Development of Island Zero

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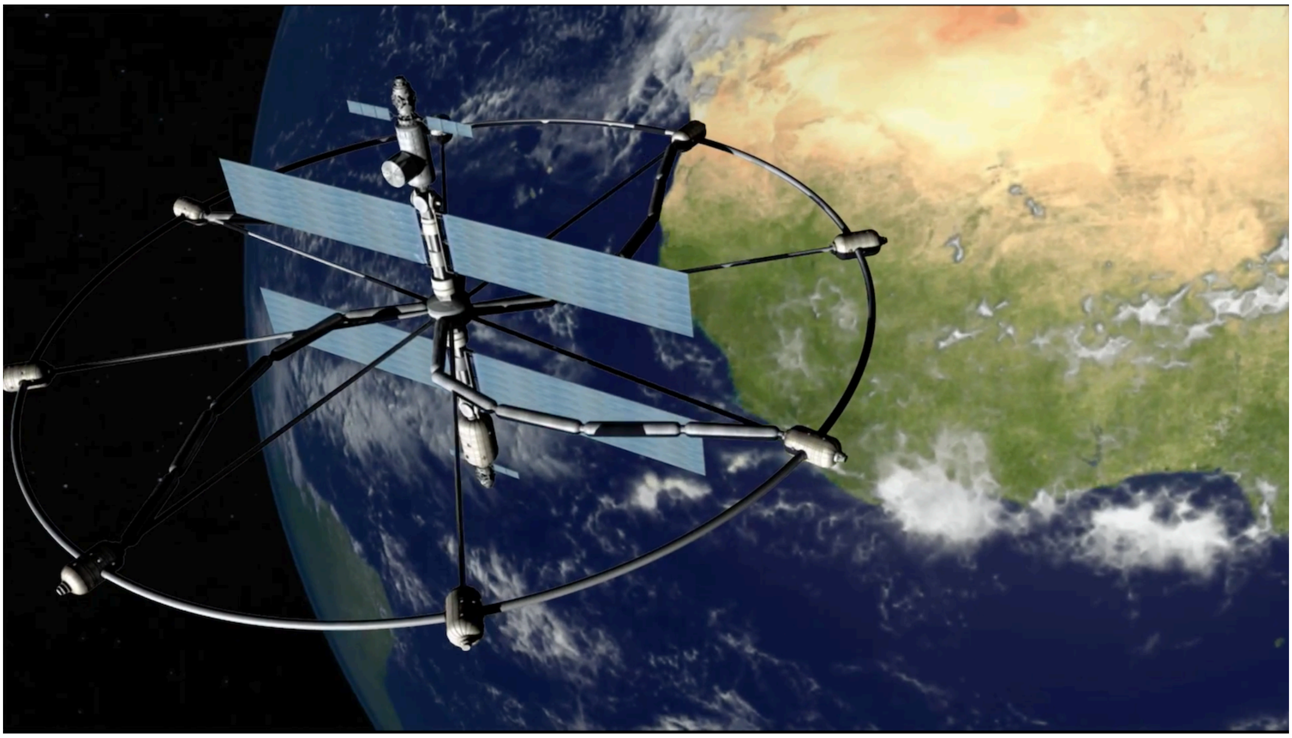
An introduction to a proposed development in the field of Space Habitats.
It describes a relatively small-scale structure that could be used in their construction.



Island Zero in Earth orbit
8 modules with a number of modules along the central hub, to which other craft will dock,
plus an outer safety ring, connecting tubes to the hub, and solar panels.

Image by Adrian Mann.

Introduction

In mid-1969 Professor Gerard K O'Neill of Princeton University put a question to a group of new students at Princeton University:
"**Is a planetary surface the right place for an expanding technological civilisation?**"

The unexpected result from their investigations was that the answer was "No".

It seemed it would be much better for them to be placed in vast habitats constructed out in free space, at special locations known as the Lagrange points L4 and L5. These are in the Moon's orbit and each make a 60º triangle with the Earth and Moon.

Further studies showed the feasibility of constructing various forms of habitats that could ultimately house millions of people.

These could provide a safety net in the event of catastrophe striking the Earth - whether it be man-made (which appeared a possibility at the time) or through other means - it was shown that building these habitats could bring enormous benefits to those remaining on Earth.

In fact O'Neill showed that **most of the major problems facing the Earth - which are still with us today - could be addressed by these vast construction projects in space**.

A major benefit could be the construction of Solar Power Satellites to provide energy to the Earth.

Unfortunately the project was never implemented, mostly due to the low launch rate and high costs of the Space Shuttle, which was needed to provide the infrastructure to launch the required material. However, with the development of new launchers which can be re-used such as Falcon and Blue Origin, and future launchers such as the UK’s Skylon, we are not far from a system that could make it possible for O'Neill's vision to become reality.

The SPACE Project

Since the original studies were conducted, many advancements have been made. The original plans were deliberately restricted to the technology of the time, so that no-one could say that it was all fantasy due to depending on materials that hadn't yet been invented. (Such as Star Trek’s transparent aluminium!) However, during the next 40 years there had been all kinds of improvements in materials science, engineering, and other areas that can make this program more efficient, such as computing and robotics, which have advanced several orders of magnitude during this period. This in particular can make the habitat development far more efficient, saving time and considerable effort, reducing the total cost greatly.

I saw that it would not make sense to wait until Skylon became operational before producing plans, so I ran a project at the British Interplanetary Society to re-examine and update the original studies, in order that we can be ready to embark on this far-reaching activity when the vehicles that can make it possible are available.
This became the **SPACE Project** - **S**tudy **P**roject **A**dvancing **C**olony **E**ngineering.

Over the next few years, a team of volunteers investigated various topics, and produced an enhanced new design. The results were published in a special issue of the BiS Journal, attracting great interest.

Island One, Two and Three

The original design was based on a sphere which could house 10,000 people. This became known as “Island One” and the idea was published by O’Neill in “Physics Today” in 1976.

NASA subsequently arrange a 3-day conference to investigate the topic further, and that resulted in a new design, based on a torus - a ring - that could house 100,000. This was “Island Two”.

O’Neill’s further work produced designs for very large twin cylindrical habitats that would each be 4 miles in diameter and 20 miles long, and which could hold millions of inhabitants. This design was known as “Island Three”.

Island One would require an estimated construction force of 2,000 and a mass of around 500,000 tons. It would be totally impractical to launch the materials for construction from the Earth. Even with fully reusable launchers, the fuel cost alone would be enormous.

However we have considerable benefits available to us - because of the Moon.

We know from the Apollo missions that Moon soil and rock contains Iron, Aluminium, Magnesium, Calcium, Silicon (for windows) - and Oxygen - (for the inhabitants to breathe).

The other advantage is not only that this material is available, but that it can be sent into space without the need to use rockets or to burn fuel.
As the Moon has no atmosphere, a Mass Driver can be used - an electromagnetic launcher - powered by the Sun.

With advances in technology, particularly in robotics, it is probable that to process the raw material to extract the elements, and then to form them into girders, panels, windows and other units for construction, particularly those that will require a large number of units - the original estimate of 2,000 workers is likely to be considerably more than will be needed.

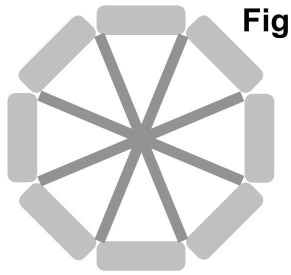
It would be likely that just a few hundred will be more than sufficient. As the personnel will be the highest single cost of the project, this will result in considerable reduction in the finances required to build the habitat.

However, it would be impractical to build Island One as an initial structure; such an undertaking would still require the establishment of accommodation and workshops for the construction crew, plus facilities to extract material from the Moon, space processing to separate the raw elements, and manufacturing facilities to construct the building units.

Island Zero

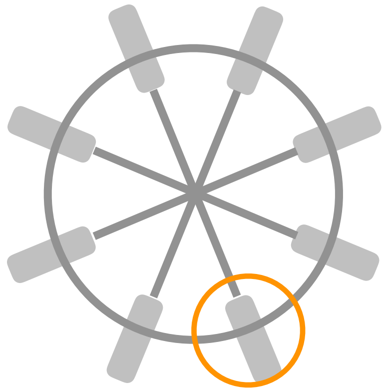
Even before that work is begun, it makes sense to establish a much smaller structure first. to house the personnel that will assemble these facilities. To do this first step should be a project that would demonstrate many of the features of a full settlement but on a much smaller scale, both in size and cost, as a way of showing the viability of some of the ideas behind space habitation. We designated this unit as “Island Zero”.

Fig 1



Ideally it would be constructed from inflatable modules, and its aims should include the following:

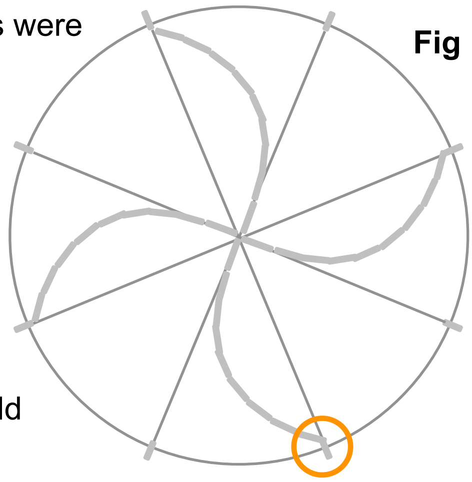
• Living under simulated gravity - something that has never been done before in space
• Construction from modular units and space-produced components
• Growing a large percentage of food in space
• Development of space processing and manufacturing facilities.



Our original proposal was for a ring of modules (Fig. 1), similar to those previously launched by Bigelow Aerospace. A ring of eight modules each 5m in diameter and 15 m long would result in a total radius of 50m, but rotating this to produce 1g would require 4 rpm; even 0.7g would require 3.3 rpm. So we developed an alternative in which the modules were arranged radially, with an outer connecting ring (Fig. 2).

Limiting the maximum rotation rate to 2 rpm, then if the modules were 225m from the central hub this would produce a simulated 1.0g.

Fig



On the ISS, where everyone is weightless, they need to exercise for 2 hours every day to offset the effect this creates on their skeletal, muscular and cardiovascular structure.

At the very start of the project, I pointed out that it was always assumed that space habitats would be rotated to produce 1g. My question was whether we need 1g. Could we live under 0.9g, 0.8 or an even lower value?

It would mean less stress on the structure, so less material would be needed in its construction.

It would also mean less stress on the inhabitants, so - over a long period of time - they would live longer, and grow slightly taller.

Fig 1 - 4 by Jerry Stone
Diagrams are at different scales

This is something that would have to be taken into consideration in the architecture - higher ceilings and doorways.

The associated question is; “At what point does reducing the gravity become a problem rather than a benefit?”. The simple answer to this is “**We don’t know**”, because no-one has ever done it.
That is why this medical research needs to be carried out, so that we learn what the acceptable “g” level is for long-term living in space.

If the access tubes to and from the central hub were straight, people and equipment would be falling at 0.5g at the outer end. This might be acceptable for transferring equipment, perhaps using ropes and pulleys. However people could not live under this value, and also it would be impractical and expensive to install lifts.

So firstly we would need a larger diameter structure so the that the “g” level at the outer ring had a higher rate than just 0.5 - a low level.

An alternative to straight tubes from the central hub is to have a series of tubes that together approximate a curve as shown in Fig. 3, so that going closer to the hub would result in a lower simulated gravity an eventually standing upright.

The modules would be divided into various levels, allowing for crew accommodation and areas for experiments. The “top” of the module would lead towards the central hub, which would consist of another module set at right-angles to the plane of rotation. Instead of a single ladder-type access between each module’s “floor” a spiral staircase could be fitted to the interior of the wall. (Fig. 4)

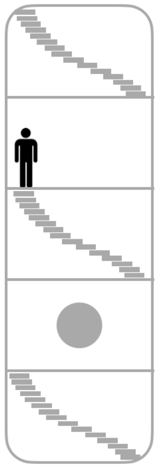


Fig 4

The initial Island Zero would be established in Earth Orbit and its primary purpose would be to study the medical issues involved with living under less than 1g.
This knowledge can only be gained by actually doing this.

As an extension to the Island Zero idea, we proposed a variant as a follow-on from NASA’s Asteroid Redirect Mission (ARM), which was planned to capture a 10m asteroid and bring it into lunar orbit. A version of Island Zero using an asteroid as the central hub would offer the following:

- Far greater studies of an asteroid than allowed by the 2 EVAs in the original ARM proposal.
- An opportunity to gain experience with materials extraction techniques, breaking down the rock and soil into its constituents.
- Establishing prototype manufacturing facilities to process these materials.
- Island Zero units could then be used to house the construction force for Island One.

Overall, Island Zero presents a relatively low-cost means of providing a logical progressive approach towards the construction of large settlements in space.

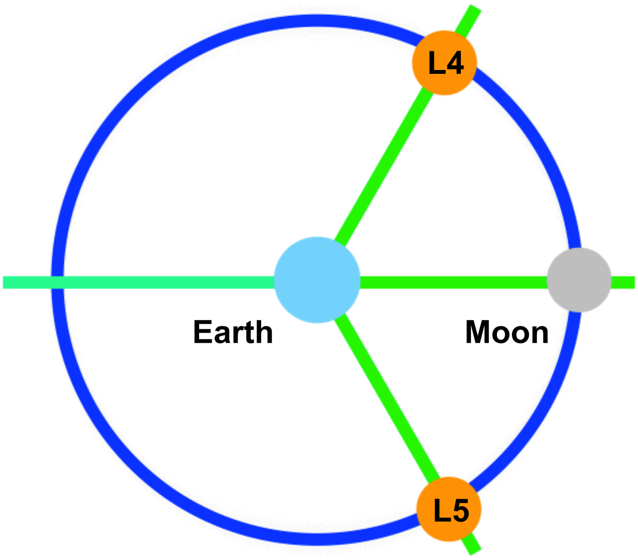
Initially it can be used to obtain data on the medical results of living under reduced gravity, and at different gravity levels. This is knowledge that we simply do not currently have, and will be utterly necessary in determining the limitations of long-term human activities in space.

Proposal to the European Space Agency

In view of the importance of the research that an Island Zero can provide to a wide range of human space activities, we propose that the European Space Agency should undertake a **Phase A Feasibility Study** to investigate how an initial Island Zero unit might be established, and what activities might be carried out on board.

In addition, in view of the decision to extend the ISS to 2030, when it is expected to be replaced by commercial space platforms, those companies would greatly benefit from experience that could be gained from living on Island Zero modules, and also from the opportunity to conduct manufacturing in space.

The simulated gravity research would only need one or two modules, so the others could be hired out to commercial or research organisations, thus providing an income to help pay for the project. Perhaps other modules could be rented for use as space hotels.



Lagrange Points

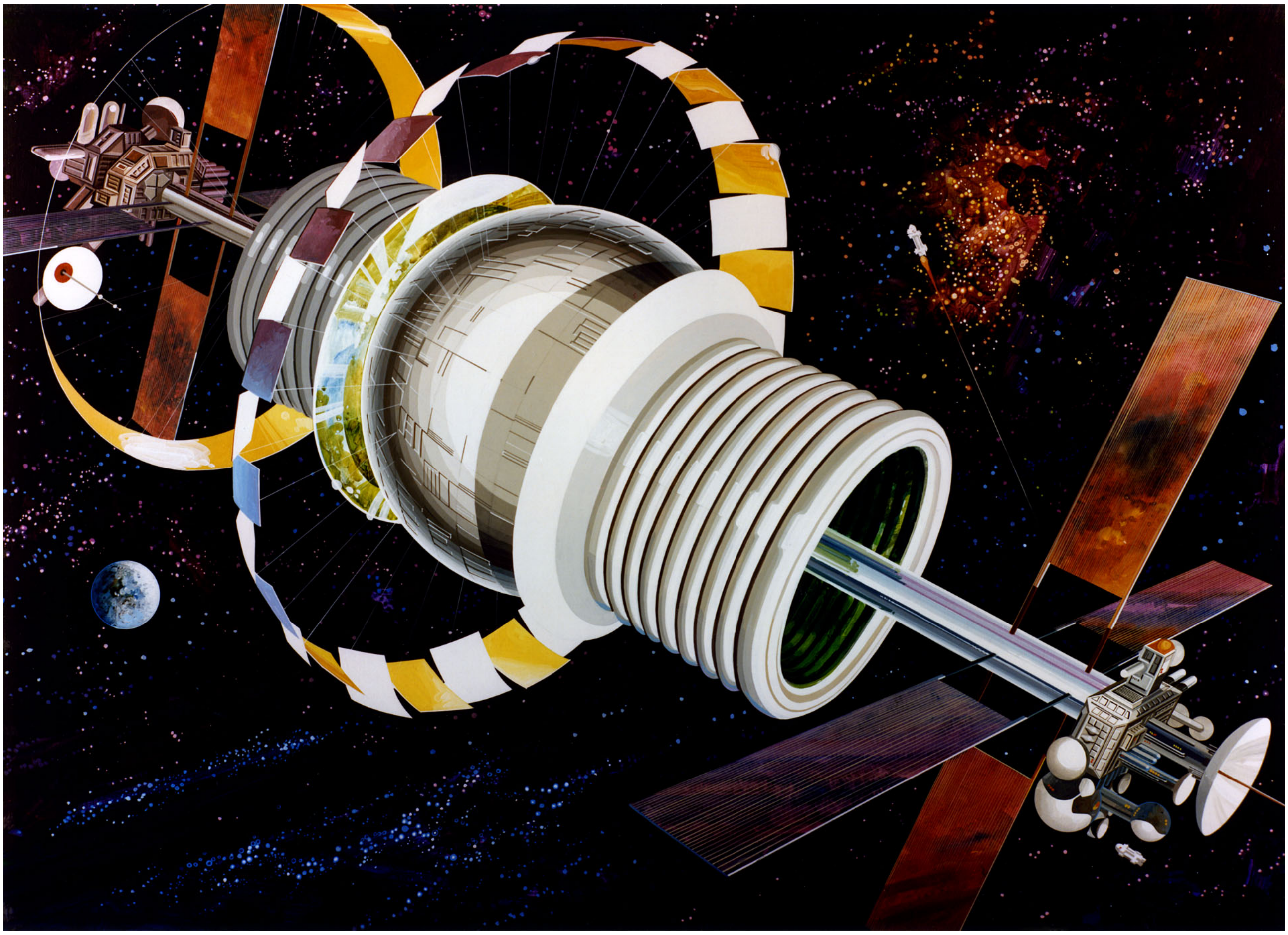
The gravity of the Earth and Moon balances at L4 and L5, so objects at those points move around the Earth at the same rate as the Moon, and so stay at the same relative position.

Also, if they move away from those points, the combined gravity will draw them back, so the positions are stable.

Initial Island Zero units will be established in low Earth orbit.

Operational units would be set up at L4 or L5.

Image by Jerry Stone



Island One: The spherical habitat is at the centre.

Image by Rick Guidice. Credit NASA AMES Centre

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