Spire Global, Inc.

6U Satellite Orbital Debris Assessment Report (ODAR) 2021 – Exhibit G

Revision History

Revision	Description of Revisions	Release Date
1	Initial Release	2021/03/01

Section 1: Program Management and Mission Overview

Table 1. Spire Mission Overview

ODAR Author	Kier Fortier
Mission Description	The purpose of the Spire Global, Inc. ("Spire") satellite constellation is to provide high-revisit rate, global maritime, aircraft and weather insights, along with hosted payload services. This orbital debris risk assessment covers 175 Spire 6U satellites proposed to be operated by Spire.[1]
Foreign Government Involvement	None
Project Milestones	Spire satellites will be launched depending on available capacity, quality of orbit, service and constellation replenishment needs, and risk profiles of the launch vehicle and campaign. Given that Spire is applying for a number of orbits, this orbital debris risk assessment covers all such orbits. Spire has historically deployed from the International Space Station and seeks authority to continue to deploy from the International Space Station ("ISS") and therefore that orbit is also considered. Given the potential long lead time for the instant application and state of the LEO launch market for secondary payloads, Spire is not capable of providing launch parameters for the satellites at the time of submission of this report. However, Spire notes that these satellites (similar to and incorporating the Phase I, IB, IC, and II satellites) will only operate at orbital altitudes from 385 to 635 km and inclinations ranging from equatorial to polar sun-synchronous (98 degrees). This analysis considers the range of representative orbits and includes a debris assessment of the worst-case altitude and lifetime in order to provide the most conservative results.
Proposed Launch Date	
Proposed Launch Vehicles	
Proposed Launch Sites	
Launch Vehicle Operator	
Mission Duration	The planned operational lifetime of each Spire satellite is 3 years following deployment from the launch vehicle.
Selection of Orbit	Orbits are selected based on availability of launches, an established range of acceptable altitudes (385km – 635km), and inclinations that support the operational purpose of the constellation.
Potential Physical Interference with Other Orbiting Objects	The Spire satellites do not have any propulsion systems to actively maintain orbital altitude. Therefore, their orbit will naturally decay following deployment from either the launch vehicle or the ISS. As detailed in Section 5, the probability of physical interference between the Spire satellites and other space objects complies with Requirement 4.5 of NASA-STD-8719.14A.

[1] All forthcoming deployments, including missions with hosted payloads, will consist of technically identical satellites with respect to ODAR Sections 1, 2, 3, 4, 7, and 8. Section 5 utilizes the worst-case area for collision risk and Section 6 utilizes the worst-case area for dwell time. They will have a mass no greater than 15.5 kg. Spire, will submit updated documents should future satellites, including hosted payloads, exceed the dimensions submitted here. This filing augments Spire's previous 3U ODAR filing. For clarity, the total number of Spire satellites, including 3U and 6U varieties, will not exceed 175. This is inclusive, not additive to the previous approval for 175 satellites.

Section 2: Spacecraft Description

The Spire 6U spacecraft is a 6U Cubesat, roughly 246mm x 120mm x 380.5mm in its stowed configuration.[2] It has deployable solar arrays and antennas, as shown in Figure 1. Each satellite includes some combination of UHF, S-Band, and X-Band communications systems for telemetry and data transmission, and a 3-axis attitude determination and control system (ADCS). There is no on-board propulsion system. The Spire satellite is compatible with standard cubesat dispensers using the rail configuration. It has protruding antennas that use the additional available 'tuna can' volume of standard cubesat dispensers. Additional details can be seen in the table and drawings below.

Figure 1 shows the dimensional envelope of a standard Spire satellite. Figure 2 shows the dimensional envelope for a Spire satellite with deployed GNSS-R antennas. For the purposes of collision analysis in Section 5, the dimensions from Fig. 2 are used. This is the worst-case (i.e. largest) spacecraft area. Figure 3 shows the dimensions for a fully stowed satellite. For the purposes of orbit dwell time, the dimensions from Fig. 3 are used. This is the worst-case (i.e. smallest) spacecraft area for orbit dwell time.

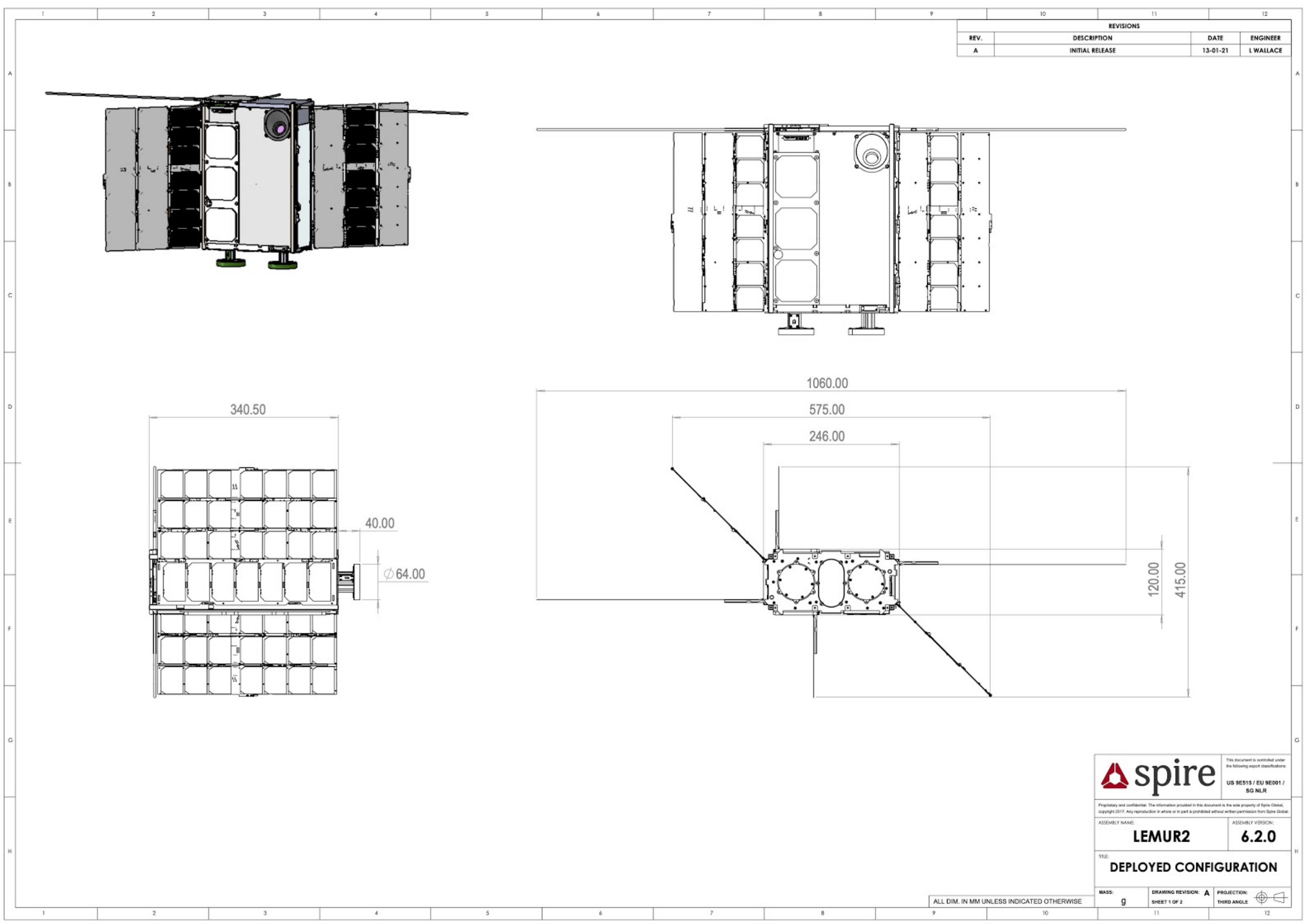


Figure 1. Spire Standard Dimensional Envelope (Fully Deployed in Mission Operation Configuration)

[2] Spire will continue to utilize both 6U and 3U cubesats, with this document specifically focusing on the 6U form.

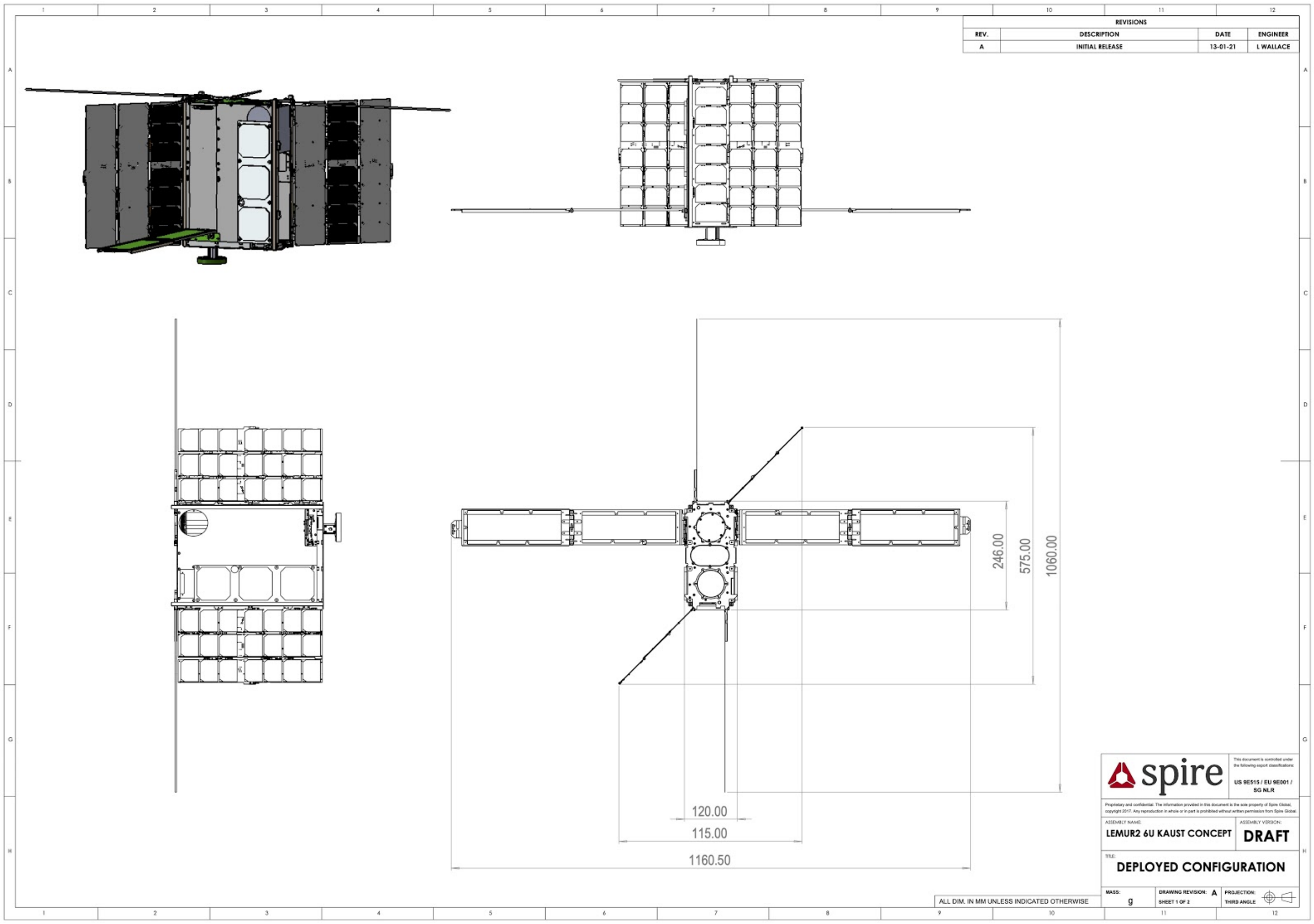


Figure 2. Spire Satellite Largest-Area Dimensional Envelope (Fully Deployed in Mission Operation Configuration)

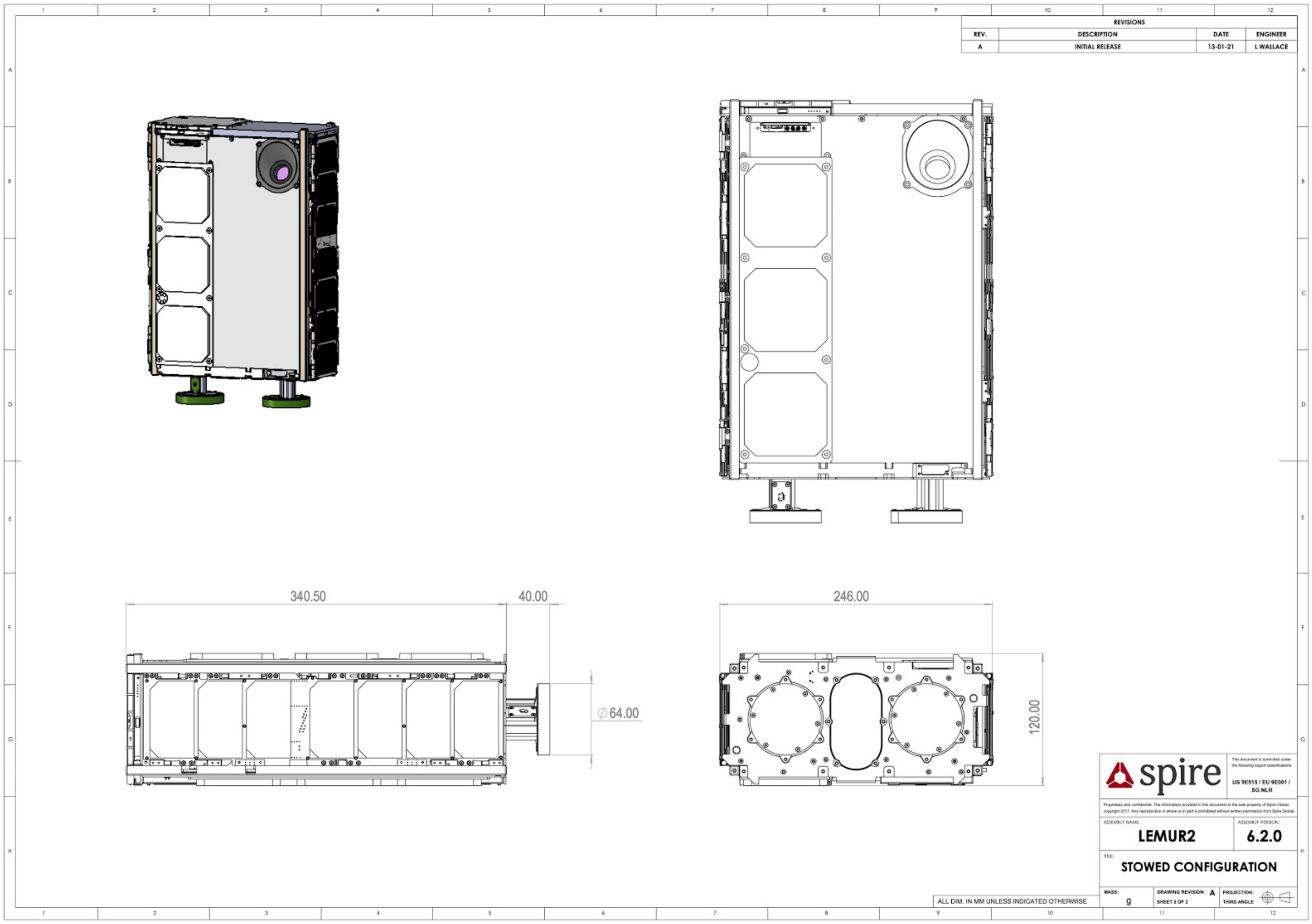


Figure 3. Spire Satellite Stowed Configuration Dimensional Envelope

Table 2. Spire Satellite Physical Description

Property	Value
Total Mass at Launch	15.5 kg maximum
Dry Mass at Launch	15.5 kg maximum (no propellant/propulsion system)
Form Factor	6U CubeSat, using "tuna-can" volume available with most standard CubeSat dispensers
COG	< 3 cm radius from geometric center
Envelope (stowed)	120mm x 246mm x 380.5mm
Envelope (deployed, max)	1160.5mm x 1060mm x 380.5mm
Propulsion Systems	None
Fluid Systems	None
AOCS	Stabilization/pointing with up to 4x reaction wheels, desaturation + coarse pointing with magnetorquers, and GPS navigation
Range Safety / Pyrotechnic Devices	None
Electrical Generation	Triple-junction GaAs solar panels
Electrical Storage	Rechargeable lithium-polymer battery pack
Radioactive Materials	None
Proximity Operations Planned	None

SECTION 3: ASSESSMENT OF DEBRIS RELEASED DURING NORMAL OPERATIONS

Spire's LEMUR satellites do not release objects during deployment or operation. Therefore, Requirements 4.3-1 and 4.3-2 of NASA-STD-8719.14A are not applicable.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:	
4.3-1a, All debris released during the deployment, operation, and disposal phases shall be limited to a maximum orbital lifetime of 25 years from date of release. 4.3-1b, The total object-time product shall be no larger than 100 object-years per mission. For the purpose of this standard, satellites smaller than a 1U standard CubeSat are treated as mission-related debris and thus are bound by this definition to collectively follow the same 100 object-years per mission deployment limit.	**N/A**
4.3-2, Debris passing near GEO: For missions leaving debris in orbits with the potential of traversing GEO (GEO altitude +/- 200 km and +/- 15 degrees inclination), released debris with diameters of 5 mm or greater shall be left in orbits which will ensure that within 25 years after release the apogee will no longer exceed GEO - 200 km or the perigee will not be lower than GEO + 200 km, and also ensures that the debris is incapable of being perturbed to lie within that GEO +/- 200 km and +/- 15 degree zone for at least 100 years thereafter. For the purpose of this standard, satellites smaller than a 1U standard CubeSat are treated as mission-related debris and thus are bound by this definition to follow this requirement.	**N/A**

Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions

Potential causes for spacecraft breakup:

Spire satellites have no propulsion and accordingly do not carry highly volatile propellant. The only energy sources (kinetic, chemical, or otherwise) onboard the spacecraft are a Lithium-Polymer battery system and reaction wheels. Thus, three plausible causes for breakup of the Spire satellites are identified:

1. energy released from onboard batteries,
2. mechanical failure of the reaction wheels, and
3. runaway torque event leading to solar panel breakup

Summary of failure modes and effects analysis of all credible failure modes, which may lead to an accidental explosion:

The battery module aboard the Spire satellites contains 8 cells in a 2S-4P arrangement. Each has a capacity of 9.62Wh, bringing the total to 76.96Wh per satellite. These batteries represent the only credible failure mode during which stored energy is released. The main failure modes associated with Lithium Polymer batteries result from overcharging, over-discharging, internal shorts, and external shorts.

One failure mode caused by the reaction wheel assemblies that could create debris would be the breakup of the wheels themselves due to mechanical failure while operating at a high angular rate.

A second failure mode caused by the reaction wheels could be a runaway torque event. In this scenario, high angular velocity could lead to the solar panels breaking up.

Risk Mitigation Plan:

The battery pack onboard the Spire satellites has been designed and built to comply with all controls and process requirements identified in NASA Report JSC-20793 Section 5.4.3 to mitigate the chance of any accidental venting or explosion caused by the above failure modes.

The reaction wheels onboard the Spire satellites are limited with respect to maximum rotational speed of the wheels and are contained within a sealed compartment, thus mitigating any risk of breakup of the wheels themselves into debris.

An analysis was performed to address the feasibility of a runaway torque event and the potential for solar panel shedding. Given the maximum stored momentum in the reaction wheels, the bending stress and shear stress at the solar panel hinges was calculated, and a Factor of Safety of over 20,000 was found against solar panel shedding. The reaction wheels cannot provide sufficient torque to cause solar panel shedding, which is the most likely mechanical shedding through rotational motion.

Given the above analysis, the risk of a runaway torque event causing breakup of satellite hardware was deemed negligible.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

There is no planned breakup of the satellites on-orbit.

Rationale for all items required to be passivated that cannot be due to design:

N/A

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:	
4.4-1, Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon: For each spacecraft and launch vehicle orbital stage employed for a mission (i.e., every individual free-flying structural object), the program or project shall demonstrate, via failure mode and effects analyses, probabilistic risk assessments, or other appropriate analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle does not exceed 0.001 (excluding small particle impacts).	**COMPLIANT**
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth, or the Moon: Design of all spacecraft and launch vehicle orbital stages shall include the ability and a plan to either 1) deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or post mission disposal or 2) control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft. The design of depletion burns and ventings should minimize the probability of accidental collision with tracked objects in space.	**N/A**
4.4-3, Limiting the long-term risk to other space systems from planned breakups for Earth and lunar missions: Planned explosions or intentional collisions shall: a. be conducted at an altitude such that for orbital debris fragments larger than 10 cm the object-time product does not exceed 100 object-years. For example, if the debris fragments greater than 10cm decay in the maximum allowed 1 year, a maximum of 100 such fragments can be generated by the breakup. b. Not generate debris larger than 1 mm that remains in Earth orbit longer than one year.	**N/A**
4.4-4, Limiting the short-term risk to other space systems from planned breakups for Earth orbital missions: Immediately before a planned explosion or intentional collision, the probability of debris, orbital or ballistic, larger than 1 mm colliding with any operating spacecraft within 24 hours of the breakup shall be verified to not exceed 10^{-6}.	**N/A**

Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

[Requirement 4.5-1] Probability for collision with objects larger than 10 cm:

The probability of a collision of any of the Spire 6U satellites with an orbiting object larger than 10 cm in diameter was calculated using the National Aeronautics and Space Administration's ("NASA's") Debris Assessment Software ("DAS") 3.1.0 software. Spire uses the maximum cross-sectional surface area for this analysis in order to produce the most conservative (worst case) results.

Table 3 below shows the risk for the longest lifetime orbits in which Spire satellites may be deployed. For completeness, DAS analysis for a 400km 51.6° and 500km SSO inclination orbits were also run, returning similarly small numbers well below the requirement of 0.001 probability.

Five different area-to-mass ratio scenarios are analyzed, including:

- Dead-on-arrival (tumbling, no panels deployed)
- ADCS non-functional, one panel deployed
- ADCS non-functional, two panels deployed
- Operational, one panel deployed
- Fully operational, nominal deployment of solar panels

Table 3. Spire Collision Risk with Objects Larger Than 10 cm, Run at Worst Case Orbit of 650km SSO

	Maximum Mass Configuration (15.5 kg) 635 km, 98 degrees (Worst Case Orbit)		
Satellite Operational State	**Effective A/M (m2/kg)**	**Collision Risk Over Lifetime (years)**	**Collision Risk per NASA DAS Analysis**
Operational, Nominal	0.0154	17.6	**2.10×10^{-5}**
Operational, Partial Deploy	0.0107	22.6	**2.16×10^{-5}**
ADCS Nonfunctional, Fully Deployed	0.0161	17.6	**2.13×10^{-5}**
ADCS Nonfunctional, Partial Deploy	0.0123	22.6	**2.21×10^{-5}**
Satellite Nonfunctional	0.0063	22.6	**2.05×10^{-5}**

[Requirement 4.5-2] Probability for collision with objects 10 cm or less:

Per the DAS User's Guide Section 3.6, Requirement 4.5-2 applies only to subsystems vital to completing post mission disposal. The Spire spacecraft does not have propulsion, nor does it require any commands or maneuvers to perform end-of-mission tasks. Therefore, requirement 4.5-2 is listed as N/A.

Assessment of spacecraft compliance with Requirement 4.5-1 and 4.5-2:	
4.5-1, Limiting debris generated by collisions with large objects when in Earth orbit: For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter does not exceed 0.001. For spacecraft and orbital stages passing through the protected region +/- 200 km and +/-15 degrees of geostationary orbit, the probability of accidental collision with space objects larger than 10 cm in diameter shall not exceed 0.001 when integrated over 100 years from time of launch.	**COMPLIANT**
4.5-2, Limiting debris generated by collisions with small objects when operating in Earth orbit: For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post mission disposal maneuver requirements does not exceed 0.01.	**N/A**

Aggregate Collision Risk

While the analysis above satisfies requirement 4.5-1 for collision risk for an individual satellite, Spire has also completed an aggregate collision risk for the Spire constellation as a whole, based on launches completed and planned.

The general aggregate risk (P_A) is summarized by Eq. 1, below:

$$P_A = [1-(1-P_1)^{N_1}] + [1-(1-P_2)^{N_2}] + ... + [1-(1-P_n)^{N_n}] \quad (1)$$

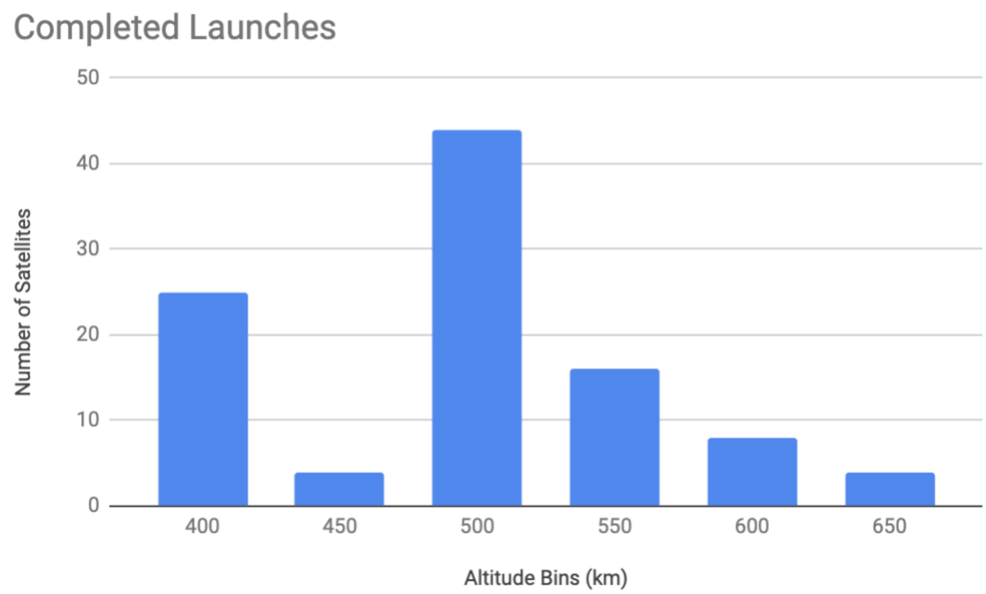
Where N is the number of satellites in a particular orbital plane and n is the number of orbital planes used for the analysis.

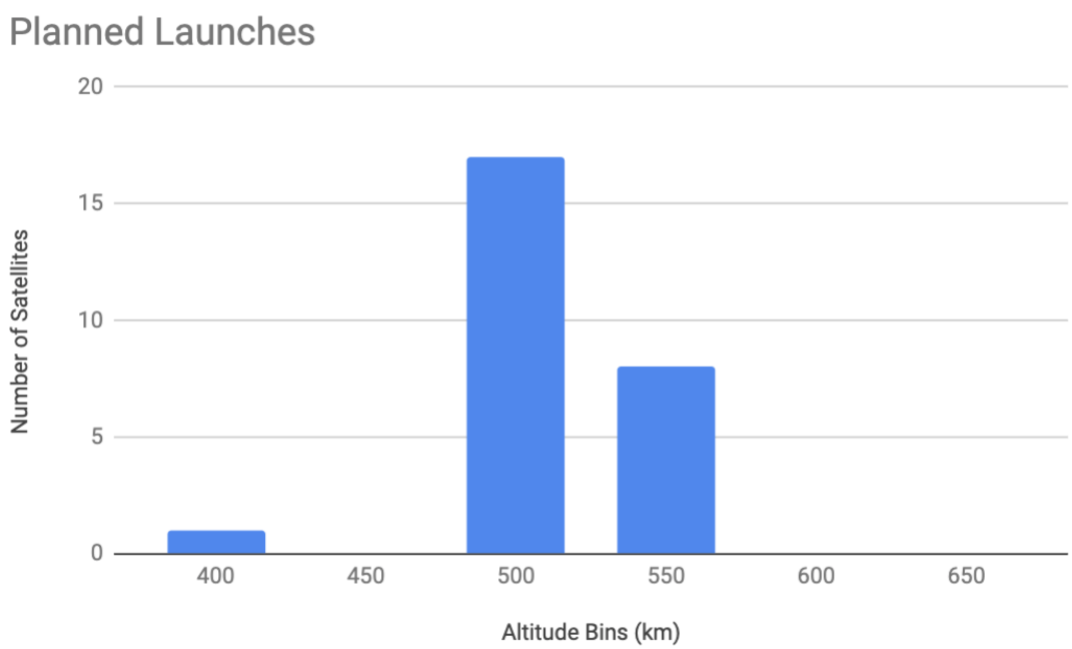
No greater than 175 Spire satellites will be simultaneously operational on orbit. For the purposes of the aggregate risk calculation, the results from the maximum mass calculations (15.5kg) will be used. For all orbits, this is a worst-case (higher) probability of collision. The results are summarized below for three deployment scenarios at six common deployment orbits. Note that Table 3 above and Table 4 below are both generated using NASA's DAS software. There is overlap between Table 3 and 4 in the 635km case of Table 3, and Table 4 extends the data to include a more representative set of orbits based on Spire's deployment practices.

Table 4. Spire Collision Risk with objects larger than 10cm (15.5 kg spacecraft)

	Scenario	**400km, 51.6° Inc.**	**450 km SSO**	**500 km SSO**	**550 km SSO**	**600 km SSO**	**635 km SSO**
(1)	Nominal Operation	7.32×10^{-8}	4.68×10^{-7}	1.48×10^{-6}	3.52×10^{-6}	1.32×10^{-5}	2.10×10^{-5}
(2)	Tumbling, full deployment	6.65×10^{-8}	4.64×10^{-7}	1.50×10^{-6}	3.56×10^{-6}	1.16×10^{-5}	2.13×10^{-5}
(3)	Dead-on-arrival	8.12×10^{-8}	3.15×10^{-7}	1.03×10^{-6}	3.61×10^{-6}	9.94×10^{-6}	2.05×10^{-5}

Considering the orbits of satellites that have already been launched, as well as those planned for the future, it is clear that the Spire constellation will comprise a variety of orbits, not just 635km. The following histograms presents altitudes for planned and completed Spire launches. Presented are the number of satellites successfully launched, or to be launched, into 50 km altitude bins.





The data from the histograms can be summarized as the following:

Completed Launches

- 25 of 101 (24.75%) at ~400 km
- 4 of 101 (3.96%) at ~450 km
- 44 of 101 (43.56%) at ~500 km
- 16 of 101 (15.84%) at ~550 km
- 8 of 101 (7.92%) at ~600 km
- 4 of 101 (3.96%) at ~650 km

Planned Launches

- 1 of 26 (4%) at ~400 km
- 0 of 26 (0%) at ~450 km
- 17 of 26 (65%) at ~500 km
- 8 of 26 (31%) at ~550 km.
- 0 of 26 (0%) at ~600 km
- 0 of 26 (0) at ~650 km

In general, the histograms of completed and planned launch altitudes have a similar distribution. This is primarily due to availability of rideshare opportunities. The majority of opportunities go to 500km, something Spire does not anticipate changing in the foreseeable future.

The completed launch distribution represents a worst-case scenario (over the planned scenario) since there is a higher percentage of satellites launching to higher altitudes in that scenario. Applying the completed launches distribution to a constellation of 175 satellites, while assuming that zero satellites deorbit, gives the following aggregate collision risk. For all altitudes, the worst-case collision probability scenario is assumed. Table 5 lists the orbit altitude bins, the worst-case single satellite collision risk for that altitude bin, and the number of satellites that would be in that altitude bin given a 175 satellite constellation that has the same percentage altitude distribution as the completed launches distribution.

Table 5. Orbital Plane Collision Risks for Aggregate Risk

Orbital Altitude Range	Worst-Case Single Satellite DAS Collision Risk (P)	Number of Satellites in Proposed Orbital Altitude (N)
~400km	8.12×10^{-8}	43
~450km	4.68×10^{-7}	7
~500km	1.50×10^{-6}	76
~550km	3.62×10^{-6}	28
~600km	1.32×10^{-5}	14
~635km	2.21×10^{-5}	7

Using the values in Table 5 and calculating the risk with Eq. 1, the resulting aggregate constellation risk is **5.62×10^{-4}**.

Section 6: Assessment of Spacecraft Post-Mission Disposal Plans and Procedures

Description of disposal option selected:

Following its deployment, a Spire satellite's orbit will naturally decay until it reenters the atmosphere. The re-entry will be uncontrolled and subject to the natural decay of the orbit. Table 6 describes the mission scenarios for which lifetime analysis of a Spire satellite was considered and the effective area-to-mass ratio of the satellite in each scenario. The ratio was calculated using the external dimensions of the Spire satellite and deployed arrays.

For purposes of Section 6, drag area from deployed VHF and UHF dipole antennas, as well as any other non-solar-panel deployable in the design, is omitted; as such, the effective area-to-mass calculated below is a conservative case.

Table 6. Area-to-Mass Ratio of Spire Satellites in Various Mission Scenarios

Scenario	Description	Effective Area/Mass Ratio (m^2/kg)
		Maximum Mass 15.5 kg
Operational, Nominal	▪ Spacecraft pointing, position is nominal, operational ▪ Solar arrays deployed	0.0153
Operational, Partial Deploy Failure	▪ Spacecraft pointing, position is nominal, operational ▪ 1 of 2 solar arrays deployed	0.0105
ADCS Nonfunctional Fully Deployed	▪ Spacecraft tumbling randomly ▪ Both solar panels deployed	0.0153
ADCS Nonfunctional Partially Deployed	▪ Spacecraft tumbling randomly ▪ 1 of 2 solar panel deployed	0.0106
Satellite Nonfunctional	▪ Spacecraft tumbling randomly ▪ No solar panels deployed	0.0063 for 5 years 0.0153 thereafter[2]

Table 7 below shows the simulated orbital dwell time for a Spire satellite in typical orbits, including the worst case scenario (longest time in orbit) of 635km altitude.

Table 7. Orbit Dwell Time for Spire Satellites in Representative Low Earth Orbits (15.5 kg)

	Maximum Mass (15.5 kg)				
Spacecraft Operational State	**Effective Area/Mass (m2/kg)**	**400 km, 51.6 deg**	**500 km, SSO deg**	**600 km, SSO deg**	**635 km, SSO deg**
Operational, Nominal	0.0153	1.1 yr	3.5 yr	13.9 yr	17.6 yr
Operational, Partial Deploy	0.0105	1.4 yr	4.3 yr	16.0 yr	22.6[3] yr
ADCS Nonfunctional, Fully Deployed	0.0153	1.1 yr	3.5 yr	13.9 yr	17.6 yr
ADCS Nonfunctional, Partial Deploy	0.0106	1.4 yr	4.3 yr	15.9 yr	22.6[2] yr
Satellite Nonfunctional	0.0063	1.9 yr	6.2 yr	18.9[2] yr	22.6[2] yr

Identification of systems required for post mission disposal: None

Plan for spacecraft maneuvers required for post mission disposal: N/A

Calculation of final area-to-mass Ratio if atmospheric reentry not selected: N/A

Assessment of Spacecraft Compliance with Requirements 4.6-1 through 4.6-4:	
4.6-1, Disposal for space structures in or passing through LEO: A spacecraft or orbital stage with a perigee altitude below 2,000 km shall be disposed of by one of the following three methods: a. Atmospheric reentry option: (1) Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission or (2) Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.	**COMPLIANT**

[3] To ensure Spire exceeds the NASA requirement in all scenarios, Spire has included a double fault-tolerant solar panel deployment mechanism, which will provide sufficient surface area and drag to comply with the NASA standard even if the Spire satellites are dead on arrival. The Spire satellite's solar panels are part of a built-in, post-deployment sequence programmed into onboard software prior to launch, which requires no direction from the ground. If for some reason the onboard sequence fails, solar array deployment can be commanded from the ground. If a Spire satellite is non-communicative, an entirely passive, redundant fail-safe is included on all Spire satellites in the form of a UV-sensitive burn wire. The tensile strength of the burn wire has been tested and verified to degrade to a breaking point after 3600 hours or 150 days of UV radiation exposure. Spire's worst-case scenario for dwell time conservatively models 5 years of non-deployed solar panels and no loss of altitude during those 5 years, followed by the dwell times for an Attitude Determination and Control nonfunctional satellite, even though a non-deployed solar panel satellite would still have some surface area that would cause some loss of altitude during that period. As such, this is a conservative worst-case scenario.

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude above 2000 km and ensure its apogee altitude will be below 19,700 km, both for a minimum of 100 years. c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.	
4.6-2, Disposal for space structures near GEO: A spacecraft or orbital stage in an orbit near GEO shall be maneuvered at EOM to a disposal orbit above GEO with a predicted minimum perigee of GEO +200 km (35,986 km) or below GEO with a predicted maximum apogee of GEO – 200 km (35,586 km) for a period of at least 100 years after disposal.	**N/A**
4.6-3, Between LEO and Medium Earth Orbit (MEO): A spacecraft or orbital stage shall be left in an orbit with a perigee altitude greater than 2000 km and apogee altitude below 19,700 km for 100 years. Between MEO and GEO: A spacecraft or orbital stage shall be left in an orbit with a perigee altitude greater than 20,700 km and apogee altitude below 35,300 km for 100 years.	**N/A**
4.6-4, Reliability of post mission disposal maneuver operations in Earth orbit: NASA space programs and projects shall ensure that all post mission disposal operations to meet Requirements 4.6-1, 4.6-2, and/or 4.6-3 are designed for a probability of success as follows: a. Be no less than 0.90 at EOM, and b. For controlled reentry, the probability of success at the time of reentry burn must be sufficiently high so as not to cause a violation of Requirement 4.7-1 pertaining to limiting the risk of human casualty.	**N/A**

Section 7: Assessment of Spacecraft Reentry Hazards

NASA DAS was used to test the major spacecraft components for re-entry hazards. The major components tested included:

- Solar panels and cells
- GPS antennas
- PCB circuit boards
- Primary structure
- Reaction wheel assembly

Summary of objects expected to survive an uncontrolled reentry (using DAS 3.1.0 software): No components are expected to survive reentry. The overall probability of human casualty is 1:100000000.

Calculation of probability of human casualty for expected reentry year and inclination: 0% (1:100000000)

Assessment of spacecraft compliance with Requirement 4.7-1:	
4.7-1, Limit the risk of human casualty: The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules: a. For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000). b. For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica. c. For controlled reentries, the product of the probability of failure to execute the reentry burn and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000).	**COMPLIANT**

Section 7A: Assessment of Spacecraft Hazardous Materials

Summary of hazardous materials contained on spacecraft: None

Section 8: Assessment for Tether Missions

Type of tether: N/A

Description of tether system: N/A

Determination of minimum size of object that will cause the tether to be severed: N/A

Tether mission plan, including duration and post mission disposal: N/A

Probability of tether colliding with large space objects: N/A

Probability of tether being severed during mission or after post mission disposal: N/A

Maximum orbital lifetime of a severed tether fragment: N/A

Assessment of compliance with Requirement 4.8-1:	
4.8-1, Mitigate the collision hazards of space tethers in protected regions of space: Intact and remnants of severed tether systems in Earth orbit shall limit the generation of orbital debris from on-orbit collisions with other operational spacecraft postmission. Tether systems should generally not remain deployed after the completion of their mission objectives. After mission objectives are met, such tethers should have provisions for disposal (full retraction/stowing and/or removal from Earth orbit) with a >0.90 probability of success, including an assessment of the reliability of the disposal system and accounting for the possibility of damage to or cutting of the tether prior to disposal.	**N/A**