

# REQUEST FOR PROPOSAL

## 3 January 2033

### "Bellevistat" Space Settlement Contract

#### INTRODUCTION

This is a request by the Foundation Society for contractors to propose the design, development, construction, and operations planning of the second large space settlement community in Earth orbit.

The first settlement in Earth orbit was initially envisioned by a consortium of satellite operators who saw that refurbishing and upgrading communications satellites in space could be less expensive than launching new replacements from Earth. None of their suppliers was willing to invest in developing infrastructure to implement this vision, so the companies turned to the Foundation Society--then a venture capital organization funding entrepreneurial space tourism launch vehicles--to lead the project. Foundation Society executives saw this as a major step toward their true goal of developing large settlements where thousands of people could live in space, and agreed to sponsor a modest manufacturing facility orbiting just below the Van Allen radiation belts.

Speedy construction was a priority, to enable the Foundation Society to start seeing a return on its substantial investment. Contractors for the International Space Station were hired to build more of their space-qualified modules and solar panels, and the Society's engineers created a modular design for a small community that would grow with expanding business opportunities, incorporating expended rocket stages as manufacturing bays. Space tugs maneuvered target satellites to the facility and returned them to their operational locations. Advantages of orbital refurbishment capability quickly became obvious: satellite upgrade hardware is small and relatively lightweight, and hence not expensive to launch; the heavy satellite structures stayed in space. Demand for the service grew, crew size increased, and profits soared.

The Foundation Society encouraged the crew at their growing orbital manufacturing facility to tinker and experiment with materials and processes in zero g and vacuum. The crew represented the largest pool of unscheduled hours ever experienced in space, and their creativity quickly produced results, including innovations in processing lunar materials. Their most stunning success was a form of silicon resembling the structure of carbon nanotubes; dubbed "buckystructures", the material is extraordinarily strong in tension, and can be formed into flexible strands and cables of unlimited length, or vast nets and sheets of fabric. Permutations are still being explored; colors range from milky white to quartzlike transparency, properties of different forms and with various introduced impurities include thermal insulating qualities, electrical conductivity, sound transmission, adhesion, or light refraction. The most exciting variant so far is a bright white fabric that tolerates the space environment and prevents penetration by space debris up to two inches in diameter (although it offers no thermal insulation).

With its new revenues, the Foundation Society expanded its investment in the facility and supporting infrastructure, pushing it to become the first true space settlement. That goal was achieved in 2031 with 1000 residents living in a structure rotating to provide 0.5g, and was commemorated by naming the facility "Alexandriat", acknowledging Alexander the Great's expanding his empire into previously unknown territories.

Alexandriat, however, was not purpose-built for everything now happening there. The Foundation Society intends to preserve Alexandriat's core value as a center for handcrafting satellite repair, upgrade, and manufacture; and its role as a research facility. Large-scale materials refining, heavy industry, and mass production will move to a second space settlement specifically established for those purposes.

For planning purposes, the Foundation Society has selected "Bellevistat" as the name of the new settlement. Loosely translated as "beautiful view", the name refers both to the spectacular views of Earth enjoyed by residents of space, and the coincidence that an oddly high percentage of Foundation Society members have lived in the city of Bellevue, Washington, USA.

**FORMAT AND SCHEDULE**

**For entries from Regions with Semi-Finalist Competitions or selection processes, follow submittal instructions from the corresponding Regional Coordinators.**

For all other entries, THREE single-sided copies and/or originals plus one pdf version of each proposal must be received by the Foundation Society no later than Wednesday 24 April.

A U.S. Mail postmark by Saturday 20 April or international air mail postmark by Wednesday 17 April will be accepted as meeting the 24 April proposal submittal deadline.

Only entries from registered teams are eligible to advance in the Competition. Submit proposals in the English language, single-sided on 8 1/2 by 11 inch paper (or nearest international equivalent), with a 40 page limit, print 10-point or larger with standard spacing, and all margins one inch or larger--print and image area 6 1/2 by 9 inches (16.5 by 22.8 cm) excluding header, footer, and page numbers. For font size reference, this page is Times New Roman 10-point text with standard spacing and required margins. Cover page, "Proposing Team Data" page, and Appendices A through C are required but do not count against the 40-page limit; table of contents and section dividers do not count against the 40-page limit. It is advised that clarity, neatness, thoroughness, and organization of the design description will aid the Foundation Society in recognizing the design's merits. Proposals must at minimum include seven sections and three Appendices, numbered as follows:

- 1.0 Executive Summary [brief description of overall design features and merits]
  - 2.0 Structural Design
    - 2.1 External Configuration
    - 2.2 Internal Arrangement
    - 2.3 Construction Process
    - 2.4 and 2.5 corresponding to SOW paragraphs
  - 3.0 Operations and Infrastructure
    - 3.1 Location and Materials Sources
    - 3.2 Community Infrastructure
    - 3.3 Construction Machinery
    - 3.4 and 3.5 corresponding to SOW paragraphs
  - 4.0 Human Factors and Safety
    - 4.1 Community Design
    - 4.2 Residential Design
    - 4.3 Safe Access
    - 4.4 and 4.5 corresponding to SOW paragraphs
  - 5.0 Automation Design and Services [computer and robot systems]
    - 5.1 Automation of Construction Processes
    - 5.2 Facility Automation
    - 5.3 Habitability and Community Automation
    - 5.4 and 5.5 corresponding to SOW paragraphs
  - 6.0 Schedule and Cost
    - 6.1 Design and Construction Schedule
    - 6.2 Costs
  - 7.0 Business Development (may reference other sections where RFP "7." requirements are met)
- Appendix A: Operational Scenario  
 Appendix B: Bibliography / References: reference ANY art or text not original for this proposal  
 Appendix C: Compliance Matrix

Due to incompatibilities of computer and software systems, proposals may not be submitted via electronic media (with ONE pdf exception, defined in separate submittal instructions), e.g., e-mail, website, or CD. Teams may, however, post artwork and design images for their proposals on websites, within the following guidelines:

- (a) Only drawings, pictorial representations, and artwork are to be posted electronically; text (except captions) and charts/tables must be included in the submitted proposal.
- (b) Drawings associated with different Statement of Work (SOW) sub-sections (e.g., 3.1, 3.2, or 3.3) must be posted in separate website locations (e.g., different links from a single site).
- (c) The first reference to a website for images in a proposal sub-section (e.g., 3.1, 3.2, or 3.3) will be included as half of a proposal page--including address for accessing the site, AND a sample image from the site. Re-emphasizing, if three sub-sections reference a website, the proposal section will include three half-page images.
- (d) Website images must be accessible by Macs or PCs and not require special software installation.

## **STATEMENT OF WORK**

**1. Basic Requirements** - The contractor will describe the design, development, construction, and operations/maintenance planning for the Bellevistat space settlement in Earth orbit.

**2. Structural Design** - Bellevistat must provide a safe and pleasant living and working environment for a population of 11,000 full-time residents, plus an additional transient population, not to exceed 500 at any time, of business and official visitors, guests of residents, and vacationers. The design must enable residents to have natural views of Earth and the Moon.

**2.1** On exterior design drawing(s), identify large enclosed volumes and their uses, and show dimensions of major structural components and design features. Identify construction materials for major hull components. Specify volumes where artificial gravity will be supplied, the means for initiating and sustaining it, and structural interface(s) between rotating and non-rotating sections. The design must show capability to isolate at minimum any five separate habitable volumes in case of a depressurization or other emergency.

Minimum requirement: overall exterior view of settlement, with major visible features (e.g., solar panels, antennas), showing rotating and non-rotating sections, pressurized and non-pressurized sections, and indicating functions inside each volume (e.g., port, residential areas, and agriculture).

**2.2** Specify percentage allocation and dimensions of interior "down surfaces", with drawings labeled to show residential, industrial, commercial, agricultural, and other uses. Show orientation of "down surfaces" with respect to overall settlement design, and vertical clearance in each area.

Minimum requirement: overall map or layout of interior land areas, showing usage of those areas.

**2.3** Describe the process required to construct the settlement, by showing the sequence in which major components will be assembled. Specify when artificial gravity will be applied. Describe a construction technique for interior structures making use of minimally refined lunar materials.

Minimum requirement: drawing(s) showing at least ten intermediate steps of settlement assembly, and method of initiating rotation for artificial gravity.

**2.4** The Foundation Society's production facility for silicon buckystructures requires 50,000 sq ft (4645 sq meters) with at least a 26 ft (8 meter) ceiling height in 0.25 g, plus a comparable volume with 10 ft (3 meters) in one dimension in zero g, and 1 MW of continuous electrical power.

Minimum requirement: show locations on overall structural drawing of buckystructures production facilities, and means for moving parts between those facilities.

**2.5** Port facilities must accommodate various sizes, configurations, and purposes of visiting ships. Minimum requirement: drawing(s) of dock configuration(s), including ships in port.

**3. Operations and Infrastructure** - Describe facilities and infrastructure necessary for building and operating the Bellevistat space settlement and its communities.

**3.1** The settlement will operate in orbit around the Earth-Moon L4 libration point. Identify sources of materials and equipment to be used in construction, (Earth, Earth's moon, asteroids, or elsewhere), means for transporting those materials to the Bellevistat construction location, and storage between arrival and use. The maximum payload size that can be launched from Earth is 20 feet (6 meters) diameter by 80 feet (24 meters) long. The maximum size that Alexandriat can build and ship is 23 ft (7 meters) diameter by 100 ft (30 meters) long, or flat plate 100 ft (30 meters) by 50 ft (15 meters).

Minimum requirement: table identifying types, amounts, and sources of construction materials.

**3.2** Bellevistat design will show elements of basic infrastructure required for the activities of the settlement's residents, including (but not limited to):

- atmosphere (identify air composition, pressure, humidity, thermal control, and quantity),
- food production (including growing, harvesting, storing, packaging, delivering, selling),
- electrical power generation (specify kilowatts distributed to habitable areas),
- water management (specify required water quantity and storage facilities),
- household and industrial solid waste management (specify recycling and/or disposal),
- internal and external communication systems (specify devices and central equipment),
- internal transportation systems (show routes and vehicles, with dimensions), and
- day/night cycle provisions (specify schedule and mechanisms/operations for providing it).

Define storage facilities required to protect against interruption in production of food (e.g., blight) or commodities needed for daily life; supply lines for imports may be interrupted for two weeks.

Minimum requirement: chart(s) or table(s) specifying quantities required of air, food, power (for residents), water, waste handling, communications devices, and internal transport vehicles.

**3.3** Show conceptual designs of primary machines and equipment employed for constructing the settlement, especially for assembling exterior hull and interior buildings / structures. Describe materials, components, and/or subassemblies delivered to the machines, and how the machines convert delivered supplies into completed settlement structures.

Minimum requirement: drawing(s) of primary construction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form.

**3.4** Experience at Alexandriat shows that supplying paper--for offices, cleaning, kitchens, hygiene, packaging, and even personal expression through artwork and games--is a major challenge in space. Show process(es) for providing paper (or equivalent) products in Bellevistat, including recycling.

Minimum requirement: chart or table listing raw materials source(s) and facilities for paper (or equivalent) production processes.

**3.5** Bellevistat will provide repair services for visiting ships.

Minimum requirement: show how docks for ship repair differ from unloading/loading docks.

**4. Human Factors and Safety** - Quality of life is important to Foundation Society members, who plan to maintain traditional comforts of Earth without the sacrifices normally associated with a frontier environment. Residents expect community attributes available to residents of Earth's large towns in developed countries (e.g., comfortable housing, good food, access to entertainment). Assure that natural sunlight and views of Earth and the Moon are readily available for residents. Provide options for residential areas in 1g, 0.8g, and 0.5g; and with 1.0, 0.8, and 0.6 times Earth sea level atmospheric pressure.

**4.1** Bellevistat communities will provide services that families could expect in comfortable modern communities (e.g., housing, entertainment, medical, parks and recreation), variety and quantity of consumer goods, and areas designed with open space and long lines of sight. List major types of consumables, and quantities. Depict or specify means of distributing consumables (including food) to Bellevistat residents.

Minimum requirement: map(s) and/or illustration(s) depicting community design and locations of amenities, with a distance scale; identify percentage of land area allocated to roads and paths.

**4.2** Provide designs of typical condominium or apartment residences, clearly showing room sizes; home designs will be no smaller than 800 sq. ft. and no larger than 1400 sq. ft. Identify source(s) and/or manufacture of furniture items, appliances, and personal items (e.g., clothing and shoes). Anticipated demographics of the initial population are:

Married adults	40% (average age 38, median age 34)
Single Men	32% (average age 33, median age 34)
Single Women	25% (average age 36, median age 34)
Children (under 18)	3% (average age 10, median age 12)

It must be expected that demographics and population of the settlement will change with time.

Minimum requirement: external drawing and interior floor plan of at least six home designs, the area (preferably in square feet) for each residence design, and the number required of each design.

**4.3** Designs of systems, devices, and vehicles intended for use by humans outside of artificial gravity and pressurized volumes will emphasize safety. Show safety systems to enable human inspection and repair of exterior surfaces of rotating volumes. Show features required for spacesuits enabling work outside of pressurized volumes. Show airlock designs for exiting/entering habitable areas from unpressurized volumes and the exterior.

Minimum requirement: drawings showing spacesuit, airlock, and exterior mobility device designs.

**4.4** Studies of human behavior in isolated environments have shown a tendency for permanent residents to regard visitors and temporary residents as outsiders or intruders. Describe community attributes intended to enable short-term residents to feel welcome and integrated into the settlement's community life.

Minimum requirement: describe at least one physical and one social community feature intended to involve non-permanent residents in social structures of the settlement.

**4.5** Visitors' first impressions of Bellevistat will be the passenger receiving areas. Create pleasant and efficient areas for passenger arrival and departure.

Minimum requirement: illustration(s) of the passenger experience when arriving at Bellevistat.

**5. Automation Design and Services** - Specify numbers and types of computing and information processing devices, multi-function personal electronic tools, servers, network devices, and robots required for Bellevistat's facility, community, and business operations. Describe types and capacities of data storage media, data security, and user access to computer networks. Show robot designs, clearly indicating their dimensions and illustrating how they perform their tasks.

**5.1** Describe use of automation for construction. Consider automation for transportation and delivery of materials and equipment, assembly of the settlement, interior finishing, and manufacture of furniture and appliances.

Minimum requirement: drawings showing automated construction and assembly devices--both for exterior and interior applications (e.g., homes)--and illustrating how they operate.

**5.2** Specify automation systems for settlement maintenance, repair, and safety functions, including backup systems and contingency plans. Robots required for emergency external repairs must survive and accomplish tasks during solar flare activity. Describe means for authorized personnel to access critical data and command computing and robot systems; include descriptions of security measures to assure that only authorized personnel have access, and only for authorized purposes.

Minimum requirement: chart or table listing anticipated automation requirements for operation of the settlement, and identifying particular systems and robots to meet each automation need.

**5.3** Describe automation devices to enhance livability in the community, productivity in work environments, and convenience in residences. Emphasize use of automation to perform maintenance and routine tasks, and reduce requirements for manual labor. Provide for privacy of personal data and control of systems in private spaces. Describe devices for personal delivery of internal and external communications services, entertainment, information, computing, and robot resources.

Minimum requirement: drawings of robots and computing systems that people will encounter in Bellevistat, and diagram(s) of network(s) and bandwidth requirements to enable connectivity.

**5.4** Ore from the Moon and asteroids will arrive in standard shipping containers, 15 ft square by 60 ft long. Automate unloading of shipping containers from ships, transfer of containers to refining facilities, and unloading of containers in zero g and vacuum.

Minimum requirement: drawings of automation systems to deliver ore to refining processes.

**5.5** Automate final docking of ships in the various port facilities. Show differences in docking procedures for different types of docks.

Minimum requirement: show automated docking aids for at least two different types of ships.

**6. Schedule and Cost** - The proposal will include a schedule for completion and occupation of Bellevistat within 13 years, and costs for design through construction phases of the schedule.

**6.1** The schedule must describe contractor tasks from the time of contract award (15 May 2033) until the customer assumes responsibility for operations of the completed settlement. Show schedule dates when Foundation Society members may begin moving into their new homes, and when the entire original population will be established in the community.

Minimum requirement: durations and completion dates of major design, construction, and occupation tasks, depicted in a list, chart, or drawing.

**6.2** Specify costs billed per year of Bellevistat design through construction in U.S. dollars, without consideration for economic inflation. Estimate numbers of employees working during each phase of design and construction in the justification for contract costs.

Minimum requirement: chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society.

**7. Business Development** - Bellevistat will host various commercial and industrial ventures, which may change with time. The basic design must be sufficiently flexible to add compatible business types with little configuration change. The original configuration must, however, accommodate three major business pursuits:

- Port for receiving lunar and asteroid materials
  - ores will arrive in standard shipping containers
  - ore arrives in batches but is delivered for continuous processes, so must be stored between delivery and use
  - provide method(s) and route(s) for transferring raw materials to processing facilities
  - most--but not all--non-bulk cargo will arrive in standard shipping containers
  - provide separate port facilities for passengers, and cargo other than raw materials

- Production of goods manufactured from extraterrestrial materials
  - materials require processing varying from minimal to refining for extraction of metals and rare earth elements
  - many processes require operations in both zero g and at least 0.2 g
  - manufacturing will encompass a wide variety of products; the Foundation Society will welcome companies to lease space for manufacturing facilities
  - products will be created at Bellevistat for export, provisioning visiting ships, and internal use/consumption; provide delivery paths from manufacturing area(s) to customer acceptance for each market
  - allow for future expansion of manufacturing areas, to eventually include assembly of large interplanetary ships
- Repair and restoration of ships and other space infrastructure elements
  - a fleet of 10 space tugs will operate from Bellevistat, of which up to 5 tugs may be docked at any one time
  - repair docks are required to accommodate different types and sizes of ships
  - allow for future port expansion, both for increasing numbers and sizes of visiting ships requiring services
  - provide safety procedures in the event a visiting ship develops a hazardous situation

**8. Appendices** - although required to be included in the proposal, will NOT count against the 40-page proposal limit.

**A. Operational Scenario** - Describe in detail processes that will occur during two different emergencies, and how normal functions will be restored after each situation is stabilized:

A.1 Hull breach at an interface between two separate habitable volumes containing residential and commercial areas, with a hole equivalent to 6 inches (15 centimeters) diameter in each volume.

A.2 Internal explosion without a hull breach in a habitable industrial area resulting in a large release of heat and toxic gas.

**B. Bibliography / References** - Any text or image that is not an original creation specifically for this proposal (e.g., artwork from a website, book, magazine, journal, or prior proposal) must be specifically referenced to source materials listed here.

**C. Compliance Matrix** - Include a table that lists each requirement in the SOW, and specifies the page in the proposal where that requirement is addressed.

## EVALUATION STANDARDS

Evaluation of each design presentation considers four general categories of factors:

**A. Thoroughness** - Design meets depth and diversity of requirements in the entire SOW. Graphs, tables, drawings, and compliance matrices aid evaluation of this factor.

**B. Credibility** - Design addresses requirements, safety, physical laws, and cost/schedule in a believable manner. Errors, impossibilities, omissions, and illogic are penalized.

**C. Balance** - Proposal places equal emphasis on four technical areas: structural design, operations, livability, and automation. Proposal is organized in a logical, easy-to-follow manner.

**D. Innovation** - Design demonstrates original thinking to address SOW requirements. Technologies are applied and combined in unique and creative ways.

## ADDENDA

Proposals may suggest alternate names for this community, within the Foundation Society's established naming convention that requires the name to begin with the letter "B" (first settlement at an "at" location) and end with the suffix "at" (settlement is in orbit "around Terra").

If a proposal is submitted that has more than the allowed 40 pages (excluding cover page, registration page, table of contents, section dividers, and Appendices A through C) only the first 40 pages will be reviewed and judged.

Drawings and/or maps included in the proposal must show dimensions consistently in English (feet/miles) or metric (meters/kilometers) notation, except when specified by the SOW.