[a]Reply to Blue Origin's Project Sunrise

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Blue Origin's plans to place 51,600 satellites in Low-Earth Orbit (LEO) must NOT be approved. The FCC should not have sole authority to approve large commercial satellite constellations because of the impact to DOD, NASA, NOAA, and USGS satellites, as well as the astronomical community and every human on Earth. The sheer numbers of proposed satellites and their intense infrared and visible signals will be a problem. Furthermore, Blue Origin has no experience with orbiting satellites, so they should not be approved for any constellation. This is yet another tech company trying to jump into orbiting data centers to avoid Space X from dominating LEO.

The process for approving satellite constellations must be revised similar to evaluations of satellite proposals by NASA, NOAA and the DOD:

- No contractor should declare nearly all of LEO as their domain of operation.
- Has the contractor demonstrated the ability to build and control comparable satellites?
- These proposals need far more detail, not just a discussion of communication links.
- What is the impact to the DOD, NASA, and NOAA satellites? These proposals need to be approved by the DOD, NASA, and NOAA.
- What is the impact to the night sky and ground-based astronomical visible, infrared, and radio telescopes? Simply saying they will work with the astronomical community carries no legal repercussions.
- What is the impact to international use of space, which can trigger space warfare?
- Can the proposal be better performed on the ground versus more clutter in Earth orbit?
- Can we de-orbit some constellations, e.g., the Starlink satellites:
    - For example, if Starlink satellites were placed above 8,000 km, they would require far fewer satellites (yet require radhard electronics & larger antennae), not interfere with our far more important LEO missions, and would only experience a data round trip delay of 53 milliseconds. The Starlink satellites are much smaller than these proposed orbital data centers, and already cause problems.

Blue Origin is requesting operation in sun synchronous orbits spanning between 500 and 1800 km, with emphasis on 500, 1190, and 1800 km altitudes, and up to a ridiculous number of 51,600 satellites. The lower two altitudes will cross existing satellite orbits over the poles.

We already use these proposed altitudes for far more important missions, and crossings will occur over the poles. A few of these existing missions follow:

a. Photo-reconnaissance in lower LEO
b. The International Space Station (ISS) at about 400 km (370-463 km)

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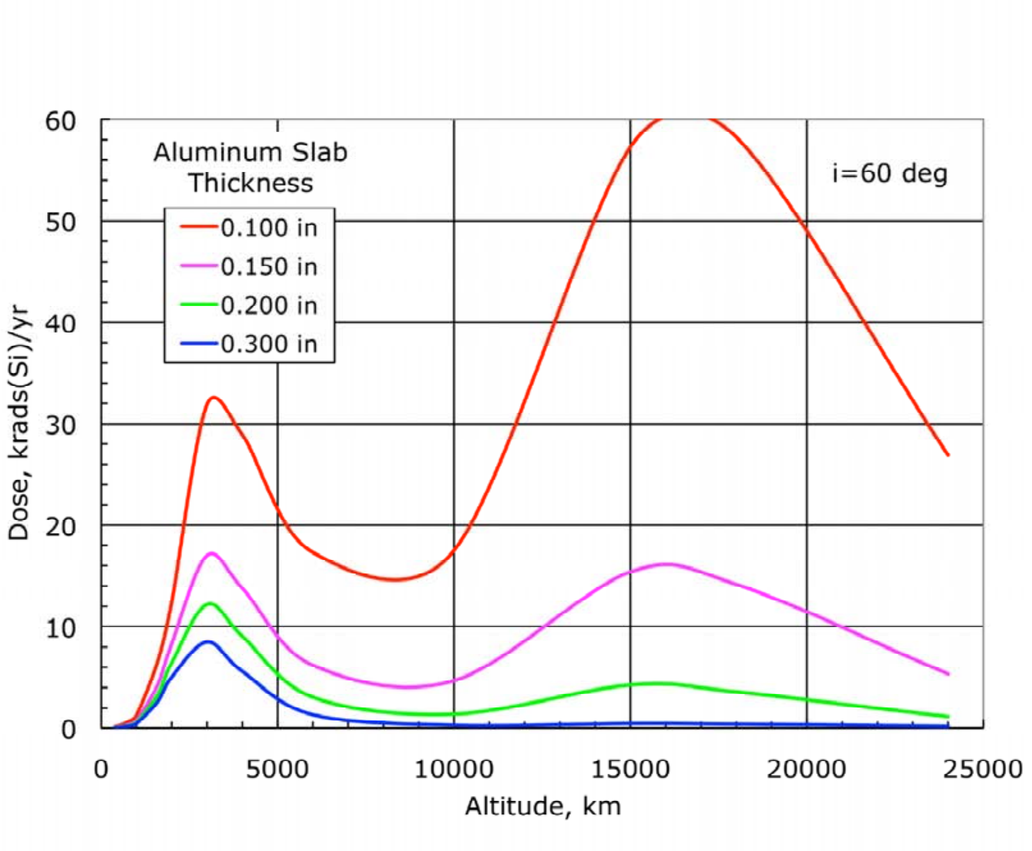
[a] Submitted to FCC Replies as PC0114676 for SAT-LOA-20260310-00118 on April 21, 2026. https://fccprod.servicenowservices.com/icfs?id=ibfs_application_summary&number=SAT-LOA-20260310-00118

c. Commercial imaging around 500 to 600 km (like WorldView)
d. Landsat at 705 km
e. NOAA 20 & 21 at 824 km
f. Numerous other DOD missions in LEO, such as radar recon
g. ICBMs operate across LEO with nominal, lofted, and depressed trajectories

There is absolutely no detail on the physical size of their proposed satellites. However, if they are on the same scale as SpaceX's proposed million 100 kW satellites, which is unacceptably large, 51,600 of them could generate about 5 gigawatts, about a quarter of that generated by ground data centers in 2023 per a congressional report [173 terawatt-hours divided by the number of hours in a year = 20 gigawatts]. The International Space Station (ISS) is the largest satellite in Earth orbit, and was originally powered with 100 kW of silicon solar cells, recently upgraded to over 200 kW using Redwire roll-out arrays with Spectrolab triple junction GaAs solar cells bonded to a flexible thermoplastic. If one simply looks at the size of data centers on the ground, the buildings are enormous and impractical to launch into space – this is why these proposals need to show the size and mass of each proposed satellite. Internal hardware is likely to survive reentry, as outer layers of these large systems are burned away during reentry.

Although Blue Origin has flown some modest size rockets, they have no experience at building satellites, and would place other existing satellites at high risk. Their emphasis on selecting 500 and 1800 km altitude orbits shows this lack of expertise. 500 km altitude has too much atmospheric drag for large solar arrays and will require frequent boosting like the ISS – the ISS flies near this altitude because the long-term radiation exposure to humans would be excessive in higher orbits. Even unhardened electronics can take about a thousand times more radiation dose than humans. No credible organization would fly satellites at 1800 km for very long because of the much higher radiation levels (that can damage many hardened electronics) as compared to lower orbits.

The following figure shows the approximate radiation dose per year versus altitude for electronics with various amounts of equivalent aluminum shielding. The spherical dose approximation in SHIELDOSE might give reasonable results for micro-satellites, but will greatly overestimate the radiation dose for larger satellites. Hence, I have found that a slab geometry shown in the figure gives a reasonable estimate of radiation dose before running detailed 3D geometrical radiation models like NOVICE. Although the figure shows dose for a 60 degree inclination, polar orbiting satellites will not experience much difference for this rough estimate. Also, solar events total dose (such as from CMEs) will be a small fraction of the total dose from the Earth's radiation belts. The inner Van Allen radiation belt is more difficult to shield against except at very low altitudes, whereas the outer belt electronics dose is dominated by high energy electrons that can be shielded against more effectively. Most circular-orbiting satellites avoid the altitudes from about 1400 to 8000 km because of high radiation levels. **It is illogical that Blue Origin would select an 1800 km orbit** that will result in over 5 krads (Si) per year of radiation dose behind 200 mils of aluminum shielding. It is also common practice to apply a 2X design margin in selecting electronics with radiation lot testing, and yet more margin if there are not test results on the same lot, because of batch-to-batch electronics manufacturing variations.



Estimating Solar Panel Size

Manufacturers of solar cells have a bad habit of quoting cell efficiencies under laboratory conditions with individual cells. Realistically, one must look at the panel efficiency by seeing how many watts it can provide at operating temperature divided by the panel area. Although it is a bit difficult to find, Spectrolab space-qualified triple junction solar panels can generate from 330 to 366 W/m^2 at 28C – corresponding to 24% to 26% solar efficiency for space solar irradiance levels. However, this must be degraded for actual operating temperatures and radiation degradation after 10 to 15 yrs on-orbit. Redwire uses these same triple-junction solar cells bonded to a Kapton substrate, and cell spacing used in roll-out arrays further decreases efficiency.

We can estimate solar array size if we know how much power is needed per satellite. Blue Origin satellites will need to generate at least 100 kW for each satellite, and assuming 20% panel efficiency, the panels would be at least 350 square meters. However, Elon Musk recently showed a sketch of their satellite using a solar array several times larger – implying they are using low efficiency solar cells on a roll-out Kapton array, likely similar to the original solar arrays on the ISS. In full sun, the solar array will run at least 60C, assuming 90% solar absorptance on the front, with optimistic emittances of 0.9 on the front and back. Spectrolab's latest solar cells with coverslides have a frontside thermal absorptance of 0.92 and emittance ~0.82, which will further increase temperatures if Spectrolab's cells are used. The Earth's albedo and thermal emissions will additionally increase array temperatures in LEO, but this would get into detailed design and operational details which does not exist at this time. If Blue Origin up-sizes to 200 kW satellites, then array size, radiator size, and brightness will roughly double.

Risks to Detect Ballistic Missile Threats after Boost

The above information allows one to estimate brightness of the solar arrays if it is “only” 350 sq meters in size. Nonetheless, at about 10 microns infrared wavelength, it will radiate ~5000 W/sr per micron (5 kW/sr-μm) at normal incidence based on a temperature of 60C. If a DOD sensor bandpass is 4 microns wide (e.g., 8 to 12 microns), the signal would be ~20 kW/sr inband. This is a very large signal for DOD missions to see above-the-horizon (ATH), when they are looking for targets of less than 10 W/sr to tens of kW/sr ATH. There is nothing that can be reduced in this LWIR signal, as high emittance surfaces are needed to keep the solar array “cool”, and 60 C (140 deg F) is quite hot. Rejecting a certain number of targets as friendly is possible, but dealing with nearly a hundred thousand targets is highly problematic and needs to seek approval from the DOD, in addition to all the possible orbital debris from malfunctioning satellites.

Advanced LEO surveillance satellites need to track hypervelocity missiles and colder targets below-the-horizon (BTH) and ATH. These require MWIR and LWIR sensors, and the longer wavelength emissions from these large satellites (due to large solar panels and radiators) will interfere with these missions. When it comes time to de-orbit old satellites, each of these Blue Origin satellites will generate mega-watts per steradian of false target signals during re-entry at visible and infrared wavelengths, in addition to megatons of re-entry debris. It is likely that the central areas of these very large satellites will survive entry, as the outer layers burn off – companies cannot say these large satellites will completely burn up without proof.

Risks to Ballistic Missile Defense (BMD) for Midcourse and Terminal GBI

Our ability to intercept ballistic missile threats using ground-based interceptors (GBI) will be impacted with bright backgrounds and false targets from these satellites. These rely on MWIR and LWIR homing sensors where these bright satellites will emit intense infrared signals while crossing the sky at altitudes and speeds comparable to ballistic missiles. The Army would have to perform a detailed analysis regarding large numbers of new objects in LEO.

Risks to Infrared Astronomy

As a side note, a 20 kW/sr signal in the 8-12 micron atmospheric window for infrared astronomy is also a problem. If an orbital data center flies at 500 km altitude, with its solar array edge-on toward nadir, the incoming signal to an IR telescope could be 20 kW/sr x cos (45 deg)/[500 km/cos(45)]^2 = 2.8 x 10^{-8} W/m^2 which will be problematic for infrared astronomy – and you cannot solve infrared signal problems by painting it black because the solar array will still have high emittance. Ground-based telescopes at high latitudes could see these satellites during the night, even if they are flying nearing the terminator.

Large Radiators Will Also Present Signal Problems for DOD and NOAA Missions

For radiators, it is not easy to calculate radiator size without knowing all the heat loads and radiator temperature. Assuming one has to reject 100 kW of heat, not including that dissipated by the satellite bus, the radiator would have to be about 300 sq meters if the radiator temperature is 20C, which seems low. 28% of this energy will be radiated into the 8 to 12 micron LWIR band, resulting in a target signal of 9 kW/sr in this band [100 x 0.28/π], an extremely bright signal. If the radiator operates at 60C, it would need to be at least 150 sq meters, and now 32% of 100 kW would be radiated into this critical LWIR band – or a target signal of 10 kW/sr radiated upward and also likely downward depending on the coatings.

This is a ridiculous target signal when our ATH DOD satellite infrared sensors are trying to detect ballistic missile reentry vehicles (RVs) that are over a thousand times fainter, as well as being in the same ballpark of tens of kW/sr for hypersonic vehicles our DOD sensors are trying to detect BTH within the atmosphere. We do not need thousands to millions of these bright objects interfering with our ability to detect enemy ballistic missiles in the post-boost phase.

Obstacles to LEO Weather Satellites

These radiator emissions will likely interfere with our NOAA LEO satellites to extract infrared weather data over polar regions, when orbits will cross critical NOAA and DOD weather satellites. We will use NOAA-20 and NOAA-21 (the JPSS project) weather satellites as an example of more issues with orbital data centers. JPSS was originally intended to be a joint weather project with NOAA, NASA, and the DOD, but because of overruns of the NPOESS project, it is now a NOAA effort with DOD efforts to follow as the half century long DMSP project is decommissioned.

These LEO NOAA satellites (not to be confused with NOAA GEO satellite pictures we see on weather reports) fly in a 824 km altitude "sun-synchronous" orbit, and can see satellite emissions operating at lower altitudes. They can discard data from a limited number of events, but thousands of orbiting data centers is a different matter, and NOAA must be contacted.

There are many instruments operating on these LEO weather satellites that are crucial to obtaining sounding data for weather forecasting. Let's look at just the M15 band of the VIIRS instrument. It will see about 10^{-10} W/cm^2-μm entering its LWIR M15 sensor when flying over mid-latitudes, more over the tropics and less over the poles. If these orbital data centers were to fly at 500 km altitude, it could produce an entrance aperture irradiance of about 5000 W/sr-μm spectral radiance target signal divided by (824 km – 500 km) squared, or ~5 x 10^{-8} W/m^2-μm = 5 x 10^{-12} W/cm^2-μm. This is roughly 5% of the signal NOAA is trying to see, and could upset their weather retrieval algorithms. This unwanted signal will increase if the satellites fly closer to JPSS. NOAA would have to perform a detailed analysis for all instruments to determine if they can tolerate thousands of bad data points per orbit. A similar issue needs to be evaluated for DOD weather satellites, like the follow-on to DMSP.

Risks to DOD Visible Tracking of Satellites

Visible scattered light is also an issue for DOD missions that track satellites from space (e.g., the SBSS satellite). Assuming this solar array is only 10% reflective in the visible and near-IR, the solar array will create a signal of ~10 kW/sr in-band to CCD detectors assuming a Lambertian reflector - and much, much higher if it is specular. Again, this is an enormous signal when DOD satellites like SBSS are trying to track smaller satellites ATH. Thousands of satellites are problematic. The impact to ground-based radar tracking of satellites should also be addressed.

Ground-Based Astronomy

Huge constellations of LEO satellites could herald an end to ground-based astronomy. This has been adequately discussed by the American Astronomical Society (AAS). Unlike SpaceX, Blue Origin is proposing to only fly near the terminator, so should only affect ground-based optical astronomy for a couple hours near the equator, but will affect telescopes at high latitudes all night.

Attempting to limit visual magnitudes m_v to 7 for large satellites must be revisited because of the sheer numbers of proposed satellites. Even binoculars and small telescopes used by kids and amateurs can see well beyond 7th magnitude – actually about 11th to 12th magnitude in dark skies. Large observatories operate at beyond 20th visual magnitude. It is very discerning to see all the existing satellites streaking across the night sky, let alone the large proposed data centers.

Destabilization of Space for Peaceful Purposes – LEO is Highly Vulnerable

Whenever a company or nation puts excessive satellites in specific orbits, it limits others from occupying those orbits. This has been a problem in GEO for decades. This means that another nation is likely to take military action to destroy these satellites, either using lower cost GBI or nuclear means.

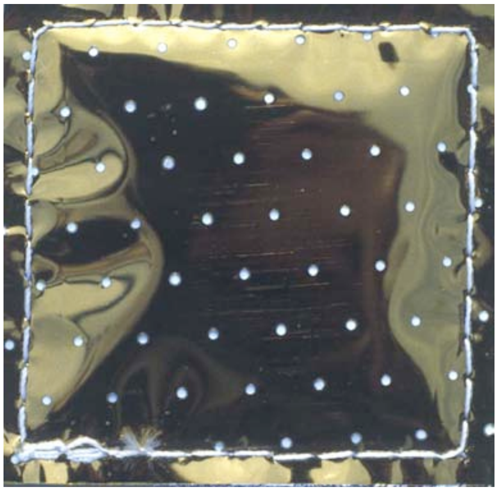
There are already over 10,000 satellites in LEO, thanks mainly to Space X. It is possible that another nation will justifiably consider exploding nuclear bombs in LEO as a deterence to placing large satellite constellations in LEO. This can destroy electronics in most LEO satellites as we demonstrated in the 1962 Starfish nuclear test. Multiple nuclear bursts can saturate the inner Van Allen belt destroying all satellite electronics whether nuclear hardened or not.

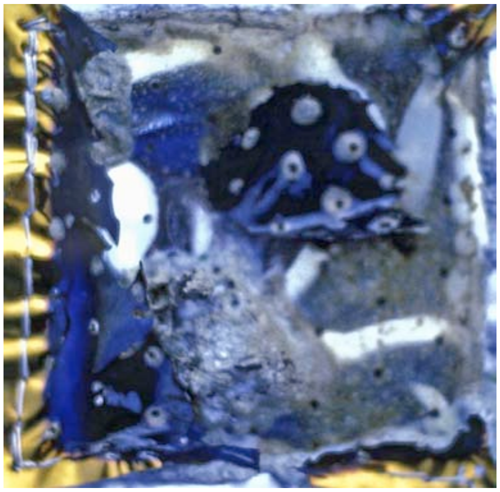
This proposal, if approved, **will likely result in Space Warfare with other countries**, which can also escalate down on the ground. Russia and China have already complained about Starlink satellites. Although ASATs generating orbital debris and nuclear explosions in LEO would be an extreme reaction to such large constellations, affecting all satellites in LEO, **subtle countermeasures like using Ground-Based Lasers (GBL) to disable satellites or deploying small pellets or BBs are well known to damage satellites**.

In the 1980s, we demonstrated that a GBL, specifically High Energy Lasers (HEL) **using existing technology** at that time**, can destroy thermal control materials and solar arrays used on any LEO satellite at very low laser irradiance** – thermoplastics like Kapton, Teflon, and

Mylar burn through in only seconds, then satellites overheat and internal electronic components are permanently damaged. Roll-out solar arrays on Kapton would simply fall apart as the thermoplastic substrate is destroyed. Laser spot diameter (1/e) will expand to many meters from ground to LEO accounting for jitter, diffraction, beam quality and atmospheric turbulence.

The photos below show a Kapton MLI blanket that was tested in a vacuum chamber to very low laser irradiance levels in 1983 that can be beamed to LEO from a GBL. The outer layer is bare Kapton with many aluminized inner layers spaced by Dacron netting. It was burned through in seconds – the edges were shielded by a laser mask in front of the MLI.





As an additional example, deploying about 10,000 kg of BBs (two Soyuz launches or multiple smaller rocket launches) uniformly in 10 km thick rings at 600 km altitude, and slowly deployed to cover all orbital rings at the target altitude, could create a collision rate of roughly one hit every two weeks per 10 square meters of satellite cross-section, or ~70 hits every month on a 350 square meter solar array. At an average collision speed of 10 to 15 km/s, **each BB would have far more energy than a rifle bullet per NASA**. In just a few years, depending on solar activity and the material used like aluminum, steel, lead, or tungsten, the BBs orbit would decay to lower orbits and burn up in the atmosphere. Very little debris would likely be sent to higher orbits, and the satellites in the targeted orbits would eventually malfunction. At 600 km and lower altitudes, these satellites would then burn up in the atmosphere within months to years. If Blue Origin attempted to put debris shields on their satellites like on the ISS, then a counter-counter measure would be to simply increase the pellet size. And, by the way, the Russians used pellets in their co-orbital ASAT tests well over a half century ago.

Dramatic Increase in Orbital Debris

Because of the large amount of debris already present in LEO, we have been putting orbital debris shields on critical satellites for many decades, including the ISS, but we cannot protect everything because a satellite needs solar power in most cases, needs views for its sensors and antennae, and needs to radiate waste heat to space.

Placing thousands to millions of satellites in LEO is an unacceptable orbital debris risk. Satellites can fail due to orbital debris, solar flares and CMEs, bad designs, improper manufacturing, etc. Nothing is 100% successful. A 1% failure rate would result in nearly a thousand errant Blue Origin satellites.

Data centers are far more practical on the ground.

These companies have impractical visions. Up-to-date rad-hard electronics are not available for space applications, like current unhardened commercial electronics available on the ground, since about the 1980s. Space-rated electronics are slow compared to the latest commercial electronics. **Ground data links can use high-speed fiber optics to customers – space cannot**. There is excess water/rainfall in the eastern U.S. and Pacific northwest causing flooding, which could be made available to cool data centers, as **water/fluid/air convective cooling on the ground is far more effective at cooling electronics than radiative cooling in space**. Space is an insulator, and radiating at infrared wavelengths is space's only cooling option. **One cannot hide a satellite at infrared wavelengths**. Numerous data center companies have stated how stupid it is to place them in orbit. **Due to existing LEO overpopulation, no satellite proposal should be accepted which can be better accomplished on the ground.**

Conclusion

These LEO data center satellites pose an unacceptable risk to current and future satellites, military missions for defense, and weather satellites, let alone problems for astronomers, nighttime enthusiasts, and potential problems for birds and animals. The knowns and unknowns are too great of a risk to more important satellite constellations, and this proliferation of Earth orbiting satellites must stop. The approval procedure for commercial satellite constellations must be completely overhauled. LEO and GEO are already overpopulated with satellites. The orbital data center proposals are a blatant abuse of Earth orbit disrupting far more important missions.

Serious consideration should be given to locating these large data centers at the L4 and L5 Lagrange sun-orbiting locations, if they really want to put them in space, despite the costs to place them at large distances from the Earth with latency issues. Solar flares and coronal mass ejections (CMEs) do not cause as significant of a total radiation dose as in Earth orbit, and there are missions that can last a long time at these distances [e.g., Kepler actually Earth-trailing; Solar and Heliospheric Observatory (SOHO) which has operated at L1 for over 30 years; James Webb Space Telescope (JWST) at L2, etc.]

Also, communication satellites with internet capability should operate in MEO and GEO, not LEO because of far more important missions in LEO that would be impacted.