

GOLD

**PROCEEDINGS OF THE
SOCIETY OF ARCHITECTURAL HISTORIANS
AUSTRALIA AND NEW ZEALAND
VOL. 33**

Edited by AnnMarie Brennan and Philip Goad

Published in Melbourne, Australia, by SAHANZ, 2016

ISBN: 978-0-7340-5265-0

The bibliographic citation for this paper is:

Craig William McCormack and **Nigel Westbrook** "After the Gold Rush, or another Spaceship Earth." In *Proceedings of the Society of Architectural Historians, Australia and New Zealand: 33, Gold*, edited by AnnMarie Brennan and Philip Goad, 452-462. Melbourne: SAHANZ, 2016.

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AFTER THE GOLD RUSH, OR ANOTHER SPACESHIP EARTH

All in a dream, all in a dream
The loading had begun
Flying Mother Nature's
Silver seed to a new home in the sun

Lyric extract from *After the Gold Rush*, Neil Young, 1970, Reprise Records

The condition of outer space presents a fundamental existential difficulty in its post-human emptiness. The most radical and at the same time arguably most common sense approach to date has been a study into creating a habitat in space accommodating a population of thousands. In 1977, following a lineage of speculative megastructures that proliferated in the architectural milieu of the post war period, Gerard K. O'Neill produced a detailed report that outlined a scenario that proposed that it would be possible to live in outer space and even prosper. A population of thousands is no longer a building, but a megastructure-equivalent to a large town or small city.

A total built environment was suggested to be located in areas of space largely unaffected by gravitational forces. O'Neill's design was proposed was to be better than self-sufficient. Although this project was envisaged in outer space, it followed a lineage of prototypical total built environments, earth-bound megastructures, within the discipline of architecture of which the most paradigmatic was Le Corbusier's Unité d'Habitation. Many if not most of these propositions were utopian in outlook and were critical projects that comprised a polemical commentary on the current terrestrial situation. Buckminster Fuller's dome for Manhattan, and his reference to Spaceship Earth, the planet conceived as a totally integrated system, typifies such approaches. This paper concerns O'Neill's project as exemplifying the utopian impulses of architectural projects even after the end of modernism and how paradoxically the earth-bound megastructure projects developed over a 50-year period served as the template for futurist outer space colonisation and how a feedback loop was generated back to terrestrial architecture.

Neil Young's lyrics from the song After the Gold Rush are complementary to O'Neill's proposal – [in the context of the oil crisis and the Vietnam War, he envisions] a migration of "new pilgrims from Earth to establish a new home...", following in the footsteps of utopian communities from the 19th century onwards. Gold rushes have historically spurred immigration, that has led to the settlement of new regions. Young describes in song, the Earth as an asset, or metaphorical gold seam that has been worked dry, necessitating the need to find another supply, planetary or otherwise. This paper also seeks to place O'Neill's project within the architecture milieu of its time, highlighting the socio-political context that saw it popularised throughout the media and establish itself as a canonical architectural (at one scale) and urban (at the other) prototype, responding like others, to the awareness of the finite nature that supports humankind.

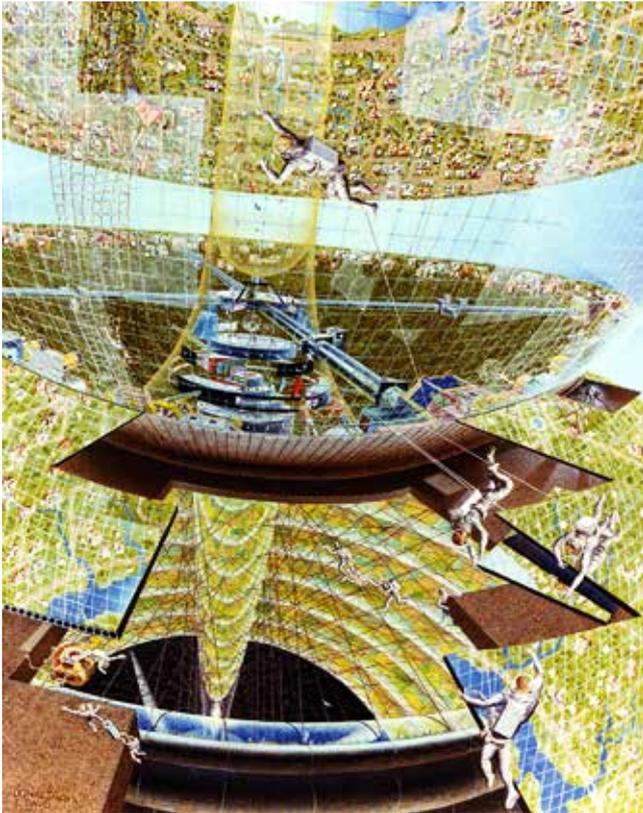


FIGURE 1 Construction crew at work on O'Neill's Island One colony. Don Davis, NASA Ames Research Center, 1976, NASA ID number AC76-1288, Public Domain.

Le Corbusier produced his Marseilles-located, *Unité d'habitation* (1947-52) as an ideal city-based community, perhaps drawing inspiration from Soviet communal housing projects, "social condensers", his interests in monasteries such as that of the Carthusian monastery at Ema, or probably both. (Figure 2) Coleman explains that these "influences coalesced in distinct proportional admixtures in Le Corbusier's various solutions to the problem of how modern individuals could interact with a collective to the benefit of both."¹ As Trummer writes, "The Modern Movement can be seen as the first variation of an undermining position toward the city. In describing the functionalist city as analogous to the organs of a body, in which the circulation system supports the bodily functions through a network of veins, Le Corbusier reduced the city to its basic element by representing the space of habitation as a biological cell."² Liberated from the ground atop large pilotis, the *Unité* becomes as Trummer describes, an island within an archipelago-city.³ Le Corbusier had created a prototype steady-state community [spaceship], the perfect machine-age environment; yet to take-off. Such was his interest in reduction to perfectible individual components that even the air humidity and temperature were elements to be optimized also, with 18 degrees Celsius being championed by Le Corbusier as the temperature to be adhered to in all seasons.

As early as 1960, Buckminster Fuller had proposed a gigantic geodesic dome that would cover a large portion of New York City in an attempt to regulate weather, avoiding the disruption from snowfalls and reduce the city's increasing air pollution. Fuller had an extensive history with domes and the control over their interior condition and even achieved some success with the *Climatron* (1960) in the Missouri Botanical Garden, effectively using his patented geometry for geodesic domes. (Figure 3) This continuing pursuit of environmental mastery was also the central tenet to Banham's *Architecture of the Well-Tempered Environment* (1969). Fuller, in 1971, proposed a megastructure that included a huge geodesic dome component with the intent of coming to the aid of marginalised citizens of East Saint Louis. The proposed megastructure was to house 125,000 people and reduce energy costs. Ultimately cost and the concern that the enclosed nature of the structure "would be used by powerful whites to control mostly black East St. Louis" denied the realisation of Fuller's ambitious project.⁴ The idea of "urban unity" that Fuller had tried to instil upon East Saint Louis was to be found again in the work of Robin Boyd and his sketch plan for the 1972 World Fair. An 'enormous translucent canopy' of undescribed structure was to capture the ideal Australian suburb. O'Neill's colonies would seem to follow in this established typology of enclosed environments and their ameliorable qualities.



FIGURE 2 Unite d'Habitation east elevation from ground level. Le Corbusier, Marseilles, 1947-52, photograph by Crooksmoor, 2012, Creative Commons.



FIGURE 3 The Climatron greenhouse at the Missouri Botanical Garden, side entrance. T. C. Howard, 1960, photograph by Maksim, 2004, Creative Commons.

The Metabolist movement that began in 1960, emblematic of Japan's post-war revival, presented ideas for the expansion of the city into megastructures not only on land but also in the sky and within the ocean. *Tokyo Bay* (1960) whose designers led by Kenzo Tange included Kisho Kurokawa, and Arata Isozaki, was planned as an extension of Japan's capital city. Designed to span across the entirety of Tokyo Bay, it was to allow for the future population increases and included comprehensive and significant infrastructural integration. Kenzo Tange although initially "doubtful about the health of a society increasingly dominated by technology", also understood its potential in the redevelopment of the city.⁵ For Tange his concern was with the mastery of technology and not subservience to it, which would allow for the overcoming of its destructive aspects.

The notion of total built environments had been explored in a more abstract and theological sense (as the author himself wrote in the updated preface) in Paolo Soleri's *The City in the Image of Man* (1969).⁶ Soleri's collection of 'arcologies' were total built environments for dense populations to live coherently within nature. Paolo Soleri, along with Fuller, Boyd, and Le Corbusier before him, were primarily concerned with terrestrial projects, in response to the better understood condition here on Earth. Fuller though, flirted with his levitating, airborne *Cloud Nine* habitats⁷ and did address the planet Earth as though it were a spaceship,⁸ conveying the similarity of the planet's situation to that of a closed system, even going so far as to create a manual for it.

Soleri did speculate on the development of habitable environments in outer space as evidenced by the projects described within *City in the Image of Man*, although he did state clearly in the books updated preface that the projects, or arcologies, were abstractions and not to be taken at face value. His arcologies were in the lineage of the social condenser, designed to provide "coherent, meaningful life."⁹ Soleri's work can also be seen to be in the lineage of Le Corbusier's large, utopian projects, tinged with the lingering fragrance of socialist utopia, and under the influence of modern transport technology. Soleri wrote that the "passenger liner is the closest ancestor of arcology."¹⁰ Soleri flirted with the notion of the human habitation of outer space with an Arcosanti named *Asteromo*.¹¹ Soleri's *Asteromo* would provide an artificial gravity through means of rotation. (Figure 4) Although Soleri (and at a later date Lebbeus Woods with his 1980 *Einstein's Tomb*) were to dabble with the idea it would take a non-architect to propose a serious speculation on a built environment in outer space.¹²

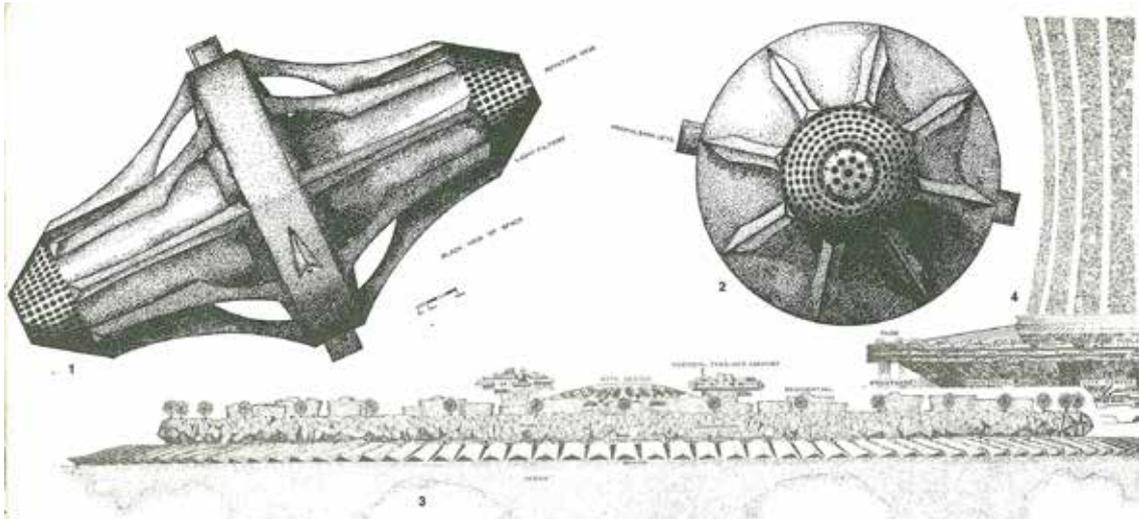


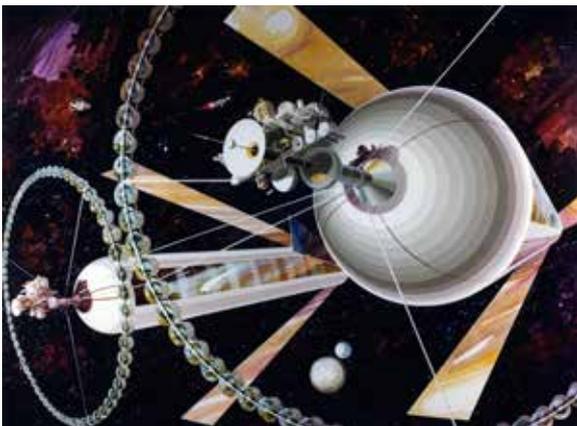
FIGURE 4 Detail of Paolo Soleri's outer space located Arcosanti, Asteromo. Paolo Soleri, *The City in the Image of Man* (Massachusetts: The MIT Press, 1969), p116.

Gerard Kitchen O'Neill (1927-1992) developed the idea of human settlements in outer space whilst serving as a Physics faculty member of Princeton University from 1956 until 1985.¹³ O'Neill was a well-known individual within the American science community, having invented the particle storage ring and the mass driver whilst at Princeton. (Figure 5) In 1977, he founded the Space Studies Institute (S.S.I.), which was involved in the research of space manufacturing and colonisation.¹⁴ While O'Neill was widely published in academic science journals, his visions for space colonies his space colonies are still alive and well in popular culture with recent science films using remarkably similar designs.¹⁵



FIGURE 5 Gerard K. O'Neill testifying before the Senate Subcommittee on Aerospace Technology and National Needs on January 19, 1976. Photo courtesy of Stewart Brand, *Space Colonies*, Whole Earth Catalogue, 1977, Creative Commons

Gerard K. O'Neill's award winning 1977 publication, *Human Colonies in Space: The High Frontier*, concerned the construction of self-sufficient, total built environments in outer space to allow human society to live successfully in outer space, and prosper.¹⁶ His study was a detailed project produced in response to speculations on a deteriorating condition here on Earth, described for example in *Limits to Growth* (1972), that modelled the world's agricultural production and population growth and their global interaction.¹⁷ The designs that were put forward as a result of a series of studies at the Princeton University conducted by O'Neill are befitting of their time. Emerging soon after images of a lonely, singular planet adrift in a sea of blackness and faint, twinkling stars were returned from outer space during the Apollo missions, the fragility of the Earth and the precarious existence of its inhabitants was understood by all. There was awakening to the realisation of a global community, whose borders faded slightly beneath photographs and videos of this new, whole Earth. A cosmic, interplanetary scale had been introduced. However, O'Neill's prototypical designs also continue the techno-utopian astrofuturism that the social movements of the 1960s condemned as a part of the military-industrial complex.¹⁸ Thus, while on the one hand he reflected the ideals of the cultural revolution of the 1960s producing an eco-futurist response, his work also embodies precisely a continuation of the same modernity that this revolution sought to overthrow. His proposed designs are of a stellar scale, meaning that they are to make use of the sun or sun-like star. O'Neill was fearful of the waste produced by nuclear power and the potential use of such materials in a weaponised form. While the designs resemble an aggregate of pure geometric elements, the habitable components are regularly described as either cylindrical or spherical in form, [forms generated from his studies of light-weight, pressure resistant skinned exoskeleton structures that are conducive to rotation, and therefore consistent, internal artificial gravity]. (Figures 6, 7 and 8) His was a space architecture of great aspiration and equal scale. Space architecture, he declared, was to be 'the theory and practice of designing and building inhabited environments in outer space.'¹⁹



Clockwise from top right

Figure 6. Exterior view of a double cylinder colony. Rick Guidice, NASA Ames Research Center, 1975, NASA ID number AC75-1085, Public Domain.

Figure 7. Interior of an O'Neill cylinder shaped colony. Rick Guidice, NASA Ames Research Center, 1975, NASA ID number AC75-1086, Public Domain.

Figure 8. Interior of a Bernal sphere shaped O'Neill colony Island One, with glider. Rick Guidice, NASA Ames Research Center, 1976, NASA ID number AC76-0628, Public Domain.

O'Neill's *The High Frontier* is possibly the most expansive singular treatise for the inhabitation of space. Encapsulating his research from the late 1960s *The High Frontier* is equal parts scientific explanation (as to how his settlements can and will realistically work), fiscal viability study (as in how much the project will not only cost, but return), and sales pitch (not only to the public but also to prospective organisations that would invest in or drive the project). The book speculates upon the possibility of an vast space station that is an evolution, in its physics and basic concept, of Noordung's wheel concept.²⁰ In the book, O'Neill explores the concept in a remarkable amount of detail, even including first person perspective, writing day-in-the-life style fictional narratives to provide the reader with tangible descriptions of what life might be like living in a totally artificial environment in outer space. Artists, such as Rick Guidice and Donald Davis, were employed to realise these voluminous space habitats using manual methods prior to the advent of digital production.²¹

O'Neill was as an individual operating in an environment when governmental, and therefore fiscal, interest in the Space Program was waning dramatically. After the initial excitement of outer space as a new and plentiful frontier that stood to be explored and conquered, technology had been developed to a sufficient enough level to debate exploring further.²² The speculation on space travel raised by the previous agents was now a reality; however, the reality was such that upon reaching the Moon in 1969, any further targets were so far beyond our reach and possessed no real immediate opportunities that interest and support became greatly reduced. Once the Moon had been visited and that immediate objective had been reached, NASA and the government came under heavy criticism regarding the immense financial impost necessitated by the exploration of space.

Between the Vietnam War (1962-75) and the 1973 Oil Crisis, Americans were concerned that their taxes could have been put to better, tangible use.²³ There were no obvious benefits from space exploration that had been discovered thus far, save for the incredible scientific accomplishment.²⁴ Space up until now had been a new frontier to be conquered with military might and was seen as an extension of the war machine. The entering of man, into space, was very much a dromological endeavour, with competing powers seeking to control this new infinite territory, or at least the small portion that encircled the Earth. As outlined by Virilio's explanation of dromology, "Whoever controls the territory possesses it. Possession of territory is not primarily about laws and contract, but first and foremost a matter of movement and circulation."²⁵ The only territory worth possessing in space (and this largely holds true today) is that space closely surrounding the Earth, and perfectly fit for the orbits of communication and military satellites.

O'Neill desired to go further than his predecessors, such as Oberth, Noordung, Goddard, and Von Braun, and rather than simply get a handful of people orbiting above the Earth for short periods of time, have them thrive in radically large populations, large enough that it would provide some relief for the Earth. O'Neill's first island was for a select few with the intention of establishing the ability to create a supply large enough to support a continual expanse of humankind. Kilgore described the second generation of astrofuturists (of which O'Neill is one) as thus: "whatever their political persuasions, [they] have found it necessary to respond to changes in American society by persuading the public of the democratic uses of the space future."²⁶ The second generation astrofuturist differed from the first with a break from being white, male, and with a military background. Where the initial group was interested in space as a site for conquest, no different to the conquering and claiming the Americas, or the Antipodes, the second group was driven by the understanding of humankind's fragile existence and the need to be sensitive about the use of our planet's resources.²⁷

Despite this apparent world-view the imperialistic undertones of the first stage of astrofuturists had not been completely abandoned. O'Neill's book was entitled *Human Colonies in Space: The High Frontier*, and featured references to the settling of outer space analogous to the period of settlement of America's own frontier land. Although O'Neill's intentions were progressive, Carl Sagan did comment that the space *colonies*, as detailed by O'Neill, should be more aptly referred to as space *cities*, to try and distance the designs from their earlier imperial counterparts.²⁸ Instead, diverse American *cities*, as suggested by Sagan, in space would enhance the survival potential of the human species. Cities too however represented capital, although it can be safely assumed that Sagan was referring to the public's accessibility to the city as opposed to a more exclusive colony.

O'Neill's response to the Club of Rome found popular accolades for his suburban realisations (diasporas) in outer space. (Figure 9) Shortly after his ideas of colonising space were made public, news stories proliferated with titles including "Modern Day Columbus Sees Camelot in Space,"²⁹ "Cities in Space Could Beam Energy to Earth,"³⁰ "City in space on longer just fantasy,"³¹ "Building suburb colonies in space for future pioneers";³² these appeared for a number of years [suggesting a considerable impact upon the popular imagination]. Impact was also had by O'Neill

within scientific journals during the same time period, however with soberer titles that included “High Frontier-Technical Progress, A Resolution, Commitments,”³³ “Engineering a Space Manufacturing Center,”³⁴ “The Low (Profile) Road to Space Manufacturing,”³⁵ and “Space Communities; The Next Frontier.”³⁶

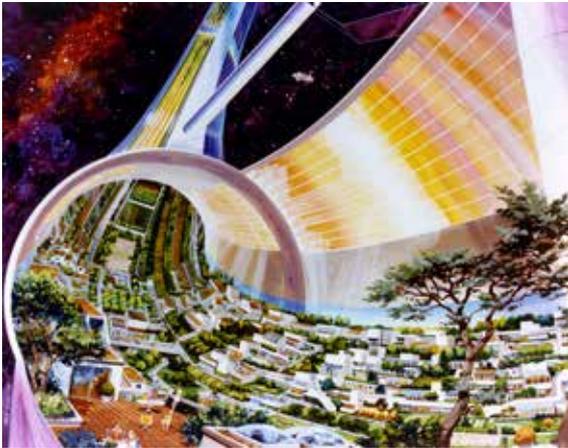


Figure 9. Cutaway view of toroidal colony. Rick Guidice, NASA Ames Research Center, 1975, NASA ID number AC75-1086-1, Public Domain.

This popularity was no doubt assisted by the presentation of visually interesting images of the ideal, every day, American, suburban paradise carefully calculated into gigantic bernal spheres, and enormous torus shapes in deep space.³⁷ These images were realised by a NASA artist at the time, Rick Guidice, who was responsible for the visualisation of many of O’Neill’s ideas (at least in the first edition of *The High Frontier*).³⁸ A trained architectural illustrator, Guidice’s background may have gone some way towards driving his description of the clean, modern, West Coast-Los Angeles bungalow laden suburbs carefully fitted into O’Neill’s gigantic geometries; of a high-modern, garden suburb inspired design not unlike a Hampstead Garden-esque development in outer space. (Figure 10) When Guidice, who was working closely with O’Neill at the time, was asked what instruction he received from O’Neill, Guidice explained that “his instructions for the first cylindrical habitat was...he wanted it to be like an English countryside, not like high density living. And so we painted it like a...countryside.” Guidice further explained that “it was more ideal, or idyllic in a sense, than practical in that regard...”³⁹ Clearly the idea was to be presented in a manner palatable to a broad audience, not unlike the way in which Australia was communicated to the English through paintings that used familiar colours and flora. Outer space was now available to the public, albeit the upper middle-class American public described in imagery within *The High Frontier*. (Figure 11)

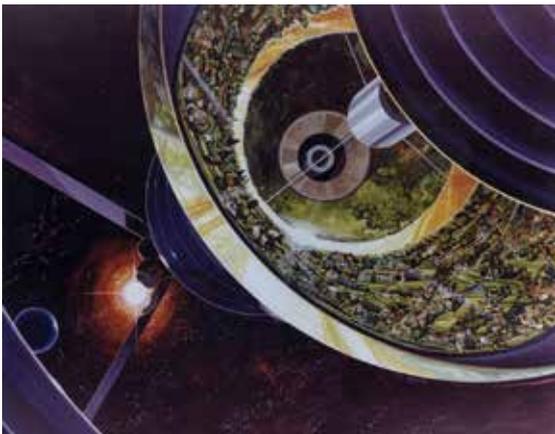


Figure 10. Cutaway view of Bernal sphere. Rick Guidice, NASA Ames Research Center, 1976, NASA ID number AC76-1089, Public Domain.



Figure 11. Detail of Island One interior Rick Guidice, NASA Ames Research Center, 1976, NASA ID number AC76-0628, Public Domain.

The living in conditions in proposed by O'Neill in outer space is that of the Earth turned inside out on itself. Unlike Robin Boyd's proposal for the 1972 World Exposition, an idyllic suburb enclosed by a Fuller-esque dome, O'Neill's colonies would be self-enclosed. Segal (2000) writing about techno-utopianism, remarks that these internal urbanities would potentially be dull for their inhabitants, referring to Fuller's geodesic domes, tetrahedral floating cities, cloud-structure spheres, and O'Neill's outer space colonies.⁴⁰

O'Neill spoke of unlimited resources that could alleviate the stresses on our home planet. Kilgore presents the counterpoint to this utopia in the form of peer-led criticisms of O'Neill's ideas as nothing more than a continuation of the cult of progress that does little more than ignore the problems on Earth, by providing an escape. Lewis Mumford was even more scornful of O'Neill's proposal remarking that, "If you were familiar with my analysis in the 'Pentagon of Power' you would know that I regard Space Colonies as another pathological manifestation of the culture that has spent all its resources on expanding the nuclear means for exterminating the human race. Such proposals are only technological disguises for infantile fantasies."⁴¹ However, O'Neill was not declaring the need to abandon the Earth, merely to illustrate the viability of life away from it which could lead to the ability to populate elsewhere in the universe. Thus he intended to improve the human prospect and as a by-product, reduce the strain on our home planet and preserve it.

O'Neill's island colonies allowed for an expansive suburban life, lacking the traditional city centre and with agriculture and energy production completely integrated yet separate from each another. The individual programs that were deduced by O'Neill to be necessary to support human life (including generation of capital) were all accounted for, yet kept reasonably separate, systematically modular, perhaps; or like organs in a body. His was a system not unlike Hilberseimer's studies on the decentralizing of large cities accompanied by the integration of nature and settlement.

The High Frontier frequently uses first person perspectives in the form of communications (referred to here as postcards) sent by people (often lay-people) describing their living circumstances aboard the cities in space; for the most part Island One, the first city (colony). The initial postcard, found almost at the start of *The High Frontier*, and written by two early settlers on a station named Bernal Alpha (for obvious and educational reasons no doubt) to friends of theirs back on Earth. The friends (Brian & Nancy) are, according to the communication, deciding whether or not to move to one of the many space colonies to live.⁴² Though their postcard to their curious friends, Edward and Jenny describe the entire process of applying (analogous to that of applying for a visa), travelling to the space site, life amongst the stars, and even opportunities to leave and homestead one's own asteroid (and one presumes start their own colony).⁴³

The second chapter to O'Neill's book, *The Human Prospect on Planet Earth*, is the main argument for the entire project; why live in space? O'Neill's project concerns sustainability - both of the human race and of the planet Earth. The living conditions of preindustrial populations are referred to as being very low. Conversely, while in O'Neill's eyes the industrialisation has improved living conditions for some it has damaged our environment and left much of the population on the brink of starvation. Based on his concise overview of fundamental world issues (O'Neill is concerned at a global scale) O'Neill derives four fundamental principles on which his treatise is based:

1. A proposal to improve the human condition makes sense only if, in the long term, it has the potential to give all people, whatever their place of birth, access to the energy and materials needed for their progress.
2. A technical "improvement" is more likely to be beneficial if it reduces rather than increases the concentration of power and control.
3. Improvements are of value if they tend to reduce the scale of cities, industries, and economic systems to small size, so that bureaucracies become less important and direct human contact becomes more easy and effective.
4. A worthwhile line of technical development must have a useful lifetime "without running into absurdities" of at least several hundred years.

Aside from the fourth principle that refers to the quest to reduce technological redundancy without resorting to a blind, religious pursuit of it, the remaining principles appear to outline values that were of importance to utopian communities that formed in a newly settled America such as Amana, Oneida, and the Shakers. Although these communities distanced themselves from urban and industrial areas, "they recognized that agriculture alone could not sustain, much less enrich, them."⁴⁴ These principles also closely resemble those of the Vancouver Action Plan.⁴⁵

While it might seem like a particularly utopian outlook, O'Neill asserts that, "Finally, as we strive to find solutions to the physical problems faced by mankind, we must realise, with humility, that we can offer no panaceas. There are no Utopias."⁴⁶ O'Neill infers by way of this statement, that although his design for the inhabitation of outer space provides a solution to the various limitations that humanity finds itself up against while based on the Earth, his suburban diasporas will not change humankind. O'Neill's islands in space are not social condensers by his design. Humankind will transfer its problems from one location to another. As Europeans had once held America up to be a potential utopia that never lived up to its expectations, O'Neill was wary of dispelling any false promises even though a sizeable faith in technology is necessary to make the leap. Segal, in referring to utopias and their ability to reveal, "... more about the times and places in which they were composed or organised than about the future they try to project", allows for the understanding that faith in the future is strong in O'Neill's *The High Frontier* as it was in frontier America; a future "based on a hitherto unswerving faith in science and technology and in the rational deployment of knowledge and natural resources."⁴⁷ This was not a proposition of a drastically altered society, merely an extension of the existing condition. It was a revisiting of the advancing frontier line that had served America so well in its recent history.

While these islands in space will not directly affect humankind according to O'Neill, he suggests that the opportunities provided by them "will make it easier for mankind to choose peace rather than war; diversity rather than repression; human simplicity rather than inhuman mechanization. Technology must be our slave, and not the reverse."⁴⁸ It is the technology that will provide the means to a better life. Is this not techno-utopia? Of course this is not the first time that architecture had been proposed with the apparent ability to exert some force to assist in the improvement of humankind. These prototypical projects were largely Earth-bound megastructures or projects of enormous expanse (in the case of some of Le Corbusier's) that sought to become analogous to a totally integrated, self-sufficient system; not unlike the way in which a spacecraft or space station must remain. These systems were a consequence of developing technology or at least its perceived ability to continue to advance and allow for the support of such radical projects. As described by Banham in *The Architecture of the Well-Tempered Environment*, the continual development of technologies such as air conditioning and mechanical ventilation systems allowed for the ever increasing control (or as Banham describes, mastery) over the environment.⁴⁹ O'Neill's project represented an ultimate control over the environment, indeed a mastery that would allow a replication, in support of expansion. On an urban scale these islands allow for the continued expansion of a simulation of Earth's urban environment into a Dyson-like scale, with little limits to growth according to O'Neill; a never ending gold rush for the support of humanity's continued advance.⁵⁰ Here O'Neill's islands are simply at the forefront of environmental control; a defining feature of modernity, which seems intent on interiorising. First the cave, then Laugier's hut, the planet, and finally the cosmos.

The island colonies proposed by O'Neill and the fictions that have been written in support of them explaining the benefits that life supported by a built environment in outer space may experience, conjure up the idea of architecture (or at a larger scale, the built environment) as social condenser, despite his resistance to his conscious designing of a utopia. Whilst this description of an improved life, lends credibility to O'Neill's ideas, it also describes an emancipation from an Eden (that is finite in both space and in its resources), and the possibility of further development. Is space architecture and therefore *The High Frontier*, a persistent strand of Modernism? Is it inherent to the discipline, and specifically O'Neill's project, that relies so heavily on technology to exist, that even in its most egalitarian manifestation it would still be a techno-utopia? Does this infer that by being a techno-utopia that it is not architecture, as is proposed by Felicity Scott's 2001 paper *Architecture or Techno-Utopia*, leaving in no doubt that it is either one or the other?⁵¹ Technology is inextricably linked to architecture and the built environment, with Segal understanding, perhaps bluntly, that technology is, "both machines and structures."⁵²

As a response to the concerns of the planet's ability to continue to support the continued expansion of humanity, O'Neill proposed a project that presented a platform that unintentionally supports the continuation of Modern ideologies and adds to the body of megastructure responses to them. O'Neill's is a project that replies to the concerns of a postmodern era with an answer that supports its predecessor and in theory supports it ad infinitum, as though to be in space is to be in Modernity. If this could be the case perhaps O'Neill's project might just be architecture and techno-utopia. It could become an architecture and urbanism that rather than seeking an equilibrium, would pursue an expansion, through an embrace of science and technology, utilising space as a genuine tabula rasa for the emancipation of humanity from our pale blue "Spaceship Earth" and providing the next gold rush for humankind.

Endnotes

- 1 Nathaniel Coleman, *Utopias and Architecture* (London; New York: Routledge, 2005), 137.
- 2 Peter Trummer, "The City as an Object: Thoughts on The Form of the City," *Log*, 27 (Winter/Spring 2013): 51-7.
- 3 Trummer, "The City as an Object", 51-7.
- 4 Geoff Koch, "R. Buckminster Fuller's Legacy Here/ Climatron Saved Garden; E. St. Louis Dome Was Dumb," *St. Louis Post-Dispatch*, 4 January 2004 (Sunday Five Star Lift Edition).
- 5 Zhongjie Lin, *Kenzo Tange and the Metabolist Movement Urban Utopias of Modern Japan* (Florence: Taylor and Francis, 2010), 173.
- 6 Paolo Soleri, *The City in the Image of Man* (Massachusetts: MIT Press, 1969).
- 7 James Baldwin, *BuckyWorks: Buckminster Fuller's ideas for today* (New York: John Wiley and Sons, 1997), 190.
- 8 Soleri does refer to the 'space ship earth' in *The City in the Image of Man* (1969), the same year as Fuller's *Operating Manual for Spaceship Earth* (1969) was published. Soleri was referring to, "...the miniaturization of the performance of the human race on the space ship earth." See Soleri, *The City in the Image of Man*, 117.
- 9 Soleri, *The City in the Image of Man* 15.
- 10 Soleri, *The City in the Image of Man*, 14.
- 11 Soleri, *The City in the Image of Man*, 116-18.
- 12 Lebbeus Woods, *Einstein Tomb* (New York: Pamphlet Architecture, 1980).
- 13 O'Neill retired from teaching at Princeton in 1985 but remained a professor emeritus at the university until his death.
- 14 Over the course of his life, O'Neill published numerous scientific papers in recognised journals including *Physics Today*, *Physical Review*, and *Astronautics and Aeronautics*, along with numerous books.
- 15 Christopher Nolan's *Interstellar* (2014) and Neil Blomkamp's *Elysium* (2013) both use outer space colonies (cylindrical and toroidal forms respectively) based almost completely on O'Neill's designs.
- 16 "Phi Beta Kappa Award in Science Winners". Phi Beta Kappa Society. 2007. Retrieved 18 April 2016.
- 17 Donella H. Meadows, Club of Rome, *The Limits to Growth: a report for the Club of Rome's project on the Predicament of Mankind* (London: Earth Island, 1972).
- 18 Felicity Scott, *Architecture or Techno-utopia: Politics after Modernism* (Cambridge, MA: MIT Press, 2007).
- 19 A. Scott Howe and Brent Sherwood, eds. *Out of this World: The New Field of Space Architecture* (Reston: American Institute of Aeronautics and Astronautics, 2009), 1.
- 20 Hermann Noordung, (Herman Potocnik), *The Problem of Space Travel: The Rocket Motor*, eds, Ernst Stuhlinger and J.D. Hunley with Jennifer Garland (Washington: The NASA History Series, 1995). Arthur C. Clarke's Hugo and Nebula award winning science fiction novel, *Rendezvous with Rama*, was published in 1973, two years before O'Neill's *The High Frontier* was published. Clarke's Rama is an alien starship that is originally mistaken for an asteroid until investigation reveals it to be a remarkably gigantic rotating cylinder fifty-four kilometres long and twenty kilometres in diameter; not altogether dissimilar to O'Neill's proposed 'islands'.
- 21 Rick Guidice (NASA artist for Gerard K. O'Neill), in discussion with the author, 24 July 2015.
- 22 The Voyager probes were both launched by NASA in 1977, their purpose being to explore the wider solar system. They are both the first man-made objects to enter interstellar space.
- 23 Roger D. Launius, "Public opinion polls and the perceptions of US human spaceflight," *Space Policy*, 19 (August, 2003), 163-75.
- 24 Not strictly true, as there have been many developments that can be attributed to the space program and its related technologies. These include but are not limited to, artificial limbs, infrared ear thermometers, scratch-resistant lenses, space blankets (obviously), aircraft anti-icing systems, chemical detection, enriched baby foods, portable cordless vacuum cleaners, freeze drying food, powdered lubricants, and more recently, self-healing materials that have been designed to resist meteorite damage that can also heal from bullet damage. This is on top of the knowledge gained about outer space.
- 25 John Armitage, "The Kosovo War Took Place in Orbital Space: Paul Virilio in Conversation," *Ctheory* (October, 2000), accessed 5 May 2010.
- 26 De Witt Douglas Kilgore, *Astrofuturism; Space, Race, and Visions of Utopia in Space* (Philadelphia: University of Pennsylvania Press, 2003), 150.
- 27 Kilgore, *Astrofuturism*, 2.
- 28 Kilgore, *Astrofuturism*, 168.
- 29 James Barren, "Modern Day Columbus Sees Camelot in Space," *The Washington Star*, 22 November 1975, 4-5.

- 30 Charles Petit, "Cities in Space Could Beam Energy to Earth," *San Francisco Chronicle*, 23 August 1975, 4-5.
- 31 Marc Salgado, "City in space on longer just fantasy," *Palo Alto Times*, 22 August, 1975, 8-11.
- 32 Walter Barney, "Building suburb colonies in space for future pioneers," *Sunday Examiner & Chronicle*, 31 July 1977, 4-5.
- 33 Gerard K. O'Neill, "High Frontier-Technical Progress, A Resolution, Commitments," *Astronautics and Aeronautics* (March, 1978), 18-21.
- 34 Gerard K. O'Neill, "Engineering a Space Manufacturing Center," *Astronautics and Aeronautics* (October, 1976), 20-3.
- 35 O'Neill, "The Low (Profile) Road to Space Manufacturing", 24-32.
- 36 Gerard K. O'Neill, "Space Communities: The Next Frontier," *Aerospace* (December, 1975), 2-7.
- 37 A Bernal sphere is named after John Desmond Bernal who in 1929 proposed a hollow, spherical shell filled with air to be used as a habitat in space for up to 30,000 inhabitants. The torus is another geometric form that lent itself to the purpose of being a space habitat as it could also be rotated successfully to produce a consistently distributed artificial gravity.
- 38 Don Davis contributed a few images to the first published edition but was the primary contributor for the second edition, aside from Pat Rawlings who produced a cover design describing life within one of the "islands" that O'Neill describes as being, "so exciting that we want to go there now."
- 39 Rick Guidice (NASA artist for Gerard K. O'Neill), in discussion with the author, 24 July 2015.
- 40 Howard P. Segal, *Technological Utopianism in American Culture* (Syracuse: Syracuse University Press, 2005), 152.
- 41 Stewart Brand, ed., *Space Colonies*, (San Francisco: Waller Press/Penguin, 1977), 34.
- 42 Gerard K. O'Neill, *The High Frontier: Human Colonies in Space*, (New York: William Morrow & Company, 1977), 13-17.
- 43 One can imagine Buckminster Fuller singing *Roam Home to a Dome* over this 'scene'. Fuller wrote the song *Roam Home to a Dome* to be sung to the tune of Home on the Range, in celebration of the geodesic dome. The song criticises architects and architectural building methods in a way that could be repurposed to support O'Neill's 'homesteading' of asteroids.
- 44 Howard P. Segal, "Eighteenth-Century American Utopianism: From the Potential to the Probable," *Utopian Studies*, 11, No. 2 (2000), 7.
- 45 "The Vancouver Action Plan", Habitat.igc.org. 1976-06-11. Retrieved 18 October 2015.
- 46 O'Neill, "The High Frontier", 22.
- 47 Segal, "Technological Utopianism", 12.
- 48 O'Neill, "The High Frontier", 18.
- 49 Reyner Banham, *The Architecture of the Well-Tempered Environment* (Chicago: The University of Chicago Press, 1984).
- 50 The Dyson Sphere, named after physicist Freeman Dyson, is the name given to an artificial structure that might surround the home star of an advanced civilisation, collecting its energy as that civilisation quenches its escalating need. Dyson's paper entitled 'Search for Artificial Stellar Sources of Infra-Red Radiation' (1960) is where the concept was first formalised. Dyson describes it as an artificial biosphere; a cloud of space habitats as opposed to what most have understood to be a solid structure. Such a sphere would be a Type II civilisation, based on the Kardashev scale for determining how advanced a civilization is. Currently the Earth could be considered close to becoming a Type I civilisation. Dyson has publicly stated that the inspiration for the idea came from the mention of the concept in Olaf Stapleton's novel *Star Maker* (1937).
- 51 Scott here is discussing the engagement of architecture with technology, at the time of the fall of modernism, and its alignment with (and even submission to) capital, where it loses any critical distance and ceases to be architecture. Felicity D. Scott, "Architecture or Techno-Utopia," *Grey Room*, 3 (Spring, 2001): 112-26.
- 52 Howard P. Segal, *Technological Utopianism in American Culture* (Syracuse: Syracuse University Press, 2005), xii.