Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Reflect Orbital Inc.	)	ICFS File No. SAT-LOA-20250701-00129
	)	
Application for Authority to Construct, Launch, and Operate a Non-Geostationary Orbit Satellite in the Space Operation and Space Research Services	)	Call Sign: S00711

ORDER AND AUTHORIZATION

Adopted: July 9, 2026 **Released: July 9, 2026**

By the Chief, Space Bureau:

GRANT
Reflect Orbital Inc.
ICFS File No: SAT-LOA-20250701-00129

ICFS File No(s):	SAT-LOA-20250701-00129[1]	**G R A N T E D – With Conditions** **Space Bureau Satellite Programs and Policy Division**
Licensee/Grantee:	Reflect Orbital Inc (Reflect Orbital)	
Call Sign:	S00711	
Satellite Name:	Earendil-1	
Orbital Location: (required station-keeping tolerance)	Non-geostationary satellite orbit (NGSO) Deployed to an altitude of 510 km, +/-20 km, MLTAN (insertion orbit) of 11:00 +60 minutes Operating at an altitude of 625 km, +/-25 km, and inclination of 88 degrees, +/-2 degrees	
Administration:	United States of America	
Nature of Service:	Space Operation Service (SOS) Space Research Service (SRS)	
Scope of Grant:	Authority to deploy and operate a space station using radio frequencies in the S-, X-, and UHF- bands.[2]	
Previous Grant(s):	N/A	
Service Area(s):	Global	
Frequencies:	SOS: 401-402 MHz (space-to-Earth) (Center frequencies: 401.3194 MHz, 401.5194 MHz, and 401.7194 MHz; bandwidth: 25 kilohertz) 2025-2110 MHz (Earth-to-space) (Center frequencies: 2040.346 MHz and 2047.654 MHz; bandwidths: 1.16 megahertz, 576 kilohertz, and 288 kilohertz) (command uplinks; deploy and test steerable sunlight reflector functionality) 2200-2290 MHz (space-to-Earth) (Center frequencies 2215.996 MHz and 2226.004 MHz; bandwidths: 1.16 megahertz, 576 kilohertz, and 288 kilohertz) (telemetry downlinks) (outside of the United States only) SRS: 8450-8500 MHz (space-to-Earth) (center frequency: 8495 MHz; bandwidths: 5.19 megahertz and 2.60 megahertz) (payload data downlinks)	
Unless otherwise specified herein, operations under this grant must comport with the legal and technical specifications and commitments set forth by the applicant or petitioner and with the Federal Communications Commission's rules not waived herein. This grant is also subject to the following conditions:		

[1] *See* Reflect Orbital Inc., Application to Construct, Launch, and Operate a Non-Geostationary Orbit Satellite in the Space Operation and Space Research Services, ICFS File No. SAT-LOA-20250701-00129 (filed Jul. 29, 2025) (Reflect Orbital Application). This Application was accepted for filing on February 6, 2026. *See* Satellite Licensing Division and Satellite Programs and Policy Division Information, Space Station Applications Accepted for Filing, Report No. SAT-01972 (Feb. 6, 2026). The American Astronomical Society filed a petition to deny in addition to comments and letters filed on the record by other organizations and members of the public. The issues raised on the record are addressed in the accompanying Order.

[2] Reflect Orbital describes Earendil-1 as a "crucial testbed" for space-based reflector technology, which it seeks to deploy to meet government, commercial, and humanitarian needs, such as directing reflected sunlight to targeted areas to "augment energy projects by extending usable hours for solar cells" and "provide an illumination solution for critical operations." Reflect Orbital Application, Legal Narrative at 5.

1. Space-to-Earth and Earth-to-space operations shall be strictly limited to durations when the Earendil-1 satellite is visible to the corresponding earth station locations listed in the Appendix of this grant, noting any additional restrictions within this grant.
2. Reflect Orbital's transmissions in the 401-402 MHz band may only be made to/from earth stations coordinated with Federal agencies, including National Aeronautics and Space Administration (NASA), Department of Commerce/National Oceanic and Atmospheric Administration (DOC/NOAA), and the United States Air Force Spectrum Management Office (AFSMO). Reflect Orbital's transmissions in the 2025-2110 MHz and 2200-2290 MHz bands may only be made to/from Federal earth stations or non-Federal earth stations coordinated with NASA, AFSMO, DOC/NOAA, and the Department of the Navy (DON). Any use of Federal ground stations shall be coordinated by Reflect Orbital's Federal government customers with AFSMO (jimmy.nguyen@us.af.mil), NASA (HQ-SatCoord@mail.nasa.gov) and DOC/NOAA (spectrum.coordinator@noaa.gov). A list of coordinated non-Federal earth stations is attached in the Appendix. Reflect Orbital shall provide the FCC with an updated list of coordinated non-Federal earth stations within ten business days following any changes to that list.
3. To protect NOAA radiosondes operations in the United States and Possessions, operations in the 401-402 MHz (space-to-Earth) band shall not exceed the long-term interference criteria limit of -162.4 dBW, as specified in Table 2 (Type C) of Recommendation ITU-R RS.1263-3.
4. We GRANT, on our own motion, waiver of the U.S. Table of Frequency Allocations (U.S. Table), 47 CFR § 2.106(a), to permit Reflect Orbital to use the 2025-2110 MHz band for Telemetry, Tracking, and Command (TT&C) uplinks.[3] In the U.S. Table, 47 CFR § 2.106(a), the 2025-2110 MHz band is allocated, *inter alia*, to the Fixed and Mobile Services on a primary basis and the SOS on a secondary basis for non-Federal use; under section 2.106(a), (c)(347) of the Commission's rules, in the 2025-2110 MHz band, non-Federal Earth-to-space transmissions may be authorized in the SRS and Earth Exploration-Satellite Service (EESS) subject to such conditions as may be applied on a case-by-case basis, and such transmissions shall not cause harmful interference to Federal and non-Federal stations that are operating in accordance with the U.S. Table.[4] However, under section 2.106(a), (c)(94) of the Commission's rules, non-Federal SOS transmissions in the 2025-2110 MHz band are restricted to telecommand use for pre-launch testing and space launch operations, subject to coordination with the National Telecommunications and Information Administration (NTIA) prior to each launch and coordination with non-Federal fixed and mobile stations.[5] Reflect Orbital's planned use of the 2025-2110 MHz band for TT&C is outside the context of pre-launch testing and space launch operations restrictions for the non-Federal SOS in the 2025-2110 MHz band,[6] so a waiver of the U.S. Table is needed. Reflect Orbital states that it will coordinate with primary users in the band and will not cause harmful interference to systems that are operating in accordance with the U.S. Table.[7] We find it is in the public interest to waive the U.S. Table, to the extent necessary, to authorize Reflect Orbital's operations in this band since doing so is consistent with the Commission's goal to efficiently use spectrum and foster innovative satellite technologies. Reflect Orbital is authorized for these operations on an unprotected and non-interference basis, and operations pursuant to this authorization must accept interference from and not cause harmful interference to authorized stations that are operating in the 2025-2110 MHz and adjacent bands in accordance with the U.S. Table, 47 CFR § 2.106(a). Reflect Orbital must immediately terminate its operations upon notification of harmful interference to authorized services.

[3] Reflect Orbital Application, Legal Narrative at 3.

[4] 47 CFR § 2.106(a), (c)(347).

[5] 47 CFR § 2.106(a), (c)(94).

[6] *Id.*

[7] Reflect Orbital Application, Legal Narrative at 3.

5. Reflect Orbital's earth station transmissions in the 2025-2110 MHz band must be coordinated with Fixed Services and Mobile Services stations in the band (e.g., via the Society of Broadcast Engineers (SBE)).
6. In the U.S. Table, 47 CFR § 2.106(a), the 2200-2290 MHz band is allocated, *inter alia*, to the SOS (space-to-Earth) on a secondary basis for non-Federal use, restricted under section 2.106(a), (c)(96) of the Commission's rules to use for pre-launch testing and space launch operations, except as provided under section 2.106(c)(303) of the Commission's rules.[8] Reflect Orbital's operations in the band will be outside of the United States.[9] We authorize Reflect Orbital to operate in this band subject to the laws, regulations, and requirements applicable to any such operations in foreign jurisdictions. Operations in the 2200-2290 MHz frequency band are permitted for use only outside of the United States, and transmissions within the SOS shall be strictly limited to durations when the Earendil-1 satellite is visible to corresponding earth station locations listed in the Appendix of this grant, subject to any additional restrictions in this grant. Reflect Orbital is required to successfully coordinate with NTIA prior to submitting any ITU filing involving any ground stations outside of the United States that operate in the 2200-2290 MHz band. NTIA will consider the request by Reflect Orbital for access to the 2200-2290 MHz band for ground stations located outside of the United States on a case-by-case coordinated basis with appropriate electromagnetic compatibility (EMC) analysis to NTIA (ravery@ntia.gov), AFSMO (jimmy.nguyen@us.af.mil), NASA (HQ-SatCoord@mail.nasa.gov) and DOC/NOAA (spectrum.coordinator@noaa.gov) to ensure compatibility of operations with the Federal government.
7. In the 2200-2290 MHz band, Reflect Orbital must comply with the following operational parameters:
    a. To the extent possible, Reflect Orbital downlink (space-to-Earth) transmissions should use a center frequency of 2226.004 MHz;
    b. Reflect Orbital downlink (space-to-Earth) transmissions using a center frequency of 2215.996 MHz must limit the operational duty cycle to no more than:
        i. 42% to the Blondous, Iceland earth station location;
        ii. 30% to the Boden, Pitea, and Umea, Sweden earth station locations;
        iii. 54% to Svalbard, Norway when JASON-3 (NORAD ID: 41240) is visible to Usingen, Germany (50° 19' 45" N 008° 28' 15" E);
        iv. 17% to Svalbard, Norway when JASON-3 (NORAD ID: 41240) is visible to Barrow, Alaska (71° 19' 27" N 156° 36' 44" W);
        v. 28% to Svalbard, Norway when JASON-3 (NORAD ID: 41240) is visible to Fairbanks, Alaska (64° 28' 21" N 147° 30' 04" W);
    c. Reflect Orbital downlink (space-to-Earth) transmissions using a center frequency of 2215.996 MHz must also ensure that spacecraft transmissions are ceased and no earth station receive operations are permitted when any of the following occur:
        i. the conjunction angle formed by the location 78° 13' 54" N 015° 22' 40" E (angle vertex), the Earendil-1 spacecraft, and any of the EZIE (NORAD IDs: 63247, 63249, 63250) spacecraft is less than or equal to 5 degrees;
        ii. the conjunction angle formed by the location 72° 00' 08" S 002° 31' 30" E (angle vertex), the Earendil-1 spacecraft, and any of the EZIE (NORAD IDs: 63247, 63249, 63250) spacecraft is less than or equal to 5 degrees;

[8] 47 CFR §§ 2.106(a), (c)(96), (303). Under section 2.106(c)(303) of the Commission's rules, in the 2285-2290 MHz band, non-Federal space stations in the SRS, SOS, and EESS may be authorized to transmit to NASA's Tracking and Data Relay Satellite System subject to conditions as may be applied on a case-by-case basis. Such transmissions shall not cause harmful interference to authorized Federal stations. 47 CFR § 2.106(c)(303).

[9] Reflect Orbital Application, Legal Narrative at 3-4.

iii. the conjunction angle formed by the location 29° 01’ 36” S 115° 20’ 40” E (angle vertex), the Earendil-1 spacecraft, and any of the following spacecraft is less than or equal to 5 degrees:
   1. EZIE (NORAD IDs: 63247, 63249, 63250),
   2. TRACERS (NORAD ID: 64870),
   3. PUNCH (NORAD IDs: 63178 through 63181),
   4. TIMED (NORAD ID: 26998);

iv. the conjunction angle formed by the location 52° 56’ 06” S 070° 52’ 12” W (angle vertex), the Earendil-1 spacecraft, and any of the following spacecraft is less than or equal to 5 degrees:
   1. TRACERS (NORAD ID: 64870),
   2. PUNCH (NORAD IDs: 63178 through 63181);

v. the conjunction angle formed by the location 67° 53’ 23” N 021° 03’ 57” E (angle vertex), the Earendil-1 spacecraft, and any of the following spacecraft is less than or equal to 5 degrees:
   1. TRACERS (NORAD ID: 64870),
   2. PUNCH (NORAD IDs: 63178 through 63181)

8. In the 2025-2110 MHz band, Reflect Orbital must comply with the following operational parameters:

   a. To the extent possible, Reflect Orbital uplink (Earth-to-space) transmissions should use a center frequency of 2047.645 MHz;

   b. Reflect Orbital uplink (Earth-to-space) transmissions using a center frequency of 2040.346 MHz must cease operation during any of the following:

      i. When the TRACERS (NORAD ID: 64873) spacecraft is within 10 degrees of the respective earth station antenna boresight of the Deadhorse, AK or Fairbanks, AK earth station locations; or

      ii. During Artemis missions when the Orion spacecraft is within horizon-to-horizon view of the respective earth station locations.

9. We GRANT, on our own motion and to the extent necessary, waiver of the U.S. Table, 47 CFR § 2.106(a), for Reflect Orbital’s proposed data downlink operations in the 8450-8500 MHz (space-to-Earth) band. In the U.S. Table, the 8450-8500 MHz band is allocated, inter alia, to the SRS (space-to-Earth) on a primary basis for non-Federal use, in all ITU regions, 47 CFR § 2.106(a). Under section 2.1(c) of the Commission’s rules, the SRS is defined as a radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes.[10] Reflect Orbital will use the 8450-8500 MHz band to transmit data “regarding the deployment and functionality of its novel reflector,” which it asserts is consistent with the definition of SRS.[11] Because Earendil-1 will only transmit or receive for short periods of time while visible to a transmitting or receiving Earth station, Reflect Orbital states it will not cause harmful interference to other operators using the band and also commits to

[10] 47 CFR § 2.1(c).

[11] Reflect Orbital Application, Legal Narrative at 4. Reflect Orbital will also use the 8450-8500 MHz band to downlink satellite health and operational data. *Id.* In a recent Notice of Proposed Rulemaking (NPRM), the Commission tentatively concluded that communications supporting emergent space operations that do not have the primary aim of providing a traditional telecommunications service may justifiably fit within the SRS allocation. *Spectrum Abundance for Weird Space Stuff*, Notice of Proposed Rulemaking, FCC-26-13, SB Docket No. 26-54 at para. 38 (rel. Mar. 5, 2026) (*WSS NPRM*). Until final rules are adopted, we find it is in the public interest to grant Reflect Orbital a waiver of the U.S. Table to the extent necessary.

coordinate with other co-primary users.[12] We find it is in the public interest to waive the U.S. Table, to the extent necessary, to authorize Reflect Orbital's radiofrequency operations in this band on an unprotected and non-interference basis. Radiofrequency operations pursuant to this authorization must not cause harmful interference to or claim protection from stations operating in the 8450-8500 MHz band and adjacent bands in accordance with the U.S. Table, 47 CFR § 2.106(a). Reflect Orbital must immediately terminate its operations upon notification of harmful interference to authorized services.

10. Power flux-density (PFD) levels from operations in the 8450-8500 MHz band must not exceed the limits in Table 21-4 of the ITU Radio Regulations and must meet the limits/protection criteria in Recommendation ITU-R SA.1157-1.

11. Reflect Orbital must provide the FCC and other Federal agencies the initial orbital parameters (e.g., operating altitudes, inclination angle) within 30 days following launch. Notification shall be submitted to the FCC's International Communications Filing System (ICFS) and provided to AFSMO (jimmy.nguyen@us.af.mil), NASA (HQ-SatCoord@mail.nasa.gov), and DOC/NOAA (spectrum.coordinator@noaa.gov). In the event changes to orbit parameters are required, Reflect Orbital shall complete coordination in advance of any such changes with AFSMO, NASA, and DOC/NOAA, and upon successful completion of coordination notify the FCC of the update within five business days.

12. Reflect Orbital's request for waivers of sections 25.156 and 25.157, 47 CFR §§ 25.156, 25.157, which provide for the processing of "NGSO-like satellite systems" under a modified processing round framework, is GRANTED.[13] Reflect Orbital is capable of sharing the spectrum in which it proposes to operate and affirms that its operations will not materially constrain future space entrants from using the authorized frequency bands.[14] Furthermore, Reflect Orbital commits to coordinate with other authorized users of these bands.[15] Given the opportunity for additional entrants to operate in these frequency bands, as well as the limits on mission duration and frequency use contained in this grant, we find that granting waiver in this instance does not undermine the purpose of the processing round rules.

13. Because Reflect Orbital must comply with technical requirements of the Commission's rules and the above-referenced PFD limits, which should prevent harmful interference to other operations in the requested bands, we grant its request for waiver of the Commission's default service rules, 47 CFR § 25.217(b).[16]

14. Reflect Orbital's request for waiver of section 25.112(a) of the Commission's rules, 47 CFR § 25.112(a), which provides for the dismissal or return of an application in the event an application "does not substantially comply" with the Commission's rules or is "identical to a pending application," is DISMISSED as unnecessary.[17]

[12] Reflect Orbital Application, Legal Narrative at 4.

[13] *Id.* at 6. Reflect Orbital requests processing under section 25.158 of the Commission's rules, 47 CFR § 25.158, which provides for processing of GSO-like satellites under a first-come, first-served framework, and only requests waiver of the Commission's processing round rules to the extent necessary to permit processing under the first-come, first-served framework. We decline to process this application under the first-come, first-served procedures. Since Reflect Orbital is not a GSO satellite and has indicated it can share spectrum with other operators, it is analogous to other applications for spacecraft communications in the SRS for which we have granted waiver of the processing round rules without processing under the first-come, first-served procedures. *See e.g., Momentus LLC*, ICFS File No. SAT-LOA-20250626-00122 (granted Jan. 30, 2026). A waiver of the processing round rules, without separate processing under the first-come, first-served procedures, is more appropriate.

[14] Reflect Orbital Application, Legal Narrative at 6-7.

[15] *Id.* at 7.

[16] *Id.* at 7-8.

[17] *Id.* at 8.

15. Unless extended by the Commission for good cause shown, this authorization will become null and void in the event that the Earendil-1 space station is not launched in accordance with the schedule set forth below:
    a. Reflect Orbital must post a surety bond in satisfaction of 47 CFR §§ 25.165(a) no later than August 10, 2026, and thereafter maintain on file a surety bond requiring payment in the event of a default in an amount, at minimum, determined according to the formula set forth in 47 CFR § 25.165(a)(1); and
    b. Reflect Orbital must launch Earendil-1, place it in the assigned orbit, and operate it in accordance with this authorization no later than July 9, 2032, 2032. 47 CFR § 25.164(b).
16. The license term is two years and begins at 3:00 a.m. EST on the date that Reflect Orbital certifies to the Commission that the Earendil-1 space station is successfully placed into orbit and the operations fully conform to the conditions of this authorization. Reflect Orbital must also file a certification within five business days of placing the Earendil-1 space station into operation.

Licensee/grantee is afforded thirty (30) days from the date of release of this action to decline the grant as conditioned. Failure to respond within this period will constitute formal acceptance of the grant as conditioned.

This action is taken pursuant to Section 0.261 of the Commission's rules on delegated authority, 47 CFR § 0.261, and is effective upon release.

Station licenses are subject to the conditions specified in Section 309(h) of the Communications Act of 1934, as amended, 47 U.S.C. § 309(h).

Action Date:	July 9, 2026	
Term Dates	**From:** See conditions	**To:** See conditions

Approved:

Jay A. Schwarz
Chief, Space Bureau

MEMORANDUM OPINION AND ORDER

I. INTRODUCTION

1. In this Memorandum Opinion and Order (Order), the Space Bureau (Bureau) addresses petitions and comments filed on the record regarding Reflect Orbital's application (Application) to use radiocommunications to deploy and operate the Earendil-1 satellite. We find that grant of Reflect Orbital's application for a single demonstration satellite serves the public interest by permitting Reflect Orbital to test emergent technology that advances American leadership in space, and that petitioners and commenters' concerns do not warrant either denial or additional conditions on this authorization.

II. BACKGROUND

2. Reflect Orbital requests authorization to deploy and operate a single satellite, Earendil-1, using frequencies in UHF, S-band, and X-band for telemetry, tracking, and command (TT&C) and data downlink to support deployment and testing of a solar reflector.[1] Earendil-1 will use a "deployable, highly specular thin-film reflector" that "is motorized and steerable to ensure reflected light is only visible in the targeted area" to reflect sunlight to a designated target on the ground at night.[2] The Application was accepted for filing and placed on public notice.[3]

3. Reflect Orbital's Application received comment from the public and one petition to deny filed by the American Astronomical Society (AAS).[4] Reflect Orbital filed a consolidated opposition and response to comments[5] and a notice of an *ex parte* meeting with Commission and Space Bureau staff.[6] AAS also filed notice of an *ex parte* meeting with Commission staff.[7]

III. DISCUSSION

4. Below, we address the various outstanding issues raised by the record. We first address comments on the record regarding Reflect Orbital's proposed deployment and operation of a space

[1] *See* Reflect Orbital Inc., Application to Construct, Launch, and Operate a Non-Geostationary Orbit Satellite in the Space Operation and Space Research Services, ICFS File No. SAT-LOA-20250701-00129 (filed Jul. 29, 2025) (Reflect Orbital Application). *See* the attached grant for Reflect Orbital's authorized frequencies and orbital parameters (Reflect Orbital Grant).

[2] Reflect Orbital Application, Legal Narrative at 2.

[3] *See* Satellite Licensing Division and Satellite Programs and Policy Division Information, Space Station Applications Accepted for Filing, Report No. SAT-01972 (Feb. 6, 2026). Unless otherwise specified, all citations to petitions, comments, letters, and other filings in this *Order* can be located in the record for this application found in the International Communications Filing System (ICFS), ICFS File No. SAT-LOA-20250701-00129, call sign S00711.

[4] *See* Petition to Deny of the American Astronomical Society (filed Mar. 9, 2026) (AAS Petition). The Asociación Argentina di Astronomia and Sociedad Española de Astronomía both filed documents titled as petitions to deny but without required affidavits and certifications of service, and we will therefore treat these filings as informal objections under our rules. *See* 47 CFR § 25.154; Petition to Deny and Request for Full NEPA Review of Asociación Argentina di Astronomia (filed Mar. 6, 2026)) (Argentina Astronomy Objection); Petition to Deny and Request for Full NEPA Review of Sociedad Española de Astronomía (filed Feb. 25, 2026) (Española Astronomy Objection). Multiple astronomical, scientific, public health, environmental, and dark sky advocacy organizations also filed comments, and more than 1,800 individuals submitted letters. *See generally* ICFS File No. SAT-LOA-20250701-00129. Approximately two-thirds of the comments filed by individuals appear to be based on templates disseminated by DarkSky International and starryprinceton.org, original versions of which Reflect Orbital submitted to the record. *See, e.g.*, Consolidated Opposition and Response to Comments of Reflect Orbital Inc., Attachments A and B (filed Mar. 24, 2026) (Reflect Orbital Consolidated Opposition and Response).

[5] Reflect Orbital Consolidated Opposition and Response.

[6] *See Ex Parte* Presentation of Reflect Orbital Inc. (filed Apr. 23, 2026) (Reflect Orbital April 23 *Ex Parte*).

[7] *Ex Parte* Presentation of the American Astronomical Society (filed June 2, 2026) (AAS June 2, 2026 *Ex Parte*).

station.[8] Next, we address issues raised on the record specifically related to Reflect Orbital's deployment of a solar reflector, which is supported by the communications authorized in this license, but which we find is beyond the scope of the Commission's authority to regulate and therefore not a basis for denial of, or additional conditions on, the Application.

A. Radiofrequency Interference

5. Under the Communications Act of 1934, as amended, "[n]o person shall use or operate any apparatus for the transmission of energy or communications or signals by radio" from or within the areas specified in section 301 or on a mobile station within the jurisdiction of the United States without a license issued by the Commission.[9] The Commission therefore licenses the deployment and operation of space stations and earth stations as it generally pertains to the communications between them.[10] Such communications may include operations for the purpose of providing a telecommunications service to the public, such as the fixed-satellite service (FSS),[11] mobile-satellite service (MSS),[12] or broadcasting-satellite service (BSS),[13] or radiocommunications services critical for controlling the physical operations of a spacecraft that do not otherwise support provision of a direct service to the public, such as the Space Operation Service (SOS) and Space Research Service (SRS).[14]

6. Reflect Orbital seeks to operate a space station in the SOS and SRS, using UHF-, S-, and X-band frequencies with technical parameters similar to those employed by numerous space station applicants, including both traditional Earth Exploration-Satellite Service missions and missions conducting emerging space activities, such as in-space servicing.[15] We are not persuaded by comments

[8] 47 U.S.C. § 309(a).

[9] 47 U.S.C. § 301.

[10] 47 CFR § 25.102(a). Under the Commission's rules, a "space station" is a "station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere." An "earth station" is a "station located either on the Earth's surface or within the major portion of Earth's atmosphere and intended for communication: (1) With one or more space stations; or (2) With one or more stations of the same kind by means of one or more reflecting satellites or other objects in space." 47 CFR §§ 2.1, 25.103.

[11] 47 CFR § 2.1 (defining FSS as "[a] radiocommunication service between earth stations at given positions, when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radiocommunication services").

[12] *Id.* (defining MSS as "[a] radiocommunication service: (1) Between mobile earth stations and one or more space stations, or between space stations used by this service; or (2) Between mobile earth stations by means of one or more space stations. Note: This service may also include feeder links necessary for its operation").

[13] *Id.* (defining BSS as "[a] radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmission").

[14] The space operation service (SOS) is defined as "[a] radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry, and space telecommand" and uses radio waves for the operation of spacecraft. Similarly, the space research service (SRS) is defined as "[a] radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes." *See* 47 CFR § 2.1; *see also Spectrum Abundance for Weird Space Stuff*, Notice of Proposed Rulemaking, FCC-26-13, SB Docket No. 26-54 at paras. 10-11 (rel. Mar. 27, 2026) (*WSS NPRM*).

[15] *See, e.g.*, Impulse Space Inc., ICFS File No. SAT-LOA-20250406-00093 (granted Aug. 15, 2025); Basalt Technologies Corp., ICFS File No. SAT-LOA-20250310-00067 (granted-in-part/deferred-in-part Jan. 23, 2026); Momentus Space LLC, ICFS File No. SAT-LOA-20250626-00122 (granted Jan. 30, 2026); Muon Space Inc., ICFS File No. SAT-LOA-20251119-00332 (granted May 1, 2026).

that Reflect Orbital will cause harmful interference into other radiofrequency services,[16] because these comments are not specific to Reflect Orbital's proposed radiofrequency operations and provide no technical support for claims of potential interference from the alleged potential reflection of radio waves by its solar reflector or other unintentional emissions. Reflect Orbital must comply with the Commission's rules in part 25,[17] the U.S. Table of Frequency Allocations (U.S. Table),[18] the technical parameters provided in its application and commitments made on the record, and conditions placed on its authorization, which have been developed in coordination with Federal agencies through the National Telecommunications and Information Administration (NTIA). Compliance with these rules and technical parameters will ensure that Reflect Orbital's communications operations will not cause harmful interference to other authorized services.

B. Orbital Debris Mitigation

7. The Commission adopted rules in 2004 requiring all applicants for space station authorizations to disclose the strategies that will be employed to mitigate orbital debris.[19] The Commission adopted its orbital debris mitigation rules based on a determination that orbital debris could affect the cost, reliability, continuity and safety of satellite operations and therefore has bearing on Congress's mandate that the FCC encourage "the larger and more effective use of radio in the public interest."[20]

8. We approve Reflect Orbital's proposed orbital debris mitigation plan. Reflect Orbital has provided the information and demonstrations required pursuant to the Commission's orbital debris mitigation rules.[21] Commenters concerns' about the aggregate risks of a hypothetical constellation of a large number of Reflect Orbital satellites, including the potential for "Kessler Syndrome"[22] or increased risks of human casualty caused by up to 50,000 satellites[23] are irrelevant to this application for a single satellite and not grounded in the Commission's current rules.[24] In this section, we discuss two main aspects of Reflect Orbital's debris mitigation plans that commenters raise with regard to Earendil-1: collision risk and post-mission disposal.

9. *Collision risk.* Reflect Orbital's proposed orbital debris mitigation plan satisfies the Commission's rules regarding large- and small-object collision risks.[25] Earendil-1 will have propulsion to

---

[16] *See, e.g.*, Comments of the International Astronomical Union at 1 (filed Mar. 3, 2026) (IAU Comments); Española Astronomy Objection at 2; Letter from Michelle Welcks (filed Mar. 9, 2026) (Michelle Welcks Letter).

[17] 47 CFR part 25.

[18] 47 CFR § 2.106.

[19] *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 (2004).

[20] *Id.* at 11575, para. 14 (citing 47 U.S.C. § 303(g)).

[21] 47 CFR § 25.114(d)(14).

[22] "Kessler Syndrome" is a hypothesized concept of a runaway chain reaction of collisions between pieces of orbital debris which in turn generate more debris and debris-generating collisions in space. *See, e.g.*, Letter from David Rosenthal, PhD (filed Mar. 6, 2026) (David Rosenthal Letter) (citing Hugh G. Lewis and Donald J. Kessler Critical Number Of Spacecraft In Low Earth Orbit: A New Assessment Of The Stability Of The Orbital Debris Environment); NASA, Micrometeoroids and Orbital Debris (MMOD), available at https://www.nasa.gov/centers-and-facilities/white-sands/micrometeoroids-and-orbital-debris-mmod/ (last visited June 25, 2026).

[23] *Id.*; Comments of the Center for Space Environmentalism at 3 (filed Mar. 4, 2026) (CSE Comments).

[24] The Commission's rules do not consider aggregate collision risks or casualty risks for satellite constellations. *See* 47 CFR § 25.114(d)(14). The Commission has sought comment on aggregate collision risk for large satellite constellations, but no rules have been adopted as of this time. *See Mitigation of Orbital Debris in the New Space Age*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 4156, 4226-29, paras. 154-159 (2020).

[25] 47 CFR §§ 25.114(d)(14)(ii), (iv), (vi).

conduct collision avoidance,[26] and under the Commission's rules, a satellite that can maneuver effectively, including by propulsion, is deemed to have a large object collision risk of zero.[27] Contrary to commenters' concerns that Earendil-1 poses an undue risk of collision with large and small objects because of its solar reflector,[28] Reflect Orbital has demonstrated that its satellite, including its reflector, complies with the Commission's rules to mitigate collision risks for large and small objects in the event of a satellite failure.[29] Specifically, Reflect Orbital provided a detailed description of its propulsion system, explanation of satellite trackability, and calculations of its collision risk using the National Aeronautics and Space Administration (NASA)'s debris assessment software (DAS), along with certifications that Reflect Orbital will take all practicable steps to avoid collisions in the event of a conjunction warning, including coordination with nearby satellite operators and government agencies.[30]

10. *Post-Mission Disposal.* Similarly, Reflect Orbital's proposal complies with the Commission's post-mission disposal rules and therefore we determine there is no need to impose additional conditions on this aspect of the operations, as some commenters suggest.[31] Reflect Orbital stated it will dispose of the satellite via uncontrolled atmospheric re-entry, using any remaining propellant to control Earendil-1 down to as low an altitude as possible at the end of the mission and certified that its post-mission disposal plan will protect crewed space stations.[32] Reflect Orbital has also demonstrated that, even without any active de-orbit maneuvers, Earendil-1 will de-orbit within one year after the end of its mission, which complies with the Commission's rule requiring post-mission disposal within five years after the end of the mission for satellites operating in low-Earth orbit and planning disposal via atmospheric re-entry.[33] Finally, Reflect Orbital has certified and demonstrated, in accordance with the Commission's rules, that its chosen post-

[26] Reflect Orbital Application, ODAR at 7.

[27] 47 CFR § 25.114(d)(14)(iv)(A)(1) ("The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.").

[28] Commenters are particularly concerned with Earendil-1's thin reflector, which is the largest cross-sectional area of the satellite, and which they argue unduly increases collision risk. *See, e.g.*, Letter from Eric Dahlstrom at 2 (filed Mar. 5, 2026) (Eric Dahlstrom Letter); Letter from Meredith Rawls and Constance Walker, PhD at 4 (filed Mar. 9, 2026) (Rawls and Walker Letter); CSE Comments at 3.

[29] Reflect Orbital Application, ODAR at 3, 7 (explaining that the reflector "is designed to be tolerant of micro-orbital debris strikes through a rip-stop design"); 47 CFR § 25.114(d)(14)(ii), (iv).

[30] Reflect Orbital Application, ODAR at 7-12.

[31] *Id.*; 47 CFR §§ 25.115(d)(14)(vii)(B), (vii)(D), 25.283(e). Two commenters specifically request the Commission require a plan for a "clear, viable, and enforceable passively and actively de-orbit the satellite in a timely manner (e.g., within five years post-mission), including contingency plans for loss of control, to mitigate orbital debris and collision risks." *See* Rawls and Walker Letter at 6. The Commission's rules already require this for all low-Earth orbit space stations, *see* 47 CFR § 25.283(e), and Reflect Orbital has submitted the appropriate information to satisfy these rules. We likewise do not adopt CSE's suggestion that we decline to grant any waiver of the surety bond for Reflect Orbital in order to ensure Reflect Orbital remains "financially accountable for the potential costs of 'active debris removal' or environmental remediation on Earth should their 'uncontrolled demise' strategy result in property damage or hazardous debris." CSE Comments at 3. This suggestion is moot because Reflect Orbital did not request waiver of the Commission's surety bond requirement and thus will be required to post a bond consistent with the Commission's rules. 47 CFR § 25.165. We also note that the Commission has previously sought comment on requiring a performance surety bond as part of its orbital debris mitigation rules but has not adopted such a requirement. *See Mitigation of Orbital Debris in the New Space Age*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 4156 at 4244-49, paras. 193-205 (2020) (seeking comment on whether a performance bond tied to successful post-mission disposal would be in the public interest).

[32] Reflect Orbital Application, ODAR at 9; Letter from Jodi Goldberg, Counsel, Reflect Orbital Inc., to Marlene H. Dortch, Secretary, FCC at 3 (filed Jan. 5, 2026) (Reflect Orbital January 5 Letter).

[33] *See* Reflect Orbital Application, ODAR at 3, 11-12; Reflect Orbital January 5 Letter at 3; 47 CFR §§ 25.114(d)(14)(vii)(B), (D)(1), 25.283(e).

mission disposal method has a 90% or greater reliability of success.[34] We therefore find DarkSky International's concern unlikely, that if Reflect Orbital loses control of the satellite during the de-orbit phase, the potential for random tumble could result in uncontrolled, random light sweeps or flashes coming from the Earendil-1 solar reflector for up to one year.[35] Finally, in response to concerns about the risk of human casualty from surviving debris,[36] we confirm that Earendil-1's calculated casualty risk complies with the Commission's rules to demonstrate a risk of human casualty of less than 1 in 10,000 for an individual spacecraft.[37]

C. Issues Beyond the Scope of FCC Authority

1. Public Interest of the Solar Reflector

11. Under the Communications Act, we may grant an application only upon a finding that the "public convenience, interest, or necessity will be served thereby."[38] After review of the record, we find grant of Reflect Orbital's application, with conditions, serves the public interest. Earendil-1 is a single satellite and a limited, short-duration technology test exercise designed to evaluate the feasibility of Reflect Orbital's proposed concept and to identify any challenges associated with future iterations of the technology.[39] The results of this single-satellite mission will inform whether the concept is viable and will assist the company, its prospective customers, and other stakeholders in assessing any future larger-scale deployment.

12. In making this determination, we note in particular the Commission's efforts to make spectrum available to promote the U.S. space industry. Authorizations for radiofrequency communications that support cutting-edge, emergent space activities are key to maintaining American leadership in the global space economy, particularly given the current geopolitical race to "commercialize and dominate the Final Frontier."[40] The Communications Act states that it is the policy of the United States to "encourage the provision of new technologies and services to the public,"[41] and Reflect Orbital's demonstration satellite is an example of a potentially groundbreaking technology that the Commission has found is in the public interest to support.[42] As discussed in more detail below, we find the risks of harm

---

[34] Reflect Orbital Application, ODAR at 11-13, Figure 3 Passive Deorbit Profile from Maximum Orbit Altitude at End of Mission; 47 CFR § 25.114(d)(14)(vii)(D)(1).

[35] *See, e.g.*, Comments of DarkSky International at 9 (filed Mar. 6, 2026) (DarkSky International Comments). Regardless, we note that random light flashes are not relevant to the Bureau's review of Reflect Orbital's proposed orbital debris mitigation plan under the Commission's rules.

[36] Commenters are concerned about the surviving debris—specifically Earendil-1's propellant tank—posing a risk of human casualty, coupled with Reflect Orbital's proposed uncontrolled reentry. *See, e.g.*, CSE Comments at 3; Letter from John Frank (filed Mar. 9, 2026) (John Frank Letter).

[37] 47 CFR § 25.114(d)(14)(vii)(D)(2); *see* Reflect Orbital Application, ODAR at 13. Reflect Orbital states that only the Titanium propellant tank has the potential to survive re-entry and no other components are expected to survive. Based on DAS analysis simulation results, the risk of human casualty is 1:119,400.

[38] 47 U.S.C. § 307(a).

[39] We grant Reflect Orbital authority to operate Earendil-1 for a total of two years, accounting for one year of operations and less than one year of deorbit maneuvers, as described in Reflect Orbital's application. *See* Attached Grant, Condition 16; *see* also Reflect Orbital Application, ODAR at 11. For comparison, the Commission's space station licenses typically authorize radiofrequency communications for a period of 15 years, though the Bureau may grant licenses for a period less than 15 years, in its discretion, if the public interest, convenience, and necessity will be served. 47 CFR §§ 25.121(a)(1), (b). We find it serves the public interest to limit the term of Reflect Orbital's authorization consistent with the limited nature of Earendil-1's operations.

[40] *WSS NPRM* at para. 1.

[41] 47 U.S.C. § 157(a).

[42] *See WSS NPRM* at 5.

raised on the record regarding Reflect Orbital's solar reflector are unrelated to the Commission's role in authorizing use of radiofrequency spectrum, and even if the Commission had authority to review and condition these operations (which it does not), these harms are unlikely to occur. Independently, we find that any such risks are outweighed by the public interest benefits of authorizing communications to support testing of the technology in a limited, short-duration manner to inform whether there are longer-term benefits from an expanded use of this technology. We therefore disagree with assertions that Reflect Orbital has not demonstrated its proposed operations are in the public interest;[43] to the contrary, it is in the public interest to make spectrum available to encourage companies to test new and innovative space activities, as it promotes American innovation and the new services and economic growth that come from that innovation.

13. The Space Bureau has reviewed this Application to assess frequency interference and orbital debris mitigation strategies of the proposed operations and finds grant in the public interest. Consistent with the authority Congress granted to the Commission in the Communications Act,[44] the Commission's rules pertain to communications licensing, including radiofrequency spectrum operations and the communications apparatus.[45] Thus, our authorization for Earendil-1 is for the radio station, including radiofrequency spectrum operations and the orbital debris mitigation plan, which is part of our review of the communications apparatus and of the public interest in maintaining a safe space environment and promoting the larger and more effective use of radio communications, as discussed above.[46] In this instance, Reflect Orbital's radiofrequency operations are limited to communications to control the spacecraft, including to steer its solar reflector, and to downlink data about spacecraft health and operations, as opposed to the operations of a traditional communications satellite providing a communications service to the public.[47] Beyond an operator's radiofrequency operations and its orbital debris mitigation during deployment, operations, and post-mission disposal of a spacecraft, the Commission's licensing authority does not inherently extend to all activities that a spacecraft conducts in space based on the Commission's review and approval of a space station's authorized communications and operations.[48] Therefore, while we have reviewed Earendil-1's solar reflector with respect to Reflect Orbital's proposed frequency use and orbital debris mitigation plan, we find in this instance that the technical operations and prospective and potential impacts of the solar reflector, apart from any impacts the Commission regulates, such as those relating to interference or orbital debris, do not bring these activities in space within the scope of the Commission's authority.[49]

14. The majority of the record in response to this Application focuses on the potential impacts of the solar reflector and Reflect Orbital's business plans. Based on the Bureau's analysis of the

[43] *See, e.g.*, AAS Petition at 1.

[44] 47 U.S.C. § 301 ("[n]o person shall use or operate any apparatus for the transmission of energy or communications or signals by radio" from or within the areas specified in section 301 or on a mobile station within the jurisdiction of the United States without a license issued by the Commission).

[45] 47 CFR § 25.102(a) ("[n]o person shall use or operate apparatus for the transmission of energy or communications or signals by space or earth stations except under, and in accordance with, an appropriate authorization granted by the Federal Communications Commission"); *see also* 47 U.S.C. § 153(40). Although the Act does not define the term "signals," it defines "communication by radio" as "the transmission by radio of writing, signs, signals, pictures, and sounds of all kinds, including all instrumentalities, facilities, apparatus, and services (among other things, the receipt, forwarding, and delivery of communications) incidental to such transmission. The Act provides that the term "transmission of energy by radio" includes "both such transmission and all instrumentalities, facilities, and services incidental to such transmission." 47 U.S.C. § 153(57).

[46] *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 (2004).

[47] Reflect Orbital Application; *WSS NPRM* at paras. 10-11.

[48] *Id.* at para. 14 ("under our rules, it is the transmitters and receivers that make up a space station that must be authorized by the Commission").

[49] *Loper Bright Enterprises v. Raimondo*, 603 U.S. 369 (2024).

Commission's authority, we find that our own public interest authority does not allow us to impose conditions on Reflect Orbital's operations unrelated to the operations of Earendil-1.[50] Courts have consistently found that the Commission may not rely on a generalized public interest requirement beyond its statutory authority in regulating communications.[51] Accordingly, the operations of a solar reflector in space would not be reviewed as part of the Bureau's public interest analysis. We find license conditions unrelated to the operations of Earendil-1 procedurally inappropriate here. The Commission has consistently recognized that novel, generally applicable regulatory obligations affecting an entire service should ordinarily be adopted through notice-and-comment rulemaking at the Commission level rather than through ad hoc licensing conditions.[52] Doing otherwise risks inconsistent treatment of similarly situated applicants, deprives affected parties of participation in the development of standards, and undermines the regulatory certainty necessary for investment and innovation in emerging services.

15. For the sake of completeness, we discuss the merits of comments raised on the record regarding the solar reflector in detail below. We find that, even assuming our review of space station applications under the Communications Act did extend to reviewing the impacts of the solar reflector, the harms that commenters allege are unlikely to materialize from the operations of a single satellite, and commenters have not sufficiently justified the necessity of conditions on or denial of Reflect Orbital's Application.[53]

16. As an initial matter, we address commenters' concerns solely with respect to the single satellite, Earendil-1, and dismiss objections based on commenters' anticipation of Reflect Orbital's long-term plans to operate a larger constellation.[54] For example, to the extent that concerns that Reflect Orbital's operations may cause glare and interfere with the public, including pilots and automobile drivers,[55] are founded on constellations comprised of tens of thousands of satellites, these concerns are

[50] *Id*.

[51] *See, e.g., FCC v. Midwest Video Corp.*, 440 U.S. 689 (1979) (emphasizing that license conditions must be traced to statutory authority in the Communications Act and may not be based solely on the public interest standard); *American Library Association v. FCC*, 406 F.3d 689 (D.C. Cir. 2005) (holding the FCC lacked the statutory ancillary authority to impose "broadcast flag" regulations on digital television receivers, as the FCC's mandate over signal reception does not extend to regulating the internal design of consumer electronics); *see also Louisiana Public Service Commission v. FCC*, 476 U.S. 355 (1986) (holding "an agency literally has no power to act …unless and until Congress confers power upon it" and rejecting FCC efforts to regulate matters beyond its delegated authority despite FCC arguments that the regulations served federal communications policy).

[52] *See, e.g., Space Exploration Holdings, LLC,* Order and Authorization and Order on Reconsideration, 36 FCC Rcd 7995, 8045-46, para. 93 (2021) (finding comments on the Commission's general process for evaluating space station applications are more appropriately addressed in a rulemaking proceeding rather than a single licensing proceeding).

[53] 47 U.S.C. § 157(a) (it is the "policy of the United States" to "encourage the provision of new technologies and services to the public" and that opponents have the "burden" to show that such technologies are "inconsistent" with the public interest). As discussed in detail below, commenters have not met this burden with regard to the single satellite Earendil-1.

[54] *See, e.g.*, AAS Petition at 1; DarkSky International Comments at 3-4; Letter from Samantha Lawler (filed Mar. 9, 2026) (Samantha Lawler Letter); Rawls and Walker Letter. In other words, grant of authority for Earendil-1 does not predetermine action on any future application that Reflect Orbital may file, contrary to the assertions of commenters. *See, e.g.*, Comments of the American Association for Variable Star Observers at 1 (filed Mar. 6, 2026) (AAVSO Comments); Letter from Stuart F. Quan, M.D. (filed Mar. 5, 2026) (Stuart Quan Letter). Should Reflect Orbital apply for authorization for additional satellites in the future, that application will be reviewed on its own merits, consistent with Commission rules, policy, and precedent. Reflect Orbital itself acknowledges that additional review may be required for a future constellation of reflector satellites. *See* Reflect Orbital Consolidated Opposition and Response at 13.

[55] *See, e.g.*, AAS Petition at 3; Comments of Aviation Safety Stakeholders (filed Mar. 31, 2026) (Aviation Safety Comments); DarkSky International Comments at 8, 9, 16. The Aviation Safety Stakeholders request the Commission "require a comprehensive aviation safety assessment." *See* Aviation Safety Comments at 4.

hypothetical and do not arise from a system of a single test satellite. Other national security and public safety concerns raised on the record are similarly based on a hypothetical constellation of tens of thousands of satellites.[56] Commenters will have an opportunity to comment on any future applications when such applications, if filed, are placed on public notice.[57] We therefore decline to consider any arguments opposing this Application that are based on speculation about Reflect Orbital's potential future plans. We address any comments specific to the operations of Earendil-1 below.[58]

17. *Technological Feasibility and Market Viability.* We find concerns about the technological feasibility[59] and the financial viability[60] of Reflect Orbital's proposed sunlight-reflecting service, on which commenters base claims that grant would not be in the public interest, are separate from our analysis of whether the proposed radiofrequency spectrum operations are in the public interest under the Communications Act. As stated above, we find that authorizing radiofrequency communications to support innovative space operations is in the public interest. The purpose of Earendil-1 is to determine if the project is technologically feasible.[61] Similarly, whether the business case for the satellite is commercially or economically viable is not a matter for the Space Bureau to decide.

18. *Local control of nighttime illumination and private property rights.* Some commenters argue that authorization of Earendil-1 is not in the public interest because it could create light trespass or public nuisance issues or violate local zoning laws, both because of the direct illumination from the satellite across a large area of the illuminated location and potential increase in background skyglow caused by atmospheric scattering.[62] Even if the Commission had authority to regulate these matters, Reflect Orbital has stated that it is already working with state and local governments to permit testing in a

[56] For example, some commenters argue that Reflect Orbital's proposal will disrupt military nighttime operations and even systematically eliminate the advantages of darkness for U.S. forces. *See, e.g.*, Letter from Dawn Davies (filed Mar. 6, 2026) (Dawn Davies Letter); Letter from Andrew J. Baker at 1 (filed Mar. 9, 2026) (Andrew Baker Letter). These commenters do not appear to have any affiliation with the U.S. military. Similarly, we find that other assertions in the record, including claims that Reflect Orbital's operations could impair missile tracking, be misused as a weapon, or create shadows that facilitate assaults, are speculative because they lack evidentiary support and therefore do not provide a basis for denial or conditioning of the application. *See, e.g.,* CSE Comments; Letter from Nathalie Ouellette, PhD (filed Feb. 26, 2026) (Nathalie Ouellette Letter); Letter from Tom Harper (filed Mar. 2, 2026) (Tom Harper Letter).

[57] 47 CFR § 25.151.

[58] *See, e.g.,* Reply of the Royal Astronomical Society at 1 (filed Mar. 27, 2026) (RAS Reply) (the harms of the single satellite are significant and the harms of the constellation so significant that testing should not even be conducted); Reply of Sheila Kannappan, PhD (filed Mar. 30, 2026) (Sheila Kannappan Reply) (arguing many comments focus on the impacts of the individual satellite, which commenters contend will have a brightness equivalent to the full moon).

[59] *See, e.g.*, DarkSky International Comments at 9, 10, 28; Comments of the American Astronomical Society et al at 2, 4 (filed Mar. 9, 2026) (28 Organizations Joint Comments); Letter from Prof. Michael Brown at 1 (filed Feb. 25, 2026) (Michael Brown Letter); Reply of Emilio Falco (filed Mar. 30, 2026) (Emilio Falco Reply). Although distinct from the question of financial viability, we note that it has been over twenty years since the Commission has required applicants to demonstrate that they have the financial resources to construct and launch a satellite or satellite constellation and to operate it for a year. *See Amendment of the Commission's Space Station Licensing Rules and Policies, Mitigation of Orbital Debris*, First Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 10760 at 10823, para. 161 (2003).

[60] *See, e.g.*, AAS Petition at 1; 28 Organizations Joint Comments at 2; Rawls and Walker Letter at 1-2; Michael Brown Letter at 1.

[61] Reflect Orbital Application, Narrative at 5.

[62] *See, e.g.,* AAS Petition at 4-5; DarkSky International Comments at 9-10; CASCA Comments at 1, 2.

manner consistent with local laws and regulations,[63] rendering these concerns moot.

2. Protection of Science Missions Using Optical Astronomy

19. We find that concerns about Earendil-1's impacts on optical astronomy[64] fall outside our review and authorization of the space station and are not a basis for denial of or additional conditions on Reflect Orbital's operations. The Commission's rules do not address the protection of optical astronomy, and thus we decline to interpret commenters' concerns in connection with the Commission's mandate under the Communications Act in this Order, as discussed above. In any event, Reflect Orbital contends that the Earendil-1 satellite is designed to mitigate harmful interference from reflected light[65] and states that it is already actively working with the astronomy community to establish exclusion zones to protect optical astronomical research sites and coordinate to protect optical astronomy in general.[66] The terms of this license require Reflect Orbital to operate in accordance with the specifications and commitments it has provided to the Commission,[67] which includes its commitment to coordinate with NASA and the National Science Foundation (NSF) to protect optical astronomy and to work with the wider astronomical community to address the concerns raised in response to this application.[68] Therefore, we decline to deny the Application or impose additional requirements to protect optical astronomy beyond these commitments. We specifically decline to impose conditions requested by the International Astronomical Union (IAU),[69] and others,[70] finding they are redundant with Reflect Orbital's commitment to coordinate

[63] Reflect Orbital April 23 *Ex Parte*, Attachment B at 2. We also note that state and local regulations regarding nighttime illumination may provide additional protection against potential harm.

[64] *See generally* ICFS File No. SAT-LOA-20250701-00129. Commenters and astronomical organizations object to Reflect Orbital's proposal for one satellite. In general, commenters are concerned about the impacts on professional and amateur optical ground- and space-based astronomy and stargazing communities, including the U.S. taxpayer dollars invested in telescopes and other astronomical infrastructure, from the potential both for Earendil-1 to directly illuminate telescopes and the atmospheric scattering of Earendil-1's beam of reflected sunlight to increase background skyglow. *See, e.g.,* AAS Petition at 1, 2-5; IAU Comments at 1, 2; AAVSO Comments at 1; Comments of the Canadian Astronomical Society/Societe Canadienne d'Astronomie at 1 (filed Mar. 5, 2026) (CASCA Comments); Comments of the Royal Astronomical Society at 1 (filed Mar. 3, 2026) (RAS Comments); Rawls and Walker Letter at 1-2, 3, 5; Samantha Lawler Letter; DarkSky International Comments at 6, 9-10.

[65] Reflect Orbital Jan. 5 Letter at 7.

[66] Reflect Orbital Consolidated Opposition and Response at 14; Reflect Orbital April 23 *Ex Parte* at 1, Attachment B at 2.

[67] *See* Reflect Orbital Grant.

[68] Reflect Orbital Consolidated Opposition and Response at 14; Reflect Orbital April 23 *Ex Parte* at 1, Attachment B at 2.

[69] IAU requests that any grant of Earendil-1 require: (1) "The submission of scattered light profiles over the visible spectrum, with estimates of the impacts on the night sky brightness, as a function of distance from the beam centre"; (2) "A viable plan for controlling the pointing of the specular beam during all mission phases"; (3) "No pointings of the beam within 160 km of observatories listed within the Minor Planet Center's observatory record"; (4) "A viable plan for providing a mirror pointing schedule to the public to help prevent public eye damage during amateur astronomy"; and (5) "Continued consultation with the National Science Foundation and the American Astronomical Society in an effort to reduce additional impacts to astronomy, such as mitigating unintended reflections". IAU Comments at 2-3; *see also* Rawls and Walker Letter at 5-6. IAU further explains that "The optical depth of Rayleigh scattering grows substantially below 30 km altitude. A distance of 160 km will help to ensure that the visible column of light will be less than 10 degrees above the horizon." IAU Comments at 2. Commenters also request the proposed scattered light profile include impacts on visible, infrared, submillimeter, and radio spectrum and the Commission require strict limits on illumination time and geographic locations to protect critical observational windows. Rawls and Walker Letter at 5, 6.

[70] One commenter requests the Commission "Require independent brightness verification against the IAU's recommended magnitude 7 threshold before deployment. Given that Reflect Orbital's design cannot reduce reflectivity without eliminating its utility, any result exceeding this threshold should be grounds for denial." He also

(continued….)

with astronomers. To astronomers' arguments that discussions with Reflect Orbital have so far not yielded the information they require to assuage their concerns,[71] Reflect Orbital has characterized these discussions as preliminary and coordination as ongoing.[72] Denying the Application or imposing additional conditions based on the presumed insufficiency or failure of these discussions would prejudge the success of the discussions.

20. We also find that eye safety concerns for telescope or binocular users do not warrant denial or further conditions.[73] These issues, concerning the potential non-spectrum related impacts of the solar reflector, are far removed from the space station's radiofrequency operations and are too attenuated from the Commission's authority to license communications in the public interest.[74] Even if the public interest required evaluation of these claims, given the short operational period, the limitation to a single satellite, and the narrow conditions under which exposure could occur, we conclude that the likelihood of harm is extremely small. Reflect Orbital explains that the risk of accidental direct viewing at harmful irradiance levels is extremely low and would require looking directly at the satellite through a telescope with a lens larger than 12 inches.[75] Moreover, Reflect Orbital has stated that Earendil-1 will exclude locations used for professional astronomical research, further minimizing that risk.[76] Furthermore, even if review under the public interest standard were appropriate, we note the Commission's public interest analysis takes into account the risks and benefits of a proposal, but does not require that there be zero risk.[77] Here, we might weigh the small risk that an individual happens to be using a large telescope at the exact moment that Earendil-1 passes overhead while actively reflecting sunlight at the angle necessary to maximize exposure without notice to the public to avoid the exposure, and that the individual stares directly at Earendil-1 through that large telescope for a sufficient time to develop eye damage, against the benefits of permitting American companies to test innovative technology in space. Under that balancing approach, we would find that the public interest benefits outweigh this small risk under unlikely circumstances.

3. Protection of the Human Environment

21. We decline to require further environmental review under the National Environmental

---

requests we require independent scientific oversight for any missions studies regarding Earendil-1, specifically "that mission studies be designed and evaluated by independent third parties, not solely by institutions contracted by Reflect Orbital," as well as a commitment from the FCC that the FCC will develop brightness standards in a rulemaking. *See* Eric Dahlstrom Letter at 2; Reply of Eric Dahlstrom (filed Mar. 28, 2026) (Eric Dahlstrom Reply). We note that Reflect Orbital states that it is commissioning third party studies of the impacts of Earendil-1 and has also offered to furnish researchers with satellite data for their own studies. *See* Reflect Orbital Consolidated Opposition and Response at 3, N.7; Reflect Orbital April 23 *Ex Parte*, Attachment B at 2.

[71] *See, e.g.*, AAS Reply at 4-5.

[72] Reflect Orbital Consolidated Opposition and Response at 14; Reflect Orbital April 23 *Ex Parte* at 1, Attachment B at 2.

[73] Commenters cite calculations purporting to show that reflected light from Earendil-1 could cause retinal injury for observers using large-aperture telescopes. *See, e.g.*, Letter from Anthony Mallama (filed Feb. 12, 2026) (citing Laframboise JG, Chou BR. 2000. Space mirror experiment: a potential threat to human eyes. J R Astron Soc Can. 94: 237– 241. https://articles.adsabs.harvard.edu/full/2000JRASC..94..237L) (Anthony Mallama Letter); *see also* AAS Petition at 3; AAS June 2, 2026 *Ex Parte*.

[74] 47 U.S.C. § 309(a); *Loper Bright Enterprises v. Raimondo*, 603 U.S. 369 (2024).

[75] Reflect Orbital Consolidated Opposition and Response at 12, n. 41.

[76] *Id*. at 14; Reflect Orbital April 23 *Ex Parte* at 1, Attachment B at 2.

[77] For example, the Commission's orbital debris mitigation rules require demonstrations that risks of orbital debris generation are within acceptable ranges, not that there is zero risk of orbital debris generation. *See* 47 CFR § 25.114(d)(14).

Policy Act (NEPA) for the Earendil-1 satellite.[78] The Commission's grant permits Reflect Orbital to deploy and operate a radio station using certain frequencies. We find that these actions are categorically excluded under section 1.1306(a) of the Commission's rules.[79] Specifically, "the textually mandated focus of NEPA is the 'proposed action.'"[80] NEPA requires an agency to consider the effects of the action at hand and does not require consideration of actions beyond its regulatory authority. Here, we consider the potential environmental effects of the Commission's approval to deploy and operate a radio station using specific frequencies. As discussed in prior Commission orders, the Federal Aviation Administration (FAA) considers environmental impacts of rocket launches, and other considerations relevant to satellite communications, such as orbital debris, are handled under the Commission's orbital debris rules.[81] Therefore, we find that operation of a solar reflector attached to the satellite is too attenuated from the Commission's action of approving use of spectrum and, thus, beyond the Commission's authority. As discussed in detail above, the Commission's authority pertains to the licensing and operation of a radio station using radiofrequency spectrum, and it does not have regulatory authority over the licensing and operation of a solar reflector.[82] As such, we find commenters' allegations related to the operation of a solar reflector to be beyond the scope of the Commission's NEPA Obligations.

22. Assuming, arguendo, that the Commission had authority to conduct environmental review of this solar reflector, we still decline to conduct additional environmental review under NEPA for

[78] Both commenters and Reflect Orbital debate the applicability of NEPA to the proposed satellite. Reflect Orbital argues that Earendil-1 should not be subject to environmental review under NEPA because satellites as a whole are categorically exempted from environmental review under the Commission's rules, and more broadly NEPA does not apply to satellites as an extraterritorial activity. Reflect Orbital Consolidated Opposition and Response at 4, 9-11, 13; Reflect Orbital April 23 *Ex Parte*, Attachment B at 1. We note the Commission recently adopted a notice of proposed rulemaking proposing to modify its NEPA regulations to conform with recent changes to the NEPA statute, Supreme Court decisions, and executive orders, including a proposal to explicitly exclude satellites and space-based operations from review under NEPA. *See Modernizing the Commission's National Environmental Policy Act Rules,* Notice of Proposed Rulemaking, WT Docket No. 25-217, FCC 25-47, para. 33 (Aug. 7, 2025) (*NEPA NPRM*). Commenters are correct, however, that under the current rules they are able to petition the Commission to review an otherwise categorically exempt activity that may impact the human environment. Our rules state that even if a "particular action" is otherwise categorically excluded from review under NEPA, an interested party who alleges that the action will have a significant environmental impact may submit "a written petition setting forth in detail the reasons justifying or circumstances necessitating environmental consideration in the decision-making process." If the Bureau "determines that the action may have a significant environmental impact," the Bureau will require the applicant to prepare an EA which will serve as the basis for the determination to proceed with or terminate environmental processing. 47 CFR § 1.1307(c).

[79] 47 CFR § 1.1306(a).

[80] *See Seven Counties Infrastructure Coalition v. Eagle County, Colorado*, 605 U.S. 168, 180-81 (2025).

[81] *See Space Exploration Holdings, LLC,* Order and Authorization and Order on Reconsideration, 36 FCC Rcd 7995 (2021); *Space Exploration Holdings, LLC, Request for Orbital Deployment and Operating Authority for the SpaceX Gen2 NGSO Satellite System*, Order and Authorization, 37 FCC Rcd 14882 (2022) (*SpaceX Gen2 First Partial Grant*); *Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022); *Int'l Dark-Sky Ass'n, Inc. v. FCC*, 106 F.4th 1206 (D.C. Cir. 2024).

[82] *See supra* Section III.C.1.

Earendil-1.[83] After reviewing the potential impacts raised on the record,[84] we find that commenters have not demonstrated with specificity that the action of granting this license may have a significant environmental effect and require preparation of an Environmental Assessment (EA) under the Commission's rules.[85] While commenters allege the potential for various general harms to wildlife and humans from reflected sunlight, we emphasize that this grant is for the limited purpose of radiocommunications connected with the testing of a single satellite, Earendil-1.[86] The majority of these comments focus on a hypothetical plan to deploy tens of thousands of satellites,[87] and those who argue the single satellite will harm the human environment[88] do not demonstrate with specificity the potential harm will be caused by the single satellite, but rather rely on the same studies as the commenters objecting to a larger constellation.

23. We review the allegations raised by commenters as petitions for environmental review under section 1.1307(c) of the Commission's rules, under which we consider whether commenters have demonstrated that the proposed action—granting authorization to deploy and operate a radio station to communicate on certain frequencies—may have a significant environmental effect.[89] Commenters cite various papers to support their claim that artificial light affects biological processes in plants, animals,

[83] In conducting this analysis, we follow the same approach the Commission has previously taken when reviewing requests for environmental review for satellite proposals, which has been upheld by the D.C. Circuit, in which the Commission assumed that NEPA applied and evaluated whether further environmental review under NEPA would have been required, without deciding whether NEPA applies to activities that take place entirely in outer space in general. *See, e.g.*, SpaceX, Gen2 First Partial Grant, 37 FCC Rcd at 14933-34, para. 103. The Commission at that time found that the concerns raised on the record did not warrant further environmental review, in the form of an EA, under NEPA. *Id.* at 14935-36, para. 109; *see also Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022); *Int'l Dark-Sky Ass'n, Inc. v. FCC*, 106 F.4th 1206; *See Space Exploration Holdings, Order and Authorization*, DA 26-36 (SB rel. Jan. 9, 2026).

[84] *See generally* ICFS File No. SAT-LOA-20250701-00129. Commenters raise a range of environmental concerns, arguing primarily that light pollution has been shown to impact wildlife population dynamics, physiology, and behavior, disrupting circadian rhythms, migration, orientation, reproduction, and predator-prey relationships in birds, insects, mammals, reptiles, amphibians, marine life, and plants, including nocturnal and endangered species. Other commenters point to potential impacts on human health caused by light pollution and consequent disruptions to circadian rhythms. *See, e.g.*, DarkSky International Comments at 5, 7, 8, 10, 18-19; CSE Comments at 2, 3; Comments of Public Employees for Environmental Responsibility at 3, 5 (filed Mar. 6, 2026) (PEER Comments); Comments of Astronomers for Planet Earth at 1-2 (filed Mar. 6, 2026) (A4E Comments); Comments of the American Bird Conservancy at 1-2 (filed Mar. 6, 2026) (American Bird Conservancy Comments); Comments of the Circadian Light Research Center at 2-5 (filed Mar. 6, 2026) (Circadian Research Center Comments); Letter from Dr. Kyle Horton at 1-2 (filed Mar. 3, 2026) (Kyle Horton Letter). The variety of concerns does not equate to a concrete concern triggering NEPA review under this finding in the alternative. Nor does it trigger the need for review under other statutory schemes that the Commission administers or which otherwise apply to the Commission's licensing.

[85] 47 CFR § 1.1307.

[86] We also decline to consider Earendil-1's potential environmental impact either as a precursor to or cumulatively as part of a larger constellation. *See, e.g.,* DarkSky International Comments, Attachment B at 4. Reflect Orbital has not applied for more than its single prototype satellite, and we decline to speculate regarding its future plans. Reflect Orbital states that Earendil-1 is designed to study potential environmental impacts from this technology, see Reflect Orbital Consolidated Opposition and Response at 13, and we find it would be inappropriate for us to require further environmental review for this single satellite based solely on the fact that it is designed to test a specific technology that may have environmental implications at a large scale.

[87] *See generally* ICFS File No. SAT-LOA-20260701-00129.

[88] *See, e.g.*, RAS Reply at 1-2; Reply of the Entomological Society of America (filed Mar. 30, 2026) (Entomological Society of America Reply); Reply of Center for Space Environmentalism at 10-13 (filed Mar. 31, 2026) (CSE Reply).

[89] 47 CFR § 1.1307(c).

and humans.[90] While these papers are offered to support commenters' claims, we find that they are insufficient on their own to support the claim that a single satellite deployed on a limited basis for the non-spectral purposes at issue here may have a significant environmental effect. Other claims, including those related to general impacts to society, heritage and culture, are speculative in nature and are beyond the scope of the Commission's environmental review.[91]

D. Other Matters

24. *Procedural arguments for denial.* We also reject procedural arguments on the record. In response to objections to Reflect Orbital's Application based solely on the fact that Reflect Orbital requested waiver of certain rules,[92] we note that applicants may seek, and the Commission may grant, waiver of the Commission's rules for good cause shown,[93] and Reflect Orbital's request meets the waiver standard.[94] Furthermore, the waivers requested by Reflect Orbital have been granted under similar circumstances.[95] Similarly, contentions that Reflect Orbital's Application does not satisfy the part 5 rules, which govern applications for experimental authority,[96] are not relevant to this application: Reflect Orbital filed for authorization under the part 25 rules, not the part 5 rules, and so our review of Reflect Orbital's Application is based on its compliance with the part 25 rules, not the part 5 rules. Notwithstanding Reflect Orbital's arguments that Earendil-1 is a demonstration satellite meant to test an emerging technology, applicants may seek authorization under part 25 of the Commission's rules even if

---

[90] *See, e.g.*, Circadian Light Research Center Comments at 2-3 (citing Sinnadurai, S. (1981) High pressure sodium lights affect crops in Ghana. World Crops 33: 120– 122. And: Briggs, W. R. (2006) Physiology of plant responses to artificial lighting: Ecological Consequences of Artificial Night Lighting (eds C. Rich & T. Longcore), pp. 389–412. Island Press, Washington, DC, USA); American Bird Conservancy Comments at 1-2 (citing Burt, C.S., Kelly, J.F., Trankina, G.E., Silva, C.L., Khalighifar, A., Jenkins-Smith, H.C., Fox, A.S., Fristrup, K.M. & Horton, K.G. 2023. The effects of light pollution on migratory animal behavior. Trends in Ecology & Evolution. https://doi.org/10.1016/j.tree.2022.12.006); Kyle Horton Letter at 2 (citing Knop E, Zoller L, Ryser R, et al. 2017. Artificial light at night as a new threat to pollination. Nature. 548: 206– 209. doi: 10.1038/ nature23288.);

[91] We similarly do not require environmental review on the basis of potential harmful radiation from the operation of a single satellite at 625 km. *See* Comments of the Friends of Merrymeeting Bay (filed Mar. 8, 2026) (Merrymeeting Bay Comments) (citing *Environmental Health Trust et al v. FCC*, 9 F.4th 893 (D.C. Cir. 2021)). A proposed project would require preparation of an EA if it "would cause human exposure to levels of radiofrequency radiation in excess of the limits" in the Commission's radiofrequency rules. 47 CFR § 1.1307(b). Commenters have not alleged that the single satellite proposed in this application, Earendil-1, will result in human exposure to radiofrequency emissions that would exceed the limits in the Commission's rules. In fact, commenter's submission to the record seems more broadly addressed to satellite technology as a whole, rather than the specifics of Reflect Orbital's application or even Reflect Orbital's potential long term business plans. Therefore, no additional environmental review of radiofrequency emission exposure is required.

[92] *See, e.g.,* John Frank Letter.

[93] Commission rules may be waived for good cause shown, in whole or in part, at any time by the Commission. *See* 47 CFR § 1.3. Waivers must articulate an "appropriate general standard," show special circumstances warranting a deviation from the general rule, and show that such a deviation will serve the public interest. *See Ne. Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990) (citing *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969)); *see also NetworkIP, LLC v. FCC*, 548 F.3d 116, 127 (D.C. Cir. 2008).

[94] *See generally* Reflect Orbital Grant.

[95] *See, e.g.*, Impulse Space Inc., ICFS File No. SAT-LOA-20250406-00093 (granted Aug. 15, 2025); Basalt Technologies Corp., ICFS File No. SAT-LOA-20250310-00067 (granted-in-part/deferred-in-part Jan. 23, 2026); Momentus Space LLC, ICFS File No. SAT-LOA-20250626-00122 (granted Jan. 30, 2026); Muon Space Inc., ICFS File No. SAT-LOA-20251119-00332 (granted May 1, 2026). We do dismiss Reflect Orbital's request for waiver of section 25.112(a) of the Commission's rules, 47 CFR § 25.112(a), as it is unnecessary given that the Commission's rules allow the Space Bureau to seek additional information and permits applicants to supplement their applications. *See* 47 CFR §§ 1.65, 25.111(a).

[96] *See, e.g.*, Eric Dahlstrom Letter at 1.

their operations may feasibly fit under the part 5 process. We find that Reflect Orbital properly applied for authorization under part 25 of the Commission's rules, and except for the waivers requested and granted, we have found that Reflect Orbital's Application otherwise complies with the Commission's rules for the reasons discussed in detail above.

25. *Standing.* Reflect Orbital asserts that AAS's petition lacks standing.[97] Specifically, AAS asserts that it has standing "because its members (1) suffer direct professional, aesthetic, and recreational injury from reflected orbital light, (2) the challenge is germane to its core scientific mission, and (3) the relief sought doesn't require individual participation."[98] Given that we have independently rejected AAS's arguments on the merits, we decline at this stage to reach its arguments regarding associational standing.

IV. ORDERING CLAUSES

26. Accordingly, IT IS ORDERED, that the Application of Reflect Orbital, Inc. is GRANTED, pursuant to sections 0.51 and 0.261 of the Commission's rules, 47 CFR §§ 0.51 and 0.261, and section 309(a) of the Communications Act of 1934, as amended, 47 USC § 309(a).

27. IT IS FURTHER ORDERED that the Petition to Deny filed by the American Astronomical Society is DENIED.

FEDERAL COMMUNICATIONS COMMISSION

Jay A. Schwarz
Chief
Space Bureau

[97] Reflect Orbital Consolidated Opposition and Response at 5.

[98] AAS Petition at 9 (citing *Int'l DarkSky Ass'n v. FCC*, 106 F.4th 1206 (D.C. Cir. 2024)).

Appendix:
Earth Station Locations Coordinated with Federal Agencies

Receive Earth Stations

1. Svalbard, Norway (S-band and X-band)
2. Troll, Antarctica (S-band and X-band)
3. Mingenew, Australia (S-band and X-band)
4. Awarua, New Zealand (S-band and X-band)
5. Hartebeesthoek, South Africa (S-band and X-band)
6. Punta Arenas, Chile (S-band and X-band)
7. Blonduoss, Iceland (S-band and X-band)
8. Pretoria, South Africa (UHF, S-band, and X-band)
9. Deadhorse, Alaska, USA (UHF and X-band)
10. Pitea, Sweden (UHF, S-band, and X-band)
11. El Segundo, California, USA (UHF and X-band)
12. Denver, Colorado, USA (UHF and X-band)
13. Fairbanks, Alaska, USA (UHF and X-band)
14. Boden, Sweden (S-band and X-band)
15. Umea, Sweden (UHF, S-band, and X-band)

S-band Transmit Earth Stations

1. Svalbard, Norway
2. Troll, Antarctica
3. Mingenew, Australia
4. Awarua, New Zealand
5. Hartebeesthoek, South Africa
6. Punta Arenas, Chile
7. Blonduoss, Iceland
8. Pretoria, South Africa
9. Deadhorse, Alaska, USA
10. Pitea, Sweden
11. El Segundo, California, USA
12. Denver, Colorado, USA
13. Umea, Sweden
14. Fairbanks, Alaska, USA
15. Boden, Sweden