Australian Space Design Competition
Regional Qualifying Competition 2019

REQUEST FOR TENDER

23 March 2054

"Columbiat" Space Settlement Contract

INTRODUCTION

The Foundation Society requests that contractors propose the design, development, construction, and operations planning of the third large space settlement in Earth orbit, which will primarily serve as a business and banking centre in cis-lunar space.

STATEMENT OF WORK

1. **Basic Requirement** - Describe the design, development, construction, and planning for operations and maintenance of the Columbiat space settlement in Earth orbit.

2. **Structural Design** - Columbiat must provide a safe and pleasant living and working environment for a population at Initial Operational Capability (IOC) of 20,000 full-time residents, a target full-time and part-time population of up to 80,000 at completion, plus an additional transient population of up to 8,000 at completion, of business and official visitors, guests of residents, and vacationers. The design must enable residents to have natural views of Earth and Luna.

2.1 On exterior design drawing(s), identify uses of large enclosed volumes, and show dimensions of major structural components and design features visible to an approaching ship. Based on preferences expressed by residents at existing Foundation Society settlements, provide residential, office, and public areas at 0.38g, 0.5g, 0.6g, and 075g. Rotation rate in residential and public areas may be up to 2.5 rpm; specify structural interfaces between rotating and non-rotating sections. Rotational interfaces must have the same atmospheric conditions on both sides.

Minimum requirement: overall exterior view of Columbiat, showing major visible features (e.g. solar panels, antennas, and radiators for thermal control), rotating and non-rotating sections, pressurised and non-pressurised sections, and indicating functions inside each volume.

2.2 On interior configuration drawing(s), specify uses and dimensions of interior “down surfaces”, with areas allocated and drawings labelled to show residential, industrial, commercial, agricultural, port facilities, community services, 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 processes required to construct the settlement, by showing the sequence in which major components will be assembled. Specify when and how artificial gravity will be applied. Describe construction of interior structures. Cargo Accommodation in Standard Space Shipping Container (CASSSC) units delivered during construction may be converted to interior structures.

Minimum requirement: drawing(s) showing at least six intermediate steps of settlement assembly to IOC, starting with the first delivery to the construction site; plus completed configuration.

2.4 At IOC, provide port / dock facilities in zero-g for simultaneously unloading and loading up to three cargo ships and one passenger liner. Most cargo will be in CASSSC units; most ships will carry six or fewer CASSSCs. At completion, up to six cargo ships and two passenger liners may dock; plan for two docks to accommodate interplanetary ships with up to 20 CASSSCs.

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 Columbiat space settlement.

3.1 Columbiat will operate in orbit around the Earth-Luna L5 libration point. Identify sources of materials and equipment that will be used in construction and operations. Use of lunar materials and products is encouraged, and transportation costs are reduced by shipping in CASSSCs.

Minimum requirement: drawing(s) of hull component parts placed in CASSSCs for shipping.

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

- food production (provide seasons for several crop types, and grow in various g levels)
- electrical power generation (specify kilowatts distributed to habitable areas)
- internal and external communication systems (specify devices for personal use)
- internal transportation systems (show routes and vehicles, with dimensions)
- atmosphere (identify composition and quantity, at 0.75 Earth sea level and 71°F / 21°C)
- household and industrial solid waste management (specify recycling and/or disposal)
- water management (specify required water quantity and storage facilities)

Define quantities of initial supplies of air, water, food, transport vehicles, power equipment, and other commodities as the number of CASSSC-loads required to be delivered for each commodity. Provide experimental agriculture and manufacturing in up to 5 rpm and artificial gravity up to 2g.

Minimum requirement: chart(s) or table(s) specifying CASSSC-loads required of commodities.

3.3 Show conceptual designs of primary machines, jigs, and equipment employed for constructing the settlement, especially for assembling exterior hull and interior buildings / structures using standard components. Show how construction machinery, jigs, and tools are shipped to the construction site. 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 Provisioning and maintenance services for on-board systems of visiting ships will include food and agricultural replenishment, livestock veterinary services, engine overhaul, fuelling, liquid and solid waste disposal, water replenishment, and replacement of commodities in living areas.

Minimum requirement: drawing(s) showing warehousing and cargo handling for provisions.

4. Human Factors and Safety - Columbiat will provide facilities for services that residents expect in comfortable modern communities (e.g., housing, entertainment, education, medical, parks and recreation), variety and quantity of consumer goods, and public and residential areas designed with open spaces. Provide natural sunlight and views of Luna and Earth.

4.1 Public living areas will include office and government buildings, meeting spaces, other community services, and agriculture as part of greenspaces. Living areas (including residential, commercial, retail) will have pressurised vertical clearance of at least 2500 feet (762 metres) outside of and above buildings. Show locations and relative sizes of buildings and facilities.

Minimum requirement: map(s) and illustration(s) depicting community design and locations of amenities, with a distance scale. Show which greenspaces feature edible landscaping.

4.2 Provide designs of typical residences in at least three different neighbourhood types: city-core condominiums, village townhouses, and rural homes. Clearly show room sizes; home designs will be no smaller than 90 m^2, and will be available at 0.38g, 0.5g, 0.6g, and 0.75 g. Anticipated demographics of the original 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 32)
- Children (under 18) 3% (average age 10, median age 12)

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

4.3 At IOC, population and community amenities will be allocated into two approximately equal volumes, either of which can temporarily accommodate the entire population if one volume becomes uninhabitable. Subsequent additions of volumes to settlement completion will be in approximately equal pairs. Provide multiple access routes

between habitable volumes. Spacesuits (not part of this contract; purchased under separate contract with a different vendor) will be required for activities outside of pressurised volumes; list quantities of spacesuits needed for work, recreation, and emergencies. Show airlock locations between habitable areas and unpressurised volumes.

Minimum requirement: identify separate populated volumes in overall structural configuration, at IOC and each intermediate addition until construction completion.

4.4 Columbiat will be the flagship of Foundation Society settlements and the most-visited single place in space Guests must have a favourable first impression upon arrival. Show passenger arrival facilities and route(s) to / from community areas. Show location(s) and design(s) of hotel(s) or other visitor lodging. Provide interesting things for residents and visitors to do, including activities for crews waiting for their ships to be unloaded and loaded. Describe security measures to unobtrusively monitor visitors and assure that their activities do not interfere with lives of residents.

Minimum requirement: drawing(s) and floor plans of arrival / departure areas and public areas of hotels, e.g., lobbies, restaurants, and shops.

5. Automation Design and Services - For each subparagraph, specify numbers and types of computing and information processing devices, multi-function personal electronic tools, servers, network devices, and robotic applications required for facility, community, and business operations. Describe types and capacities of data storage media, data security, and user access to computer networks. Define robot functions, quantities of each robot type, and locations where they operate.

5.1 Describe uses of automation for construction. Show appropriate automation systems to assist with transportation and delivery of materials and equipment, assembly of the settlement, installing utilities and infrastructure, and interior finishing. Describe how humans monitor automated construction processes and progress, and where/how human interaction is required during construction. Show how jigs hold robots in position to perform construction tasks in zero g.

Minimum requirement: dimensioned drawings showing automated construction and assembly devices, and systems enabling human intervention, including displays for monitoring and control.

5.2 Specify automation systems for settlement business, maintenance, repair, security, and safety functions -- including for restaurants, retail, offices, hotels, agriculture (including in experiment volumes hazardous to humans), and landscaping and facilities maintenance. Show monitoring and control centre(s) to assure safety of residents, and define numbers of display and control systems required. Describe security measures to allow only authorised personnel to access critical data and command computing and robot systems. Provide automated alarms and announcement of hazards.

Minimum requirement: chart, table, or list(s) of settlement systems and parameters that must be monitored and controlled for safe and productive operations of Columbiat.

5.3 Specify automation systems to enhance liveability in the community, productivity in work environments, and convenience in residences. Define automation systems for use in homes, and automation aids for games, sports, entertainment, and recreation. Describe secure access to community computing assets and robot resources from homes and workplaces, including access to automated transportation services for goods and people. Describe devices for personal delivery of communications services, information, entertainment, computing, and robot assistance. Describe appropriate applications of Artificial Intelligence (AI), with recognition that AIs programmed to optimise order and harmony will conclude that getting rid of pesky humans meets the goal.

Minimum requirement: descriptions of robots and computing systems that people will encounter in Columbiat, and diagram(s) of network(s) to enable secure connectivity.

5.4 Provide automation for port and cargo operations, with human monitoring. Show systems / vehicles to unload and load CASSSCs on visiting ships, move / store / track goods in warehouses and other logistics inventory, transport passengers, and deliver goods to / from and between businesses and homes. Define which systems are autonomous, teleoperated, and otherwise.

Minimum requirement: show automation system(s) for warehouse and logistics operations.

6. Schedule and Cost – The proposal will include a schedule for development and occupation of Columbiat, and costs for design through construction phases of the schedule.

6.1 The schedule must describe contractor tasks from the time of contract award (1 April 2054) until the customer assumes responsibility for operations of the settlement at IOC. Show schedule date when Foundation Society members may begin moving into their new homes.

Minimum requirement: durations and completion dates to IOC of tasks from design to occupation, depicted in a Gantt chart with no longer than monthly increments, clearly correlating with costs.

6.2 Specify costs billed per year from design through construction to IOC in Australian dollars, without accounting for economic inflation. Separately show added costs to completion after IOC. Do not include costs of consumables shipped and delivered in CASSSCs; do specify number of CASSSC-loads of each commodity to be shipped to the construction site. Do include costs to ship construction equipment, tools, jigs, materials, and components. Estimate numbers of employees working during each phase of design and construction in the justification for contract costs.

Minimum requirement: spreadsheet(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 – Columbiat will host various commercial and industrial ventures, which may change with time. The original configuration must, however, accommodate three major business pursuits:

- Transportation node and port
  - most cargo will arrive in CASSSCs
  - visiting ships will be docked and serviced in a zero-gravity environment
  - visiting ships may be crewed passenger transports with limited cargo, crewed freighters with limited passengers, or autonomous freighters
  - visiting ships may require refuelling, limited repair services, and tugs to assist with docking; include a base for operating a fleet of up to 10 tugs and tow / rescue vehicles
  - configure port design so that docking locations for more ships can be added to meet demand for future traffic
  - provide unpressurised warehouse / storage area(s) for CASSSCs near ships' unloading / loading facilities
  - provide means for goods delivered for use on Columbiat, or products shipped from Columbiat, to be unloaded / loaded in CASSSCs in a pressurised environment
- Commerce and financial centre
  - provide office facilities to enable businesses to establish a presence in space; interest has been expressed by four companies to establish 150-person offices, eight companies to establish 100-person offices, 15 companies to establish 30-person offices, and 30 companies to establish 5-person field offices at IOC.
  - provide facilities at IOC for three banks to establish centres to service financial needs of space-based companies, space settlement residents, and ships' crews.
  - provide suitable facilities for the new Foundation Society Headquarters, with a 300-person staff managing its far-flung business and investment empire, researching new settlement opportunities, and providing services to members
  - computing assets will assure secure networked internal communications for each company while providing interconnectivity for transferring data between companies
  - a conference centre will enable meetings for up to 2000 people, with break-out rooms
- Provisioning and maintenance base for visiting spacecraft
  - at IOC, one spaceship dock will be configured to enable emergency repair; at completion, one dock will provide major maintenance, repair, and overhaul (MRO).
  - fuelling services for visiting spacecraft will include fuel storage facilities for hydrazine, nitrogen tetroxide, helium-3, and deuterium, with capacity to offer additional options
  - excess agricultural production, storage, and processing capability (beyond the needs of settlement residents) will service needs of visiting spacecraft, and serve as a back-up supply in the event of a food crisis in another space settlement.

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EVALUATION CRITERIA

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

- **Thoroughness** - Design meets depth and diversity of requirements in the entire SOW. Graphs, tables, drawings, and compliance matrices aid evaluation of this factor.
- **Credibility** - Design addresses requirements, safety, physical laws, and cost/schedule in a believable manner. Errors, impossibilities, omissions, and illogic are penalised.
- **Balance** - Proposal places equal emphasis on four technical areas: structural design, operations, liveability, and automation. Proposal is organised in a logical, easy-to-follow manner.
- **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 "C" (third settlement at an "at" location) and end with the suffix "at" (settlement is in orbit “around Terra”).

DELIVERABLE REQUIREMENTS

Teams shall develop a proposal in accordance with the following:

Report

- Submissions shall be in the form of a technical report
- A maximum of fifty (50) pages (including Appendices) may be submitted
- Use a standard font (e.g. Arial, Calibri, Times New Roman)
- Pages must be clearly legible when printed in black-and-white on A4 paper
- Reports are not to include student details or name of school
- Include the team’s registration number on report cover page

Company

- Teams are to select a company from the Scenario Background document
- Report is to identify which company they have selected

Measurements and Values

- All measurements shall be in standard engineering metric units, except where specified by the RFT
- All values and budgets shall be in $AUD as at January 2019 and shall not consider economic inflation.

Diagrams

- All diagrams must be appropriately captioned
- All diagrams must be appropriately dimensioned unless specified as artistic impressions

Tables and Figures

- All tables and figures must be appropriately titled

References

- All attributable content including, but not limited to, diagrams, research, and text must be appropriately and uniformly referenced
- The reference list is not included within the 50 page limit
- Use your school’s preferred reference style (e.g. Harvard, APA, MLA, Chicago etc.)
- Declare which reference style you have used

Submission

- Entries must be submitted electronically (PDF) 5pm 6th of September 2019
- Submissions to occur through a file upload link on the ausspacedesign.org.au website (subject to confirmation)
- If the file size exceeds limits (indicatively 10MB), provide instructions on how to download from a secured external system (e.g. Google drive, Dropbox, etc.)