ORBCOMM

August 9, 2012

VIA IBFS

Robert Nelson, Chief
Satellite Division
International Bureau
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Application of ORBCOMM License Corp. For Authority to Modify its Non-Voice, Non-Geostationary Satellite Service Space Segment License (S2103) to Revise the Next-Generation Satellite Deployment Plan

File No. SAT-MOD-20111021-00207

AMENDMENT, SUPPLEMENT & UPDATE
FCC FORM 312 EXHIBIT

Dear Mr. Nelson:

By this submission, filed together with the required FCC Form 312, ORBCOMM License Corp. ("ORBCOMM") amends, supplements, and updates the above-referenced October 21, 2011, application (the "Modification Application") to modify its Non-Voice, Non-Geostationary Satellite Service FCC space segment license to revise the deployment plan for the eighteen currently authorized ORBCOMM Generation 2 ("OG2") satellites.[1] Specifically, **Attachment 1** to this submission provides updated information regarding revisions to the OG2 deployment plan. **Attachment 2** provides a revised and updated orbital debris mitigation showing. **Attachment 3** is an updated version of Appendix B to the original Modification Application Narrative Exhibit, providing the details of the revised first OG2 satellite launch mission profile. **Attachment 4** is a request for modification or waiver of the fourth satellite implementation milestone in ORBCOMM's current space segment license (FCC Call Sign S2103) that requires

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[1] ORBCOMM's Modification Application was accepted for filing and placed on Public Notice on December 2, 2011. See, *FCC Public Notice*, Report No. SAT-00825, released December 2, 2011. No oppositions to the Modification Application were entered in the IBFS record of the Modification Application or served on ORBCOMM.

ORBCOMM to complete construction and launch of the first two OG2 satellites by September 21, 2012.[2] ORBCOMM is also concurrently filing a revised electronic FCC Form 312 Schedule S that reflects the changes to the OG2 deployment plan described in this filing. Please associate these submissions with ORBCOMM's Modification Application.

Kindly direct any inquiries concerning this submission to the undersigned.

Respectfully submitted,

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[2] *See*, *In the Matter of Applications by ORBCOMM License Corp. For Authority to Modify its Non-Voice, Non-Geostationary Satellite System*, Order & Authorization, DA 08-633 (March 21, 2008), 23 FCC Rcd 4804 (2008) (the "Next-Generation Space Segment License"), at ¶ 23(d).

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ORBCOMM GENERATION 2 SATELLITE DEPLOYMENT PLAN UPDATE

ORBCOMM and launch service provider Space Exploration Technologies ("SpaceX") have made further revisions to the planned deployment plan for the eighteen currently authorized ORBCOMM Generation 2 ("OG2") satellites since the last update of May 21, 2012 (the "May 21 Supplement"), submitted in the record of ORBCOMM's above-referenced application (the "Modification Application"). The details of the further revisions to the OG2 deployment plan are provided below.

As ORBCOMM informed the Commission in the May 21 Supplement, due to circumstances beyond ORBCOMM's reasonable control, the launch plan for of the first OG2 spacecraft has been revised, and is now planned as a secondary payload on the first SpaceX Falcon 9 International Space Station ("ISS") Commercial Resupply Services ("CRS-1") NASA mission. The primary payload will be the SpaceX Dragon reusable spacecraft on its first commercial ISS resupply mission. The CRS-1 mission launch is currently planned for early October 2012. The first OG2 spacecraft will be deployed to a target 750 kilometer operational circular orbit with a target inclination of 51.7 degrees in a separate one satellite orbit plane. The full details regarding the revised plan for the first OG2 satellite launch are provided in the concurrently filed updated version of Appendix B to the Modification Application Narrative Exhibit.

The operational orbit plan for the other seventeen authorized OG2 spacecraft proposed in the Modification Application has also been revised. These satellites will now be deployed in four (4) evenly phased orbit planes, each with a target inclination of 52°, and a target operational altitude of 750 kilometers. Three of these planes will consist of four satellites each, and the fourth plane will consist of five satellites. Except as otherwise provided in this ORBCOMM Generation 2 Satellite Launch Program Update and other concurrently filed submissions relating to the Modification Application, all other details of the OG2 program remain as previously proposed in the Modification Application.

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REVISED ORBITAL DEBRIS MITIGATION SHOWING

The showing set forth below revises and updates the Section 25.114(d)(14) compliance information previously provided in the record of ORBCOMM's above-referenced application (the "Modification Application").[1]

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§ 25.114(d)(14) A description of the design and operational strategies that will be used to mitigate orbital debris:

As demonstrated below, the ORBCOMM Next-Generation space segment, as modified in accordance with this Application, will remain in compliance with the Commission's orbital debris mitigation Rules and policies.[2]

(1) OG2 Spacecraft Hardware Design. ORBCOMM has assessed the potential for any debris to be released into the space environment in connection with the OG2 satellite program, and has taken all possible spacecraft hardware design and operational planning measures to minimize the possibility of any such orbital debris. There are no planned intentional releases of any objects during any OG2 mission phase,

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[1] *See, Modification Application,* Narrative Exhibit, at pp. 19-29 (October 21, 2011).

[2] 47 C.F.R. § 25.114(d)(14). *See, also,* FCC Public Notice DA 05-2698, Report No. SPB-112, *Disclosure of Orbital Debris Mitigation Plans, Including Amendment of Pending Applications* (Rel. October 13, 2005).

including deployment, operations, and disposal. The OG2 satellite design does not utilize any shrouds or other temporary covers to be removed upon deployment, no shrapnel will be generated as a result of antenna and solar array deployments, and the specified OG2 satellite launch vehicle separation system uses non-explosive actuators with a cup-and-cone design that retains all separation hardware.

ORBCOMM understands and appreciates that small debris and meteoroids have the potential of colliding with and doing damage to spacecraft components. Such impacts pose a risk to a satellite's mission, its ability to maintain control, and its ability to perform post-mission disposal maneuvers. Using NASA's Debris Assessment Software (DAS v2.0.1), ORBCOMM has assessed the probability of OG2 satellite collisions with untrackable particles larger than one centimeter. At the target nominal operational orbital altitude of 750 km and with a 52 deg inclination,[3] DAS produces the annual collision probability for OG2 satellites of 1.6×10^{-4}, as summarized in the table below.

ORBCOMM Satellite	Nominal Inclination	Nominal Altitude	Avg Cross Sectional Area	P(Impact w/ debris >1cm)/yr
OG2	52^o	750 km	$3.2\ m^2$	1.6×10^{-4}

[3] The first OG2 satellite is planned for launch as a secondary payload, to be deployed to a target 750 kilometer operational circular orbit with a target inclination of 51.7 degrees. *See*, *ORBCOMM Generation 2 Satellite Launch Program Update*; *see, also*, *Updated Version of Appendix B to the original Modification Application Narrative Exhibit* (concurrently filed with this revised orbital debris mitigation showing). The .3 degree difference in 51.7 degree target inclination for the first OG2 satellite, and the 52 degree target operational inclination for the seventeen other OG2 satellites does not have a material impact on the results of this orbital debris mitigation showing.

It is unknown what the minimum particle size is that could potentially cause critical damage to an OG2 satellite in the event of an impact. Among other things, that threshold would vary depending on impact location, angle, and velocity. Due, however, to the fact that the debris population increases logarithmically with decreased debris size, the probability of impact similarly increases above 10^{-4} when debris smaller than one centimeter is considered.

The OG2 satellites have been designed to be as impact-tolerant as possible, with particular focus on minimizing the vulnerability of critical systems to small debris impacts. For example, external exposure is minimized for components critical to OG2 functionality. Additionally, internal components are provided with physical protection, either by the bus structure or thermal insulation that serves to break up small debris or meteoroids upon impact. It is also important to note that OG2 spacecraft use the same subsystems (*e.g.*, propulsion system) for operation and disposal, so the disposal operation is no more susceptible to small debris impacts than normal operational functions. These design features minimize to the greatest extent possible the probability of critical component damage resulting from any impacting debris or vapor penetrating the interior of an OG2 spacecraft during all phases of deployment, mission operations, and end-of-life disposal.

In summary, the risk of and OG2 satellite being disabled by debris smaller than 1 cm is negligible, and there is a low rate of probable impact of small debris larger than 1 cm. Protective OG2 spacecraft design measures substantially further minimize the likelihood that small debris impacts would disable an OG2 spacecraft or render it unable to conduct disposal maneuvers.

(2) Minimizing Accidental Explosions. There is virtually no possibility that an OG2 spacecraft will accidentally explode on-orbit, either during normal operations or during end-of-life disposal. As discussed more fully below, all components involved in the retention and control of energy sources are space-qualified, and energy sources will be managed autonomously, minimized, or depleted upon disposal of the spacecraft. These sources include pressurized fuel tanks for propulsion, chemical batteries, and momentum wheels. To further support this showing, on October 21, 2011, ORBCOMM submitted in the record of the Modification Application copies of hazard analyses, related presentation materials prepared by the OG2 satellite manufacturer, and information presented to NASA during the Falcon 9 ORBCOMM mission safety coordination process, together with a Request For Confidential Treatment. Those submissions are incorporated herein by reference.

Each OG2 satellite will carry up to 10.3 kg of hydrazine fuel at launch. Propellant will be used during all phases of the mission, from attaining the initial operational orbit, to performing maintenance thrusts throughout the operational life, and through end-of-life disposal maneuvering. While fuel is budgeted for disposal, any additional fuel remaining after an OG2 satellite reaches the target disposal altitude will be consumed while continuing to lower the orbit, and thereby the orbital lifetime. Thus, OG2 satellite fuel tanks will be left with very small, residual amounts of fuel, very little pressure, and no potential for chemical combustion.[4] The thermal management devices used to maintain the hydrazine fuel temperature during operations are not capable of causing the hydrazine to disassociate. Fuel tank heaters will not heat the hydrazine to a point where it will be a hazard, even in the presence of a failure that sets the fuel heaters to the full-on setting.

The OG2 satellite power subsystems use lithium-ion batteries and are designed to maximize the possibility for recovery from low states of charge. As a consequence, the OG2 design does not permit permanent disconnection of the batteries from the solar arrays. In fact, the satellites have a hard-coded protection mechanism (the load disconnect switch, or LDS) that triggers at low battery states-of-charge to prevent total battery depletion and premature mission failure. The LDS disconnects the satellite bus and payload from the battery and connects all solar array strings to the battery to optimize power recovery. Then, once charging (by drifting through an attitude that illuminates the solar arrays sufficiently), as the battery reaches state-of-charge that support minimum satellite operation, the LDS sequentially powers on various elements of the satellite bus and payload.

This feature cannot be disabled, but upon decommissioning, OG2 satellites are expected to tumble randomly. This will keep the batteries at low states-of-charge as the

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[4] The OG2 fuel tank manufacturer has indicated that the unusable amount of residual fuel that will remain in the tank will be approximately 0.27 kg. The residual internal pressure in the fuel tank from the GN2 pressurant will be less than 100 PSI. Although the tank valves cannot be left in an open position indefinitely due to the design of the OG2 propulsion system, they will be exercised in the disposal operation until there is no discernable pressure drop or delta V associated with the exercise.

power production will be small and reconnection of spacecraft elements will consume stored charge. Nevertheless, to further reduce any possibility of overcharge, decommissioned satellites will be re-configured to maximize power drain when the first elements are turned back on, thereby driving the battery charge back down. This will be facilitated with a software upload that limits charge accumulation in the initial satellite boot sequence, unless the battery charging capability of the particular satellite undergoing decommissioning does not require such intervention.

Furthermore, in the unlikely event that an overcharge condition occurs despite this design, the batteries are designed such that the pressure disc integrated into the battery cell will burst and vent/leak before a catastrophic burst of the battery occurs. Thus, the OG2 batteries have a mechanical overcharge disconnect and a leak-before-burst architecture, and therefore do not pose an explosion risk even if overcharge conditions were to occur. In addition, it is also important to note that the batteries being used in OG2 satellites are on the list of approved satellite components issued by the Eastern Test Range.

Finally, the principal source of internal kinetic energy is the satellite's suite of four momentum wheels. There are no credible failure scenarios in which this rotational kinetic energy could become sufficient to fragment the spacecraft.

(3) Safe Flight Profiles. ORBCOMM recognizes that there is some small possibility of physical collision with large objects in low-Earth orbit (including other operational satellites, spent hardware, and debris). Such a collision would clearly generate additional orbital debris. While ORBCOMM is unaware of other operators currently occupying or planning to occupy orbits identical to its own operational orbit, 750 km is a relatively populated region of LEO, and objects will most certainly be passing through this altitude regime.

To assess the likelihood of colliding with objects large enough to render an OG2 satellite a source of debris, ORBCOMM again turned to NASA's Debris Assessment Software. The calculated annual collision probability with objects larger than 10 cm for the OG2 operational orbit is shown in the table below. This debris size corresponds roughly with the lower size threshold for cataloged objects in LEO and is in keeping with the analysis requirement for large debris specified in the US Government Orbital Debris Mitigation Standard Practices (Objective 3-1). The upper risk threshold identified in DAS is 10^{-3} for the orbital life of any individual OG2 spacecraft. As computed, the accumulated risk over 30 years (five operational and up to 25 for disposal) for each OG2 spacecraft comes to $3x10^{-4}$. It should be noted that this is a conservative estimate. The analysis presumed a nominal altitude of 750 km for the entire 30-year span. In fact, OG2 satellites will spend a majority of the 30-year analysis period at lower altitudes, where the debris population is smaller.

Based on these findings, OG2 satellites do not constitute a significant risk of further contributing to the debris environment. The low probability of catastrophic collision over the life of the OG2 satellite mission satisfies the intent of the Commission's orbital debris mitigation Rules and policies.

ORBCOMM Satellite	Nominal Inclination	Nominal Altitude	Avg Cross Sectional Area	P(Impact w/ debris >10cm)/yr
OG2	52^o	750 km	$3.2\ m^2$	$1x10^{-5}$

Because there are no mission requirements to do so (nor any Commission requirements to do so, unlike requirements for geostationary satellites), no active measures are necessary to maintain OG2 satellite orbital parameters to any prescribed accuracy. During the operational life of the OG2 satellites, the orbit altitude is expected to decay less than 10 kilometers. The inclinations should remain stable at the specified operational inclinations, and the eccentricity will exhibit small oscillations above its target value of zero. The ascending node and true anomaly will obviously take on all possible values as they secularly and continuously precess. Nonetheless, as reflected in the table above, the risk of collision in the selected target altitude and inclination is *de minimis*.

Despite the low collision probabilities demonstrated above, ORBCOMM obviously has a clear business interest in protecting its on-orbit assets. ORBCOMM also takes very seriously the potential environmental impact that collisions can have in LEO. In this regard, with respect to the OG2 satellites, ORBCOMM intends to continue its established practice of coordinating with U.S. Government organizations and other satellite operators to improve space situational awareness and avoid physical collisions. For example, ORBCOMM currently receives daily conjunction summary messages (“CSM”s) from the Joint Space Operations Command (“JSpOC”), identifying conjunctions predicted 72 hours into the future between any ORBCOMM asset and any tracked object. ORBCOMM, in turn, provides JSpOC with high-accuracy ephemeris predictions for involved assets, as available, and keeps JSpOC informed of all anticipated maneuvering plans. This enables JSpOC to provide more accurate warning services to the entire operator community regarding the location of ORBCOMM satellites.

ORBCOMM also coordinates directly with other operators. For example, established lines of communication are maintained with Iridium and Radarsat, both of whom operate assets in the same altitude regime as ORBCOMM's current satellite constellation. Informal coordination arrangements among LEO satellite operators have proven quite effective, due among other things, to the mutually beneficial incentives for cooperation. Typically, if an operator has a concern over an upcoming conjunction, contact is initiated with the other affected operator to jointly review the severity of the situation and coordinate any maneuvering plans that may be deemed warranted. ORBCOMM definitely intends to continue this practice with regard to OG2 satellite operations.

One final example of collision avoidance coordination is the much more formal collaboration being undertaken among ORBCOMM, Space Exploration Technologies ("SpaceX"), and the Trajectory Operations Office ("TOPO") at NASA's Mission Operations Directorate ("MOD") relating to the first OG2 launch as a secondary payload on the upcoming Commercial Resupply Services mission ("CRS-1") being conducted by SpaceX and its Falcon 9 launch vehicle. The primary payload, SpaceX's Dragon capsule, will be deployed into a low orbit allowing it to rendezvous with ISS. The F-9 second stage will then execute an engine burn to boost ORBCOMM into a 345 km x 750 km orbit. Because this orbit crosses the ISS altitude, special attention is being paid to minimize any collision hazard OG2 poses to ISS. A more complete description of the mission and the process of pre-mission safety coordination being undertaken with NASA are given in Appendix B of this Narrative Exhibit.

(4) End-Of-Life Disposal. ORBCOMM recognizes that responsible disposal of post-mission hardware is the most practical and effective means of preserving the orbital environment for future use. Upon completion of its mission, the perigee altitude of each OG2 satellite will be lowered using its on-board propulsion system to facilitate a more rapid, uncontrolled re-entry into the atmosphere. In each case, the perigee of the satellite will be lowered sufficiently to ensure that following completion of the disposal maneuver, the orbital lifetime of the hardware will be less than the Commission's guideline of twenty-five years.

In order to determine the required target disposal perigee altitude, ORBCOMM again utilized NASA's DAS software. The target nominal operational altitude of 750 km was used as the apogee altitude, and the required disposal perigee altitude and corresponding delta velocity are given in the table below.

ORBCOMM Satellite	Apogee Alt	Ave Area/Mass	Required Perigee Altitude	Required Delta Velocity
OG2	750 km	.0204 m^2/kg	650 km	26.46 m/sec

Sufficient fuel is being budgeted on each OG2 spacecraft to perform these disposal maneuvers. The propulsion system uses hydrazine fuel, with an Isp of 222 sec. Thus, from the following equation, the average fuel efficacy ratio of 13.6 m/sec per kg is derived, and the nominal disposal reserve is to be 26.46/13.6 = 1.95 kg.

$$dV = Isp \times g \times \ln(M_{initial}/M_{final})$$

Fuel levels during the mission will be closely monitored both through direct measurements of tank pressure and temperature and by tracking usage. Comparing two measurement techniques will provide a check on expected fuel efficacy and fuel gauging uncertainty during the course of the mission. It is expected that inefficiencies from nozzle misalignment, CG misalignment, and ACS pointing error will sum to less than one percent loss. Nevertheless, a margin of 5% is added to the nominal disposal reserve to account for inefficiencies and gauging uncertainties, yielding a total disposal reserve of 2.04 kg.

DAS modeling of the basic OG2 satellite physical elements indicates that, upon atmospheric re-entry, the OG2 satellites will completely disintegrate and burn up, with no elements of the spacecraft surviving to hit the surface of the Earth. In general, spacecraft components that are most likely to survive re-entry are those that are protected by multiple layers of material (e.g., those inside a box that is inside another …), or of particularly high density (e.g., solid metal reaction wheels). Therefore, it was not necessary to construct a minutely detailed OG2 satellite model to conduct the DAS re-entry analysis. Focus was placed instead on the “nested-ness” and density of representative components. Toward this end, ORBCOMM created a satellite model consisting of an OG2 outer bus structure with the following internal components: the fuel tank; structural pylons; reaction wheels; and an internal electronics box. External spacecraft elements, such as the solar array and the antenna were not included in the model, as these components will most certainly disintegrate early in the re-entry phase.

The OG2 fuel tank was included because of the unique aerodynamics characteristics that spherical tanks possess. The structural pylons and reaction wheels were included because of their density, and because they are the most solid elements on an OG2 spacecraft. Finally, the internal box was chosen as being representative of the multiple internal OG2 satellite structures that house circuit cards and other smaller components.

The DAS analysis indicated that the OG2 outer bus will yield at an altitude of 78 km, exposing internal components to aerodynamic forces and heating. None of the modeled components were predicted to survive to an altitude of lower than 49 km. Because no OG2 component will survive to strike the ground, no casualty assessment is necessary. It can be concluded, therefore, that the OG2 satellite end-of-life disposal plan fully complies with the Commission's orbital debris mitigation Rules and policies.

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REVISED APPENDIX B TO NARRATIVE EXHIBIT

Details of First ORBCOMM OG2 Satellite SpaceX Falcon 9 Launch Mission Profile and ISS Collision Avoidance Coordination

The first ORBCOMM Generation 2 ("OG2") satellite is planned to be launched as a secondary payload on a Space Exploration Technologies ("SpaceX") Falcon 9 launch vehicle. The primary payload will be the SpaceX Dragon reusable spacecraft on its initial NASA Commercial Resupply Services ("CRS-1") mission to the International Space Station ("ISS"). The CRS-1 mission launch is currently planned for early October 2012.

SpaceX and ORBCOMM have participated in a series of NASA safety review Technical Interchange Meetings ("TIMs") to ensure, among other things, that there will be no ISS conjunction issues posed by the mission. SpaceX is coordinating with NASA's Trajectory Operations Office ("TOPO") directly on ISS safety with respect to the Falcon 9 launch vehicle and the primary Dragon mission. ORBCOMM has the lead in establishing coordination procedures with TOPO regarding the OG2 spacecraft following separation from the launch vehicle.

Mission Profile

The OG2 spacecraft will be mounted on a custom truss that is mated within the Falcon 9 second stage extension, below the Dragon spacecraft as depicted in the photo and accompanying illustration provided in Figure 1. SpaceX will initially target a 200 km x 345 km, 51.7 degree inclined orbit, where the Dragon spacecraft will be deployed. The Falcon 9 second stage will then be reignited for 1.9 seconds at apogee to boost the perigee from 200 km to 750 km. The OG2 spacecraft will then be released into a target 345 km x 750 km elliptical orbit. Onboard propulsion will then be utilized to climb to the designated target operational altitude of 750 km circular.[1] The planned Falcon 9 launch sequence is depicted in Figure 2.

Figure 1: OG2 interface truss structure mated to Falcon 9 second stage extension

[1] If the orbit injection accuracy of the launch vehicle is sub-optimal, special care will be taken to preserve sufficient fuel for the OG2 satellite's end-of-life disposal maneuvers. Under such circumstances, it may be necessary to limit fuel used for initial circularization, resulting in a lower operational perigee altitude for the first OG2 satellite.

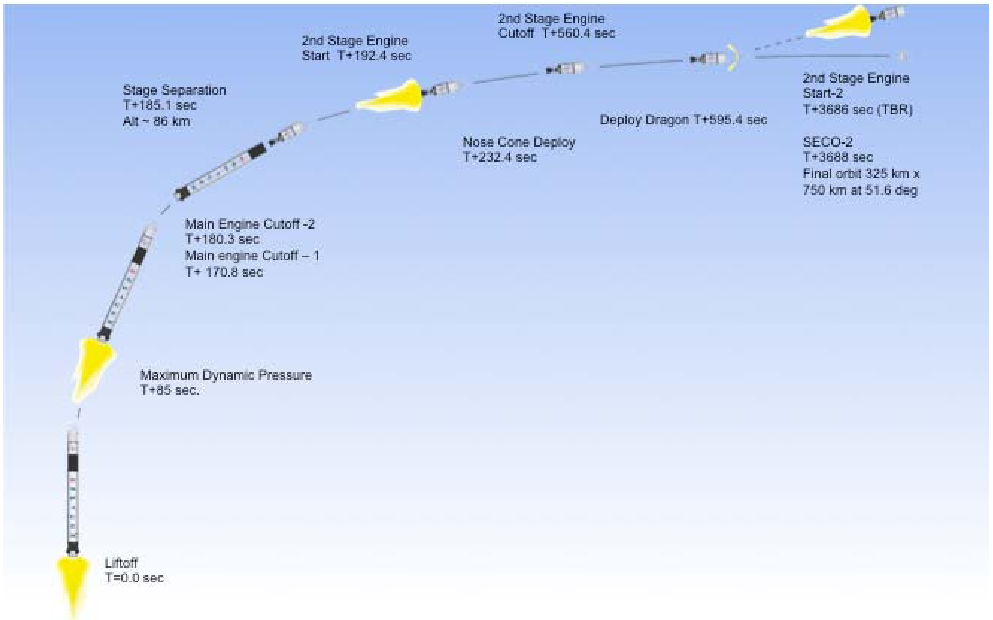

Figure 2: Falcon 9 CRS-1 mission launch sequence

Following launch vehicle separation, the OG2 spacecraft will undergo a preliminary sequence of in-orbit-tests prior to commencing a maneuvering campaign to raise the perigee. The first thrusts are expected no sooner than 3-4 days after launch, which will provide adequate time to establish the health status and determine precise ephemeris information of the OG2 spacecraft. Once begun, the priority of the thrust campaign will be to raise the first OG2 satellite perigee to above ISS orbit altitude[2] as quickly as possible. Thrust durations may be varied, but nominal durations of 50 sec will produce velocity changes of 30.3 cm/sec, resulting in increases of 1.07 km with each maneuver. This initial phase of the OG2 satellite maneuver plan will require approximately 100 individual thrusts and take several weeks to complete.

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[2] The apogee altitude of ISS at the time of launch is currently expected to be in the range of 400-425 km.

Following completion of the first-phase maneuvers to raise the OG2 spacecraft above the ISS apogee, two additional launch and early orbit phases ("LEOPs") are planned. The OG2 spacecraft will be subjected to a more complete battery of functional testing, and a less intensive campaign of thrusting will raise the perigee to 750 km. These two phases likely will be executed concurrently to some extent and are expected to take 2-3 months to fully complete.

Collision Avoidance Coordination

Although the OG2 spacecraft will pass through the ISS altitude for only a few weeks following LV separation, the ISS collision risk is being minimized and managed in close coordination with NASA through a series of technical interchange meetings and the establishment of formal information exchange procedures.[3]

NASA has indicated that ISS requires 56 hours to evaluate pending conjunctions and make necessary preparations if the ISS is required to maneuver. Therefore, SpaceX and NASA/TOPO are establishing launch window criteria that will ensure comfortable ISS separation distances from all objects associated with the launch that will pass through ISS's altitude within 56 hours of launch. This is being accomplished via trajectory analysis, and the net result is expected to be a small cut-out of injection phase angles for

[3] ORBCOMM's point of contact within MOD/TOPO is Bryan Corley, DM33/ISS Trajectory Operations, ph: (281) 483-8013, email: bryan.m.corley@nasa.gov.

Dragon that effectively translate to minor launch window timing restrictions.[4] Collision risk mitigation beyond this initial 56-hour period will be accomplished through operational coordination rather than purely through pre-launch analysis. The Falcon 9 second stage will be treated by NASA as is any other uncontrollable, tracked object, but OG2 spacecraft trajectories will be managed actively to avoid ISS conjunctions. The specific procedural details are still being finalized, but the general process of coordination with NASA has been established. Maneuver plans will be created in advance and shared with NASA and JSpOC along with ephemeris predictions and characterizations of related uncertainties. These plans will be assessed by NASA, and any anticipated ISS safety perimeter violations will be investigated and cleared, or thrust plans will be modified to assure adequate separation. Thrusts will then be executed and confirmed, and post-maneuvering ephemerides will be provided to NASA and JSpOC.

It should be noted that even unmanaged, ORBCOMM/ISS conjunctions are not likely to occur often, if at all. The initial OG2 elliptical orbit following separation from the launch vehicle will assure that the ORBCOMM spacecraft will spend very little time in the ISS altitude range. Additionally, this initial orbit will not be exactly coplanar with the ISS orbit. Deploying Dragon into a proper rendezvous orbit requires a small initial difference in ascending node between OG2 and ISS, and this difference will grow over time at the rate of approximately 0.34 deg/day, owing to the higher mean altitude of the initial OG2 orbit. This will rapidly provide an increasing cross-track degree of separation

[4] Exhibit 1 to this Appendix B is a document provided by SpaceX that provides more detail ISS collision risk mitigation procedures that are undertaken with respect to the initial 56 hour period following a SpaceX Falcon 9 ISS mission launch.

that further reduces the probability that OG2 spacecraft will penetrate ISS's safety perimeter.

Furthermore, the initial difference in period between OG2 and ISS causes ISS to overtake OG2 in-track (in a lapping sense, that is) approximately every two days. This means there is only one opportunity every two days for a conjunction to exist, and a safety perimeter violation would only occur if OG2 is also within +/-2 km in altitude AND within +/-25 km cross-track at the same time.[5]

In addition to the initial safety provided by the trajectory design, ORBCOMM will use on-board GPS receivers to actively monitor the location of the OG2 spacecraft, and produce and share ground-based orbit determination solutions derived from this telemetry. Early GPS data will be taken at high rates to assure rapid and accurate orbit solutions, and timely downloading of this telemetry will be made possible by ORBCOMM's extensive worldwide Gateway Earth Station ("GES") network.[6] Figure 4 depicts GES satellite tracking coverage at 750 km altitude. To further ensure accurate tracking of the OG2 spacecraft following launch vehicle separation, ORBCOMM will also actively coordinate with NASA and JSpOC to exchange maneuver plans and

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[5] The periodicity of altitude/cross-track alignments is on the order of about four weeks, making the probability that all three conditions required for a conjunction would actually occur unlikely during the brief time that OG2's perigee is below the ISS altitude.

[6] There are currently sixteen (16) ORBCOMM GESs deployed throughout the world.

confirmations thereof, ORBCOMM-generated ephemeris solutions, and JSpOC conjunction summary messages ("CSM") as they are derived.[7]

It should be noted that ORBCOMM has an established internal operations policy for responding to close conjunctions that is adhered to during all phases of ORBCOMM satellite operations (*i.e.*, during initial maneuvering campaigns, in operational orbit, and during disposal maneuvering). No fuel needs to be specifically allocated for collision avoidance during orbit raising or disposal maneuvering, however, as any such maneuvers are typically planned to coincide with the orbit-raising/lowering objectives.

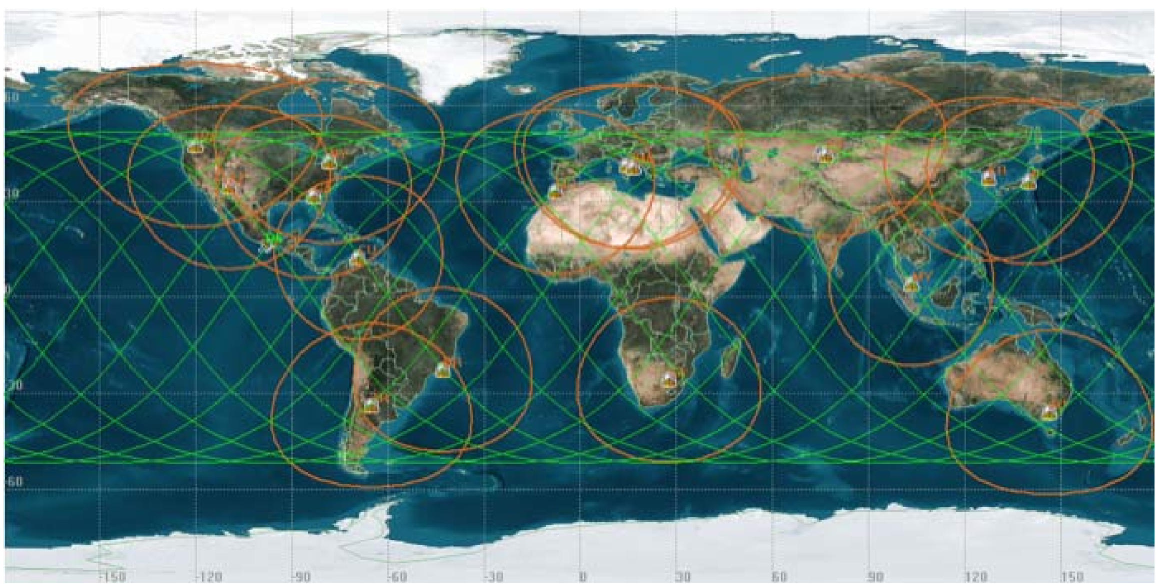

Figure 4: ORBCOMM satellite tracking coverage provided at 750 km altitude by existing worldwide ORBCOMM GES network

[7] ORBCOMM and JSpOC have had a long-established relationship with regular exchanges JSpOC CSM and internally generated ephemeris data for the operational ORBCOMM satellite constellation.

Following the first above-described OG2 Falcon 9 launch mission, ORBCOMM currently plans to launch the remaining 17 OG2 satellites on subsequent Falcon 9 missions. The OG2 spacecraft carried on these later Falcon 9 launches will be inserted either directly into the target 750 km circular operational orbit, or at a lower parking altitude that will facilitate separating satellites into different nodal planes for operational deployment. In either case, these subsequent launches are planned to be conducted several hundred kilometers above the ISS operational altitude, and thus, will not pose any ISS conjunction hazards.[8]

At end-of-life, ORBCOMM satellites will be placed into a disposal orbit with a target apogee altitude of 750 km and a maximum target perigee altitude of 650 km. This orbit will decay over a period of 20-25 years, ultimately resulting in atmospheric reentry. During this decay, atmospheric drag is most influential at the orbit's perigee, so the orbit will become more circular prior to reaching the ISS altitude regime. This is important, since a circular orbit for a descending OG2 satellite will spend less time at ISS altitude than an elliptical orbit. The total duration of altitude overlap between a decommissioned OG2 satellite and ISS is expected to be short – only on the order of months.

During this period in which the altitudes of ISS and an OG2 satellite overlap, there will be no preferred relative orientation of the planes, and the two orbits will cross twice per orbit. This is true of any two orbits sharing the same altitude, regardless of

[8] ORBCOMM is also continuing to investigate alternative cost-efficient launch opportunities that meet OG2 mission requirements.

their inclinations, so there is nothing particularly unique about the descending retired OG2 satellites being at or near the same inclination as the ISS.[9]

All safety review and other planning activities for the OG2 launch program are being undertaken in full accordance with NASA procedures for ISS-related missions. ORBCOMM and SpaceX have had extensive coordination discussions, and NASA has never raised any concern regarding potential decommissioned OG2 satellite conjunctions with ISS. It is expected that NASA will treat decommissioned OG2 satellites as it does any other inactive satellite or debris. They are easily tracked, and the ISS has standard procedures for assessing collision threats and maneuvering to avoid known debris.

Finally, it should also be noted that OG2 satellites are not expected to reach ISS altitudes until very close to the end of orbital life, which only happens after 5-10+ years of operational life and another 20+ years of orbital decay. The ISS would have to remain operational through 2040 or beyond for OG2 spacecraft conjunctions to even raise a theoretical concern.

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9 The revised OG2 operational orbit plan calls for one OG2 satellite to be deployed at a 51.7 degree inclination and the other 17 satellites to be deployed at 52 degrees inclination.

SPACEX

Space Exploration Technologies

APPENDIX B

EXHIBIT 1

1. Concerning collision avoidance between the second stage of the SpaceX launch vehicle and the International Space Station, please indicate whether Orbcomm or its launch provider are undertaking operator-to-operator coordination with NASA, and in particular with respect to operations of the second stage following separation of the Dragon capsule.

SpaceX Response:

SpaceX has worked closely with NASA's Trajectory Operations Officers (TOPO) within the Mission Operations Directorate (MOD) to establish tracking and conjunction criteria, as well as mitigate any threats to the ISS. Initially, NASA TOPO identified a period in the ISS standard debris avoidance process whereby the ISS would be unable to mitigate any conjunction prior to 56 hours after launch. SpaceX then performed analyses to show that for all planned launch opportunities, no probability of conjunction exists during this time period. To make this true, SpaceX will implement a small phase angle cut-out slightly limiting launch opportunities. This has been discussed and has a negligible impact on launch planning due to other launch constraints. After the 56-hour period concludes, ISS standard debris analysis screening applies and no further action is necessary by SpaceX.

SpaceX analysis also covers Orbcomm for the 56-hour period as no operational maneuvers are planned by Orbcomm. After the 56 hour period concludes, Orbcomm will begin operator-to-operator coordination with NASA TOPO to coordinate orbital maneuvers to reach their final operational orbit.

Additionally, SpaceX performed standard launch vehicle-to-spacecraft (Dragon and Orbcomm) re-contact analyses for the Falcon9/Orbcomm mission. This same type of analysis has been successfully employed for Falcon 1 flight 5 for the Razaksat satellite, and on Falcon 9 flight 2 for the Dragon Spacecraft and eight secondary payloads (PPODs). The results of this analysis for the Falcon9/Orbcomm mission show that the deployment strategy is robust and no risk of re-contact exists.

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Application of ORBCOMM License Corp.
For Authority to Modify its Non-Voice, Non-Geostationary
Satellite Service Space Segment License (S2103) to
Revise the Next-Generation Satellite Deployment Plan

File No. SAT-MOD-20111021-00207

REQUEST FOR MODIFICATION OR WAIVER OF MILESTONE

In connection with this amendment, supplement, and update to the above-referenced application, ORBCOMM License Corp. ("ORBCOMM") also respectfully requests that the Commission grant a modification and/or waiver of the fourth satellite implementation milestone in ORBCOMM's current FCC space segment authorization (FCC Call Sign S2103) that requires ORBCOMM to launch the first two ORBCOMM Generation 2 ("OG2") satellites by September 21, 2012.[1] As demonstrated below, grant of the proposed milestone modification is consistent with the applicable Commission Rules as well as the underlying objectives of the Commission's satellite implementation milestone policies, and would well serve the public interest.

The public policy objective of the Commission's satellite system implementation milestones is to deter speculation, to ensure that the licensee is progressing with the development of a new satellite system in a timely manner, and to preclude "warehousing" of the authorized

[1] *See, In the Matter of Applications by ORBCOMM License Corp. For Authority to Modify its Non-Voice, Non-Geostationary Satellite System*, Order & Authorization, DA 08-633 (March 21, 2008), 23 FCC Rcd 4804 (2008) (the "Next-Generation Space Segment License"), at ¶ 23(d).

frequencies and orbital resources.[2] It is quite clear that there is no speculation or "warehousing" occurring with respect to ORBCOMM's Next-Generation Space Segment License.

The ORBCOMM system commenced commercial operations in 1995. Since that time, the ORBCOMM system has and continues to make full use of its authorized spectrum and orbital resources through the ongoing operation of the first generation ORBCOMM satellite constellation. The OG2 satellites authorized under the Next-Generation Space Segment License will replenish and upgrade ORBCOMM's currently operating system, and thus cannot be characterized as a speculative new satellite system. The milestone modification requested in this submission will not disrupt the continuous provision of service.[3] Moreover, as demonstrated by ORBCOMM's previously submitted milestone completion filings, construction of all eighteen currently authorized OG2 satellites is well underway and scheduled for completion in a timely manner.[4]

ORBCOMM requires additional time to complete the first OG2 satellite launch as a result of delays due to circumstances that are beyond ORBCOMM's reasonable control. For this reason, ORBCOMM requests a six (6) month extension of the fourth satellite implementation milestone established by the Next-Generation Space Segment License. ORBCOMM also

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2 *See, e.g., Amendment of the Commission's Space Station Licensing Rules and Policies*, 18 FCC Rcd 10760 (2003), at ¶ 175.

3 *Cf., Intelsat LLC*, 19 FCC Rcd 5266 (2004), at ¶ 4 ("Intelsat further asserts that since the INTELSAT 10-02 satellite is a replacement satellite for the existing INTELSAT 707 satellite currently operating at 1º W.L., the short delays in construction and launch will not result in the warehousing of orbital locations.").

4 *Id.*, at ¶ 5.

respectfully requests a further modification or waiver of the subject initial launch milestone to require deployment of one instead of two satellites.[5]

There have been several revisions of OG2 launch plans due to changes in launch vehicle availability and delays in satellite production, both of which have been beyond ORBCOMM's reasonable control.[6] ORBCOMM is now planning to launch the first OG2 satellite as a secondary payload on the upcoming first Space Exploration Technologies ("SpaceX") International Space Station ("ISS") Commercial Resupply Services ("CRS-1") mission. The remaining seventeen authorized OG2 satellites are planned to be deployed on subsequent launches of an upgraded version of SpaceX's Falcon 9 rocket. Program delays that are beyond the reasonable control of the satellite system licensee are not an uncommon occurrence in the

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[5] Although the fourth satellite implementation milestone in the Next-Generation Space Segment License requires launch of the first two OG2 satellites by September 21, 2012, Section 25.164(b)(4) of the Commission's Rules setting forth the standardized fourth satellite implementation milestone for non-geostationary satellite system licenses only requires launch of, "the first satellite in the licensed satellite system." 47 C.F.R. § 25.164(b)(4), 68 FR 51507, Aug. 27, 2003, as amended at 69 FR 51587, Aug. 20, 2004. In the unlikely event that the Commission does not grant ORBCOMM's request to modify the fourth OG2 satellite implementation milestone to require launch of one instead to two satellites, ORBCOMM respectfully requests that the Commission grant an additional six (6) month extension (until September 21, 2013) for launch of the second OG2 satellite.

[6] Launch opportunities for OG2 satellites (and commercial satellites in general) are quite limited, with long lead times, and many other variables that are beyond the reasonable control of an FCC satellite licensee. Among other things, because small satellites such as the OG2 spacecraft are often launched as secondary payloads, unforeseeable delays and other changes relating to primary payload missions dictate the final launch date and mission profile. Similarly, unforeseeable satellite manufacturing delays beyond the reasonable control of the FCC satellite licensee are not uncommon in the satellite industry, particularly in cases such as the OG2 program that entail innovative new satellite designs.

space industry, and the Commission has previously granted modifications of launch milestones based on similar circumstances.[7]

As previously stated, there is no speculation or "warehousing" occurring, and the proposed milestone modification otherwise comports with the Commission's Rules and public policy objectives. Moreover, by obtaining launch services from a relatively new provider using a groundbreaking new-generation launch vehicle, ORBCOMM is helping to support the entry of an additional competitor into this currently limited market.[8] Having additional launch options will allow ORBCOMM (as well as others) to replace or replenish satellites more quickly and more efficiently, thus enhancing system reliability. Similarly, Sierra Nevada Corporation ("SNC"), ORBCOMM's prime contractor for the OG2 program, is also a recent new entrant in the limited commercial satellite manufacturing sector. Moreover, because SpaceX and SNC are both U.S. companies, their key involvement in the OG2 program will help to strengthen the competitiveness of the U.S. launch and commercial satellite production industries, not to mention the substantial added benefit of sustaining and creating jobs in this country. Indeed, strengthening U.S.-based commercial space capabilities also enhances national security.[9]

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[7] *See, e.g., Intelsat LLC*, 19 FCC Rcd 5266 (2004) at ¶ 7 (launch provider had assigned a new launch window). Even when the Commission has not granted requests for satellite implementation milestone modification, it has acted to provide the requested relief by waiver in situations such as the instant case, where "…*the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest*." *See, e.g., Echostar Satellite Corporation*, 18 FCC Rcd 15875 (2003), at ¶ 9.

[8] *See generally*, CSIS Report "National Security and the Commercial Space Sector," (July, 2010), attached to the Joint Comments of Echostar, Intelsat, SES World Skies and Telesat Canada submitted in IB Docket No. 10-99, filed August 23, 2010.

[9] *Id.*

For all of the above-stated reasons, the public interest will be well served by the prompt grant of the requested modification or waiver of the first OG2 satellite launch milestone.

Respectfully submitted,

ORBCOMM LICENSE CORP.

By: ______________________

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