“Aynah” 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 first large space settlement community in orbit around the planet Mercury.

After fusion propulsion technology enabled relatively rapid and cost-effective interplanetary transportation, the Foundation Society embarked on more aggressive investigations of possible commercial opportunities throughout the solar system. An inexpensive “experiment of curiosity” by a geologist and an engineer -- leaving samples of various alloys on the surface for an entire 175 Earthday-long day of Mercury -- led to the discovery that long exposure to solar heat and radiation, followed by a long “cold soak”, changes material properties in unexpected ways. Further experimentation led to the development of a true miracle metal; lightweight, strong, amenable to producing complex shapes, self-lubricating, and providing protection from heat, cold, and radiation. So similar was it to the miracle metal called “Reardon Metal” in Ayn Rand’s novel Atlas Shrugged, including the blue-green color -- its inventors named it “reardonium”.

The metal is now refined and manufactured in small batch quantities at an underground base on Mercury. Variations in the material properties are created through differing exposure times to 700°K days and 100°K nights, accomplished by transporting parts on the surface. Although the unique curing requirements of reardonium necessitate keeping parts on the surface of Mercury for an average of one Earthyear, the Foundation Society’s metallurgists can create a wider range of desirable material properties with on-orbit manufacturing in environments between 0 and 0.5g, and vacuum to 20 psi. An orbital location can also provide electrical power in the massive quantities required by the production process, enabling uninterrupted production of reardonium.

Each existing Foundation Society settlement has a unique culture and business base. Alexandriat continues to support operations and maintenance of the Sun-Earth L1 solar shield built by its original population (which, as planned, abated onset of global warming). This original settlement is, however, primarily a university town, retirement community, and suburb for executives who prefer its laid-back culture. Bellevistat is a center for zero-g heavy manufacturing, with a work-hard/play-hard culture. Columbiat is a cosmopolitan and sophisticated city, an orbital commercial and banking center, and the location of Foundation Society headquarters. Alaskol mines and refines lunar regolith and offers lunar tourism opportunities; its residents display eccentric behaviours and a propensity for innovative fun that are typical in remote frontier towns. Balderol mines more valuable ores in older rocks on the lunar far side. Aresam is primarily a Port of Entry for Mars and surface settlements Argonom and Bradburyom. Astoria is a harvesting and processing center for resources in the asteroid belt between Mars and Jupiter.

For planning purposes, the Foundation Society has selected “Aynah” (pronounced “Anna”) as this community’s name, honoring author Ayn Rand, who described properties of the technology-changing “Reardon Metal” in her novel Atlas Shrugged. The suffixes “ah” and “oh” represent Foundation Society operations at Mercury because Hermes is the Greek equivalent of the Roman god Mercury, and Hg is the chemical symbol for the element Mercury.
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, FOUR single-sided copies and/or copies and/or originals plus one pdf version of each proposal must be received by the Foundation Society no later than Wednesday 16 March. A U.S. Mail postmark by March 12 or international air mail postmark by March 9 will be accepted as meeting the March 16 proposal submittal deadline.

Only entries from registered teams are eligible to advance in the Competition. Submit proposals in the English language, single sided on Letter Size (8½ by 11 inch) or A4 (8.69 X 11.29 inch) paper, with a 40 page limit, print 10-point or larger with standard spacing, and all margins one inch or larger -- print and image area 6½ X 9 inches (16.5 X 22.8 cm) excluding header, footer, and page numbers. Cover page, registration 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 organisation of the materials describing the design will aid the Foundation Society in recognising 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 Sequence
3.0 Operations and Infrastructure
   3.1 Location and Materials Sources
   3.2 Community Infrastructure
   3.3 Construction Machinery
4.0 Human Factors
   4.1 Community Design
   4.2 Residential Design
   4.3 Safe Access
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
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 the ONE pdf exception, defined in separate submittal instructions), e.g. E-mail, website, CD, or data stick. Teams may, however, post artwork and design representations for their proposals on Internet/Websites within the following guidelines:

(a) Only drawings, pictorial representations, and artwork are to be posted electronically; text (except captions) and charts/tables/diagrams must be included in the submitted proposal.
(b) Drawings associated with different Statement of Work (SOW) sub-sections (e.g. 3.1 or 3.2) must be posted in separate Internet/Website locations (e.g. different links from a single page).
(c) The first reference to an Internet/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 instructions and address for accessing the site, AND a sample image that resides on the site. Re-emphasizing, if three sub-sections reference a website, the proposal section will include three half-page images from the website.
(d) Internet/web images must be accessible by MACs or PCs. Internet/websites requiring special software installation (i.e. Added complication, expense, or hard drive resources) will not be judged.
STATEMENT OF WORK

1. Basic Requirements - The contractor will describe the design, development, construction, and operations/maintenance planning for the Aynah Space Settlement in the Mercury Orbit.

2. Structural Design - Aynah must provide a safe and pleasant living and working environment for a population of 14,000, and up to 200 short-term visitors. The design must enable residents to have natural views of Mercury below.

2.1 On the exterior design drawing(s), identify attributes and uses of large enclosed volumes. The exterior hull and major load-bearing structures will be manufactured of reardonium. Show dimensions of major hull components and design features. Specify volumes where artificial gravity will be supplied, structural interface(s) between rotating and non-rotating sections, and rationale for selected rotation rate and artificial gravity magnitude(s). The design must show capability to isolate at minimum any two separate habitable volumes in case of a depressurisation 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, pressurised and non-pressurised 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 supplied. Existing manufacturing facilities on Mercury can produce components no larger than 40 by 20 feet. Early completion of manufacturing areas of at least 100,000 square feet with 60 foot ceiling height will enable production of components up to 100 by 40 feet. Describe a construction technique for interior structures making use of minimally refined materials from the Mercury surface.

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

2.4 Reardonium parts production will require refining and manufacturing capability in 0 to 0.5g and vacuum to 20 psi.

**Minimum requirement:** show how manufacturing areas will provide required range of conditions.

2.5 (reserved)

**Minimum requirement:** (reserved)

3.0 Operations and Infrastructure - Describe facilities and infrastructure necessary for building and operating the Aynah space settlement and its communities.

3.1 The settlement will operate in a sun-facing Mercury polar orbit; recommend an orbital altitude (i.e., distance from Mercury) for Aynah and the reasons for its selection. Identify sources of materials other than reardonium and equipment to be used in construction, then in settlement operations after construction is complete (using as much material as possible from Mercury).

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

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

- atmosphere/climate/weather control (identify air composition, pressure 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 (show 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 one month.

**Minimum requirement:** chart(s) or table(s) specifying the 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 Foundation Society metallurgists have determined that power requirements for anticipated production of reardonium can be met with solar panel dimensions equivalent to 4 square miles.

Minimum requirement: show solar panels in drawing(s) depicting Aynah design.

3.5 (reserved)

Minimum requirement: (reserved)

4.0 Human Factors - Aynah will offer attributes available to residents of Earth's small cities in developed countries. Provide natural sunlight and views of Mercury below for residents. Establish roads and paths in a diamond-grid pattern, enabling access throughout residential and commercial areas with a practical minimum of motion (e.g., head-turning when rounding corners) that has been found on existing space settlements to cause mild discomfort due to Coriolis effects.

4.1 Aynah will provide services that residents expect in comfortable modern communities (e.g., housing, entertainment, medical, parks, and recreation), variety and quantity of consumer goods, and public areas designed with long lines of sight. List major types of consumables, and quantities. Depict or specify means of distributing consumables (including food) to Aynah 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 townhouse residences, clearly showing room sizes; home designs will be no smaller than 1000 sq. ft. And no larger than 2500 sq. ft. Identify source(s) and/or manufacture of furniture items and appliances. Anticipated demographics of the nominal population are:

- Married adults: 60% (average age 40, median age 35)
- Single Men: 20% (average age 31, median age 35)
- Single Women: 15% (average age 35, median age 33)
- Children (under 18): 5% (average age 10, median age 9)

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

4.3 Designs of systems, devices, and vehicles intended for use by humans outside of artificial gravity volumes will emphasize safety. Show spacesuit stowage, and airlock designs for exiting/entering habitable areas from unpressurised volumes.

Minimum requirement: drawing(s) showing examples of handrails, tethers, cages and/or other systems enabling safe human access to any location on or in low-g settlement areas.

4.4 Experience on existing Foundation Society space settlements proves that while adults prefer living at less than 1g, acceptable development of children through their growing years requires daily exposure to 1g for at least 3 hours per Earthday.

Minimum requirement: drawing(s) of means of children to spend time in 1g.

4.5 (reserved)

Minimum requirement: (reserved)

5.0 Automation Design and Services - Specify numbers and types of computing and information processing devices, multifunction personal electronic tolls, servers, network devices, and robots required for Aynah'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, and interior finishing.

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 in extreme solar environments and during solar flare activity. Describe means for
authorised personnel to access critical data and command computing and robot systems; include
descriptions of security measures to assure that only authorised personnel have access, and only for
authorised 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 labour. Provide for privacy of personal data and control
systems in private spaces. Describe devices for personal delivery of internal and external communications
services, entertainment, information, computing, and robot resources.

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

5.4 Provide automation for efficiency of reardonium manufacturing processes, including unloading raw
ore arriving from Mercury’s surface, moving ore through refining processes, forming and handling parts, and
loading/unloading parts sent to Mercury’s surface for curing.

Minimum requirement: drawings of robots employed in reardonium parts manufacturing and handling.

5.5 (reserved)

Minimum requirement: (reserved)

6.0 Schedule and Cost - The proposal will include a schedule for completion and occupation of Aynah,
and costs for design through construction phases of the schedule.

6.1 The schedule must describe contractor tasks from the time of contract award (8 May 2077) 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 Aynah 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 to design and build the settlement.

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.

7.0 Business Development - Aynah 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:

• Infrastructure for refining and manufacturing reardonium parts
  - Capability for handling and processing raw ore from the surface of Mercury, including systems
to prevent dust and grit from entering habitable areas
  - Manufacturing capability in various gravity and pressure environments
    - (reserved)
    - (reserved)
• Receiving and shipping reardonium parts
  - Perform inspections and quality checks of reardonium parts returning from curing processes on
    the surface of Mercury
  - Install completed parts in standard shipping containers or on pallets of delivery to customers
    throughout the solar system
    - (reserved)
    - (reserved)
• Port of Entry for Mercury
  - Operate a fleet of interorbital shuttles to transfer personnel and cargo in standard shipping
    containers from/to interplanetary spaceliners.
  - Operate a fleet of landing shuttles to transfer personnel and cargo to/from the surface of
    Mercury
    - (reserved)
8.0 Appendices - although required to be included in the proposal, will NOT count against the 40-page proposal limit.

A. Operational Scenario - The reardonium production process at Aynah entails delivery of ore from the surface of Mercury, transporting ore to the refining area, manufacturing refined reardonium into desired shapes and parts, transporting manufactured parts to the surface of Mercury for an average of one Earthyear of curing, transporting the parts on the surface of Mercury to achieve desired curing properties, transporting parts back to Aynah, and shipping completed/cured parts to customers. Select one small (less than one cubic foot) and one large (100 by 40 feet construction panel) part made of reardonium after Aynah is operational. Show the processes each part goes through, from mining on the surface of Mercury to shipping as a completed product; show and describe requirements for every facility, every vehicle, every robot, and every human interaction each part encounters.

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 referred 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 penalised.

C. Balance - Proposal places equal emphasis on four technical areas: structural design, operations, livability, and automation. Proposal is organised 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 “A” (first settlement at an “ah” location) and end with the suffix “ah” (settlement is in orbit “around Mercury”).

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 in the SOW.