

# ATTACHMENT

## **3.7 GHz TRANSITION FINAL COST CATEGORY SCHEDULE OF POTENTIAL EXPENSES AND ESTIMATED COSTS**

July 30, 2020

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## I. ABOUT THIS CATALOG

This cost category schedule (Catalog) contains descriptions of the potential expenses and estimated costs that (1) incumbent space station operators and incumbent earth station operators may incur as a result of the required transition out of the 3700-4000 MHz band into the 4000-4200 MHz band in the contiguous United States<sup>1</sup> and (2) that Fixed Service operators may incur as a result of transitioning out of the entire 3700-4200 MHz (C-band) into one of the following bands: 5925 – 6425 MHz; 6525 – 6875 MHz; 6875 – 7125 MHz; 10,700 – 11,700 MHz; 17,700 – 18,300 MHz; 19,300 – 19,700 MHz; and 21,200 – 23,600 MHz. While the Catalog is relatively comprehensive, it does not include every expense for every situation, nor is it an exhaustive list of all expenses that may potentially qualify for reimbursement.

RKF Engineering Solutions, LLC assisted the Wireless Telecommunications Bureau with developing this Catalog after the release of the Commission's *Order* in March 2020. This Catalog is subject to the provisions of the *Order* and the rules adopted therein.<sup>2</sup> To the extent there are any discrepancies between the requirements adopted in the *Order* or the relevant rules and this Catalog, the *Order* and the rules govern. The categories and costs contained in the Catalog are intended to serve as a reference guide and are not intended to identify the specific reimbursable expenses incurred by individual satellite, earth station, and fixed service operators.

Individual operators may incur only some of the expenses listed in the Catalog, depending upon the operator's existing equipment and the particular transition changes that the entity must make. Some of the expenses will apply only in limited situations, such as, for example, satellite operators that only need to move a service from the lower 300 megahertz of the C-band to the upper 200 megahertz. The Catalog specifies presumptively reasonable costs on a per unit basis. Further, while the cost items below are grouped in tables based on the likelihood that the cost item may be needed for a particular transition type, we acknowledge that some transitions may need cost items from different tables.

Supply and demand constraints may impact future costs, but this Catalog does not attempt to account for future costs.

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<sup>1</sup> Note that such expenses and costs incurred extend to earth stations located outside of the contiguous United States to the extent it can be demonstrated that the system modifications for which they seek reimbursement are necessary as a direct result of the C-band transition. See *Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, GN Docket No. 18-122, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343, 2428, para. 204 (2020) (*Order*). In addition, earth station operators electing the lump sum do not need to continue to operate on the C-band but can elect to transition their operations to another mechanism (e.g. fiber) or to discontinue operations.

<sup>2</sup> See, e.g., *Order* at 2422-30, paras. 193-210 (establishing guidelines for compensable costs).

## II. SATELLITE OPERATOR COSTS

The transition will require eligible space station operators to incur new capital costs and short-term operating expenditures. Reimbursable space station operator costs are limited to the actual, reasonable relocation costs associated with clearing the lower 300 megahertz of the band while ensuring continued operations for their customers.<sup>3</sup> Thus, reimbursable costs could include all reasonable engineering, equipment, site, and FCC fees, as well as any reasonable, additional costs that eligible space station operators serving earth stations in the contiguous United States may incur as a result of relocation.<sup>4</sup>

### A. EXPECTED COST TO REPACK EXISTING SATELLITES

Clearing the lower 300 megahertz will entail ensuring that current services offered across 500 megahertz of the 3700-4200 MHz band, are efficiently transitioned to the upper 200 megahertz. Most of this clearing effort is operator labor, so a range of costs for this labor is provided in Table II-A-1 below on a per satellite basis inclusive of load balancing.

Table II-A-1: Satellite Repacking	Range of Estimated Cost (\$)
Engineering and Execution Labor	150,000 – 350,000

### B. IN-ORBIT DELIVERY OF NEW SATELLITE(S)

While some satellite operators may be able to transition their operations above 4000 MHz with existing satellite capacity, some operators may need to launch additional satellites to complete the transition. The following table includes the expected range for total sum of costs for the in-orbit operational delivery of satellite(s). The costs are inclusive of spacecraft, launch, financing, mission operation, spacecraft-specific ground costs, program management/oversight, and insurance. Costs are broken out by a single launch or a shared launch.

Table II-B-1: Expected Total Costs for Satellite(s) Delivered In-Orbit	Range of Estimated Cost (\$)
2 Tandem Launched C-Band Space Satellites	240M – 768M
1 Single Launched C-Band Satellite	120M – 450M

In section II-B above and in section II-C below, the low estimates are based upon satellite operator procurement of multiple, identical launch vehicles, where spacecraft are assumed to be standard C-band payloads with minimal spacecraft redundancy to satisfy basic mission objectives and an adequate number of amplifiers to clear the 300 megahertz of spectrum per satellite operator requirements. High

<sup>3</sup> Order at 2422, para.194.

<sup>4</sup> Order at 2422, para.193.

estimates assume a significantly accelerated build/launch timeline to offer satellite operators the ability to begin testing and verification of ground relocation equipment over the satellite in under 24 months and/or the potential to “backstop” other satellite builds as a fail-safe to delays. High estimates also assume additional technical spacecraft margins for reliability and redundancy and propulsion systems that accommodate rapid mission transfers to final orbital positions.

## C. SPACE SEGMENT COST BREAKOUT

In this section, the costs from Table II-B-1 are broken down further to account for the procurement, launch, and financing of individual satellites.

### 1. Spacecraft

The table below presents the costs associated with building a new satellite.

Table II-C-1: Satellite Procurement of 1 Satellite	Range of Estimated Cost (\$)
1 C-Band Satellite for Replacement/Diversification	89M – 205M
Satellite Procurement Program Management (per satellite)	5M – 8M

### 2. Launch Costs

Cost of launches for the replacement satellites varies greatly. Contributions to this range include reusability of the rocket, development of multi-satellite stacks for the rockets, and the launch-on-demand requirements for meeting the timelines.

Table II-C-2: Launch Costs	Range of Estimated Cost (\$)
Launch Per Satellite (Dual Launch)	36M – 83M
Launch Per Satellite (Single Launch)	62M – 140M

### 3. Other Potential Costs

Other potential costs include financing (spacecraft and/or launch), insurance, legal, and supplemental engineering. Satellite operators may seek reimbursement for the costs of acquiring financing for clearing costs that are directly attributable to relocation. The estimated costs below are on a per satellite basis.

Table II-C-3: Consulting Fees	Range of Estimated Cost (\$)
Satellite System Engineering Planning	25,000 – 75,000
Coordination of New Satellite	35,000 – 125,000

Table II-C-4: Attorney Fees	Range of Estimated Cost (\$)
Prepare and File FCC Forms	1,500 – 5,000
Prepare and File ITU Forms	5,000 – 20,000

Table II-C-5: Filing Fees	Estimated Cost (\$)
FCC Satellite Application Filing Fee	136,930

Table II-C-6: Finance & Insurance	Range of Estimated Cost (\$)
Cost to Finance Satellite	3.5M – 11M
Cost to Finance Launch	2M – 5M
Insurance	15M – 30M

## D. RELOCATION PROGRAM MANAGEMENT

In addition to the space station operator expenses outlined elsewhere in the Catalog, space station operators will also expend efforts to coordinate the relocation of customers and repacking of transponders. An overall program manager for transition logistics and execution may be necessary for each satellite operator as provided in the table below.

Table II-D-1: Program Management	Range of Estimated Cost (\$)
Cost to Manage Satellite Relocation Program	200,000 – 400,000

### III. EARTH STATION MIGRATION AND FILTERING COSTS

Earth station transitions may vary widely depending on the actions of the satellite operator, the age of the earth station antenna(s), the location and use of the earth station site,<sup>5</sup> and other factors. Earth station filtering will be a uniform transition task necessary to prevent interference from flexible-use operations below 3980 MHz. Beyond that, the transition may consist of expenses such as retuning or repointing an antenna, up to and including replacement of equipment that cannot be reasonably transitioned (e.g., replacing receivers, amplifiers, or other equipment that due to age or other factors must be replaced to allow the transition).

The satellite operator is expected to transition its services in the lower 300 megahertz to the upper 200 megahertz of the 3700-4200 MHz band. This effort will require, on the part of the satellite operator, frequency planning and coordination with the earth station operators on the move timing and logistics, and the purchase and installation of passband filters in all primary and redundant antenna receive paths for those earth station operators not electing the lump sum (see Section E below). Note that although the satellite operator would also perform analyses of optimum carrier assignment for the frequency move to include carrier-to-interference ratio (C/I) analysis, potential increases in effective isotropic radiated power (EIRP), satellite power availability, and other radio frequency (RF) performance factors, these analyses are included in the repacking modification costs detailed in Table II-A-1. This section details expenses that satellite or earth station operators might incur from transitioning service to the upper 200 megahertz of the band. Many of the costs described in the Catalog will be incurred on a per-antenna basis. An earth station operator may require migration activities for multiple antennas at a single or multiple sites. Estimates for equipment installation are assumed to include acceptance or benchmarking testing.

Earth station migration “includes any necessary changes that will allow the earth stations to receive C-band services” throughout the transition period and after the applicable relocation deadline once satellite operators “have relocated their services into the upper portion of the band.”<sup>6</sup>

#### A. ANTENNA FILTERING/RETUNING/REPOINTING

First, we address the costs associated with a simple filtering, retuning, or repointing of various earth station antennas because we believe the majority of antennas can be migrated through these simple mechanisms. In section B below, we address the costs for more complex and expensive migrations that will involve replacing equipment or migrating complex gateway facilities.

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<sup>5</sup> We note that an earth station site refers to an incumbent earth station location with one or more registered antennas receiving or receiving/transmitting signals to a satellite.

<sup>6</sup> Order at 2426, para. 201.

We note that costs are specified per antenna unless noted otherwise, but for earth station sites with more than one antenna, some of the cost items could be used once to transition multiple antennas (e.g., rental of bucket truck or tree removal). Further, some items such as travel could be applied once if the work is accomplished in one trip or more than once if different antennas have to be transitioned on different trips. Accordingly, the tables are set up to be applied flexibly, but the Clearinghouse has the discretion to determine the reasonableness of costs submitted for reimbursement and to audit entities that receive reimbursements.<sup>7</sup> Tables III-A-1 and III-A-2 outline costs for filtering, retuning, and repointing antennas.

Table III-A-1: Retuning to Frequency in 4.0-4.2 GHz	Range of Estimated Cost (\$)
Passband Filter	400 – 900
Passband Filter Installation (for two low-noise block converters (LNBS))	300 – 1,350
Passband Filter Installation in Remote Locations (per site)	1,600 – 2,000
C-band Phase Locked Loop (PLL) LNB (for two LNBS)	500 – 1,100
Perform Retuning	400 – 700
Acquisition of Ladder or Bucket Truck Rental	500 – 5,500
Retrofit a Dual-Feed onto a Single-Feed Antenna	1,000 – 2,200
Retrofit a Triple-Feed onto a Single-Feed Antenna	1,500 – 3,300
Fiber Transmitter	1,500 – 3,000
Fiber Receiver	1,500 – 3,000
Fiber Optic Chassis	1,500 – 3,300
Chassis Frame Controller	1,000 – 2,200
Travel Costs (per site and per trip)	150 – 1,500

<sup>7</sup> Order at 2447-78, paras. 260-62.



Table III-A-2: Repointing to a Different Satellite	Range of Estimated Cost (\$)
Perform Repointing (includes labor for repointing and small changes in waveguide or new intrafacility link runs)	400 – 3,000
Low Noise Amplifier/Block Downconverter	250 – 600
Upgrade/Change Polarization	300 – 600
Install a Spare Portable or Trailer-Mounted Antenna	2,000 – 3,300
Rental of Spare Portable or Trailer Mounted Antenna (per month)	3,000 – 5,700
Filter for Seeded <sup>8</sup> Antenna	400 – 900
Filter Installation in Seeded Antenna	600 – 1,100
Filter Installation in Spare Antenna (if seeding antenna is not needed)	600 – 1,100
Initiate Operations Via Dual Illumination (with seeded or spare antenna) (per antenna)	500 – 12,000
Planning for Dual Illumination	10,000 – 30,000
Dual Illumination for Repointing (per dual illumination uplink per month) <sup>9</sup>	10,000 – 28,000
Third-Party Uplink Costs for Dual Illumination (per transponder)	75,000 – 125,000
Replace Cabling from Antenna to Headend	1,000 – 3,000
Travel Costs for Rural, Mountainous, Hard-to-Reach Areas (per trip)	150 – 1,500
Labor Fee for Installations or Emergency Situations (per hour)	300 – 800

Table III-A-3: Earth Station Migration Project Costs	Range of Estimated Cost (\$)
Project Management (including technical support, engineering, administration, accounting, and legal fees) (per site)	400 – 1,000
System Integration of Modified Antenna with Other Gateway Components <sup>10</sup> (per antenna)	600 – 1,600
Application Fee for New Earth Station License	2,985
Application Fee to Modify Existing Earth Station License	210
Third Party Frequency Coordination and Report	3,000 – 4,000

<sup>8</sup> When a spare antenna is not available, the seeded antenna refers to the antenna utilized during dual illumination while transitioning out of the band.

<sup>9</sup> Includes end-to-end verification.

<sup>10</sup> Verification testing to confirm system end-to-end operation.

Table III-A-4: Gateway - RF Uplink Chain	Range of Estimated Cost (\$)
<i>RF Uplink Chain for Limited Motion Antenna Configuration</i>	
Solid State Power Amplifier (cost per polarization) Note: At least two polarizations expected	75,000 – 340,000
Block Upconverter (BUC)	35,000 – 45,000
Fiber System	45,000 – 55,000
RF Distribution	25,000 – 35,000
<i>RF Uplink for Extended/Full Performance Antenna Configuration</i>	
Travelling Wave Tube Amplifier	75,000 – 260,000
BUC	35,000 – 45,000
Fiber System	25,000 – 35,000
RF Distribution	25,000 – 35,000
<i>Supporting Equipment</i>	
Uplink Filter	500 – 1,500
Modulators	30,000 – 45,000
Transport Stream Switches	40,000 – 55,000
Waveguide Switches	5,000 – 10,000
RF Load	2,500 – 8,000
Dehydrators	6,000 – 12,000
Customized Waveguide Sections	1,000 – 10,000
Power Meter	12,000 – 18,000

Table III-A-5: Gateway - RF Downlink Chain	Range of Estimated Cost (\$)
<i>RF Downlink Chain for Limited Motion Antenna Configuration</i>	
Block Downconverter (BDC)	35,000 – 45,000
Fiber System	45,000 – 55,000
RF Distribution	15,000 – 25,000
<i>RF Downlink Chain for Limited Motion Antenna Receive Only Configuration</i>	
Fiber System	45,000 – 55,000
RF Distribution	15,000 – 25,000
<i>RF Downlink Chain for Extended/Full Performance Antenna Configuration</i>	
BDC	35,000 – 45,000
Fiber System	45,000 – 55,000
RF Distribution	15,000 – 25,000

Table III-A-6: Terrestrial Link	Range of Estimated Cost (\$)
Core Network Components - Routers, Switches, Server (per component)	1,000 – 30,000
TS Switching and Failover	40,000 – 50,000
Platform and Network Installation/Testing	9,000 – 17,000
RF Routing/Distribution	25,000 – 40,000
RF Over Fiber System	20,000 – 30,000
Bandwidth Augments to Existing Circuits	60,000 – 300,000
Trenching/Boring for New Fiber Paths	250,000 – 400,000
Circuits	240,000 – 1,500,000

## B. EQUIPMENT COSTS

The earth station migration and filtering costs are likely to vary based on the type of antennas installed at each earth station location. The following tables include equipment costs for receive-only antennas (single feed and multi-feed), bi-directional antennas (e.g., transmit-receive), and temporary fixed antennas. Near full-arc antennas refer to non-parabolic multibeam antenna types (e.g., torus). In most instances, the existing equipment and infrastructure will continue to be usable and will not require replacement, but in some instances, one or more of these basic components may need to be replaced to facilitate the transition.

## 1. Receive Only Antennas

Table III-B-1: Receive Only Antenna Equipment	Range of Estimated Cost (\$)
<i>Single-Feed System</i>	
3.7m Antenna with a Single-Feed System (2 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	4,000 – 6,600
3.8m - 4.2m Antenna with a Single-Feed System (2 PLL LNBS, Pipe mount hardware, Installation and Instruction manuals) (per unit)	8,000 – 12,000
4.5m Antenna with a single-feed system (2 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	9,000 – 16,400
<i>Dual-Feed System</i>	
3.7m Antenna with a Dual-Feed System (4 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	5,000 – 7,700
3.8m - 4.2m Antenna with a Dual-Feed System (4 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	9,000 – 13,100
4.5m Antenna with a Dual-Feed System (4 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	10,000 – 17,500
<i>Triple-Feed System</i>	
3.7m Antenna with a Triple-Feed System (6 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	5,500 – 8,200
3.8m - 4.2m Antenna with a Triple-Feed System (6 PLL LNBS, Pipe mount hardware, installation and instruction manuals) (per unit)	9,500 – 13,700
4.5m Antenna with a Triple-Feed System (6 PLL LNBS Pipe mount hardware, installation and instruction manuals) (per unit)	10,500 – 18,000
<i>Supporting Equipment and Installation</i>	
Antenna Installation or Move with Foundation (includes foundation materials, equipment rental and logistics/freight) Note: The low estimate is for non-penetrating mount installation, and the high estimate for concrete foundation; assumes a concrete pad and pier, general conditions, surveyor, anchor bolts placement, grounding, A/C outlets (quantity of two - Utility and Technical)	5,000 – 30,000
Antenna Installation for Large Antenna (4.5m – 13m antennas)	8,000 – 55,000
Foundation Work for 4.5m Antenna	34,000 – 40,000
Foundation Work for 5.6m Antenna	37,000 – 43,000
Foundation Work for 7.3m Antenna	40,000 – 48,000
C-Band Feedhorn Replacement	150 – 600
Single Feed Assembly	150 – 300
Dual Feed Assembly	1,000 – 2,200
Triple Feed Assembly	1,500 – 3,300
C-Band Feedhorn Installation (for single, dual, or triple-feed)	300 – 3,000
Additional Cable & Other Spare Equipment for Install (cable length dependent)	500 – 3,300

Shipment of Antenna Equipment (size of antenna and shipping distance dependent)	500 – 5,500
Trenching for Cable for Antenna Installation (if needed)(up to 150ft max for new trench and new cabling; note, cables that need to be buried may be different and more expensive than over ground cabling and will often need conduits or armor)	1,000 – 14,000
Mount Upgrade Options (includes antenna relocation kit, anchor bolt kit and/or new jack screws)	1,000 – 15,000
Snow Cover (3.7m)	500 – 1,100
De-Icing System	4,000 – 12,000
Lightning Protection Kit	1,000 – 2,500
Tree Removal and/or Pruning (including local permits)	500 – 5,000
Landscaping Service in Accordance with Zoning Ordinance (City/County) Coordination	5,000 – 25,000
Travel Costs to non-CONUS Earth Station Site (CONUS to Hawaii or Alaska, where required as part of the transition)	5,000 – 10,000
Installation for TV Receive Only Earth Station on Vessels (filter replacement and rebalancing; used for network monitoring of services destined to vessels, but are at fixed locations)	1,500 – 3,000
Fencing Requirements (120 linear ft, 6ft high, double gate)	6,000 – 9,000
Daily Travel Costs by Vehicle (1 hour driving each way only on low end; driving, eating, one-night stay on high end)	250 – 750

Table III-B-2: Receive Only Antenna - Complete Systems	Range of Estimated Cost (\$)
<i>Small Near Full-Arc<sup>11</sup> Multibeam Antenna: Replacement Only</i>	
Multibeam Antenna (4.5m equivalent)	70,000 – 80,000
Cable Junction Box	2,000 – 2,500
Full Reflector Heating System	20,000 – 25,000
Lightning Protection Kit	1,000 – 1,500
Reflector Antenna Installation	9,000 – 10,500
<i>Small Near Full-Arc Multibeam Antenna: Complete System</i>	
Multibeam Antenna (4.5m equivalent) and Standard Mount	125,000 – 140,000
Foundation Kit	2,000 – 9,000
C-Band Dual Polarity Feed Assembly (per feed)	1,500 – 2,500
C-Band PLL LNB (per feed)	500 – 1,100
Cable Junction Box	2,000 – 2,500
Full Heating System	20,000 – 25,000
Lightning Protection Kit	1,000 – 1,500
Full System Installation	9,000 – 10,500
Shipping and Handling	15,000 – 17,000
<i>Large Near Full-Arc Multibeam Antenna: Complete System</i>	
Multibeam Antenna (6m equivalent) and Standard Mount	400,000 – 475,000
Foundation Kit	3,500 – 4,500
C-Band Dual Polarity Feed Assembly (per feed)	1,500 – 20,000
C-Band PLL LNB (per feed)	500 – 1,100
Cable Junction Box	4,000 – 4,500
Full Heating System	55,000 – 65,000
Lightning Protection Kit	2,000 – 2,500
Full System Installation	70,000 – 250,000
Shipping and Handling	25,000 – 30,000
<i>Limited Motion Antennas (LMA): Complete System</i>	
6.5m Linear LMA Antenna System (includes 2-Port receive-only feed system, 3 axis motorization Next-Generation Controller (NGC) along with recommended antenna accessories such as maintenance platform/ladder kit, lightning protection, antenna grounding, NGC environmental system)	150,000 – 175,000
7.2m Linear LMA Antenna System (includes 4-Port feed system, 3 axis motorization NGC along with recommended antenna accessories such as maintenance platform/ladder kit, lightning protection, antenna	230,000 – 245,000

<sup>11</sup> These antennas are not a full parabolic shape (e.g., torus). This antenna type is applicable for, but not limited to, complex multichannel video programming distributor.

grounding, NGC environmental system)	
13.5m Linear LMA Antenna Systems (includes 4-Port feed system, 3 axis motorization NGC along with recommended antenna accessories such as maintenance platform/ladder kit, lightning protection, antenna grounding, NGC environmental system)	720,000 – 735,000
<i>Supporting Equipment</i>	
Passband Filter	400 – 900
Multibeam Bubble Cover Kit	1,000 – 3,300
Feed Peaking Kit	500 – 1,100
C-Band Ortho Mode Transducers	1,000 – 2,200
C-Band Antenna Feed Assembly (per feed)	1,500 – 2,200
2 Cables with 4 Connectors (cable length dependent)	500 – 3,300

## 2. Bi-Directional Antennas

Table III-B-3: Bi-Directional Antenna Equipment	Range of Estimated Cost (\$)
2.4-3.0m Tx/Rx Antenna Terminal	2,500 – 18,000
3.7m Tx/Rx Antenna Terminal	10,000 – 30,000
4.5m Tx/Rx Antenna Terminal	25,000 – 45,000
6m Tx/Rx Antenna Terminal	60,000 – 200,000
BUC 2W to 80W (outdoor unit)	2,000 – 20,000
BUC 100W to 300W (outdoor unit)	20,000 – 40,000
Duplication of Hub Platforms for Transition - Single Site	200,000 – 1.5M
Additional Line Cards for Transition	6,000 – 10,000
Additional Modems for Transition	2,000 – 8,000
Additional Chassis	3,000 – 10,000
Core Network Components - Routers, Switches, Server (per component)	1,000 – 30,000
Platform and Network Installation/Testing	9,000 – 17,000
Shipping Antenna Equipment	10,000 – 30,000
Antenna Installation or Move with Foundation (includes foundation materials, equipment rental, and logistics/freight)	10,000 – 120,000

## 3. Temporary Fixed Antenna

Table III-B-4: Temporary Fixed Antenna Equipment	Range of Estimated Cost (\$)
4.5m Transmit Antenna	25,000 – 45,000
Shipping & Installation	10,000 – 15,000
Mobile Truck Rental (cost per day)	4,000 – 5,000
Upconverter/Modulator	50,000 – 75,000
High Power Amplifier	75,000 – 170,000



#### 4. Gateway and Large Aperture Point to Point Systems

The following table, III-B-5, lists items related to gateway or large aperture point-to-point systems including teleport equipment costs associated with common configurations for antenna sizes, e.g., 7.3m and 13m antennas with limited motion, extended performance, and full performance capability. Telemetry, Tracking, and Control (TT&C) consolidation costs are covered in section C below. 7.3m limited motion antennas (LMA) are anticipated to be used for Remote Monitoring System monitoring and also receive-only configurations; 13m LMAs are anticipated to be used for TT&C and Commercial Traffic; 13m Extended Performance Antennas (EPAs) are anticipated to be used for TT&C Rover and site backup; and 13m Full Performance Antennas (FPAs) are anticipated to be used for TT&C Rover and, where applicable, transfer orbit support services. The antenna is considered to be procured as a package from a single vendor per system, where major components include the antenna pedestal, hub, reflector, sub-reflector, low noise amplifier/low noise block downconverter (LNA/LNB), where LNB is used if the system is used for receive-only, and tracking/drive system. A vendor contract is assumed for the antenna hardware and installation services.

Table III-B-5: Gateway Equipment	Range of Estimated Cost (\$)
<i>7.3m LMA</i>	
7.3m LMA	550,000 – 700,000
7.3m LMA Installation	150,000 – 250,000
7.3m LMA System Integration	250,000 – 300,000
7.3m LMA Receive Only System Integration	80,000 – 120,000
<i>9m LMA</i>	
9m LMA	650,000 – 900,000
9m LMA Installation	200,000 – 350,000
9m LMA System Integration	150,000 – 250,000
<i>11m LMA</i>	
11m LMA	750,000 – 900,000
11m LMA Installation	250,000 – 400,000
11m LMA System Integration	150,000 – 250,000
<i>13m LMA</i>	
13m LMA	950,000 – 1.7M
13m LMA Installation	350,000 – 500,000
13m LMA System Integration	250,000 – 300,000
<i>13m Extended Performance Antenna (EPA)</i>	
13m EPA	1,550,000 – 1,950,000
13m EPA Installation	350,000 – 500,000
13m EPA System Integration	250,000 – 300,000
<i>13m Full Performance Antenna (FPA)</i>	
13m FPA	3,600,000 – 3,800,000
13m FPA Installation	450,000 – 600,000
13m FPA System Integration	250,000 – 300,000

<i>Supporting Equipment</i>	
Network Routers	55,000 – 200,000
Program Management for Antenna Installation	60,000 – 210,000

### C. TT&C CONSOLIDATION COSTS

The following table outlines the estimated costs associated with consolidating the TT&C sites.

Table III-C-1: Consolidation of TT&C	Range of Estimated Cost (\$)
13m Antenna System (full motion, calibrated) - Single Antenna	1.5M – 2M
Antenna Installation - Single Antenna	600,000 – 733,000
Timing System	36,000 – 105,000
Baseband Unit	100,000 – 600,000
Test Loop Translator	25,000 – 75,000
Digital Interfacility Link to Existing Teleports for Translation to Baseband	700,000 – 800,000
Upgrades to Satellite Ground Control System (per satellite)	200,000 – 1,500,000
Land/Facility Acquisition (includes cost of civil works)	500,000 – 2.5M
Site Infrastructure Buildout (includes cost of civil works)	18M – 35M

### D. POTENTIAL TOTAL COSTS – ANTENNA REPLACEMENT

While it is not the case for all entities, some entities may have to replace an entire antenna system either due to a need to relocate the antenna or because the system is too old or incompatible with a simpler upgrade. Maximum costs are based on like-for-like replacements. An overall rollup range is provided and supporting information is provided above.

Table III-D-1: Potential Total Costs for Antenna Systems	Range of Estimated Cost (\$)
Receive Only Earth Station Antenna Reflector Replacement	39,000 – 210,000
Receive Only Earth Station Complete Antenna System <sup>12</sup> Replacement	180,000 – 880,000
Bi-Directional Earth Station Antenna System Replacement Cost	40,000 – 1.9M
Temporary Fixed Earth Station Antenna System Replacement Cost	164,000 – 310,000
Gateway Antenna Replacement Cost	1.1M – 4.8M

<sup>12</sup> Includes near full-arc multibeam antennas.

## E. LUMP SUM PAYMENT TRANSITION

The Commission established the option for earth station operators to accept a lump sum amount “based on the average, estimated costs” of relocating their earth stations.<sup>13</sup> The lump sum option allows operators to transition to the upper 200 megahertz themselves or to move to alternative technologies (e.g., fiber) on their own without seeking reimbursement for actual costs of the transition. The Commission outlined that entities selecting this choice would get the average, estimated costs of relocating all of the entity’s incumbent earth stations to the 4000-4200 MHz band, and would not be able to seek additional funds if the actual expenses to transition (including transitioning to alternative technologies) were more.

We note for clarification purposes that the “Base Lump Sum Payments” referenced in Table III-E-1 are calculated per antenna and apply to each antenna specifically identified and included within an earth station registration listed in the International Bureau Filing System (IBFS). Incumbent earth station operators that elect the lump sum will be eligible to receive the Base Lump Sum Payments identified in Table III-E-1 for each registered antenna included in an IBFS registration for an incumbent earth station site. For clarification of terminology used below, a Receive Only ES Single-Feed Antenna means an antenna with a single polarization receiving a signal from a single satellite; a Receive Only ES Multi-Feed Antenna means an antenna that receives two polarizations from the same satellite effectively doubling the available bandwidth; a Multi-beam ES Antenna means an antenna that can receive signals from multiple orbital slots simultaneously.

For each type of earth station antenna outlined below (e.g., ranging from simple receive-only antennas to gateway antennas) the lump sum includes the estimated reasonable costs of upgrades/modifications (excluding compression upgrades, which are discussed below) that the average earth station antenna in that category would need for the transition.<sup>14</sup> The cost of the modification used for the calculation of the Base Lump Sum Payments was the average cost of the range from the various components of this Catalog. Depending on the type of antenna, different modifications or component changes were used based upon an expectation of the typical range of changes that would be necessary for this type of earth station transition. Some cost elements like soft costs, travel, and filtering apply to all types of earth station transitions, whereas monthly rental antennas, fiber transmitters, and other cost elements only apply to more complex earth station transitions. For example, all earth station antennas will require new filters. Some antennas, however, will require new LNBS that will contain the new passband filter. Accordingly, a determination was made based upon the comments and our judgement as to the percentage of each and then factored into the average estimated cost.

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<sup>13</sup> *Order* at 2427, para. 202. While reimbursement of expenses on an itemized basis is available for earth stations located outside of the contiguous United States to the extent they can demonstrate that the system modifications for which reimbursement is sought are necessary as a direct result of the C-band transition, the lump sum payment is not an option for earth stations outside of the contiguous United States. *Id.* at 2428, para. 204 n.550.

<sup>14</sup> *Order* at 2428, para. 203 & n.547.

The lump sum payment for Multichannel Video Programming Distributor (MVPD) earth stations will include the “MVPD Per Site Technology Upgrade Installation Lump Sum Payment,” which is calculated based on the average costs of installing compression/encoding equipment (i.e., integrated receivers/decoders and transcoders) for an average MVPD earth station site, and includes the estimated cost of labor and basic components (e.g., line cards, equipment rack, and cables) to install that equipment where necessary to the transition. As with the “Base Lump Sum Payment” calculation, the “MVPD Per Site Technology Upgrade Installation Lump Sum Payment” accounts for the probability that certain installation costs would be incurred at an MVPD earth station site. The “MVPD Per Site Technology Upgrade Installation Lump Sum Payment” does not include the cost of compression/encoding equipment or the cost to ship that equipment to the MVPD earth station sites.

Table III-E-1: Estimated Lump Sum Payments for Incumbent Earth Stations	Average Estimated Cost (\$)
<i>Base Lump Sum Payments (Per Registered Antenna)</i>	
Receive-Only Earth Station (ES) Single-feed Antenna	8,948
Receive-Only ES Multi-feed Antenna	16,997
Small Multi-beam (2-4 beams) ES Antenna	42,062
Large Multi-beam (5+ beams) ES Antenna	51,840
Gateway ES Antenna (bi-directional)	20,854
Temporary Fixed ES Antenna (e.g., mobile Electronic News Gathering trucks)	3,060
<i>Additional Lump Sum Payment for MVPD Earth Stations (Payment Available Per MVPD Earth Station Site Registered in IBFS)</i>	
MVPD Per Site Technology Upgrade Installation Lump Sum Payment	47,598

## IV. FIXED SERVICE COSTS

As the *Order* states, “[i]ncumbent licensees of point-to-point Fixed Service links that relocate out of the 3.7-4.2 GHz band by December 5, 2023, shall be eligible for reimbursement of their reasonable costs based on the well- established ‘comparable facilities’ standard used for the transition of microwave links out of other bands.”<sup>15</sup> Costs are stated on a “per link” relocation cost, where a discounting is associated with temporary fixed links (e.g., Electronic News Gathering and similar transportable fixed operations) versus permanent fixed links.

Depending on a Fixed Service operator’s new frequencies, it may be possible to retune existing transmitters/receivers to operate on new frequencies rather than replace them. Whether retuning is feasible depends on a number of factors, including the type of equipment, the frequency range(s) for which component parts are designed, the length of the path, and whether replacement parts and manufacturer support are available. In some cases, C-band Fixed Service equipment includes the capability to support the extended C-band (i.e., 5850-6725 MHz), which could potentially reduce the relocation effort required for some Fixed Service operators. In many cases, replacement may be the preferred option if the cost of retuning exceeds the cost of a new transmitter or the performance degradation is too severe or technically infeasible. Regardless of whether an operator chooses to retune or replace the equipment, the associated filters are channel-specific and must be replaced to accommodate any channel change.

The range of costs associated with Fixed Service relocation can vary widely from as little as \$2,000 for a retune in cases where existing equipment support the new frequencies outside the 3700-4200 MHz band to as much as \$290,000 for a complete like for like replacement of all equipment on both sides of the link for a 12-channel-or more system and significant tower and engineering labor. Historical data support an average link replacement cost of approximately \$185,000. A collection of costs associated with a simple retune are provided in Section IV-A below followed by more complicated relocation cost estimates.

### A. RETUNING ONLY RELOCATION

We anticipate that a simple retune (e.g., to the extended C-band in cases where this is possible) will fall in the ranges found in Table IV-A-1. This includes the labor associated with the retune and any consulting, attorney, and FCC fees as defined in Section IV-B, where the low end of the range assumes only filing fees and the high end assumes electromagnetic analyses and other support (e.g. consultants/attorneys).

Table IV-A-1: Fixed Service Retune Only Total Costs	Range of Estimated Cost (\$)
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<sup>15</sup> See *Order* at 2465, para. 326.

Permanent Fixed Link Relocation Cost	2,000 – 25,000
Temporary Fixed Link Relocation Cost	1,500 – 15,000

## B. PROJECT MANAGEMENT, CONSULTING, ATTORNEY, AND FCC COSTS/FEEES

Table IV-B-1: Fixed Service Relocation Project Costs	Range of Estimated Cost (\$)
Project Management of the Transition, if Needed (cost per hour)	62 – 200
Address Transition Timing and Coordination Issues with Other License Holders, if Needed	850 – 2,750
Prepare and/or Review Reimbursement Form	250 – 2,750
Comprehensive Study/Verification of Link Performance and Reliability, if Needed for New Electromagnetic Environment (Note - Engineering /Electromagnetic Environmental Studies are commensurate with relocation activity complexity and the amount of analyses required for new band access.)	2,750 – 19,500

Table IV-B-2: FCC Filing Fees (adjusted biennially)	Range of Estimated Cost (\$)
New, Renewal, or Renewal/Modification FCC Form 601/159 - Application Payment/Fee (per call sign)	305
New, Renewal, or Renewal/Modification FCC Form 601/159 - Regulatory Payment/Fee (per call sign)	250
Special Temporary Authorization Request	140
Extension of Construction Authority FCC Form 601/159 - Application Payment/Fee (per call sign)	110

Table IV-B-3: Consulting/Attorney Fees	Range of Estimated Cost (\$)
Prepare and File Engineering Section of FCC Form 601, Schedule I	1,000 – 5,250
Prepare and File Engineering Section of FCC Form 601, Schedule K (Notification of Completion of Construction)	500 – 2,250
Prepare and File Special Temporary Authorization	1,000 – 3,500

### C. SITE/PROJECT COSTS FOR SAME TOWER EQUIPMENT REPLACEMENT

In most cases, replacement of Fixed Service equipment may be necessary to relocate to a new frequency band. In these cases, Fixed Service operators may seek to limit new tower construction by instead performing a like-for-like replacement of equipment that *must* be replaced. This subsection addresses costs associated with project and equipment replacement costs occurring on the towers where existing links reside and thus no costs are associated with new land access and/or a new tower. Costs are broken out by equipment costs, installation/pathing/testing costs, and radio frequency (RF) engineering required to replace both ends of a point-to-point microwave link in Tables IV-C-1, IV-C-2, and IV-C-3, respectively.

Table IV-C-1: Fixed Service Equipment for Single Microwave Path (2 ends of a point-to-point microwave link)	Range of Estimated Cost (\$)
Channel Filters	450 – 2,100
Indoor Radio Pair	6,000 – 26,000
Modem Pair	650 – 5,500
Microwave Antennas - 2 Parabolic Dish Antennas	2,880 – 24,200
Outdoor Units - 2 Radios and Enclosures	1,000 – 7,750
Microwave Network Management System Equipment (server and redundant server hardware)	20,000 – 30,000
Miscellaneous Materials (e.g., waveguide, dehydrator, grounding, DC to DC Converter, Racks, PDUs, Disposal, Delivery, Storage and Handling)	3,000 – 25,000



Table IV-C-2 Installation/Pathing /Testing Costs	Range of Estimated Cost (\$)
Microwave Changeout Per Elevation (one site, each hop is two sites) (includes feedlines and sweep testing)	28,000 – 38,000
Microwave Pathing	12,000 – 16,000
Radio, Modem, and Cabling	5,000 – 7,000
Microwave Dish Antenna	10,000 – 15,000
Waveguide, Jumpers, and Connectors	3,000 – 5,000
Dehydrator System	1,000 – 1,500
DC Breaker Installation	400 – 600
New Ground Bar for Waveguide	700 – 1,000
New Ice Bridge from Shelter to Tower	6,000 – 8,000
Dish Alignment	2,500 – 3,500
Radio Acceptance Testing	4,000 – 6,000

Table IV-C-3 RF Engineering Costs	Range of Estimated Cost (\$)
Perform Engineering Study for New Operating Frequencies and Antenna & RF Equipment Development/Selection	2,000 – 15,000
Comprehensive Coverage Verification Via Field Study, if Needed	21,000 – 84,200

#### D. ADDITIONAL SITE/PROJECT COSTS ASSOCIATED WITH NEW SITE(S)

In cases where a new site is required either for lease or purchase and access to an additional tower, existing or new, is necessitated due to no other options being available for legacy Fixed Service systems to relocate to new spectrum bands, this section identifies costs that might be incurred in association with Fixed Service migration. Costs are grouped in terms of site acquisition costs, architecture/engineering costs, survey costs, environmental costs, and structural engineering costs.

Table IV-D-1 Site Acquisition Costs	Range of Estimated Cost (\$)
Search Ring for New Viable Tower or Ground Space, Confirm Zoning and Permitting Process, Site Candidate Application in Existing Asset, Lease Package or Ground Lease	7,500 – 10,000
Obtain Building Permits from Local Zoning Authorities (cost of preparation, submission and prosecution of necessary forms or applications)	1,500 – 6,000
Obtain Local Permits Other Than for Zoning (cost of preparation, submission, and prosecution of necessary forms or applications)	500 – 2,500

Table IV-D-2 Architecture/Engineering Costs	Range of Estimated Cost (\$)
Civil Site Visit & Lease Exhibit (local site for 4 hours including travel time and no report)	1,000 – 1,500
Zoning Drawings	950 – 1,250
Construction Drawings (CDs) - Co-Location (per carrier)	1,500 – 2,500
Lease Exhibit Revisions	250
CD Revisions (major changes, i.e., compound shift or access road shift)	1,500
Power Utility Coordination	750 – 5,000
Telco Utility Coordination	750 – 5,000
Gas Utility Coordination	750 – 5,000
Building Permit Submittal (not including jurisdiction fees)	1,000 – 1,250
Perform Engineering Study for New Operating Frequencies and Antenna & RF Equipment Development/Selection	2,000 – 15,000
Comprehensive Coverage Verification Via Field Study, if Needed	21,000 – 84,200
RF Exposure Measurements (for sites where post-construction measurements have customarily been required or conducted)	3,150 – 21,050

Table IV-D-3 Survey Costs	Range of Estimated Cost (\$)
Survey & 1-A Note: additional fees may be incurred for access over 500' long \$1/ft beyond 500'	2,500 – 4,500
Title Review	500 – 600
Construction Staking	1,000 – 2,000
Survey - Additional Access Road	1/ft beyond 500'
Survey Revisions (major change, i.e., compound shift or access road shift)	1,500

Table IV-D-4 Environmental Costs	Range of Estimated Cost (\$)
Environmental Site Visit Phase I Environmental Site Assessment (ESA)	1,900 – 4,500
National Environmental Policy Act (NEPA) Section 106 Environmental Review	2,000 – 6,300
Desktop Scrub	350 – 400
Non-Ionizing Electromagnetic Radiation (NIER) Letter	1,250
Geotechnical - Soil Boring and Report (assumes 1 site visit, 1 report stamped by an engineer and 1 test bore hole)	3,000 – 6,000
Environmental Assessment (if triggered by NEPA/Section 106 or for certain structures over 450 feet) (cost in addition to NEPA Review)	5,260 – 10,520

### E. POTENTIAL TOTAL COSTS - FIXED SERVICE

An expected total cost on a “per link” basis is provided below for both sides of a point-to-point microwave link. Maximum costs are based on like-for-like replacements of 12-channel-or-more systems.

Table IV-E-1: Fixed Service Expected Total Costs (2 sides of a point-to-point microwave link)	Range of Estimated Cost (\$)
Retune Permanent Fixed Link Relocation Cost	2,000 – 25,000
Retune Temporary Fixed Link Relocation Cost	1,500 – 15,000
Replacement - Permanent Fixed Link Relocation Cost	30,000 – 290,000
Replacement - Temporary Fixed Link Relocation Cost	15,000 – 150,000

## V. TECHNOLOGY UPGRADES

Multiple activities are understood to be required to clear the lower 300 megahertz of spectrum in the 3700- 4200 MHz band, inclusive of repacking via load balancing across existing satellites, the deployment of new satellites, and the installation of new receiver/decoder/encoder devices that incorporate compression technologies.

Compression/multiplexing approaches and related technologies are not considered to either improve or degrade performance of a link. Not all earth station links will require compression in order to clear the lower 300 megahertz. Further, the costs associated with new transcoding equipment at the transmit/uplink site and integrated receiver/decoder devices at the receive site can be expensive. Therefore, new encrypt/encode/compress and decode/decrypt/decompress equipment will only be needed where such equipment is reasonably necessary for the transition. However, if one side of the link (e.g. the transmit/uplink) is replaced then so too must the other (e.g. the downlink). The reimbursement for and distribution of both the compression and decompression equipment is anticipated to flow through the satellite operators (in cooperation with programmers) and is typically not part of earth station costs (except for labor for installing said equipment, and necessary equipment associated with installation). In this way, the satellite operators are both responsible and accountable for the successful repacking of their operations into the upper 200 megahertz.

Costs associated with compression equipment are included in the table below. Operators are responsible for justifying the number of pieces of equipment they need to completely repack into the upper 200 megahertz.

Table V-A-1: Uplink Technology Upgrades	Range of Estimated Cost (\$)
Project Management (per uplink location)	150,000 – 250,000
Shipping and Installation (per earth station site)	30,000 – 75,000
Equipment Maintenance (per uplink location) (per month)	1,500 – 7,500
High Power Amplifier Equipment	75,000 – 170,000
Encoding / Statmux Equipment (per transponder) (may include Encoder Hardware, Encode/Mux Software, Encryption Systems, Transport Stream Switching, Integrated Receiver/Decoder Management Systems, TS Switching and Failover, and Core Network Components (routers, switches, server))	275,000 – 1.31M
Modulation and Coding Equipment (per transponder) (may include Modulators, Upconverters, Redundancy Switches, Test and Measurement, Waveguide Sweeper (Leak Detection) and Test Loop Translator)	50,000 – 85,000

Table V-A-2: Downlink Technology Upgrades	Range of Estimated Cost (\$)
Project Management Allowance (per earth station site)	500 – 1,000
Shipping (per earth station site)	800 – 8,200
Installation (per transponder)	600 – 900
Equipment Maintenance (per earth station site) (per month)	25 – 170
<i>Integrated Receiver / Decoders (per unit)</i>	
Transcoder	5,000 – 10,000
Multi-channel decoder	9,000 – 24,000
Demodulators/RF Analysis Tools	25,000 – 75,000
RF Over Fiber System	20,000 – 35,000
A/V QC/TS Analyzer	20,000 – 35,000
Multi-Viewers	25,000 – 50,000
L-Band Distribution (Splitters/Combiners)	1,000 – 10,000