.80E-13
3100	1.17E-10	10:39:20 PM	0.002408	2.82E-13

Table 14, Calculation of Overall Probability of Strike by Large Debris

Percent of time below 3100 km	7.22%
Total annual dose	6.75E-08
Number of years	15
Total P(strike) per unit area	1.01E-06
Total sfc area	73
Overall P(strike)	0.0000740
Limited to <2K	
Total annual dose	6.72E-08
Number of years	15
Total P(strike) per unit area	1.01E-06
Total sfc area	73
Overall P(strike)	0.0000736

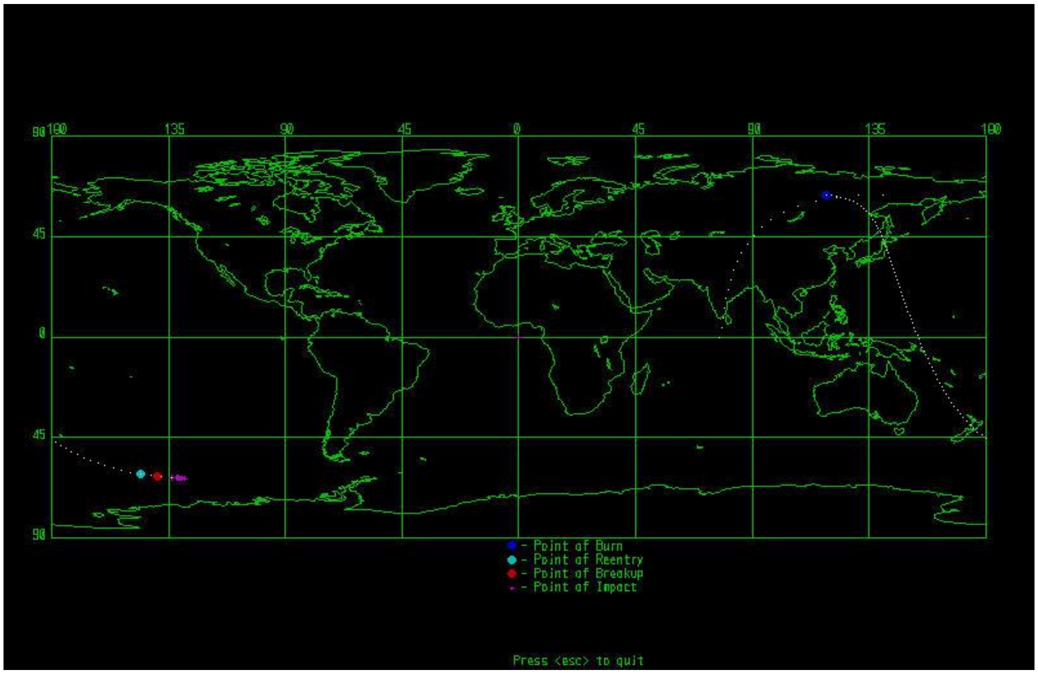


Figure 22, Reentry and impact of Aurora I Satellites per DAS. Retro burn at apogee to depress perigee to 60 kilometers, causing satellite to reenter at perigee into the Southern Pacific Ocean as shown. This is a controlled reentry that avoids any populated area. All Aurora I satellites will use this track.

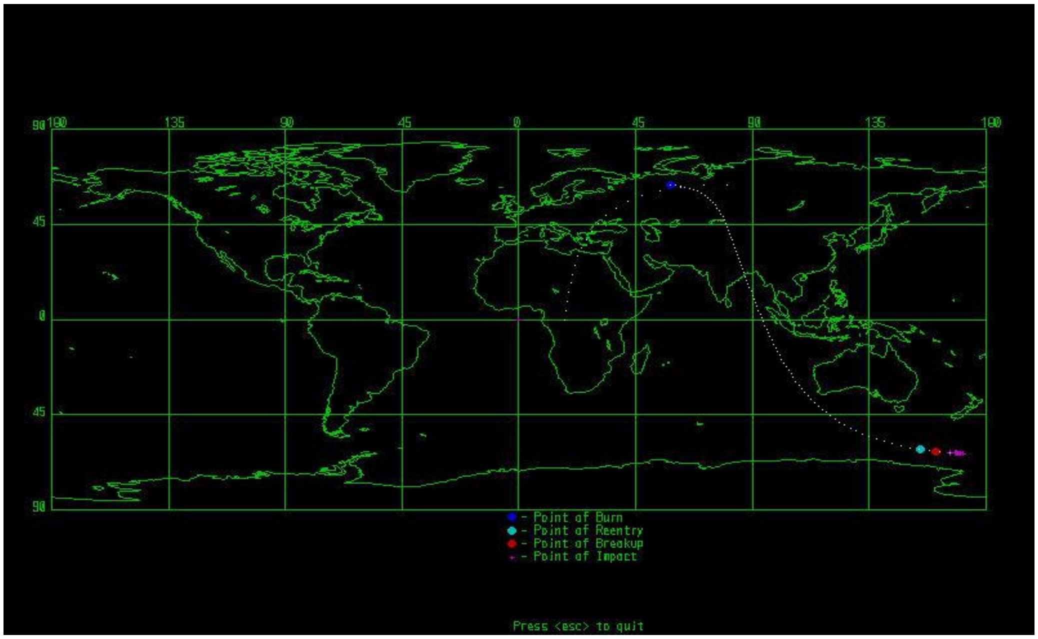


Figure 23, Reentry and impact of Aurora II Satellites per DAS. Retro burn at apogee to depress perigee to 60 kilometers, causing satellite to reenter at perigee into the Southern Pacific Ocean as shown. This is a controlled reentry that avoids any populated area. All Aurora II satellites **will** use this track.shown. This is a controlled reentry that avoids any populated area. All Aurora II satellites will use this track.

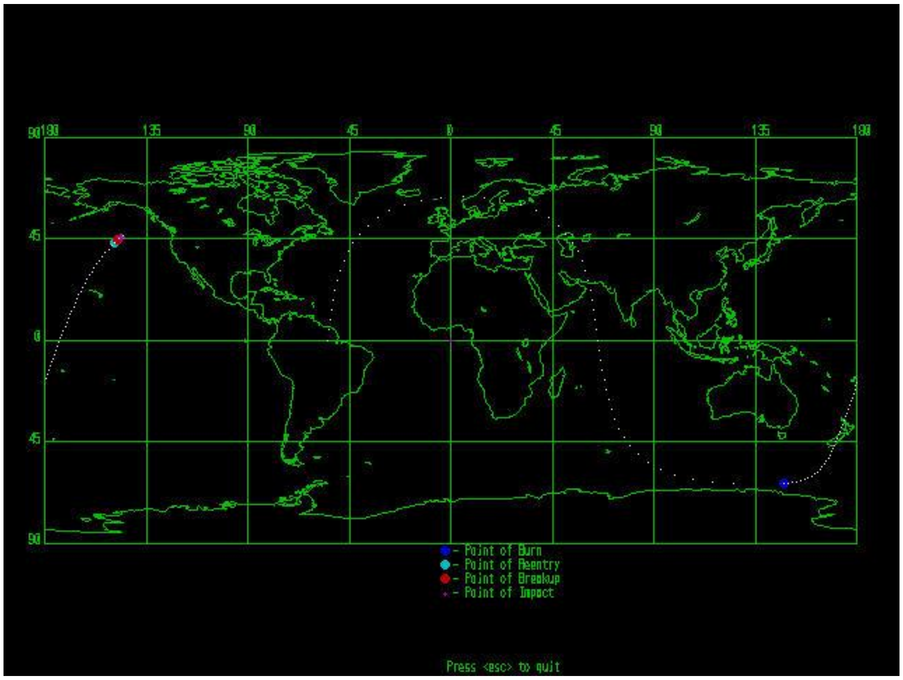
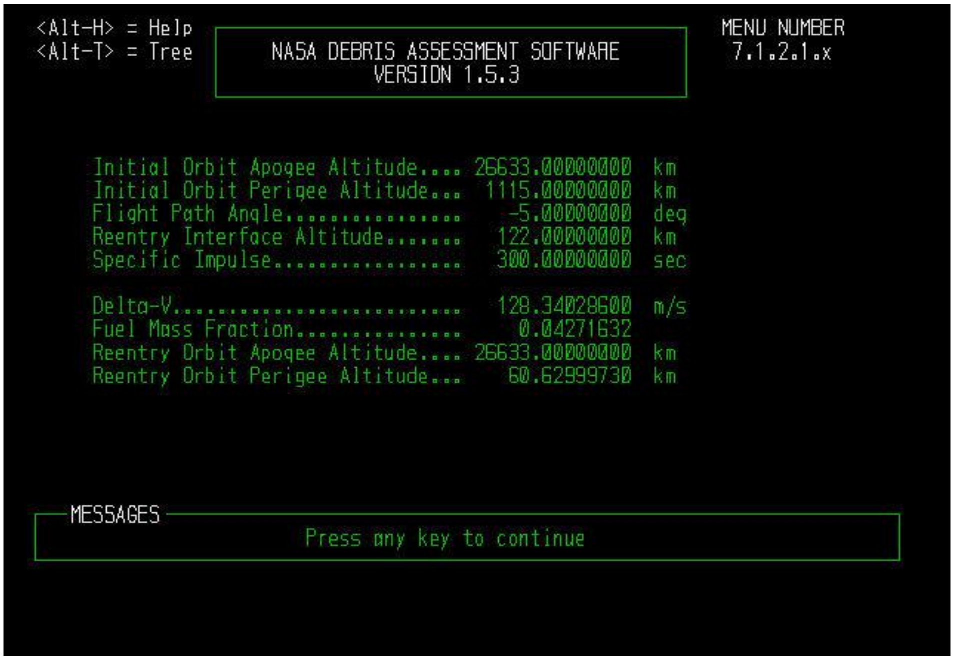


Figure 24, Reentry and impact of Australis Satellites per DAS after drift maneuver to shift apogee to the desired point to yield reentry into water. Retro burn at apogee to depress perigee to -500 kilometers, causing satellite to reenter at perigee into the North Pacific Ocean as shown. This is a controlled reentry that avoids any populated area and remains well clear (>200 nautical miles per NASA guidelines) of any landmass. All Australis satellites will use this track.



```
<Alt-H> = Help                                              MENU NUMBER
<Alt-T> = Tree        NASA DEBRIS ASSESSMENT SOFTWARE        7.1.2.1.x
                              VERSION 1.5.3

    Initial Orbit Apogee Altitude.... 26633.00000000  km
    Initial Orbit Perigee Altitude...  1115.00000000  km
    Flight Path Angle................    -5.00000000  deg
    Reentry Interface Altitude.......   122.00000000  km
    Specific Impulse.................   300.00000000  sec

    Delta-V..........................   128.34028600  m/s
    Fuel Mass Fraction...............     0.04271632
    Reentry Orbit Apogee Altitude.... 26633.00000000  km
    Reentry Orbit Perigee Altitude...    60.62999730  km

MESSAGES
                        Press any key to continue
```

Figure 25, Reentry Delta-V requirements per DAS from the Aurora operational orbits.

```
<Alt-H> = Help                                          MENU NUMBER
<Alt-T> = Tree        NASA DEBRIS ASSESSMENT SOFTWARE    7.1.1.1.x
                               VERSION 1.5.3

     Initial Orbit Apogee Altitude.... 26633.00000000  km
     Initial Orbit Perigee Altitude...  1115.00000000  km
     Decay Orbit Perigee..............  -500.00000000  km
     Specific Impulse.................   300.00000000  sec

     Delta-V..........................   203.12120100  m/s
     Fuel Mass Fraction...............     0.06675971
     Reentry Orbit Apogee Altitude.... 26633.00000000  km
     Reentry Orbit Perigee Altitude...  -499.98999000  km

MESSAGES
                        Press any key to continue
```

Figure 26, Reentry data for Australis satellites

11 Requested Waivers of the Commission's Rules

NSS requests a waiver of Section 25.210 of the Commission's Rules, 47 C.F.R. § 25.210. This rule contains technical requirements that apply generally to fixed-satellite service spacecraft. The particular provisions of this rule, however, are tailored to the typical design specifications of geostationary satellites, and are technically inapplicable to nongeostationary satellites (which are inherently incapable of meeting the specific requirements set forth in Section 25.210). Notwithstanding the facial inapplicability of the rule, NSS's Pleiades system is consistent with the purpose of Section 25.210 to the extent that they maximize the efficient use of the spectrum in which its satellites will operate. NSS also requests a limited waiver of Section 25.208. The Pleiades system will be coordinating by Canada, so that detailed information on the PFDs is unnecessary for this FCC application. Thus, a waiver is warranted.

12 CONCLUSION

The Pleiades satellite system is an innovative concept that will be capable of providing affordable and highly desirable satellite services to businesses and end users in most of the heavily populated areas of the world. Pleiades is a model of how the orbital/spectrum resource can be shared on a co-frequency basis by multiple services in order to maximize efficiency and will help maintain U.S. leadership in commercial satellite technology.

For all of the reasons set forth in this application, NSS respectfully urges the Commission to grant this application and authorize it to operate the Pleiades in the United States, so that the promised public interest benefits will be realized as rapidly as possible.

Respectfully submitted,

New Spectrum Satellite, Ltd

By: /s/
David Castiel
Managing Director

Dated: May 26, 2020

<u>Of Counsel</u>:

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Alexandria, VA 22314
(202) 607-6756
stephenlgoodman@aol.com

13 REQUIRED CERTIFICATIONS

Pursuant to Section 304 of the Communications Act (47 U.S.C. § 304), New Spectrum Satellite, Ltd ("NSS") waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise.

The undersigned further certifies, under penalty of perjury, that neither NSS nor any party to this application is subject to denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 862.

The undersigned certifies under penalty of perjury, individually and for NSS, that the statements made in this application are true and correct to the best of his knowledge and belief, and are made in good faith.

By: /s/
David Castiel
Managing Director
New Spectrum Satellite, Ltd

May 26, 2020

Technical Certificate

The undersigned hereby certify, under penalty of perjury, that I am the technically qualified person responsible for the preparation of the technical information contained in the foregoing application, that I am familiar with Part 25 of the Commission's Rules, and that I have either prepared or reviewed the technical information in the foregoing application and found it to be complete and accurate to the best of my knowledge and belief.

/s/
John W. Brosius
Chief Technical Officer
New Spectrum Satellite, Ltd

May 26, 2020

ATTACHMENT: OWNERSHIP INFORMATION
New Spectrum Satellite, Ltd

FCC Form 312, Question 40
July 26, 2017

1. NSS is currently a wholly-owned subsidiary of Virtual Geosatellite, LLC. NSS's Directors are:

   David Castiel P.O. Box 40246
   Washington, DC 20016
   Elie Castiel 1200 McGill College Avenue, Suite 1100
   Montreal Quebec, Canada H3B 4G7

2. Virtual Geosatellite, LLC is a wholly-owned subsidiary of Ellipsat, Inc.
   David Castiel is Managing Director, same address as above

3. The following shareholders control and/or hold 10% or more of Ellipsat, Inc.

David Castiel	29.13%
John Q. Piper	11.04%
Global Spectrum Investment Partnership, LLC	10.65%

All the above are US citizens and/or entities controlled by US citizens. Each of these shareholders can be reached at:

c/o Virtual Geosatellite, LLC
P.O. Box 40246
Washington, DC 20016

The Officers of NSS are:

David Castiel President/Managing Director
John W. Brosius Acting Chief Technical Officer

New Spectrum Satellite, Ltd

FCC Form 312, Question 36
July 26, 2017

ADVERSE ACTIONS CONCERNING FCC LICENSES OR APPLICATIONS

New Spectrum Satellite, Ltd's affiliate, Virtual Geosatellite LLC, itself had an affiliate relationship with Mobile Communications Holdings, Inc. ("MCHI"). In 1997, MCHI was licensed in to operate Ellipso, a 1.6/2.4 GHz Mobile-Satellite Service ("MSS") System. *See Mobile Communications Holdings, Inc.*, 12 FCC Rcd 9663 (1997). As a result of the adverse impact on the market for MSS due to the Iridium bankruptcy, MCHI failed to satisfy an implementation milestone and the International Bureau declared this authorization null and void. *See Mobile Communications Holdings, Inc.*, 16 FCC Rcd 11766 (IB 2001), *recon. denied*, Memorandum Opinion and Order, 17 FCC Rcd 11898 (Int'l. Bur. 2002), *rev. denied,* Memorandum Opinion and Order, 18 FCC Rcd 11659 (2003).

In 2001, MCHI was also licensed to operate "Ellipso 2G," a 2 GHz MSS system. *See Mobile Communications Holdings, Inc.*, 16 FCC Rcd 13794 (Int'l. Bur/OET 2001). In 2003, the International Bureau likewise declared MCHI's Ellipso 2G authorization null and void on the ground that the licensee had failed to satisfy an implementation milestone included in its authorization. *Applications of Mobile Communications Holdings, Inc. and ICO Global Communications (Holdings) Limited for Transfer of Control, Constellation Communications Holdings, Inc. and ICO Global Communications (Holdings) Limited for Transfer of Control, Mobile Communications Holdings, Inc. for Modification of 2 GHz License, Constellation Communications Holdings, Inc. for Modification of 2 GHz License*, Memorandum Opinion and Order, 18 FCC Rcd 1094 (Int'l. Bur. 2003), *rev. denied sub nom. Joint Application for Review of Constellation Communications Holdings, Inc., Mobile Communications Holdings, Inc. and ICO Global Communications (Holdings) Limited*, Memorandum Opinion and Order, 19 FCC Rcd 11631 (2004).