Terms of Reference (TOR) for the

NSS Orbital Space Settlement Design Project (OSSD Project)

Version 12

July 27, 2026

Terms of Reference Definition: Formally defines the mandate, scope, responsibilities, boundaries, and working methods of an organizational entity or activity. TORs are recursive, and a project can be subdivided, with each subdivision having its own TOR. The TOR is a powerful technique borrowed from the ITU (International Telecommunications Union).

Required Approvals for Project Initiation:

- Reviewed by the Space Settlement Advocacy Committee (SSAC)
- Approved by the Board of Scientific and Technical Advisors (BSTA)
- Approved by the Executive Committee (Executive Committee).

The NSS Executive Committee officially approved the OSSD Project on March 11, 2026.

1. Purpose / Mandate

What problem is addressed?

- The first complete engineering design for an orbitalOrbital space settlement.
- The OSSD Project is mainly an engineering and systems-design effort; it is not a policy activity. However, there are both legal and economic aspects to the project.

Why?

- Orbital space settlements will remain an empty dream until they become buildable realities.

- To many, it has not yet been fully established that orbital space settlements are feasible.
- A fully realized engineering design will be a huge leap toward making the case that settlements in free space lie in our future.
- The research and development needed to produce a buildable engineering design of an orbital space settlement promises to address many important issues on the Earth.

Why the NSS?

- The NSS is non-partisan
- The NSS is not aligned with a particular company or region
- The NSS is interested in broadening access to space for all of humanity
- The NSS has the contacts needed to set up such a project
- The NSS has the longevity and reputation to be taken seriously in doing such a project
- The NSS is in a good position to be a respected "honest broker" between different companies, products, technologies, and design approaches
- The NSS is a non-profit

Why Now?

- It's time – 50 years since the NASA-Ames space settlement summer study and 50 years since the founding of the L5 Society.
- NSS laid the foundation with a 2021 workshop "A Dream Renewed: O'Neill's Vision in the 21st Century", now available in book form
- Enough knowledge has accumulated over 50 years that O'Neill's designs are in need of updating.
- With the near-term advent of low-cost fully reuseable launch vehicles, the kind of ships that existed only on paper in 1975 are now a reality on the launch pad
- The open-source movement has shown a path to the democratization of technology not envisioned in the time of O'Neill.

- The advent of increasingly powerful artificial intelligence tools creates the potential for a relatively small science and engineering team to address large questions on a level impossible during O'Neill's time.

What is a complete engineering design?

- Provided as a series of question-focused Recommendations that contain all the technical information needed to construct a working system. However, this is not a "screw and bolt hole" level-design but is similar to the level of technical information provided in international technical standards. Such standards typically, as is the case with patents, contain drawings, flow charts, tables, charts, etc. that are needed to understand the implementation. The Recommendations will be capable of implemention by those skilled in the relevant art, with the phrase "those skilled in the art" having the same meaning as within the U.S. patent system.
- In some cases, Recommendations will suggest multiple options, i.e. varying sizes with sensitivity analysis and associated assumptions.
- In some cases, Recommendations do not contain a description of a buildable item, but a specific answer to a technical question such as "Where should the first orbital space settlement be constructed?"
- Recommendations should be written at the standard of professional technical papers with sufficient references to allow any background material needed to be found by the reader/implementer who is skilled in the art.
- Covers all major subsystems of an orbital space settlement (structures, attitude and spin control, power, thermal, radiation protection, life support, habitability, logistics, operations, and safety) to conceptual/preliminary engineering design level, with quantified performance, margins, and mass/power budgets.
- Be "buildable" under an explicitly stated technology and industrial baseline without requiring speculative science or undefined technologies. Specifically, the technology used in the design must be:
    - Currently available, or
    - Agreed by working group participants to be under development, and achievable in operational practice within 5 years with 80% probability.
- Be "buildable" under a plausible set of economic and legal assumptions which are documented as part of the project and appear in Recommendations addressing

economic and legal matters. These Recommendations must be internally consistent and grounded in existing legal frameworks and economic mechanisms.

- All source code and designs will be publicly available, but the project will include a patent pool for proprietary technology as is common practice for international standards
- No classified information or trade secrets will be used in the engineering design
- Impact of ITAR/EAR Rules:
    - Functions with significant ITAR sensitivity such as detailed rocket engineering or guidance systems design will either be limited to widely available uncontrolled current technology or will be presented as requirements without details. It is not currently expected that the project will involve reentry technology, so this should not be an issue.
    - Functions with significant EAR sensitivity such space-rate electronics or AI systems will be specified at a high-level only. This should not be an issue as these elements are not critical to the design and are widely understood. Care will be taken than any orbital system element such as flywheels does not exceed the information that is publicly available. Additionally, any usage of advanced materials will be considered carefully before inclusion in the design.
    - Details of encryption technology will not be part of the design and will be described with terms such as “encryption systems well known to those skilled in the art.”
    - Since novel radiation protection designs will be a significant part of the project, a special effort will be made to ensure that ERA rules are not violated in this regard.
    - Before Recommendations are issued, pro-bono legal review will be sought to identify any areas of concern related to ITAR/EAR.
    - Because resilience to kinetic and electromagnetic assaults will be a vital part of the project, a special effort will be made to ensure that these efforts do not violate ITAR or EAR rules. Such systems may be described via only high-level requirements in some cases, and especially with regard to active defenses against kinetic attack.

2. Scope of Work

- Topics included:
    - Engineering design for an orbital space settlement
        - Where people, including families, can safely live on a permanent economically self-sustaining basis. In this context, permanent means that those who live there intend to live there with their families on a long-term basis, i.e. no routine crew rotations.
        - In this context "permanent" means that people intend to live their lives on the settlement, birth to death.
        - In this context "economically self-sustaining" means that the work performed by the population of the settlement has sufficient value that their collective income covers needed imports, repairs, and allows for some savings. Additionally, it must be possible for investors in the project to achieve significant returns.
        - The nominal population target is 1,000, with the expectation that populations from 100 to 10,000 will be considered as part of the work.
        - The target population will be one of the questions studied, in the context of seeking to define the human population size for the first economically sustainable permanent orbital human settlement in space, with the requirement that as a permanent settlement it will include a significant degree of local food production.
        - For purposes of comparison, the recommended settlement will be scaled to allow a direct comparison to the 10,000 population NASA Ames summer study and the BIS Avalon project[1].
        - That is designed as a component in a cislunar economic network and is not required to be autarkic or to be totally biologically self-sufficient. Inclusion in the cislunar economic network excludes certain use cases, such as Earth-Mars cyclers and also means that medical evacuation will be possible with travel times less than a week. It also means that high-value repair parts may be Imported from the Earth, along with consumable trace elements and medical supplies.

[1] https://www.bis-space.com/membership/jbis/2019/JBIS-v72-no09-September-October-2019_dk64ll.pdf

        - The baseline human species is assumed; solutions that involve human modification are out of scope.
        - Since the minimum gravity level for human thriving has yet to be firmly established, the design target will be either 1 gravity or a high fraction of 1 gravity to be achieved via “spin gravity”, with a collateral goal of supporting a partial gravity research environment.
    - Examination and development of assumptions related to available construction materials and their costs.
    - Examination and discussion of the legal, treaty, and economic prerequisites for the construction of the engineering design to be feasible.
    - Examination of resilience to both natural and artificial assaults. In particular matters related to electromagnetic hazards, biological threats and meteor/space debris strikes are in scope.
    - See Annex A for a draft list of included questions
- Topics explicitly excluded
    - Lunar mass drivers
    - Lunar mining technology
    - Construction shacks
    - Asteroid mining technology
    - Launch vehicles
    - In-space transport vehicles
    - Detailed design of robotic construction equipment
    - Means by which a settlement might become sovereign
    - Weapons systems for the purpose of settlement defense that are not necessary to protect against natural phenomena.
    - Military plans relating to settlement defense
- Rationale for exclusions
    - Since the time of O’Neill, there has been significant, on-going work in the areas of mass drivers, lunar mining, asteroid exploration, asteroid mining,

launch vehicles, in-space transportation, and robotics. The ISRU Roundtable[2] is a good place to go to catch up on much of this work, as is the NSS Space Settlement Workshop Book[3].

- NASA has operated the ISS for decades, and it is now running the Commercial LEO Destinations program to replace the ISS with multiple commercial LEO Stations. Taken as a whole, this represents a large amount of work related to in-space construction "shacks." A recent book provides a current summary of the state-of-the-art in microgravity habitat construction.[4]
- At the same time, there has been at best modest work done on the actual design of a rotating orbital space settlement, with the BIS SPACE Avalon design as a notable exception.
- Thus, it is the engineering design of an orbital space settlement where the NSS can have the greatest incremental impact.
- Although of great interest, the topic of settlement sovereignty lies with high probability during a future period in which large numbers of humans live in space and thus is considered out-of-scope for this project.
- The NSS has traditionally avoided discussion or advocacy related to force structure or military planning, so these matters are out-of-scope for this project unless there is a material overlap between natural and artificial assaults.

3. Responsibilities

Deliverables

- The output of the project will be series of Recommendations that address Questions related to the engineering design of an orbital space settlement. In some cases, the recommendation will be for a high-level yet concrete direction, such as the preferred location for the first orbital space settlement(s). In other cases, the recommendations will be technical documents that describe the engineering solution to particular questions. Taken as a whole, the entire set of

[2] https://isruinfo.com/public/
[3] "**A Dream Renewed: Space Settlement in the 21st Century**" by Dale Skran and Rod Pyle; ISBN 978-1-960259-61-5, 2026.
[4] "**Space Architecture: Principles, Challenges, and Innovations**," by Daniel Inocente, Wiley, ISBN 978-1-394-31810-0, 2026.

Recommendations should provide a detailed specification for the construction for the first rotating orbital space settlement.

- The Recommendations will be published as they are approved in the *NSS Journal of Space Settlement* so that they are available to the public at no charge. Additionally, all Terms of Reference, including this one, and the living list of questions guiding this project will be appear on the NSS website nss.org.
- Unlike ITU Recommendations, but following the model of the IETF RFCs[5], the Recommendations produced by this product will have named authors. The reason here is that (1) being publicly acknowledged for contributions will encourage participation, and (2) gathering a list of significant contributors to this project will increase the credibility of the work and of the space settlement enterprise in general.
- Anyone involved in this project may write for and submit to peer reviewed journals papers based on their work as part of this project, with the professional obligation to invite any significant co-contributors to join the paper as co-authors, and for anyone who meaningfully contributed to the paper to be credited with a footnote or reference.
- As part of this project, the Orbital Space Settlement Study Group may solicit and organize the creation of a summary or other papers from group members for submission to peer reviewed journals. A stretch goal is that at the conclusion of this project, it can be asserted that these papers, when combined with the Recommendations themselves, and with other peer-reviewed papers, make a strong case that an orbital space settlement is feasible scientifically, as well as from an engineering, economic, and legal perspective.

Project Organization:

- The BSTA acts as final high-level group that approves recommendations and makes use of them
- The BSTA organizes the Orbital Space Settlement Study Group
- The BSTA appoints/recruits the Lead for the OSSD Study Group
    - This position will be jointly held by Dale Skran and Rick Jenet

[5] IETF – Internet Engineering Task Force, RFC – Request for Comment

- The OSSD Study Group Leads recruit collaborators as needed to support the work of the OSSD Study Group.
    - Bryce Meyer, the editor of the NSS Space Settlement Journal, and author of the recently published book "**Designing Farms in Space: Balances for Life Support, Food, and Settlement**" Springer 2026 will be invited to join the OSSD Study Group, along with Dale Skran and Rick Jenet. As the project develops, others may be invited to join this group.
- The OSSD Study Group defines questions and submits them to the BSTA for approval; the question list is updated as needed, but at least annually.
- The OSSD Study Group recruits a Rapporteur for each question
- Using methods described below, each Rapporteur answers their question with a Recommendation.
- Each Rapporteur is tasked with recruiting and organizing collaborators to advance the work of their question. This may include one or more editors for each Recommendation, as well as named collaborators.
- The OSSD Study Group forwards Recommendations to the BSTA
- The BSTA approves recommendations and forwards them to the Executive Committee for publication. *Note that any BSTA member who serves as a Rapporteur, Editor, or named author for a particular Recommendation must recuse themselves from the approval of that Recommendation.*
- The OSSD Study Group Chair will submit an annual progress report to the BSTA, which after approval will be forwarded to the Executive Committee
- The OSSD Study Group Lead(s) will submit a budget for BOD approval as part of the normal NSS annual budget process. This budget will appear as a project under Class 56-13 Projects General in the NSS budget.
- The OSSD Study Group Lead(s), with the approval of the BSTA Chair and the NSS CEO, may decline or suspend participation of parties whose conduct materially undermines the technical integrity, safety, or credibility of the project. It is recognized that individuals may be sent to disrupt the project for various reasons as participants, and that it may be necessary to ban the participation of such individuals. The primary responsibility for rejecting disruptive, useless, misleading, or delaying submissions lies with the Rapporteurs, but they may seek help from the OSSD Study Group Leads as needed.

Conditions of Participation

- Participation in the OSSD Project is open to individuals and organizations acting in a personal or corporate capacity, subject to the following conditions:
    - They must apply to the Rapporteur to participate and be accepted as a collaborator by the Rapporteur
    - Agreement to conduct work transparently, including attribution of sources and disclosure of relevant assumptions
    - Agreement not to introduce classified or export-controlled information without authorization
    - Agreement to only introduce proprietary information with the understanding that if it appears in a Recommendation, the owner of the information will participate in a patent pool containing that information.
    - Agreement to engage in good faith technical collaboration and consensus-building, and to abide by the decisions of the Rapporteurs and OSSD Study Group Leads.
    - Agreement to abide by the NSS codes of conduct and the project governance rules documented herein , and in particular to follow the NSS Policy Against Harassment.

4. Relationship to Other Groups

Usage of International Standards:

- Wherever appropriate, existing international standards will be referenced in engineering design.

Anticipated Partners:

- The cooperation and support of the British Interplanetary Society SPACE project will be solicited. The BIS SPACE project has been developing a series of papers describing the Avalon orbital space settlement. Although this project has a somewhat different set of goals than the NSS project, it may be that the BIS SPACE team will wish to participate in the NSS project, and indeed to submit the design, or elements of the design, of the Avalon settlement to the process described in this TOR. Such submissions are encouraged and will be treated on an equal basis with all other submissions.
- It is anticipated that the companies involved in the Commercial LEO Destinations program or similar Space Act Agreement managed programs will have an interest in the questions being studied and will be invited to participate in this project. These

companies include, but are not limited to Axiom, Voyager Space, VAST, Blue Origin, Sierra Space, Thales Alenia Space, and Max Space.

- All participants in the NSS Space Settlement Workshop will be invited to engage with the OSSD Project.
- Paragon Space Development Corporation and Redwire will be invited to participate in the OSSD Project.

5. Working Methods

Recommendation Development Process:

- Generally follow the methods used to develop international technical standards in the ITU.
- The project will be open to all who are willing to work and follow the participation requirements above, but will be led by the NSS
- Individuals from all nations will be considered for participation, but note that Recommendation approval is by the NSS BSTA, not the voting of national entities as in the ITU.
- The process is open to individuals, for-profit corporations, and all types of non-profits. Participation does not imply representation of any State, nor endorsement of any national policy or position. There is no "national" representation or voting.
- Each Rapporteur organizes their work as they see fit, and reports at least annually but more frequently as needed to the BSTA OSSD Study Group with draft recommendations
    - The normal working method will be workshops and virtual meetings, but other means can be used
    - Unlike the ITU-T, which rotates continents, workshops will typically be held in the USA, although this is not required
    - Rapporteurs are unpaid volunteers typically with jobs in the space industry
    - Decision making is by consensus, and consensus follows ITU practice - it is defined by the Rapporteur, but consensus is not unanimity, and there are no votes. Any significant unresolved technical disagreements shall be documented in reports to the OSSD Study Group, including a brief summary of dissenting views and their technical basis.

    - Submissions or participation intended primarily to obstruct progress, re-litigate foundational premises outside the scope of the project, or advance ideological positions inconsistent with the stated mandate of the project may be ruled out of scope by the Rapporteur.
    - If participants feel a Rapporteur is biased or unprofessional, they should raise the complaint with the OSSD Lead(s) and failing that with the BSTA Chair and failing that, with the NSS CEO.
- Workshop Structure
    - Nominally four "questions" per meeting [Real number TBD by the OSSG]
    - Live shared-text negotiation led by the Rapporteur or Editor is highly preferred as a method.
    - One live workshop per year followed by 2-3 zoom calls leading to an annual report at the last zoom call.
    - Additional meetings of questions will be driven by the work
    - The number of in-person meetings may increase if more funds are raised.
- Rollout Plan
    - Review of these TOR by the SSAC
    - Review and approval of these TOR by the BSTA
    - Presentation to and approval of these TOR by the Executrive Committee
        - Formal start of the project/March 11, 2026
    - Orbital Space Settlement Study Group Lead selected by the BSTA
    - OSSG Leads Draft Questions
    - External solicitation for input on the Questions; external announcement of the project. Currently planned to follow the NSS 2026 Space Settlement Summit.
    - BSTA approves the Questions
    - OSSG recruits rapporteurs for the questions chosen for the initial workshop and other sources.
    - A sponsor or sponsors are found for the first workshop

- SSSG Lead(s) announces first workshop and sends out invitations
    - A university that offers free meeting space is the preferred location, with the University of Central Florida being the first choice

6. Duration / Review Conditions

Duration:

- The nominal time span of the project is five years
- On an annual basis, when the budget for the next year is considered, the expected continuation and duration of the project will be reviewed.

ANNEX A [initial draft only]:

- Questions: Population size
    - What population is required for social stability and family life?
    - What population is required for operational stability?
    - What population is required for economic viability?
    - What population is required for mental health?
- Questions: System Architecture
    - Overall configuration (e.g., shape of habitat, number of modules). Target will be 0.9 to 1.0 gravity.
    - Orbit/location (e.g., LEO, NRHO, EML1, L5, etc.) and rationale.
    - Population, use case, and design life. Target will be 100 to 10,000 residents, with 1,000 as a nominal goal.
- Questions: Structure & Mechanics
    - Primary structure (geometry, major dimensions, mass breakdown).
    - Spin gravity parameters (radius, rpm, Coriolis limits, internal deck layout).
    - Load cases (spin loads, docked mass, MMOD, emergency off-spin scenarios). “Docked mass” refers to attached payloads and craft that are not part of the rotating structure.
    - Interfaces for modular construction/expansion.
- Questions: Attitude & Spin Control

    - Spin-up/spin-down methods and Δv requirements.
    - Attitude control concept (control moment gyros, RCS, reaction wheels, tethers, etc.).
    - Momentum management and propellant budgets over life.
- Questions: Power & Thermal Control
    - Power architecture (e.g., solar, nuclear, distribution buses, redundancy).
    - Power budget (steady-state and peak; growth margin).
    - Thermal balance, radiator sizing, and placement.
- Questions: Radiation Protection
    - Required dose limits and design philosophy.
    - Shielding mass/arrangement (regolith, water, plastics, etc.).
    - Active vs passive shields
    - Trade studies between location, shielding, and operational constraints.
    - Storm shelters
- Questions: Life Support & Habitability
    - Air, water, waste, food production approach (closed/open loop targets).
    - Crew/resident per-capita resource budgets.
    - Internal layout: decks, streets, agriculture, workplaces, emergency egress.
        - In Ag areas, power, lighting, tankage?
        - Allowance for graywater taps for plants?
    - Plumbing, HVAC standards, layouts and comfort control for each room?
        - Layout of restrooms, public areas, provision for restaurants and kitchens, showers?
        - Humidity control (dehumidifiers) in each area? Hallways?
    - Lighting, day-night cycles, noise limits, time zone, psychological considerations. What common rules apply to common areas? Vaping, behavior, clothing, pets, etc?

- Questions: Logistics & Operations
    - Launch/assembly campaign concept: stages, required LV capabilities, number of flights.
    - On-orbit construction methods (robotic assembly, EVA limits, in-space manufacturing).
    - Resupply cadence, spares philosophy, maintenance concepts.
- Questions: Medical, dental, and other health related services
    - What medical equipment and facilities will be on the settlement?
    - What medical staffing levels will be needed?
    - What medical evacuation procedures are provided for the settlers?
    - How long will medical evacuation take? This may vary based on the preferred location, and in turn impacts on the services and staff needed.
- Questions: Safety, Reliability, & Risk
    - Fault-tolerant architecture (compartmentalization, redundancy, safe-haven areas).
        - Consider usage of SCADA and AI structures to enable safety Which standards and response times are preferred
    - Major hazards analysis (depressurization, fire, spin failure, toxic release, power loss, space debris impact, disease outbreak, agriculture collapse, vermin outbreak, sabotage).
    - Reliability targets (e.g., probability of loss of habitat per year) and how you model them.
- Questions: Communications:
    - Nature of communications with the Earth and objects in cislunar space.
    - Internal communications links and infrastructure, including information management.
- Questions: Defense and resilience:
    - Resistance to and protection against EMPs, both natural and artificial.
    - Protection against kinetic attacks, both natural and artificial.

    - Protection against biological attacks, both natural and artificial.
- Questions: Law enforcement and governance:
    - Assuming that the settlement operates under the laws of a single Earthly nation, consider the preferred approach to and staffing for law enforcement.
    - Assuming the settlement operates under the laws of a single Earthly nation, consider the preferred approach to settlement governance in the context of the economic models that are Recommended.
- Questions: Economics
    - Order-of-magnitude cost model (capex/opex bands, not exact dollars)
    - Order-of-magnitude income model for at least three potential business models (e.g. real estate, production of intellectual property, tourism, transportation, partial gravity applications, etc.)
    - Order-of-magnitude annual P&L for the settlement
    - Sensitivity analysis for economic assumptions, including costs for construction materials
    - What are the preferred options for the ownership structure of the space settlement?
    - What are the expected sources of investment funds and how does this impact the design?
    - Will there be incubator space/tenant space for businesses or research entities? What resources will be provided for each? What percentage of the station would be allocated to these?
- Questions: Standards & Interfaces
    - Defined interface specs for modules, docks, utilities, software and networking protocols where relevant.
    - Assumed external standards (e.g., docking systems, data protocols, etc.).
    - Assumed standards for construction elements
- Questions: Legal
    - Has it been established that a private entity may own and profit from a space settlement constructed entirely from Earth-launched materials?

- Has it been established that a private entity may own and profit from a space settlement constructed from both Earth-launched materials and materials sourced from the Moon and/or asteroids?
- Has it been established that the laws of the country under which the corporation owning the settlement is registered are binding on the settlement?
- How can the right of unhappy settlers to leave the settlement be established and supported practically?
- What happens if settlers refuse to pay required bills, or to perform required work?
- How and at what level will ownership rights be protected and enforced?
- How will labor rights issues be handled on the settlement?
- What service level agreement between the constructing entity and the settlers will be applied with respect to provision of networking, safety, and security for both residents and tenants?
- Is there an at-risk assumption for people on the settlement? What agreements exist for fatalities or injuries?