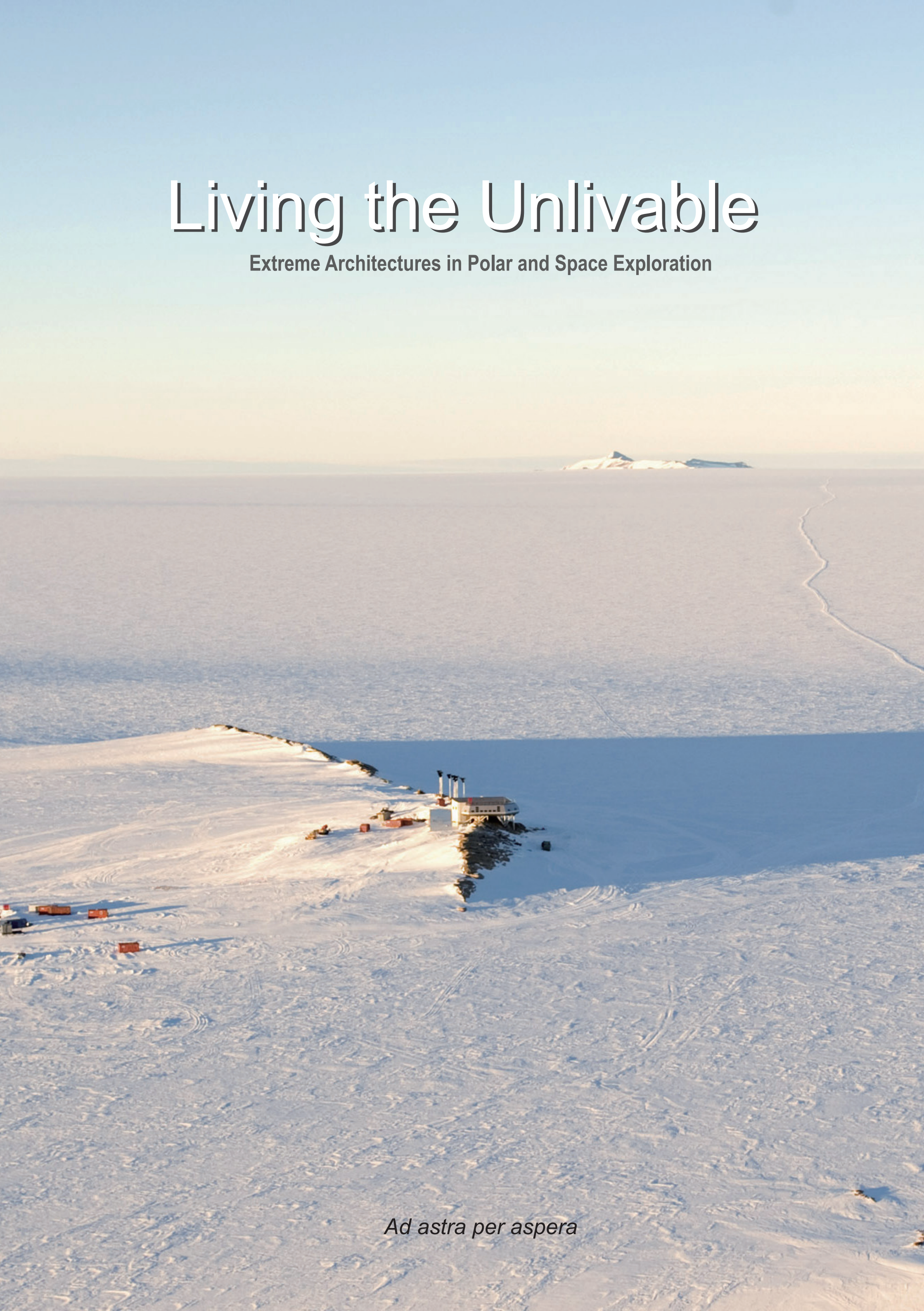
Living the Unlivable

Extreme Architectures in Polar and Space Exploration



Ad astra per aspera

Princess Elisabeth station in Antarctic. Photo by René Robert. Image courtesy of International Polar Foundation. "Princess Elisabeth Antarctica."

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When an architecture is designed in our neighbourhood, it was likely to be considered as a daily component of life, no matter who inhabits it. In other words, it was imagined with a way of life; and that imagination consolidates into the stroke of lines, curves, and dots – symbols that insinuate a better picture of the world. This is very much true all across the borders and throughout times, from the primitive hut to Polynesian shrines. The title is therefore interpreted as architectures in extreme environments, where extreme surviving conditions for humans makes architecture special, not that architectures are attributed with exceptionality. It is a way of adaptation. There are quite many extreme environments that humans have so far encountered, only three will be focused on in this research: The Arctic, Antarctic, and outer space. Coldness and scarcity dominate the zone of death, and these domains are continually haunted by similar political and cultural narrations.

Since the 1950s, humans have dedicated tremendous effort to exploring these formerly impenetrable places, and strived to extend the duration of stay. The architectures that made the mission possible have been showing a trend of resemblance in terms of forms and functions: not only the architectures are becoming similar within the same domain, but from different domains, too. How site conditions contribute to shape this development is one question, and why humans build architectures in those places is quite another. Given the brief history and a small number of precedents, the architectures from the three extreme environments are perhaps more important in what they open up for. They are often characterized by enterprise spirit, colonial sentiments, scientific curiosity, and so on. By carefully isolating perceptions from the architectures themselves, this research is to unveil the cultural and political connections, apart from the similar physical conditions, behind the resembling architectural typologies.

There has been considerable scholarship on the architectures in the aforementioned domains. There are not, however, many juxtapositions of those architectures in terms of their history, development, and regulations. Especially, the compared cultural and political analysis of those architectures since the early Cold War remained under the radar. As a history-theory researcher, I wish to trace the history of human exploration in the three realms. Topics such as the Cold War, Space Race, and cultural movements will be discussed alongside the architectural development: They often provide valuable insights and different perspectives. Site conditions will be studied and compared. Furthermore, technological transfer within and across the domains will be examined through the lenses of political conflicts and cultural constructs.


USA

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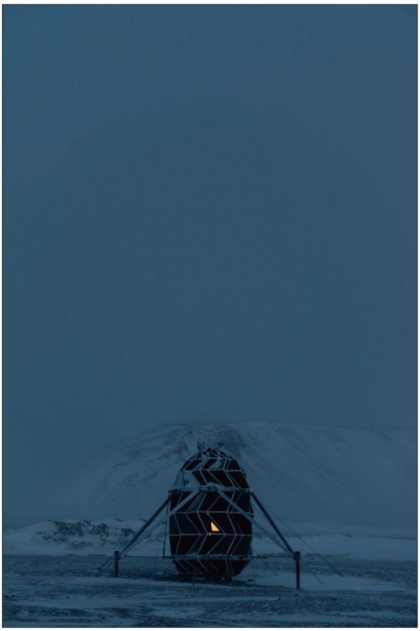


Upper. The first humans who reached magnetic South pole. Photo by Edgeworth David (center). January 16, 1916. Public domain. Wikimedia commons.

Lower. LUNARK analogue pod in Canadian Arctic. Photo by Sebastian Aristotelis and Karl-Johan Sørensen. Image courtesy of Saga Space Architects. Press kit image ID: DSC 3540.

Right. Apollo lunar module on moon surface. Photo by Eugene A. Cernan. Image courtesy of NASA. Archive ID: AS17-134-20442.

Introduction

What use can you see in a new-born baby?

---- Benjamin Franklin

On February 6, 2022, *Agulhas II* left the port and set her course towards the Southern seas from the African continent.[1] Its mission was to search for the ship rack of *Endurance*, which served Ernest Shackleton's 1914 Antarctic expedition. The later was unfortunately trapped in sea ice; with a slim chance of sailing out again, Shackleton had to order his crew to abandon the ship in October, 1915.[2] After the men settled on Elephant Island, Shackleton led a smaller group to reach out for help in a lifeboat named after James Caird, one of his sponsors for the trip.[3] The rest of the crew were rescued at last by the returning squad and a Chilean ship. On March 9, 2022, *Agulhas II* finally located the remains of *Endurance*,[4] thus concluding the legend of 108 years.

Despite the age, the ship was preserved in a visibly intact condition – and it was to be left in this way, too. Like many monuments, Endurance demonstrates the ultimate human bravery and perseverance in the most unforgiving place. This research is dedicated to the pioneers and the shack, cabin – or whatever word we use to honor the architectures in the frontiers of human civilization, namely the North and South poles and outer space.

"Extreme architectures" is how I refer to those remote habitats. They are credited extreme for multiple reasons: They are placed in the most extreme domains with extreme engineering effort and carrying out the most extreme tasks. The coldness, scarcity, and remoteness push the architectures to a limit where not only survival must be sustained, but also the furthering of novel discovery. Arguably, other places on Earth such as the desert and tall mountains are also challenging for human living. However, I did not and could not include those settlements for mainly two reasons: First, they are not as unhabitable as our popular culture often portrayed; and second, they do not

Upper. *Endurance* trapped in Antarctic sea ice. Photo by James Francis Hurley. Late October, 1915. Image courtesy of National Maritime Museum. Wikimedia Commons.

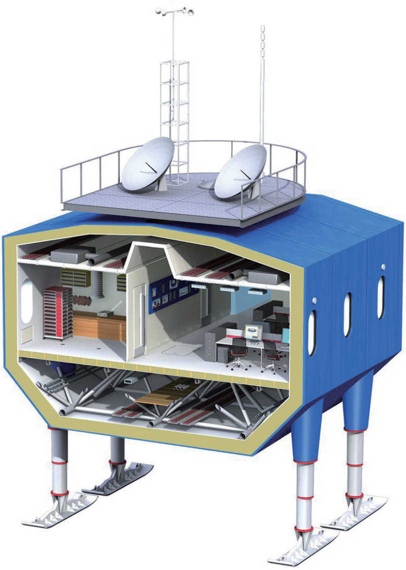
Lower. *Endurance* on sail in the Southern seas. Photo by James Francis Hurley. 1915. Image courtesy of State Library of New South Wales. Wikimedia Commons.

fit into the general narration framework of this research. A fundamental piece of tale usually contains six “Ws” – Who, what, where, when, why, and how. A serious academic work could be quite different from story-telling, but the basic technique of narration is adoptable, as it helps to illustrate a clear image.

For the extreme architectures, the two main questions are “what” and “why.” What has been built in Arctic, Antarctic, and space? And why does the best of us even bother to settle there anyway? “When” is another interesting question as my study frames the beginning of our quest in the early post-war years. The exploration in the poles coincided with that in space; furthermore, we see the ice stations and space stations, built or fantasized, started to resemble one another in forms and functions. This phenomenon is going to be investigated as the inquiry of “how.” Regarding “who,” I will track a number of people in the history of polar and space exploration and construction. There are also people who indirectly associated with the activities – they are discussed because the extreme architectures are never isolated from our Earthly world in spite of the distance. At this point, it is fair to say that there exists yet another criterion of extreme architecture: Built during and beyond the Cold War with mixed political and scientific intension. These architectures are considered extreme as result of our very goal to make them extreme.

As an architectural study, the later chapters will analyze the designs and constructions of these habitats. Besides the material structures, the site conditions are also a part of my interest, especially the intangible site conditions which involves geopolitical struggle, cultural movement, and economic reform. These discussions often redirect my observation – back from the distant realms – on the surrounding society. Meanwhile, as a historical (or even cultural) study, relating topics such as megaproject and Biosphere 2 laboratory will be compared alongside the stations. The chapter “Pioneer’s Footprint” focuses on the history of architectures in the Arctic, Antarctic, and space. At the starting point of discourse, the foremost task is to define the history itself: This chapter will dig into the technological and socio-political development in those three domains and our societies. This chapter will divide this specific history into four stages, each characterized by distinct political and technological condition. During the investigation, we could see a correlation between the architectural typologies being built up for their engineering solution, science discovery, and geopolitics. A quintessential incident is the International Geophysical year from 1957 to 1958, where the major scientific discoveries and achievements ignited the Space- and Polar Race. Furthermore, it reveals a general trend of architectural evolution on the frontiers: A station – no matter where it is built – is expected to support larger crews and longer missions. To put it colloquially with the urbanist terminology, we may say that the stations are transforming into settlements. This pattern will be discussed in a technical way in the next chapter.

“Pushing Architecture to a limit” will redirect the attention onto the engineering and architectural solutions of the extreme architectures. A design will be evaluated from the requirements and its later improvements. Proposals and science fictions will also be studied as they usually reflect new strategies which are, perhaps, too advanced at the time. For example, a greenhouse compartment could be a practical solution to achieve long-term sustainability for its dual role of providing nutrients and purifying water and air. It was envisioned as early as 1920s, and its early experiments can be traced back to the 1980s; but greenhouse is only introduced in a small scale in the recent



Upper. Halley I, the first of its series in Antarctic. Photo by George Hemmen. January, 1957. Image courtesy of British Antarctic Survey. BAS Archive ref: AD6/19/3/C/Z6

Lower. Halley VI crosssection (Office module). Hugh Broughton Architects. Image courtesy of Hugh Broughton Architects. Studio webiste.

years. One explanation is that the other technologies at the time were not yet ready for prolonged missions, and hence new forms and functions will only be actualized when they are needed. Accordingly, this chapter categorizes design solutions into two levels of sustainability: Temporary stay and long time stay. Not only that mere survival requires different amenities than quality life, larger crew and longer mission will undoubtedly complicate the social interactions. Interestingly, it was until the 1990s when the concept of ICE (Isolated, Confined, and Extreme environments) was formulated by psychologists. The extreme architectures are, therefore, fine specimens of architectural and engineering collaboration. The sensitive mediation of personal space and life pattern fall into the hands of architects, whereas the "energetic shells," or techno-spheres, are works of engineers. In this chapter, designs such as modular structure, safety redundancy, and bioregenerative life support system will be given detailed analysis. Most importantly, the phenomenon of "convergent evolution" is observed across the ice and space stations, and such a matter is approached from the material perspective.

In chapter "We Choose to Go to The Moon," I will proceed to investigate immaterial aspect of the site condition that drives the cross-typological resemblance in architecture. Due to the broad coverage of content, the research on political, social, economic, and cultural conditions will be divided into two chapters. This chapter will expose the interplay between science and geopolitics in the polar and space exploration. Science and politics represent the fundamental idealism and realism in explorations. It is not to judge which one is better or superior; instead, the two are supplementary to one another and together, they create a complete logic. On the one hand, scientific discoveries deepen our understanding of the living environment, and also offer the theoretical foundation for future military practices. On the other hand, continual military investment will boost the support for more expeditions and research. In this chapter, the international treaties are studied and some common patterns are found, such as the agreements to avoid military confrontations, and creation of increasingly prestige councils or governing bodies. Socio-economic transitions in the 1970s are examined for the impact on space and polar explorations. It shows that domestic political situation entered a new stage in many societies, as public opinions regarding huge national expenditures shifted. In the light of social movements, the opposition against the megaprojects in the western cities will be studied for its collateral influence to extreme architectures. The idea of progress will be discussed along with the maturation of civil society.

The last chapter “Once upon The Time in The future” will firstly continue the discussion of progress. The very concept will be approached from the struggle between the individualism and collectivism. The extreme architectures, at this point, is a tool of Cold War propaganda. In domestic society, the propaganda promotes a mainstream dialogue or “grand narration,” and a degree of cultural, technological, and (thus) political supremacy on the international stage.The famous “Kitchen debate” provides an opportunity to evaluate both, but it was surely not the only debates in kitchen at the time. This chapter will dive into the cultural phenomenon such as feminism and technological sublime: How is one absorbed into the larger cultural apparatus that we call mass-society? For the later, methods of visual study will be employed to study sublime. As it turned out, the appreciation of technological sublime and the sublime idea of frontier is broadly held by human civilization – oftentimes it is reduced to the worship of tremendous power and vastness. If the images of extreme architectures are exploited for seizing individuals back to

Upper. Yuri Gagarin and Valentina Tereshkova, first man and woman who went into space. Photo by United Nations. October 16, 1963. Image courtesy of United Nations. UN Audiovisual Library asset ID: C1023.

Lower. Movie poster of 2001: A Space Odyssey. Illustrated by Robert McCall. 1968. Image courtesy of Heritage Auctions. Heritage Auctions lot number: 86452.

the mass-society, the sense of devotion is perhaps how individuals submit to the crowd. The innate anxiety of life discontinuance, or pursuit for immortality, will be analyzed along with the monumental qualities of the extreme architectures.

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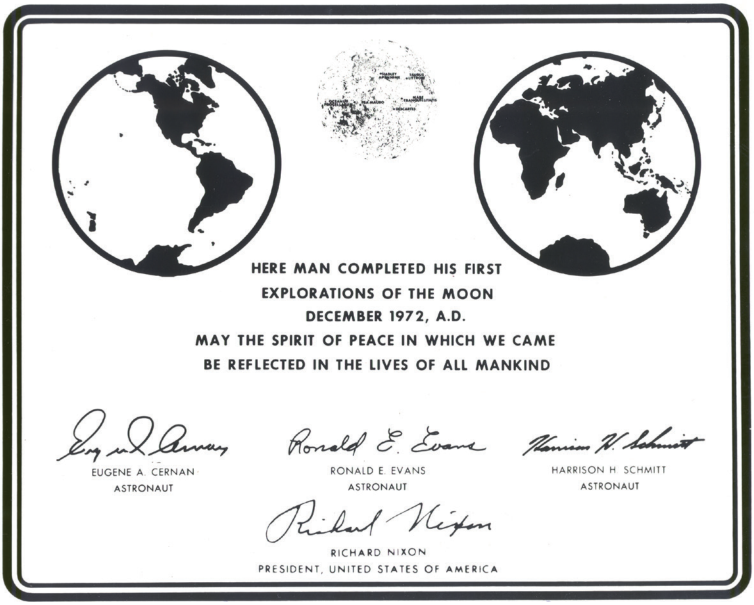
What can we expect besides the answers to what and why? First of all, throughout the course of investigation, the meaning of architecture is constantly interrogated. Designing a kitchen is, to a certain degree, equivalent to



Upper. Apollo 17 plaque left on moon surface. Photographic replica by NASA. December 13, 1972. Image courtesy of NASA. NASA ID: S72-55169.

Lower. My "ticket" to Mars. Illustarted by NASA. November 7, 2022. Image courtesy of NASA. Certificate number: 188418104137.

designing a space station, as they both impose a living pattern. And how is architecture different from engineering on those extreme architectures? This research forces me to see through the forms to confront the spirit of architecture. When we build a settlement on the edge of civilization, what exactly are we trying to build? An outpost for its nation? A monument for a privileged few? A small habitable world that allows us to play God? Perhaps it is all of them, but in the end of the day, we must justify our desire by adding layers of disguise. Philosophical inquiries will be presented in the last chapter and "Beyond The Horizon."

Personally, it has been a great opportunity for me to connect to something larger than myself. In the past months, I often feel relatable to the early pioneers who strived to expand the territory of human activities and discovery. When questioned for the value in such an endeavor, I often responded with this story of Benjamin Franklin. On December 1, 1783 when hydrogen balloon first lifted off in France,[5] people ask him what value can he see in this invention – among the crowd he replied: "What use can you see in a new-born baby?"[6] The answered is self-dignified as Franklin was gathering support for the independence of the new country now we are all taught as the United States of America. As there are countless instances of failure, there are also countless instances that people dedicate great effort to a mere potential. Although there have been many studies on the Arctic, Antarctic, and space stations, only a small proportion of them tries to establish some connections in between, and there is hardly anyone to set up a unified framework: By this I mean the integrative analysis of the stations' history, technology, political, and culture background. In many sleepless nights, this quasi-religious momentum pushed me, like it did to Earnest Shackleton 109 years ago, to dwell in the unknown yet enchanted domains, to boldly go where no man has ever gone before.

[1] Endurance 22, “Expedition blog,” catalogue, Endurance22 website. Accessed on May 15, 2023. https://endurance22.org/expedition-blog

[2] Endurance 22, “History of Endurance,” web article, Endurance 22 website. Accessed on May 1, 2023. https://endurance22.org/history-of-endurance

[3] “A letter from James Caird to earnest Shackleton. June 1914.” Web entry. University of Cambridge: Scott Polar Research Institute database. Accessed on May 14, 2023. https://www.spri.cam.ac.uk/archives/shackleton/articles/1537,2,30,22.html

[4] Endurance 22, “Expedition blog,” https://endurance22.org/expedition-blog

[5] Nicholas De Monchaux, *Spacesuit: Fashioning Apollo* (Cambridge: MIT Press, 2011): 17.

[6] Mary Roach, *Packing for Mars: The Curious Science of Life in the Void*, Kindle edition (New York: W.W. Norton, 2010): 272.

Pioneer's Footprint

"Leave her Johnny, leave her!
Oh, leave her Johnny, leave her!
For the voyages is long and winds don't blow
And it's time for us to leave her." [1]

---- *Sea shanty*

Created by the modern musician, the sea shanty captures inner conflictions of sailors in the age of discovery. “Her” in this case could imply either the loved ones or the ship: Would you choose the exciting and potentially profitable adventures, and leaving the family behind; or rather jump off board in the last minute, cherish the intimacy and forgo the journey to a mirage. It is a riddle that haunts all pioneers, whom this chapter is dedicated to. This time, the stage is the Arctic, Antarctic, and space, somewhere more distant than the unknown shores. Instead of treasure, knowledge is the reward – and arguably a little more than that. To understand how did humanity extend into these domains, as we have found us casually talking about them today, we shall look back into the history.

The time was 1959, The International Geophysical Year just ended with promising yields of scientific discoveries, marking a new stage of human exploration in polar regions and space: Canada launched its Arctic Program; the first artificial satellite, and later the Soviet dog Laika, was sent to the Earth orbit. Around the world, and especially Antarctic, a considerable number of scientific stations were set up. In the spring of this year, the newly formed NASA announced its crew for the manned space program in the future: The so-called “Mercury Seven.” In summer, American firms and the vice president, Richard Nixon, were invited to Moscow to display their latest achievements in home-bound technologies. On September 30, one day before NASA’s first anniversary, TV show Man into Space started its triumph as first space-themed Sci-Fi drama, and opened a new age of television programs. NASA adopted its iconic meatball logo, eleven countries with exceptional interests in Antarctic had their statesman gathered in Washington for the discussion of the Antarctic treaties.

The time was ever good, and the world was ever divided. New homes were built on each side of the Iron Curtain, and consumer goods were flooded to kitchens and living rooms. People were convinced of the approaching of a bright future, whether that of communism or capitalism. But if we are to look back in history, the year of 1959 is nothing particular and registered no iconic significance; it hardly denotes the end of one period and the beginning of another. To an individual, 1959 may recall a certain memory, or at least a segment of personal development. Frank Llyod Wright deceased in April of this year; there is the end of one life, a famous one perhaps. But zooming out on the timescale, 1959 might as well be “another year” from 1958 or 1960 in human history (even a short one, such as the history of polar and space exploration). CIAM had its last assembly in this year, one may say it marked the death of a genre by another – indeed a questionable assertion because CIAM’s modernist interventions on city still persist till this day and not merely as legacies.

Dividing history into smaller and smaller periods requires not only tremendous courage to make a bold proclamation, but also ample understanding of the underlying facts. That being said, single incidents do not challenge the fluidity of history, which, unlike a history book, has no page number. Instead, they are pinpointing people’s effort to rationalize history. This section is no exception. Abraham Lincoln did not and could not emancipate those of salved overnight, but the legislation and military effort provide us with tangible evidence to trace his endeavour. Philosophical debates aside, this section is to establish a basic understanding of human exploration and development of architecture in Arctic, Antarctic, and outer space by the virtue of historical study. Technical facts shall be discussed alongside the political and cultural interpretations, as what happened in those three distant domains is not only linked, but reflecting our surrounding reality. To better grasp the progressions of architectures, I propose that there are in total of four periods in the integrative history of polar and space exploration, each characterized by a general tone.

The first period covers early attempts in those three domains, and it ended in the early post-war years. In this period, human began to expand the territory and activities in Arctic and Antarctic. The pioneers must endure the harsh conditions, typically coldness, loneliness, and famine, with no guarantee of return. The phrase “Heroic period” is used to describe the polar expeditions of this time. Colonial sentiments and military confrontation cohabited with scientific enthusiasm in the polar regions. Rocketry was experimented with military support. Application of rockets in space travel was foreseen by a few, despite the fact that missile strikes were far from accountable success.

The second period overlaps with the “golden decades” in the west, ranging from 1950s to 1960s. Peace and cooperation was soon threatened by Cold War adversary; while no major military conflict surged between the superpowers, regional proxy wars kept sparkling around the world. On a smaller scale, it was also an age of profound transformations and confliction where popularized TV programs continually reminded people of exciting news about the recent conquest in science and technology, and the danger of the ever-approaching thermal nuclear war. Space Race, as a part of Arm Race, transcends the realm of idealism and realism, cooperation and competition.

The third period dates back to the 1970s and 1980s, when cultural support to the explorations began to dwindle. Disenchantment to utopic narratives led to the doubts on expensive expeditions. Institutional reform was underlined by shifting economic model. Seeking to minimize the chance of conflict, hands were reached out for cooperations in Arctic, Antarctic, and space.

The last and most recent period began in the 1990s, when Cold war ended with the collapse of the red empire, and the world is caught into the globalizing process. More multilateral agreements were made between states and organizations regarding the governing and management of the three domains, and new players began to emerge. Sustainability and environmental concerns were taken account in habitat and mission design, while political standoffs are undertaken in a more subtle way.

There have been many symbolic moments in history that highlighted the connection between space and polar explorations, as well as the military and civilian efforts, reality and fiction. For example, the history of the International Geophysical Year cannot be separated from that of International Polar Years, which advocate for international cooperation on polar expeditions. An Austrian navy officer, Karl Weyprecht craved for such chance before he died from tuberculosis one year before the first International Polar Year in 1881.[2] His expedition to the North pole from 1872 to 1874 was proven to be tragic as the hypothetical ice-free passage in Arctic was never found.[3] The crew abandoned the ship after it was trapped in sea ice and chance for escape is remote. They were fortunate enough to be rescued by a Russian ship *Nicolai*,[4] which coincides with the last name of Yuri Gagarin's commander Komanin Nicolai. He was awarded the honour of Hero of the Soviet in 1934 as a pilot and participated the rescue of *Chelyuskin*, a Russian ship looking for a Northern Sea route.[5]

There are considerable number of similar instances;

they are the visible threads that interweaves Arctic, Antarctic, and space other than political and cultural interactions. This section will present the interplay in the direct and indirect ways among the three domains. It is clear that those places are mirrored image of elsewhere. The architecture in such domains tells what we are, and most importantly, what we want.

Early Attempts

The Arctic was long aquatinted by people of North. Judging by its geographical location, it is practically the backyard of civilizations. Circumpolar communities of Indigenous people settled along the coast before borders can be drawn: The Arctic cultures predate sovereignty. To Scandinavian societies, their “Old North” is inseparable from national history. The South, though, situated quite differently in human memory before the discovery of the Antarctic continent in the nineteenth century. Hundreds of years before, writers started to diptych the Earth as a human body where it consumes ocean from the North pole, processes it, and defecates the refusal from the South.[6] The undignified picture precedes the retrospect on Global South by four hundred years, even though Arctic and Antarctic were soon proven to be equally deadly. “Going south” can mean something different from purely navigational bearing, as it was in the early days of Antarctic expedition. People would have to sail through the infamously rough seas, survive the dwindling supplies, and the growing lonesome. Russians in 1821 accomplished the first circumnavigation in Antarctic as well as the survey of its landform.[7] It later became the foundation for the Russian territorial claim – after they missed the opportunity of colonization due to the lacking of public interest and political instability.[8] Some of the islands they discovered were then taken possession by Norway a hundred and ten years later.[9] Perhaps to a colonizer’s eye, discovery do not guarantee the right of ownership, unless it is followed by continual appearance or activity.

The nineteenth century is the beginning of bold attempts in the North and South poles. The world was shrinking as unknowns receded before new knowledge and technologies produced out of scientific revolution. The modern experimental science was founded on the basis of hypothesis and experiments; those are all it takes to start a trip to the unknown realms: Curiosity and bravery. Besides the story of Karl Weyprecht, which was motivated by miscalculation of Arctic ice condition,[10] the young country of the United States of America had its Congress approved an Antarctic expedition in 1836.[11] The petition gained public support with the background that the Antarctic landform was largely unknown as the early expeditions were inconclusive, just like the existence of the Arctic hole.[12] Islands and peninsula around the continent were the furthest reach, the on-ground survey would have to wait until the dawn of the twentieth century. The Norwegian expeditioner Roald Amundsen was the first one who made it to the South pole in 1911, followed by his British counterparts, led by Robert F. Scott in a month. [13]The later never survive the trip and found dead not far from their resupply station,[14] poor navigation and communication can surely compromise the safety of such activities. In 1867, Edward Everett published his story The Brick Moon on Atlantic monthly, in which he fantasized a satellite built from bricks, catapulted to low Earth orbit to provide reference for sailors. Accident occurred as the brick moon was launched during the construction, along with some people and livestock on board.[15]

This fiction was credited to be the first one that discuss the application of navigational satellite and space habitat. This is fifty years before Konstantin Tsiolkovsky's *Vne Zemli*, which had the earliest discussion on space station in terms of the technical detail and mechanisms.[16] He proposed the space greenhouse that generate unlimited oxygen, and rotating capsule that generate artificial gravity.[17] Due to his cutting-age contribution to science and aeronautical engineering – by inspiring young minds – he was regarded as one of the fathers of rocketry.[18] Another one

Upper. Commemorative post ticket for Russian expedition that discovered Antarctic. Post stamp illustrated by Ulyanovsky I.. January 28, 2020. Image courtesy of RusMarka. RusMarka No.2591-2592.

Lower. *The Brick Moon*, novel written by Edward Everett Hale. Illustrated by unknown author. circa 1882. Image courtesy of NASA. Wikimedia commons.

Left. China's world map from the 17th century. Scan of paper rubbing. Created between 1662 and 1722, published in 1939. Image courtesy of Harvard Library. Harvard Map Collection: Old Maps Online.

Left. 18th century map of Pacific Ocean. Created by Thomas Kitchin. 1780. Image courtesy of Norman B. Leventhal Map Center. Wikimedia commons.


A CHART
of the Discoveries made
by the late
CAPT. COOK.
in the great
PACIFIC OCEAN
between
ASIA & AMERICA.
No 2
FROZEN OCEAN
Here the Ice
Arctic Circle
SIBERIA
EASTERN OCEAN
SEA of OCHOTSK
EMPIRE
NORTH AM
NORTH PACIFIC OCEAN
Tropic of Cancer
Ladrone Islands
Caroline Is
BORNEO
Equator
SOUTH PACIFIC OCEAN
NEW HOLLAND
NEW ZEALAND
Tropic of Capric

is the Hermann Oberth, who wrote dissertation on rocket-propelled space flight as a physics student during his study at Heidelberg University.[19] In 1922, it was rejected, similar to Weyprecht's idea of circumpolar chain of scientific stations in Arctic in the 1880s.[20] Oberth's student, Werner von Braun, realized his idea of space travel and even moon landing decades later. In the 1920s, the Soviet Union began to practices the communist rule and Tsiolkovsky's science fictions were adored by the authority: His space utopia in the book were found to be resonating the Bolshevik ideology.[21]

The space greenhouse lives all the way to today's design on Mars settlement; if more, it incorporates the concept of ecosystem. Six years later in 1926, the Soviet scientist V.I. Vernadsky had his book Biosphere published: not only does it introduced the very word of "Biosphere," but also the term "Anthropocene." [22] The idea of Anthropocene acknowledges human as a dominant shaping force to Earth landform and ecology.[23] Oftentimes the process of cartography can be reversed as we exert anthropogenic changes on landscape. However, drawing borders on map usually lacks respect to local culture which subscribes to different set of boundaries. In Antarctic, the debate on sovereignty took off before culture or civilization had a chance to land. After Norway "took" the Russian islands in 1931, the Soviet Union responded with rejection of Norwegian Antarctic sovereignty – eight years later.[24] Stalin might be busy with his political terror in party and country. Sergei Korolev grew up while reading Tsiolkovsky's space fantasies and determined to dedicate himself to rocketry. But before he got chance to shine in the 1950s, he was prosecuted and sent to Gulag during the Great Purge,[25] like many intellectuals of his generation. Andrei Tupolev, an aircraft designer managed to transfer Korolev to his program, somehow saved the future Soviet space pro-

Upper. Crew ploughing snow at the front deck of HMS Belfast during the Arctic Convoy. Photo by Royal Navy photographor. November, 1943. Image courtesy of Imperial War Museum. Wikimedia commons.

Lower. Konstantin Tsiolkovsky. Unknown photographor. 1924. Image courtesy of Russian Academy of Science. Archive ID: АРАН. Ф. 555. Оп. 2. Д. 126. Л. 5.

Right. Hermann Oberth (forefront), Ernst Stuhlinger (seated left), and Werner von Braun (seated right). Photo by U.S Army. Image courtesy of NASA. Wikimedia commons.

gram. Korolev worked under secret detention before he was freed after the war in 1945.[27]

The Soviet rocketry undertook different approach from Germans. While von Braun tried to increase the accuracy of his V-2 missile, the Soviets chose cheaper rockets that carry explosives in a smaller range and nearly unguided trajectory. The adversary between the two extended into Arctic, the North Sea route became the artery for the Soviet Union to receive the American aids while bypassing the German blockade. In 1941, Lend-lease Act was ratified in the U.S. congress, convoys were sent to Murmansk and Arkhangelsk via water ways in Arctic.[28] The ships must dodge the icebergs and German interceptions; furthermore, rough seas and weather put the convey in the same condition of the early explorers, except for the foreseeable return if without the air strikes and Kaiser’s navy. For sake of alliance, the Antarctic sovereignty disputes were suspended during the war. The Soviet Union found itself in the awkward position regarding the Antarctic affairs. Its regime was founded upon the communism ideal – that includes the condemn and abolishment of imperialism – thereby leading to a vain territorial claim in Antarctic. In other words, all the proposals of Soviet Union on Antarctic must be decorated with internationalism and idealistic rhetoric, even though the realistic rationale could be as simple as: “If I cannot have it, nobody can dominate it” and “use it or lose it.”

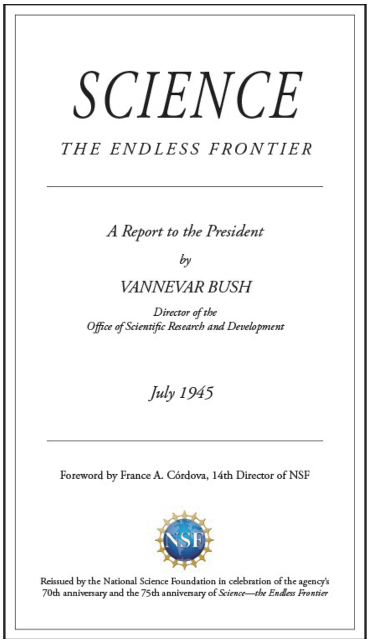
Near the end of the second world war, two events came to form the foundation of the architectural history of

Right. Hermann Oberth (forefront), Ernst Stuhlinger (seated left), and Werner von Braun (seated right). Photo by U.S Army. Image courtesy of NASA. Wikimedia commons.

Arctic, Antarctic, and space, as well as the narratives, in the decades to come. The first is the report Science: The Endless Frontier by Dr. Vannevar Bush. Dr. Bush was the director at the Office of Science Research and Development (OSRD) during the second world war. This facility was set up to guide the military technological development, or in short, weapon research. During the course of war, many new inventions came out of its door such as the proximity fuse of the anti-aircraft guns, and famous-yet-kept-under-secret Manhattan project.

In November, 1944, president Roosevelt wrote a letter to Dr. Bush with four questions: What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during the our war effort to scientific knowledge; With particular reference to the war of science against disease what can be done now to organize a program for continuing in the future the work which has been done in medicine and related science; What can the government do now and in the future to add research activities by public and private organizations; Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing of scientific research in this country may be assured on a level of comparable to what has been done during the war?[29]

The report is Dr. Bush's response eight months later, though the President have then passed away on his duty. He consulted his fellow scientists and formulated advice from a policy point of view. Besides the proposal such as investing in public science education and setting up the National Science Foundation, one of the major legacies is his encouragement of associating long-term civilian research with military applications.[30] This had a phenom-



SCIENCE

THE ENDLESS FRONTIER

A Report to the President

by

VANNEVAR BUSH

Director of the
Office of Scientific Research and Development

July 1945

Foreword by France A. Córdova, 14th Director of NSF

NSF

Reissued by the National Science Foundation in celebration of the agency's 70th anniversary and the 75th anniversary of *Science—the Endless Frontier*

Upper. German Scientists and Engineers collected after operation *Paperclip*. Photo by U.S Army. January 11, 1946. Image courtesy of NASA. NASA ID: 8915531.

Middle. The symbol of National Science Foundation. Updated September 12, 2018. Image courtesy of National Science Foundation. NSF Multimedia Gallery.

Lower. The report cover of *Science: The Endless Frontier*. Image courtesy of NSF. *Science: The Endless Frontier*, 75th anniversary edition, C2.

enal impact on later establishments in the forementioned environments. Polar stations and space stations were built and presented for civilian exploitation, but technologies and discoveries travel freely to military application, or vice versa. The entanglement of civilian and military motives embodied, if not further complicated, the intra- and international struggles of idealist and realist approaches over Arctic, Antarctic, and space.

Another event is the negotiation in the Bretton woods, where the post war economic order was arranged. Along with the General Agreement on Tariffs and Trade (GATT), it paved the way for the golden ages of the post war years. Consumerism was promoted within the Fordism-Keynesianism framework and secured by the coordinated international trade.[31] The Soviet Union was excluded from such an international system and Marshal plan; the split of world might have started before the Churchill's Iron Curtain speech in 1946. Antarctic sovereignty dispute was ignited again as a result of confrontation between the East and West especially during the Berlin blockade in 1948.[32] The U.S. and other western countries had no interest to invite the Soviet Union in Antarctic negotiations.[33] After the Berlin Blockade, the Soviet Union sent memorandum to Argentina, Australia, France, Norway, New Zealand, the U.K., and the U.S., suggesting an international practice in Antarctic problem solving.[34] The invitation was hardly dignified with a response, except for Argentina and Chile which, again, stressed its territorial claim and rejected the Soviet proposal.[35]

On North, Arctic Institute of North America (AINA) was set up by the U.S. and Canada with defence and strategic visionaries.[36] Canada eagers to study its Northern territories: By imagining the Arctic as future battle ground, more knowledge of its geography shall be acquired in advance.[37] In fact, Canada had its military presence in Arctic during the second world war.[38] In Europe, the legacy of German rocketry was harvested by the two emerging superpowers. The Operation Paperclip of the United States transferred scientists and engineers such as von Braun back to America,[39] while Korolev had opportunity to closely examine the German rocket and initiate the Soviet missile project.[40] Now have the new world order been consolidated, geopolitical and technological conditions have prepared human for new era of exploration.

Progress, Proxy wars, and Propaganda

The 1950s broke out with Korean War. The first hot conflict in the Cold War proved the necessity of proxies giving the agreement between the two superpowers not to escalate the situation. In addition, the war helped the Soviet Union to gain more leverage during the other diplomatic stalemate. The west, especially the United States realize that it is practically impossible to exclude the Soviet Union in any international affairs.[41] Participation of the Soviet Union in such events is no longer a question of "why," but "how" – perhaps another major breakthrough of the early exploration of global governance. In 1952, International Council of Science Union (ICSU) proposed extensive set of geophysical research;[42] it was responded positively by the American National Academy of Science (NAS). One of the promoters in NAS is Lloyd Berkner, who majored in electric engineering and performed the first radio transmission between Antarctic and civilized world when he flied along with Richard Byrd in 1929.[43] Although Berkner never finished his Ph.D. study after he returned, his fine combination of science and politics was highly respected and thus elected him into the NAS.[44] He dated the third International Polar Year to be 1957, seventy-fifth anniversary of the first conference.[45] Traditionally, the IPY is held every fifty years, but Berkner was fascinated by new technologies emerged during and after the war and had no intention to wait.[46] With the unprecedented international participation and subjects of interest, it was renamed as the International Geophysical Year.

Like Berkner, President Eisenhower did not want to waste time. Two years later in 1954, he approved the construction of the Distant Early Warning (DEW) line: A chain of radar stations across the North American Arctic, what Weyprecht imagined seventy years ago is now half-realized. [47] The line was deemed hardly valuable by military, but favoured by civil defence; it does not stop the potential Soviet raids, but at least gave enough time for Americans and Canadians to evacuate their cities nevertheless.[48] Canadians saw this construction as a bargain to negotiate its Arctic sovereignty, and its great North was incorporated into the cultural strategy as “nation building” during the leadership of Pierre Elliot Trudeau,[49] the father of current Canadian Prime Minister. The Arctic line was supplemented by Mid-Canada line and Pinetree line further South; three lines of the system illustrated the economic and cultural boundaries of the country. The huge system took only two years to build, thanks to the early surveys by AINA.[50] Back from the frontier, the magazine Collier’s familiarized Americans with spaceflight promoters like von Braun, who now works for America.[51] His idea of a taurus space station was visualized by Chesley Bonestall and animated in the show *Man into Space*.

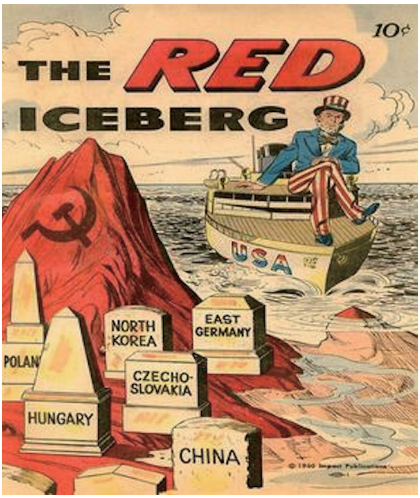
In the Soviet Union, the Korolev-led development of R-7 rocket pleased the leaders. Out of the concerns that it may cause unnecessary distraction, the Politburo approved Korolev’s petition to launch a satellite with the R-7 rocket as a reward to the engineers, even though it appeared somewhat childish to the politicians.[52] Ten days later, on August 18, 1955, Politburo also set up the TASS Communique, a propaganda institution one may say, to convey the country’s achievements in space science to its people and the world.[53] Meanwhile, the Soviet Antarctic programs were launched in Leningrad. In February of 1956, the Soviet Union set up its first station in Antarctic, Mirny (namely “peaceful”), in the Australia-claimed sector. [54] British Antarctic Survey (BAS) also set up its station Halley I, first generation of the series.[55] When the Soviets were busy with building their Peaceful station, their new leader Nikita Khrushchev was carrying out his doctrine

Upper. A Distance Early Warning radar station in Canadain Arctic. Unknown photographor. circa 1960s. Image courtesy of Canadain Centre for Architecture. Archive ID: PH2016:0004:015.

Lower. The Symbol of International Geophysical Year. NAS. circa 1957. Image courtesy of NAS. Wikimedia commons.

of peaceful coexistence and competition, and criticism at Stalin – in a not-so-peaceful way. In the same year, the Suez Crisis reaffirmed the international community that the two giants have replaced the traditional colonial powers.

The scientific event realized the collaboration among countries in eleven fields of Earth science research.[56] Three major achievements were made: The discovery of continual ocean ridges, the estimation of Antarctic icecap, and the discovery of an electrically charged layer above the atmosphere, also known as the van Allen belt.[57] Antarctica was firstly associated with Space by the Soviet Union's launch of the world's first satellite Sputnik 1 on October 4, 1957. The small object triggered political and cultural unrest on the opposite side of the Earth: The satellite could be a potential platform of weapon deployment, and the United States is now lagging behind. It is natural to have such a reaction giving that the Soviet Union launched its first Intercontinental Ballistic Missile (ICBM) a few weeks ago.[58] American people might feel naked at this point as their sky is now under the Soviet eyes, so as their homes to the Soviet spies. Fears intensified the political prosecution under McCarthyism, and fostered the founding of National Aeronautical and Space Agency (NASA).[59] Less than a month from the Sputnik 1, Sputnik 2 was launched with a passenger: A dog Laika on board.[60] This space journey of an Earth-bound life soon turned into a tragedy: The capsule was overheated and killed the dog inside during the orbit.[61] In the end of 1957, the Soviet Union has established a station at the magnetic South pole: Vostok.[62] The series of glories was followed by US' launch of its first satellite Explorer 1 on January 31, 1958, which helped to discover the layer of protons and electrons above Earth surface that shield cosmic rays from reaching the surface.[63] By finally recognizing the de-facto international order, the U.S. sent invitations to eleven



Upper. Commemorative post ticket for Russian expedition that discovered Antarctic. Post stamp illustrated by Ulyanovsky I.. January 28, 2020. Image courtesy of RusMarka. RusMarka No.2591-2592.

Lower. *The Red Iceberg*. Illustrated by unknown author. 1960. Wikimedia commons.

Upper. Antarctic survey ship and satellite. Post stamp issued by Japan. July 1, 1957. Image courtesy of Carpkazu (user name). Wikimedia commons.

Lower. The Soviet commemorative post ticket shows the Antarctic stations including Mirny and Vostok. Issued by Russia. 1959. Image courtesy of Gilad's Maps on Stamps. Item ID: SG2373.

countries to resolve the Antarctic disputes in May.[64] Also, the U.S.S Nautilus, the world's first nuclear submarine performed the navigation to the North pole under Arctic sea ice: A show of technological muscles in response to Sputnik. Apart from NASA, a civilian space agency – inspired by the Soviet national space agency,[65] the military sectors, from Navy to Air Force, continued their independent space programs.[66] *Project Horizon* was sponsored by the defence sector to study the possible military outpost on moon.[67] In public realm, the U.S. Air Force even provided the film crew of *Man into Space* with pressure suits.[68]

Seven months later after the NASA announced its astronauts for Mercury program, in September of 1959, the Soviet Union's moon probe Luna 2 impacted the moon surface and thus created the first architectural ruins in space.[68] As the two countries tried to outperform the other in space, they also decided to settle the Antarctica affairs based on the U.S. proposal in 1958. In December 1959, 11 countries signed Antarctica treaty.[70] After so many amendments and compromises, the single treaty becomes a system (ATS) and is now recognized by 54 countries.[71] The agreements secured Antarctica as an international territory and peaceful use of its resources.[72] Most important of all, the treaty prevent the expansion of Cold War frontier into Antarctica, even in the most unpredictable time. Antarctic Treaty Consultive meeting was set up as a governing panel to determine policies and carry out inspections of the conduct.[73] As of today, there are in total of 29 ATCP out of the 54 Antarctic Treaty States (AT); among which, Europe has thirteen seats contrasting only one from Africa (South Africa) – not to mention that only half of the eight countries who insist territorial claim over Antarctic actually locate in the Southern hemisphere.

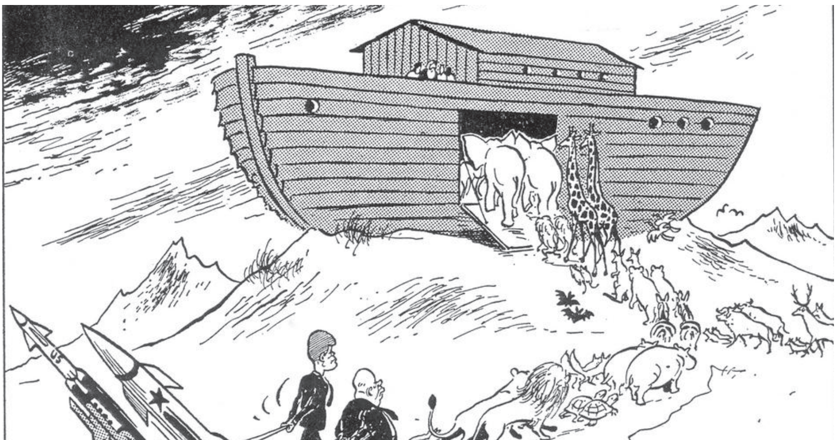
Scholars argue that the Space Race can be regarded as a proxy war: Its alternative use of mass destructive weapons signifies the reluctance of the superpowers to fire up a total war with another. [74] Nevertheless, the Arm race and Space Race caused the national defence funds to be poured to the seemingly-civilian sectors in a way of “military Keynesianism,” otherwise known as industrial-military complex.[75] President Eisenhower expressed his concern of the potential danger of such organization on his farewell address in 1961.[76] Industrial-military complex might be a necessary evil at the time, and more importantly, a much desired evil. Compared to the Soviet

The Emblem of Antarctic Treaty. Adopted on September 20, 2002. Image courtesy of Secretariat of Antarctic treaty. Attachment from Decision 2 (2002) - ATCM XXV - CEP V, Warsaw.

space program that sent human into Earth orbit, the United States desperately need to prove itself. On September 13, 1962, President Kennedy announced the American moon landing by the end of the decade.[77] The ambitions to win the technological competitions enlisted his Rice University Address into one of the most memorable moments in Space Race, usually introduced as “we choose to go to the moon” speech. It was inevitable to rely on the companies like Boeing and Grumman whose products were used in both civilian and military realms. As a matter of fact, the two companies produced the Saturn V rockets and lunar module that made Apollo landing possible. On the one hand, the Cuba missile crisis reminds the hard truth that we live in a brink of another world war and it is only sensible to prevent thermal nuclear war from a near possibility. This is later reflected in the United Nation Outer Space Treaty (OST) and resolutions of total disarmament in space. In 1963, outer space joined Antarctica to be the domains of solely peaceful use for all humankind and no-nuclear zones. [78]

Rachel Carlson’s book *Silent Spring* spoiled the American technological craze at the moment, if it was not already disturbed by the nuclear standoff. Environmental movements pushed the agenda of pollution and resource depletion. Saving our water and forests by birth control overflew from the socio-economic debates into the discussions “whether we shall extract space resource” among the scientists and engineers. In 1960, physicist Freeman Dyson pioneered the concept of exploiting untouched resource in space. By the time he was working on the idea latterly referred to as “Dyson ball:” a sphere engulfing the sun to enable 100% efficiency of solar energy. It was during the 1960s that intellectuals begin to seriously consider the possibility of space colonization, complemented by the Club of Rome and their pessimistic scenarios on uncontrolled development. A series of space records such as gender rebalance in space by Valentina Tereshkova and prolonged mission all pointed to the bright future that technology can be used to build a better world – on Earth or not.

British built a new Halley station in 1967, and the USSR's space superiority could not last. Luna 13 in 1966 was the Soviet's last chance of soft moon landing before a continual sequence of failures.[79] The Soviet Union started its study of a moon city, Zvezda, since 1962, but the super-heavy carrier rocket N-1 was never finished.[80] The project fell later than the star of Soviet space program, Korolev, who died in 1966 in a colon surgery.[81] The Soviets



A cartoon on Cuba Missile Crisis. Created by Fritz Behrendt. October, 1962. Image courtesy of CVCE.

had lost their opportunity to land on the moon before their American counterparts – Luna 15, launched a day before Apollo 11, was caught up by the later on their way to moon, signifying that the Soviet Union has lost the “moon race” literally and figuratively. Both countries were undergoing significant cultural and political change during their final approach to the end of the 1960s; with ambivalent views on technology and political authority, people began to contemplate on whether if there is any end to these competitions at all.

Upper. Newspaper on the Cuba Missile Crisis. October 22, 1962. Image courtesy of Arizona State Library, Archives and Public records.

Lower. The Soviet Lunar 15 probe in front of Apollo 11. Photo by Apollo 11 crew. July, 1969. Image courtesy of NASA. Paul Meuser, *Architectural Guide: Moon*, (Berlin: DOM publisher, 2019): 123.

Phoenix Weather

THE ARIZONA REPUBLIC

Today's Chuckle

THE STATE'S GREATEST NEWSPAPER

73rd Year, No. 57. 40 Pages

Phoenix, Arizona, Tuesday, October 23, 1962

Ten Cents

U.S. BLOCKADES CUBA, TELLS RUSS 'LAY OFF'

Will Sink Ships That Won't Halt

President's Cuba Stand Far-Reaching

Southeast Gears To War Pace

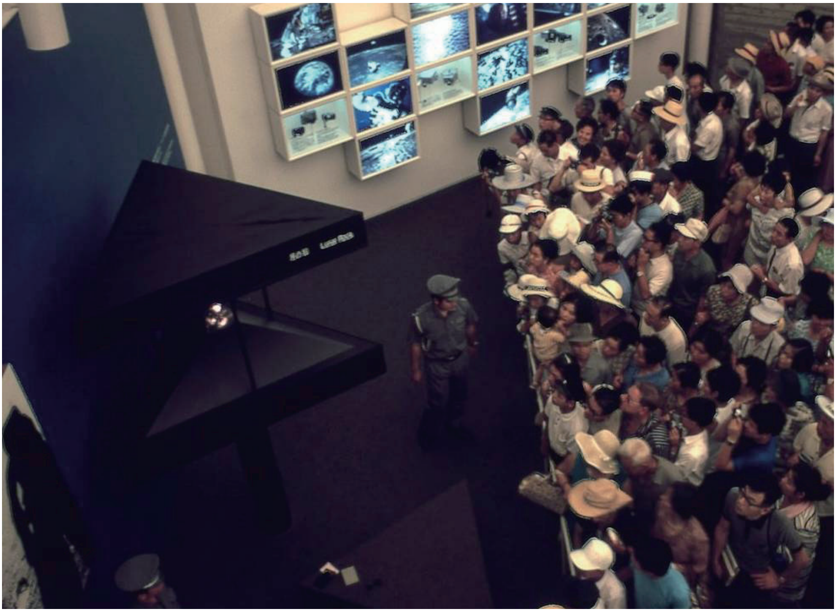
President Acts
Island's A-Missile Build-Up Cited

Stretching A Little Bit Too Far

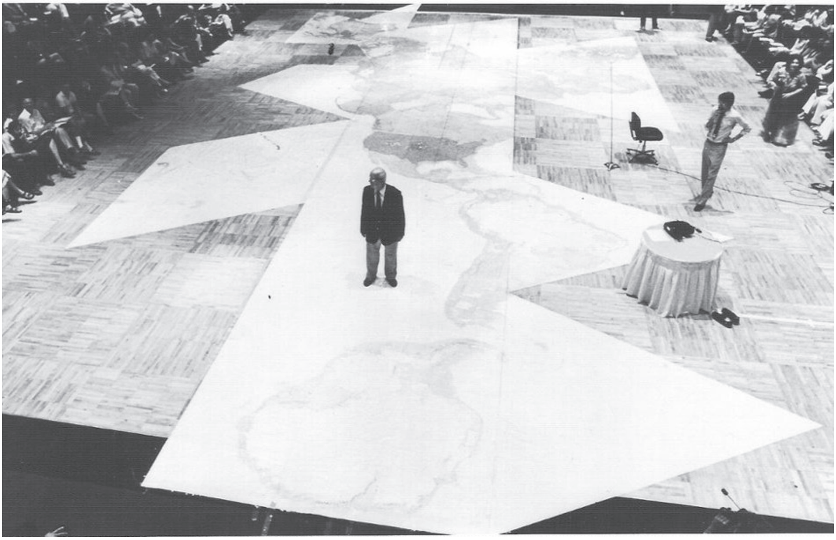
The 1970s begins with the Osaka World Expo. The international celebration of harmony and progress set the tune of this stage of human explorations. One of the attractions was moon rock retrieved from the Apollo 12 mission.[82] The second moon landing was located near to the surveyor 3, the earlier scouting probe; the astronauts were given a task of taking back some parts of the probe as souvenirs.[83] Gemini capsule and Apollo landing modules were displayed in the U.S. Pavilion with the moon rock,[84] adding to the space craze of the time. On the other hand, the Soviet Union also had its spaceship displayed in their pavilion: The mock-up of the Soyuz-Soyuz docking happened a year ago.[85] But like its Luna 16 and Luna 17, the first moving object on moon,[86] the Soviet Union's space program was overshadowed by that of NASA. A month later after the opening of the Osaka Expo, China launched its first artificial satellite, *Dong Fang Hong* 1 (DFH-1). Having its space program established in 1956, the country struggled to demonstrate its national power and finally bought its tickets to the space club. The distance to the two technological giants remained vast: Less than a year from the DFH-1, the world's first space station Salyut 1 was launched into the orbit by the Soviet Union when Americans have managed to land on moon for three times.

Through its history, the world expositions are always architectural festivals which condense the most updated understanding and prospective of our habitat; if more, the latest experimental technologies. Buckminster Fuller's geodesic dome at the Montreal Expo 67' rendered the environmental fantasy, if not a satire, in plain visual representation by capsulating our home in a techno-sphere. Perhaps the design took off from the postapocalyptic scenario of indiscriminate nuclear attack, or could it be the same rationale that he adopted to challenge the Mercator projection of world map; in either case, he proposed a realistic reasoning of the surrounding reality. In 1969, his World Game, a multi-player, role-playing, real-time competition, computer game was set up as an experiment under the grand inquiry of “How to Make the World Work?”[87] The classic resource-centric geopolitical tension would be balanced by a war-phobic logic in a way that a player loses the game if he chooses to start a war.[88] His game setting might be shared by many at the time; in 1972, the Club of Rome published its book The Limit to Growth. Can human sustain progress without resorting to military conflict?

Like the World Game, there are different approaches to such an interrogation, and Gerard O’Neill answered it in an unprecedented way. As a Princeton physics professor, he liked to challenge the ambitious students with additional problems to solve.[89] The problem sets were oriented around the construction of a hypothetical space settlement: How big the habitat should be and what the structural strength of the artificial ground needs to be? The questions turned into seminars, and the seminars turned into conference. To clarify the basis of my argument, professor O’Neill was definitely not the first one to propose space habitation, but he was the first one to have the topic registered to serious study. His idea of space colonization was formulated in the late 1960s, but only published in 1974 due to rejections of many journals.[90] The publishers might not take him seriously due to his Sci-Fi-like proposal; meanwhile, he tried to distance himself from the popular culture of science fiction.[91] In his framework, the space colonization involves advancements of space settlements by exploiting moon soil and asteroids.[92] Initially, small stations, or “mother settlement,” would be built to house the construction workers and factories that process space materials.[93] Space manufacturing allows the colonization to


Lunar Rock

be financially independent from Earth, and not only does the colonization payoff its cost, civilizational expansion into outer space can relief the developmental stress on Earth.[94] The next colony, or “daughter settlement,” would be built in a bigger size to host a larger population and agricultural facilities which induce a higher productibility thereby allowing the construction of larger “daughter settlements.”



Upper. The moon rock put on display at U.S Pavilion during Osaka World Expo, 1970. Photo by NASA. 1970. Image courtesy of NASA.

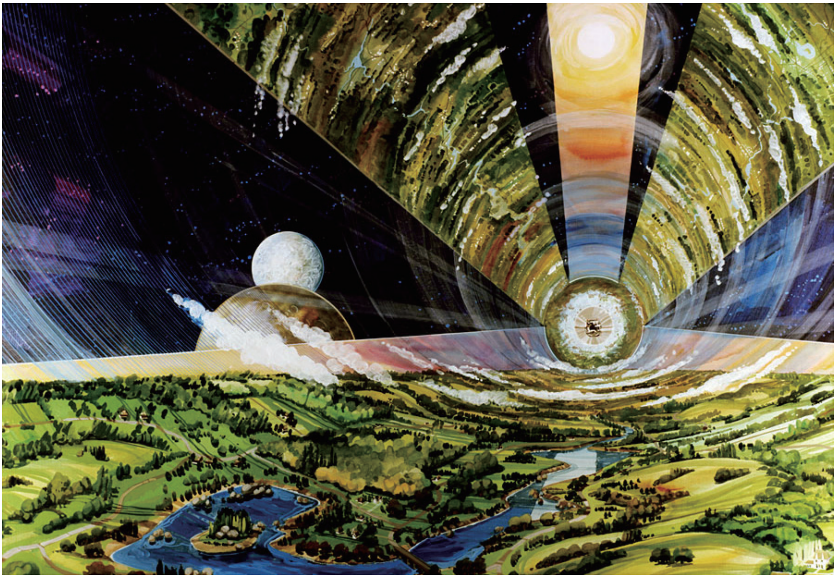
Lower. The U.S Pavilion of 1967 Montreal World Expo. Photo by Wernher Krutein. 1967. Image courtesy of Photovault.com. Code number: PF-WV01P02_19.

Right. Richard Buckminster Fuller and his world games. 1969. Image courtesy of Game for Cities.

The settlements, shaped as cylinder with a conditioned internal surface for living, would be landscaped and urbanized, and stationed at the Lagrange 5 point in the Earth-Moon system.[95]

Deemed space colonization feasible with contemporary technology, O'Neill calculated that we could have four such cylinders by the year of 2008 if we started as early as possible.[96] Space colonization seemed to bypass the premise held by the Club of Rome: the limitation of resources. Its potential to solve pollution and famine is truly an alluring offer. With private and public sponsorship, O'Neill finally had his space colonization studied publicly by scholars next year in the 1975,[97] and again in 1977.

But O'Neill's strategy to tackle the future energy crisis could not resolve the immanent one. The Oil crisis aggravated the already-trembling economic situation in the west when the Fordism-Keynesianism economic order was facing internal pressure of growing labour cost and external pressure of international trading competitions.[98] On cultural level, nuclear family was fragmenting as a result of increased women involvement at workplace, men's authority in the family was challenged, so as the government in the society. Two decades after the war, the civil society with a dominant middle class was established in many western countries. As the American policy makers hoped in the early 1950s, people with a land and property of their own will naturally become conservatists and turn their back to radical politics, namely, communism. [99] It was later discovered that not only does communism people stood up against, but also totalitarian masterplans, which transcended political borders in reality. Tired of grand narration sold on TV, people of East and West retracted their attentions from the propaganda subjects.



Upper. Gerard O'Neill's space cylinder. Illustrated by Rick Guidice. circa 1975. Image courtesy of NASA. NASA ID: AC75-1085.

Left. The emblem of The Club of Rome. 1972. Image courtesy of The Club of Rome. Wikimedia commons.

Right. The emblem of the United Nations. 1945. Image courtesy of United Nations. Wikimedia commons.

In July 1971, Apollo 15 delivered the first automobile to the moon.[100] The crew demonstrated an experiment that a hammer and a feather fell to ground with the same speed.[101] This experiment was broadcasted on TV and its replication of that performed by Galileo three hundred years ago marks the superiority of western science and enlightenment, yet the mission was hunted by its postcard scandal. The crew "smuggled" a pile of postcard in the Apollo spaceship and sold them as "the postcard from moon."[102] The scandal spoiled NASA's noble quest – and it end up costing three astronauts' job for good.[103] It is necessary to keep in mind that astronauts are essentially public servants due to their workplace and funds they consume. While the legitimacy of business in space is nearly unquestioned nowadays, Apollo-15 crew's abuse of power only reflected a lack of integrity and descipline under the national spotlight. On the other hand, the Soviet people seemed to lose their patience when waiting for communism to arrive. Nikita Khrushchev failed to address the economic reform and provide universal housing with livable conditions.[104] His declaration of attaining communism by 1980 was rendered an empty promise. And to worsen the situation, his liberation of censorship backfired at the party during the 1970s, the era of stagnation.

The last Apollo mission, Apollo 17, concluded the entire program. It carried a plaque engraved with the wish for world peace, it was put on moon as a monument.[105] Another legacy was the famous photo Blue Marble, it was taken from the Apollo spaceship on its way to the moon.[106] Where is the end of the Space Race? In 1970, President Nixon might have wondered this question when he was offered three alternative projects after the Apollos: A space station that orbits the moon, a Mars mission, and an Earth space station with reusable shuttles.[107] With restraining budgets, he chose the third option, even so it was

Upper. Apollo-Soyuz docking. Illustarted by Robert McCall. 1974. Image courtesy of NASA. Archive ID: S74-29150.

Lower. Blue Marble taken on the trip to moon in 1971. Photo taken by Apollo 17 crew. December 7, 1972. Image courtesy of NASA. Archive ID: S17-148-22727.

curtailed to the later shuttle program.[108] The Soviets failed their research of super heavy rockets, the foundation of their moon city Zvezda, resulting the ultimate cancellation of the project in 1974.[109] The Americans were gaining on the Soviets on space station fast with the launch of Skylab in 1973. Perhaps it is no longer necessary to build up the rivalry when victory is already in sight, or the rivalry is difficult to build when public sensation was diverted away from space, NASA found itself an opportunity to catch a break. The summer study of O'Neill space colonization estimated that it would cost $1400 billion to build a settlement, and the payback period was calculated to be thirty-eight years within O'Neill's framework.[110] It was simply unacceptable to pour the Apollo-size investment each year into a distant and doubtful goal, a mirage, for decades. It was a financial trap – nowadays we call it a "scam." This justifies the termination of space colonization, before it had a chance to start. In the same year, NASA changed its logo from "meatball" to "worm," as answering to the contemporary minimalist culture.

American glimpsed their victory in sky and acquired political leverage by exploiting the Sino-Soviet split. As reacting to American advantage and the Soviet disadvantage, the two signed the Anti-Ballistic Missile Treaty (ABMT) before the tenth anniversary of the Cuba Missile crisis. In 1975, when O'Neill was working on his space colony, the Apollo commanding module docked with the Soyuz capsule, and thus achieved the world's first peaceful attachment of space vehicles of two systems – that of technological and political. To a certain extent, docking two spaceships with different standards is still easier than asking Americans to use "meters" and Russians to use "feet." The two countries with different, and even opposite world views managed to design the bridge structure that fits Apollo hatch on one end, and Soyuz on another.[111] It is a phenomenal event considering the political possibility this docking has opened up for. In 1977, Voyager 1 was sent to outer space and later became the first artificial interstellar object. It carries a record that introduces Earth living-beings and sends out greeting on behalf of the entire human race.

Throughout the 1970s, several amendments were made to the ATS to conserve the natural resources, including the animals in the Antarctic region. In 1981, a book titled Hitler Survival Myth discussed Hitler's secret escape from his fate after the second world war – it is by no means different from the other urban legend, but it puts the south-most continent as Hitler's destination,[112] like many fictionists imagined a habitat of extinct animals there.[113] By the end of 1970s, China started to reopened its doors to the international opportunities, which also opened up to China. In 1983, China joined the Antarctic Treaty System and built its first station a year later the same time when British station Halley IV was launched. In 1985, two incidents happened in Antarctic: China was granted ATCP seats as a member of international governance, and it complicated the future geopolitical drama. Another striking news is the discovery of ozone hole in Antarctic atmosphere by Halley IV, it triggered the prolonged environmental concerns. The defective atmospheric condition somehow reminded people of the fundamental fact that all human is living on the spaceship Earth, like Blue Marble portraited thirteen years ago. Inspired by such an idea, the Institute of the Ecotechnic (IE) started the design of the world first closed ecological system, otherwise known as Biosphere 2. In 1977, President Carter sent out the friendly message to hypothetical aliens in space; next year, he donated 500-gram moon rock to China, which just decided to reform and open its gate again.[114]

国家海洋局极地考察办公室
Chinese Arctic and Antarctic Administration

Upper. The siging of Anti-Ballistic Missile Treaty. Photo by official photographor. May 26, 1972. Image courtesy of Richard Nixon Presidential Library. Gallery code: 37-whpo-9204-31-a.jpg.

Lower. Symbol of CAAA, was initially founded in 1981 as Antarctic expedition committee. Photo taken by Apollo 17 crew. December 7, 1972. Image courtesy of NASA. Archive ID: S17-148-22727.

Unlike Antarctic, an international territory remaining neutral to international politics, the Arctic is characterized by international tensions, but not as an international territory. Triggered by the Soviet development in the Arctic, Canada initiated its Northern strategy as early as the 1950s. In the 1980s, the Canadian Arctic was dominated by security approach from security perspective under the conservative regime.[115] In 1987, the Soviet leadership Mikhail Gorbachev made his Murmansk address, in which he expressed the willingness to shape Arctic as a zone of peace and expand the scientific exchanges with the West.[116] Mark Nelson, the co-founder of IE, have travelled to Siberia a couple of years ago to seek the cooperation between the American and Russian ecologists.[117] The Soviet scientists have the extensive research experiences of bio-regenerative life-support system from their suspended space program;[118] and by sharing them with Americans, the construction of Biosphere 2 was considerably accelerated.

By the end of the 1980s, the space superiority looks to be inversed: The American space program hit the reef after the its space shuttle challenger exploded half way in air. NASA lost seven crew members and two years to recap from its failure.[119] A month later, in February 1986, The Soviet Union launched the world's first modular-designed space station Mir (meaning "Peace"). The Soviet shuttle Buran, though, never had a crewed flight before it was cancelled.[120] It reveals that neither of the two can keep a perfect track of space missions. By acknowledging the weakness and increasingly eased political tension, a path of cooperation is paved. In 1989, the second international conference of closed ecological system was held in the Siberia (Institute for Biophysics), marking the opening age for the Soviet science.[121] Nelson invited Soviet scientists to Arizona to see what his team had built with their help. In the same year, President George H. W. Bush announced a manned mission to Mars by 2017.[122] It all seemed that the ambition is restored again, but with more international player this time.

Upper. Halley IV, the station that found the ozone hole. Photo by Doug Allan. 1985. Image courtesy of British Antarctic Survey. BAS image library ID: 10004222.

Lower. Founder of Biosphere 2 talking to Russian scientist. Image courtesy of Mark Nelson. *Pusing Our Limits: Insights from Biosphere 2* (Tucson: University of Arizona Press): 6.

Global Space

The beginning of the last decade of the twentieth century was iconized by an arrival and a departure. In January, Japanese probe Hiten reached moon; it became the first one after the Soviet and American missions.[123] Two weeks later in February, Voyager I sent out the last image of solar system and went on its solo journey to where no man has ever gone before. The last, and also our current phase of polar and space exploration is marked with more global participation and ambitions in deeper space and harder missions. Globalization and regional integration have started a little earlier – the change in European and Asian political and economical borders is propagating a new world order. In 1991, Russia settled the borer disputes with China. Further North, Arctic Environmental Protection Strategy was structured institutionalized by transnational forces of indigenous communities.[124] Madrid protocol was added into the ATS to enhance the environmental protection effort in Antarctic concerning mining and fishing.[125] Later this year, the United States congress ratified the Cooperative Threat Reduction (CTR) Program which aimed to fund the Russians to retire the nuclear warheads and submarines.[126] In September, eight people of different backgrounds, including Mark Nelson, entered into Biosphere 2 for their two years closed experiment. The Soviet flower that blossomed on the foreign soil would have to see the disintegration of its country in the last days of the 1991.

Also in 1991, NASA replaced its old space station initiative, commissioned in 1984, with its Space Station Freedom program.[127] In the next year, NASA switched back to its “meatball” logo. The Space Station Freedom was again replaced by Space Station Alpha, when the U.S. and Russia decided to build a space station tother in 1993.

[128] A peaceful outreach was observed in space, where the Americans were invited to the latest Soviet space station Mir to familiar themselves with operating the Russian equipment.[129] Two years later, American space shuttle Atlantis docked to the Russian station: echoing the first space cooperation twenty years ago. For a brief period in the early 1990s, the cosmonauts on Mir had to worry if their ground control have forgotten them giving the chaos in the former-Soviet states.[130] Russia could not afford the Soviet space program alone, the U.S. dollar stepped in to stabilize the joint research of the International Space Station (ISS).[131] The reason is two-fold: The U.S. wanted to keep the Russian scientists and engineers in their position so they would not slide to North Korea or Iran; and design work of a big station is complicated and the U.S. could use some Russian expertise.[132] The similar intention was implied with the CTR program. The Soviet nuclear scientists were offered job positions by the U.S., and funds were sent to the former defence industry to facilitate “conversion:” A wise investment considered by the U.S. defence secretary to minimize the potential nuclear threats.[133] During the design stage, America resisted the Russian proposal to build new international space station by adding components to Mir: It was too old and overused and two major accidents had happened to it after the cohabitation of the two.

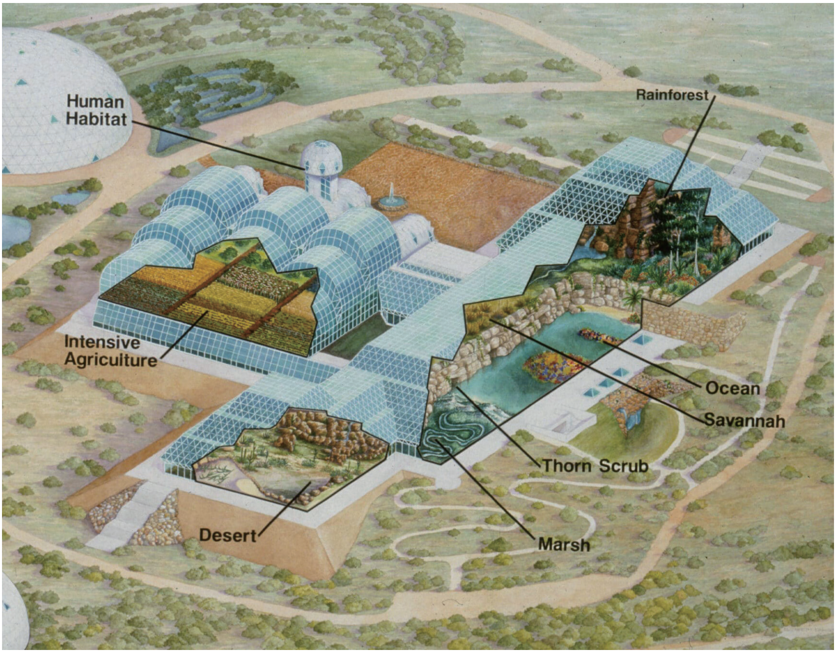
On September 19, 1996, the eight Arctic States, or A8 (U.S.A, Canada, Russia, Norway, Denmark, Iceland, Finland, and Sweden), signed the “Ottawa Declaration” to establish the Arctic Council.[134] Unlike the ATCP, Arctic Council had no governing authority. It is merely a forum for countries to discuss and organize their activities, except for the military operations, which is excluded from the agenda at the Arctic council.[135] Arctic Military Environment Cooperation (AMEC) was signed between Norway, the U.S., and Russia (A3) to set up another forum that is en-titled to zero legal binding.[136] The ambiguity of the terms guarantees the flexibility of practice; in contrary to Antarctic legal framework, the ambiguous terms could at least keep the countries communicating, if nothing more to expect. It is by this sense, that Arctic is also designed as the last resort of, not peace, but dialogue. The Arctic council has observer seats open to countries with interest in Arctic, and permanent seats for indigenous ethnics who made this transnational interaction possible in the first place.[137]

In November, the core module of the ISS was launched into space. It was produced by Russia. Modelled based on the Mir command module,[138] the ISS inherited a share of the Soviet legacy, like the Biosphere 2 laboratory. The International Space Station Intergovernmental

The symbol of Arctic Council. Image courtesy of Arctic Council.

Agreement was signed among 15 participants. According to which, the Japanese and Europe space agencies will contribute to the project by adding their modules. In December, space shuttle Endeavor delivered the components of the ISS to the orbit according to plan. The shuttles were designed to ferry the crews and cargos to the ISS, while the Soyuz capsules hung to the station will be used as lifeboats in case of emergency.[139] However, such an arrangement was disrupted by another shuttle accident in 2003, when Colombia disintegrated during the re-entering and cost the life of its crew members. An investigation board was setup and the shuttle fleet was again grounded for two years during the process. The Colombia reports accused administrative flaws as the main factor that led to the disaster: Although the files acknowledged that it was the foam that fell from the fuel tank hitting the shuttle's left wing and damaging its heat-shield integrity, but it was the safety waivers that killed the crew by granting the shuttle's re-entry.[140] In short, the NASA promised to reform and, at the same time, phasing out its shuttle fleet by the early 2010s.[141] The reform of NASA was considered cosmetic, but reflections on publicly funded space program led to the entrance permission of private space business.[142] After the last flight of Atlantis, the Soyuz capsules became the only way for astronauts between the ISS and home planet – until the Dragon spaceship lifted off in 2020. On the other hand, China achieved its first manned space travel by the end of 2003, making it the third place after the Soviet Union and the United States.

In 2004, realizing that its Halley V will be lost by a matter of time, the British Antarctic Survey (BAS) initiated a public competition for its next generation of Antarctic station. Halley V has its platform supported by pillars. The height of the station can be adjusted to prevent snow blockage.[143] The issue is that the ice shelf the station an-

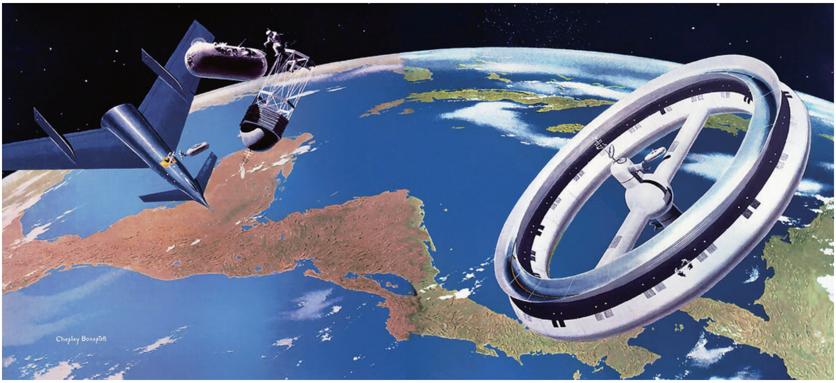

Human
Habitat
Rainforest
Intensive
Agriculture
Ocean
Savannah
Thorn Scrub
Desert
Marsh

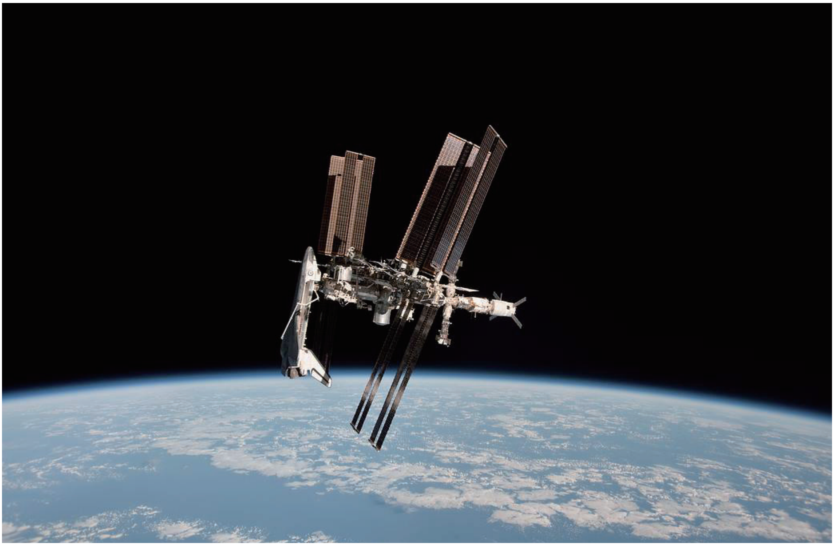
chored to is slowly shifting towards the sea.[144] One architect back in London, Hugh Broughton, joined the competition out of curiosity.[145] His studio had only a handful small projects and he had no experience in designing architecture in Antarctic, but he had an engineer friend who does.[146] The two form the team and studied the BAS handbook on the lessons they learned over the decades.[147] Meanwhile, the France-Italy jointly owned Concordia station became one of the bases for ESA to test its gray water purification technology, MELiSSA.[148] The concept was revealed in 1988 and usually discussed alongside the Biosphere 2. Both projects engage the idea of regenerating desired resources, like water, with bio-ecological means. The isolation and confinement in the polar region turn the frozen desert into ideal laboratory for space analogue study. In Arctic, Canada Space Agency (CSA) funded expansion of the McGill University's high Arctic station in 2005.[149] The enlargement of the station will facilitate future studies with space applications.

It was surely a debating subject whether Arctic stations are still needed after the cold war. With the downgraded military tension, the scientific frontier seemed to lose its momentum of expansion. In 2006, An article on Nature complained that automated meteorological stations transmit errored data and advocate for more "human touch" in Arctic.[150] Many manned stations were retired in the 1990s to cut cost; they were replaced by the auto-

Upper. The Biosphere 2 lab. Illustrated by Institute of Ecotecnics. Image courtesy of Institute of Ecotecnics. Biosphere 2: Project Overview.

Lower. Canadian Astronaut Chirs Hadfield onboard space station Mir. Photo by NASA. 1995. Image courtesy of NASA.

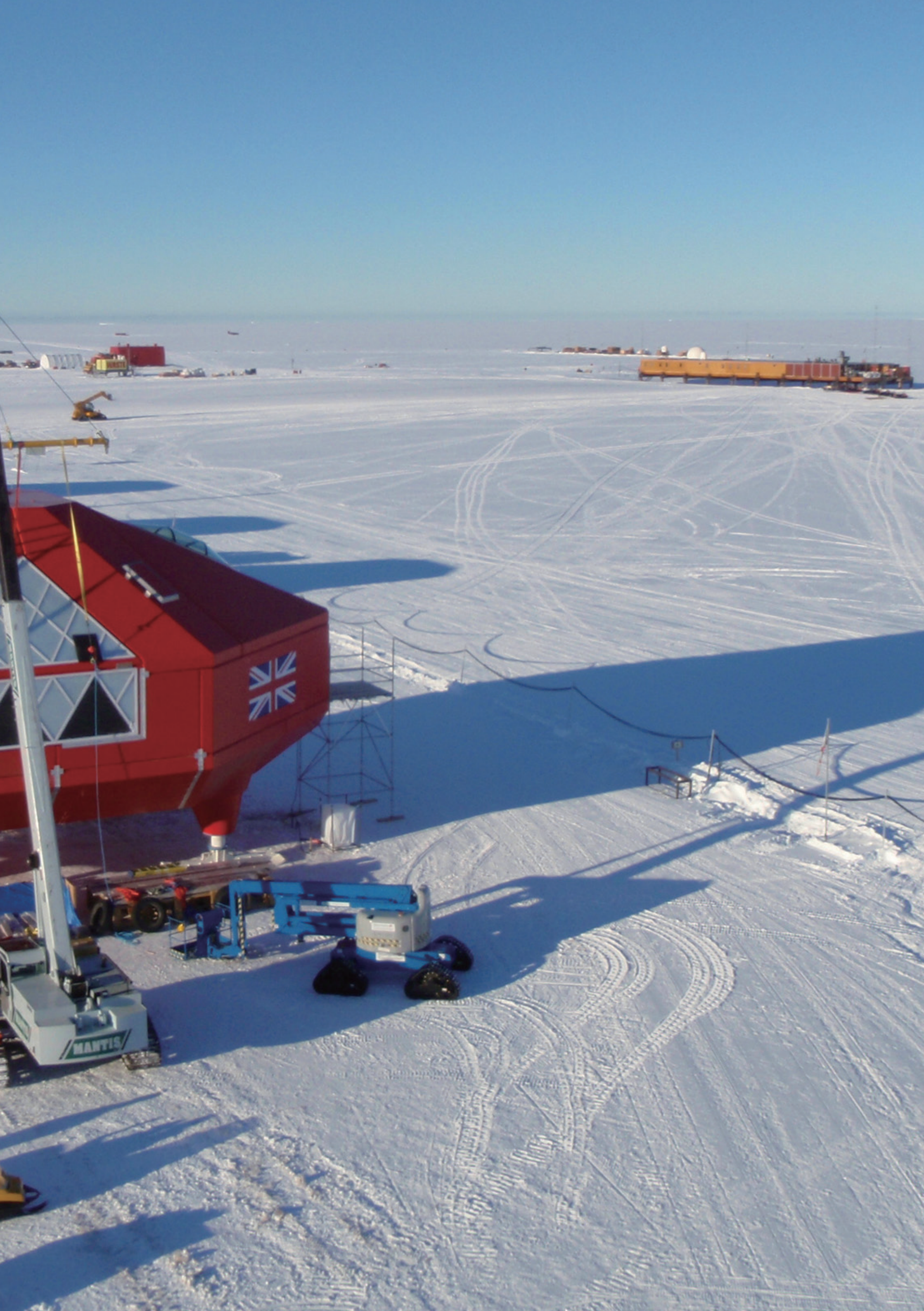




Upper. A von Braun space station. Illustrated by Chesley Bonestell. Image courtesy of *Collier's* magazine. March 22, 1952, 24-25.

Lower. Space shuttle Endeavor docking at the International Space Station. Photo by Dmitry Kondratyev, Cady Coleman, and Paolo Nespoli. May 23, 2011. Image courtesy of NASA. Archive ID: ISS027-E-036710 mated stations, which scattered around the vast North and remote to fix in case of malfunction.[151] If the 2004 Canada federal budget of $69 billion for Arctic seabed surveying did not raise any concern,[152] the Russian's flag planting on seabed of the magnetic North in 2007 must have surged some tension.[153] In 2008, the Arctic Ocean States, or A5 (Canada, U.S.A, Denmark, Russia, Norway) signed the "Ilulissant Declaration."[154] The countries agreed that the marine activities in Arctic will be carried out in accordance to the United Nations Convention on Law of the Sea (UNCLOS),[155] which was, ironically, not ratified by the United States Congress.[156] It seems that even in a prestige club like A8, there are more prestige smaller clubs like A3 and A5. With the broad background of globalization, there are forces in Arctic that resist globalizing the Arctic governance – except for Denmark, to which the Greenland is its only ticket to get into this club.[157] BAS team not only had a stop at the Falkland Islands on their way to Antarctic,[158] their Halley VI station was constructed on the overlapped territory claimed by the U.K and Argentina.

In space, China was catching up quickly to its predecessors. In 2007, Chang'e 1 probe was sent to the moon orbit, making China, again, the third place after the U.S.S.R and U.S.A to map the moon. One year later, China performed its first space walk. By this moment, China was undoubtedly an emerging space power. In April 2011, China launched its experimental space station Tiangong 1, two weeks later, the U.S. Congress passed the Wolf Amendment that legally banned to access the ISS by American congress,[159] though the two never docked in space anyway. The possibility for such an occasion, however, remains as China's docking hatch is compatible with the American standard.[160] The following years were the breath-catching period for the Chinese space program. It became the first country to reach the far side of moon. It


MANTIS

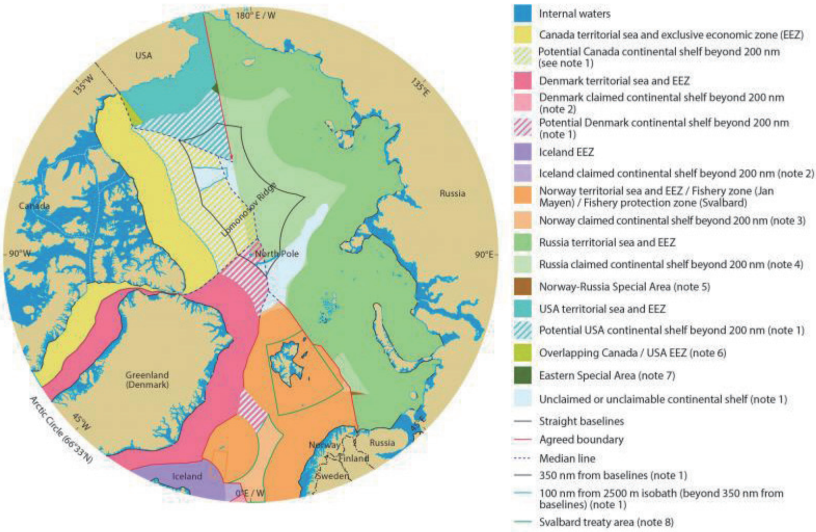
Upper. France-Italy jointly-owned Concordia Antarctic station. Photo by Stephen Hudson. January 29, 2005. Image courtesy of Stephen Hudson. Wikimedia commons.

Lower. Russian submarine plant a flag at the geo-magnetic North pole. August 2, 2007. Image courtesy of Reuters.

Left. Halley VI station with Halley V in the background. Photo by British Antarctic Survey. Image courtesy of BAS.

Arctic Monitoring and Assessment Programme

Arctic Climate Issues 2011



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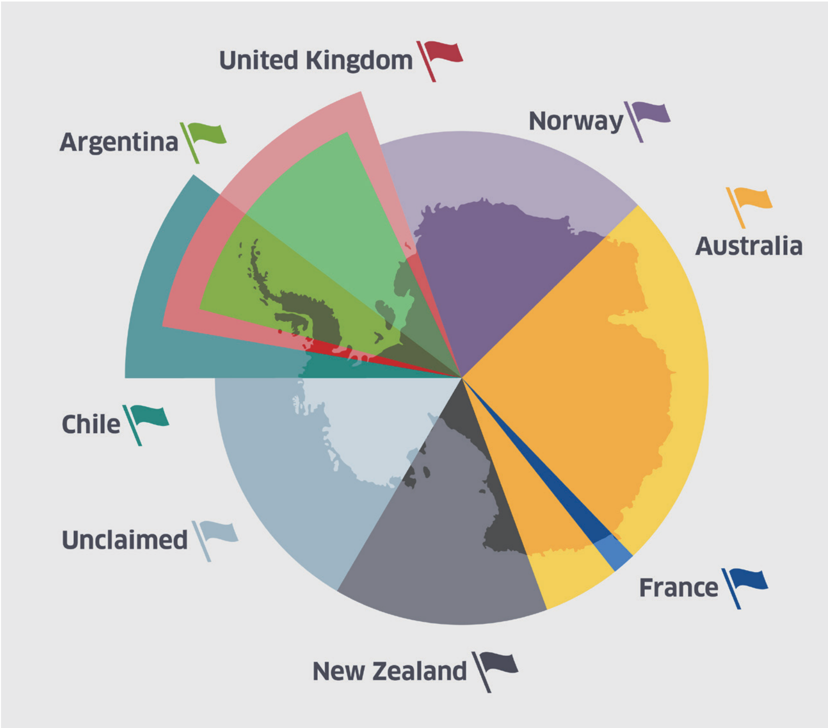
		Kingdom of Denmark								
	CANADA	DENMARK	FAROE ISLANDS	GREENLAND	FINLAND	ICELAND	NORWAY	SWEDEN	RUSSIAN FEDERATION	U.S.
MEMBERSHIP OF THE ARCTIC STATES TO MAIN RELEVANT ORGANIZATION										
Arctic Council *(AC)*	Member	Member	V	V	Member	Member	Member	Member	Member	Member
Arctic Economic Council *(AEC)*	Member	Member	V	V	Member	Member	Member	Member	Member	Member
Barents Euro-Arctic Council *(BEAC)*	Observer	Member	Member	Member	Member	Member	Member	Member	Member	Observer
Conference of Parliamentarians of the Arctic Region *(CPAR)*	Member	Member	V	V	Member	Member	Member	Member	Member	Member
European Economic Area *(EEA)*	X	X	X	X	X	Member	Member	X	X	X
Overseas Territories and Countries *(OTC)*	X	X	X	Member	X	X	X	X	X	X
Member State of the European Union *(EU)*	X	Member	X	X	Member	X	X	Member	X	X
The Group of Eight *G8* [1]	Member	Via EU	X	X	Via EU	X	X	Via EU	SUSPENDED [2]	Member
Ilulissat Declaration , *"Arctic 5"*	Member	Member	V	V	X	X	Member	X	Member	Member
Nordic Atlantic Cooperation *(NORA)*	X	X	Member	Member	X	Member	Member [3]	X	X	X
North Atlantic Treaty Organization *(NATO)*	Member	Member	V	V	X	Member	Member	X	X	Member
Nordic Council of Ministers *(NCM)*	X	Member	Participant	Participant	Member	Member	Member	Member	X	X
Northern Dimension *(ND)*	Observer	Via EU	X	X	Via EU	Member	Member	Via EU	Member	Observer
The Northern Forum *(NF)*	X	X	X	X	X	Member [4]	X	X	Member [5]	X
United Nation *(UN)*	Member	Member	V	V	Member	Member	Member	Member	Member	Member
UN-Security Council	X	X	X	X	X	X	X	X	Member [6]	Member [6]
UN Economic Commission for Europe *(UNECE)*	Member	Member	V	V	Member	Member	Member	Member	Member	Member
West-Nordic Council	X	X	Member	Member	X	Member	X	X	X	X

LEGEND

Member	Full member of the organization
Observer	The country can observe the works of the organization
Participant	Greenland, the Faroe Islands and Åland have had increased representation and more prominent roles in the Nordic Council of Ministers, with the same representation as the other member countries. They contribute to the work of the Nordic Council of Ministers. The Faroe Islands, Greenland and Åland can choose to adopt the decisions made in the Nordic Council of Ministers as permitted by their agreements on autonomy.
via EU	EU is member to the Organization. The State is therefore represented through the EU
X	Not a member of the organization
V	Member of the organization via Denmark

1 The Group of Eight (currently known as Group of Seven) G7
2 Russia has been suspended form the G8 over annexation of Crimea in 2014.
3 Only the 9 coastal counties of Norway
4 Only the munipiciality Akureyri
5 Chukotskiy AO, Kamchatskiy Krai, Khanty Mansiysky AO - Yugra Krasnoyarsky Krai (Chair), Magadanskaya Oblast, Nenetsky AO, Primorsky Krai, Sakha Republic (Yakutia), Yamalo-Nenetskiy AO Murmanskaya Oblast'
6 Permanent Member

ARCTIC PORTAL



Upper. Arcrtic territory disputes. Map by Arctic Monitoring and Assessment Program. Image courtesy of AMAP.

Lower. The tittles of Arctic States. Chart by Arctic Portal.org. Image courtesy of Arctic Portal. Arctic Cooperation: Overview.

Right. Arcrtic territory disputes. Map by Discovering Antarctica. Image courtesy of Discovering Antarctica.

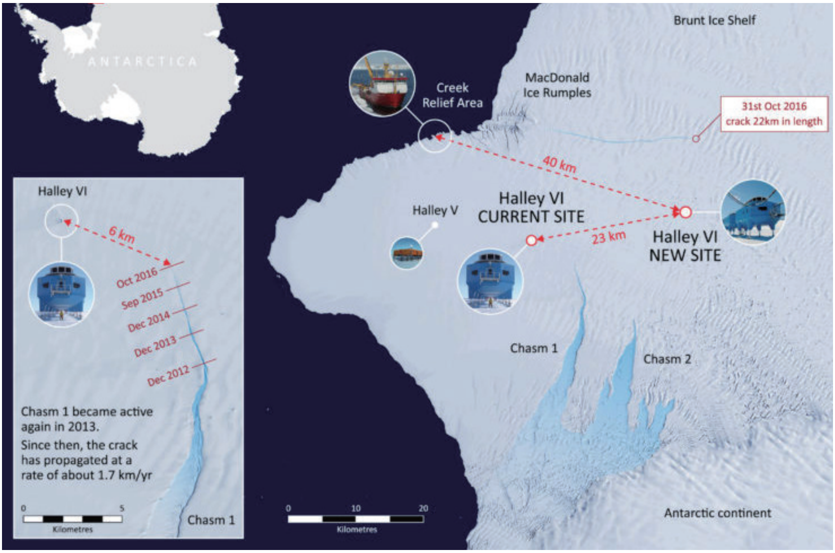
launched its space station Chinese Space Station (CSS) in 2021, and signed agreements with Russia two months later to build an International Lunar Research Station (ILRS).[161]

ESA has a growing interest in the CSS, and began to train astronauts together with China National Space Agency (CNSA) as early as 2017.[162] As for Antarctic, China held the 2017 Antarctic conference in Beijing, and its high-level science program has come to match those of the Antarctic states.[163] The fifth Chinese station was built in the Australian sector; it triggered the similar reactions like the Soviets did in 1956 – in 2019, an article was published on The Times that criticized the expansionism of China in Antarctic; it was written from Sydney, Australia.

The future of space and polar exploration will likely to follow the similar trajectory: International competition and cooperation occurring at the same time; military and political confrontation would persist in a subtle way; and that longer missions with larger crew can be anticipated. From the history we can see that architecture in those three domains have complicated from an outpost to settlement. This requires larger internal space and higher level of sustainability – economic sustainability in terms of the financial support to the mission, and material sustainability in terms

Upper. Halley VI's relocation within the overlapped territory of the UK and Argentina. Map by British Antarctic Survey. Image courtesy of BAS.

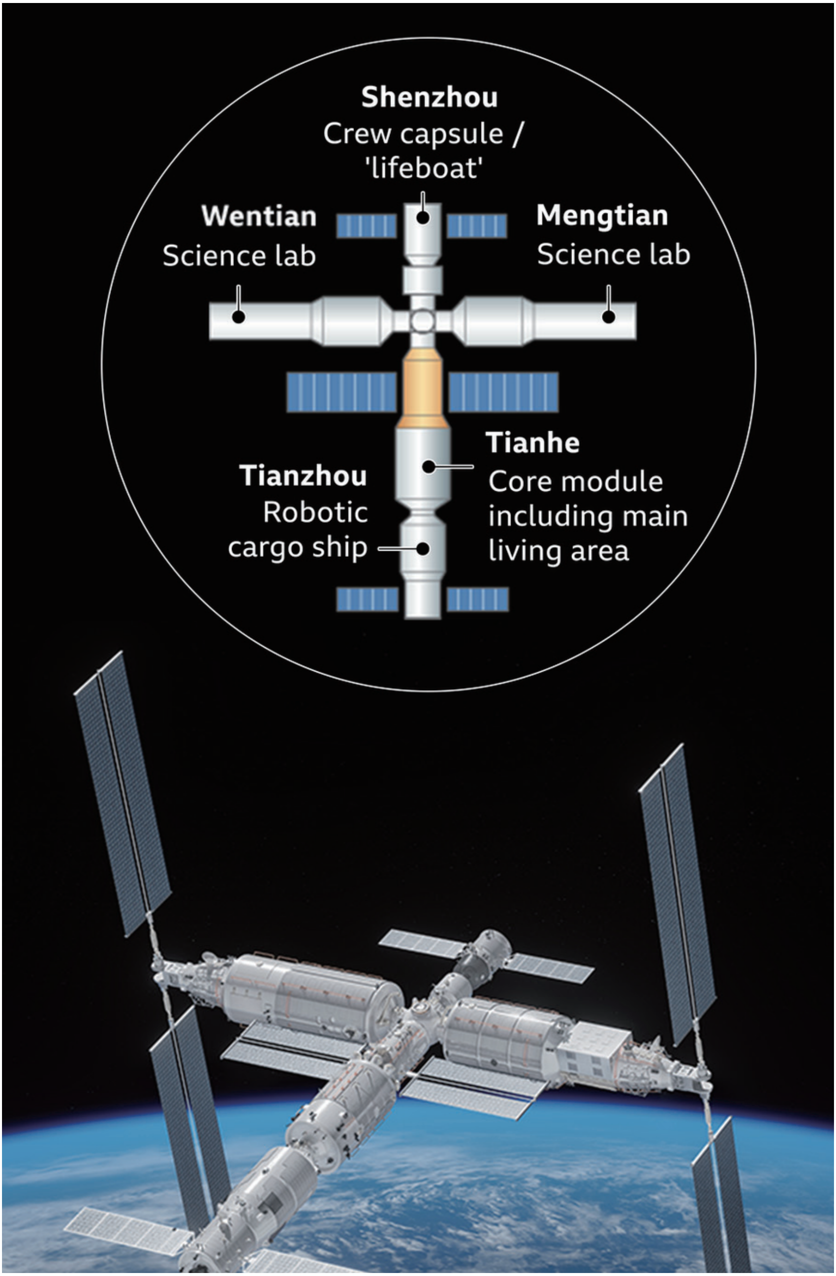
Lower. The *Times* newsreport on China's new Antarctic station. April 8, 2019. Image courtesy of Liu Shiping.



China's march across Antarctic raises fears of expansionism

of life-support in the extreme environment. Perhaps the international society will continue to distance space, Arctic and Antarctic away from severe geopolitical conflicts, but international governance will be contested with national interests. In addition, issues such as climate change and new challenger are believed to raise the level of uncertainty to the ecological, economical, and political balance. These places are never truly at peace but either anywhere close to wars. Cooperation or competition, everything happens in there mirrors the outside. They are far from being fully tamed, but they pushed us to break the limits.

The structure of Chinese Space Station, also known as Tiangong Station. Illustarted by BBC. July 26, 2022. Image courtesy of BBC.


Shenzhou
Crew capsule / 'lifeboat'
Wentian
Science lab
Mengtian
Science lab
Tianhe
Core module including main living area
Tianzhou
Robotic cargo ship

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Pushing Architecture to A Limit

Imagine you are working in a place where, while perfectly comfortable indoors, you have to wear special protective clothing if you want to go outdoors. A place that is cut off from the outside world for about eight month of a year, where all your needs have to be delivered by a ship that arrives just twice in the brief summer season, and where the building that you inhabit is not only your home but is all that stands between you and near-certain death. [1]

---- *Ice Station*

Those are words to picture a typical architecture in Antarctic; but considering replacing the word “summer season” with “launch window” and removing the word “near,” the paragraph will perfectly diptych a space station. Giving the equally harsh conditions for human to survive, architectures in outer space and polar regions must endure the similar physical challenges: coldness, remoteness, and minimal productivity; if more, the construction difficulties. As the technology of transportation and life-support has advanced greatly since the early days, current missions and expeditions demand a lot more than merely staying alive. Since the second phase, living is no longer a top priority of the crews but the foundation for the tasks carried along – usually science experiments. Stations will have to incorporate working areas, and explicit equipment will require a specific design and solution. Longer stay and larger crew seem to be the goal for future missions, especially when planning a flight to Mars and overwintering in the poles. While a round trip to moon is scheduled in a matter of days, that of Mars could take months or even years. Prolonged day and night are proven to disturb the human biology, and psychological stress can induce negative impact to the mission. The design principle of architecture in polar regions and space is contradictory to itself: the minimal weight and space is needed to save transportation cost, but it shall also accommodate as many functions as possible for the tasks and contingencies.

Such a design philosophy has engendered some habitations with highly integrative design and spatial efficiency. The space capsules, perhaps, are fine examples to reconciliate such ambivalence: With amenities encapsulated in a cozy room for living and working, a lonely explorer roams in the middle of nowhere. Certainly, the capsules are only the preliminary approach, as now we are seeing stations transforming from outposts to settlements. Considering the recent trends of architectural studies, criteria of sustainability should also be added to the equation. Economic sustainability should be considered to propose and articulate the mission; environmental sustainability (or material sustainability) determines the life-support and living environment for the crew; and cultural sustainability can be vaguely interpreted as psychological integrity of crew member. It is noted that human functions differently from the machines in those forsaken places; thus, the human factor should be taken into account. Since the 1990s, more studies have focused on mental condition of people in space and polar regions. The term ICE was dedicated to attribute the living conditions as: Isolation, confinement, and extreme environment.

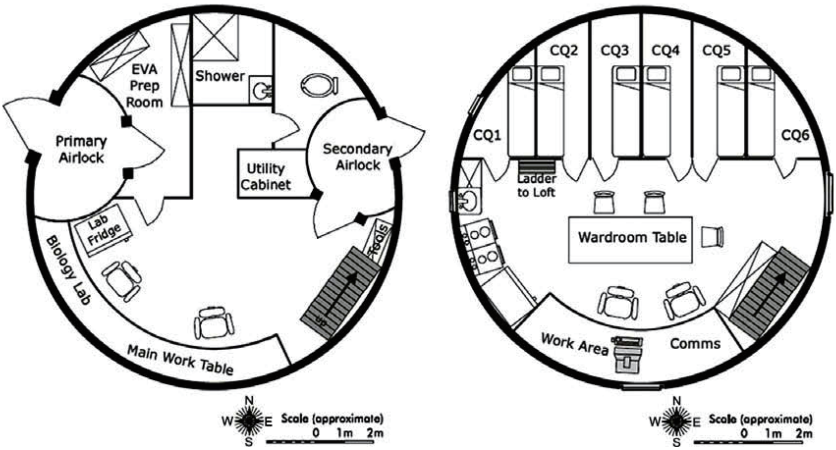
In 1972, when Nagakin Capsule Tower was revealed to the public, it attracts international attention by the bizarre look and novel concept. Arguably an architectural masterpiece, the capsule tower demonstrates a look of the soul retreat in a vast ocean of collectivism. The Metabolist sensation of Japanese society phased out quicky, its demolishment in 2022 began with dismantling its capsules: Some of which will be sent to museums. Yet the capsules' portability suggests, if not recalling the Salyut station, two separate sets of architectural challenges of a successful mission in the extreme environment – first, one has to get there; and second, stay there.

This section will, therefore, be arranged according to the division of those two tasks. A number of architectural designs and lessons will be discussed alongside the trace of technological development. The first part of "getting there" will discuss the construction of habitats, means of life support, and transportation. The second part of "staying there" will focus on mental health and resupply.

Going There, Staying Alive, Coming Back

It is without any doubt that neither space nor North/South poles could provide local material for the construction of the station, at least not for explicit equipment and long-term living. A station will be divided into smaller parts and built in the home country; and the components will then be sent to the destination for final assembly. This opens up the opportunity for modular design, where desired function can be added to the structure in future. The modular design assures great flexibility which not only enables expansion of the structure, but also potential rearrangement of the functions. The cost of transportation is significantly lowered by sending the parts of a station. Salyut and Skylab were launched to space in only one module – the mission was simple: to test whether space station is feasible. It was not until the end of the 1980s human first launched the modular space station that extended the horizon of space habitation to long term stay. The early space stations only support living for nearly a month,[2] while the Russian cosmonauts onboard Mir station stayed long enough to begin worrying if their ground control have forgotten them at all. The BAS' Halley VI station adopted modular design as well. The architect, Hugh Broughton, assigned specific service to different modules – some of which are repetitive, such as sleeping and generator. Halley VI now comprises in total of eight modules, three modules less than the original design.[3] Its construction was commissioned in the UK and South Africa. Components were assembled together into modules for testing purpose; and the modules were then disassembled again for transportation. The individual component must not exceed nine tons due to the weight limit on the edge of iceshelf.[4] On the ISS, modules come from many different countries such as the US, Russia, Europe, and Japan.[5] They were built with different objectives and technical specifications, yet the connections in between, namely docking hatches, are standardized for the final assemblage.[6] The connection between the modules, by definition, must integrate the separate systems into a complete whole. The docking mechanisms were developed since the 60s and it was achieved by soft capture and hard capture. The soft capture between spacecrafts aligns the docking hatch of the two, and the hard capture enables the connection of the electricity, command, and pressurized passage.[7] For Halley VI, the modules are linked with Trelleborg connections,[8] the technology borrowed from trains. The soft connection on Halley VI creates a conditioned space in between, while the hard connection beneath the floor allows the exchange of electricity and other circular. On the ISS, participant countries contribute modules of varied functions: Kibo of Japan, Hubble of America, and Columbus of Europe.[9] To enable the docking of modules that subscribe to varied technological specifications, adaptors were installed to fit openings of different countries.

Dwelling in polar regions and space is a self-conflicting mission: designer must promote the habitat's sustainability in the fundamentally unsustainable environment. Coldness, isolation, and lacking of productivity mandate a degree of closeness: Structurally and culturally. This is best described by Paul Meuser in his book Moon: Architectural Guide as "introverted architecture,"[10] where he explained "Inside the buildings, there is a claustrophobic labyrinth of corridors and airlocks; outside, there is an oversized city structure that is always shown without any people."[11] It captures two main features of the extreme architectures in the forsaken domains. The first is airlocks that stands between habitable and hostile world. It is the outmost reach of both, and it enabled a rational environmental control of the inside. Second, it reveals that the minimalist exterior is always compensated by the highly integrated interior. In



Upper. FMARS2007 Expedition site.

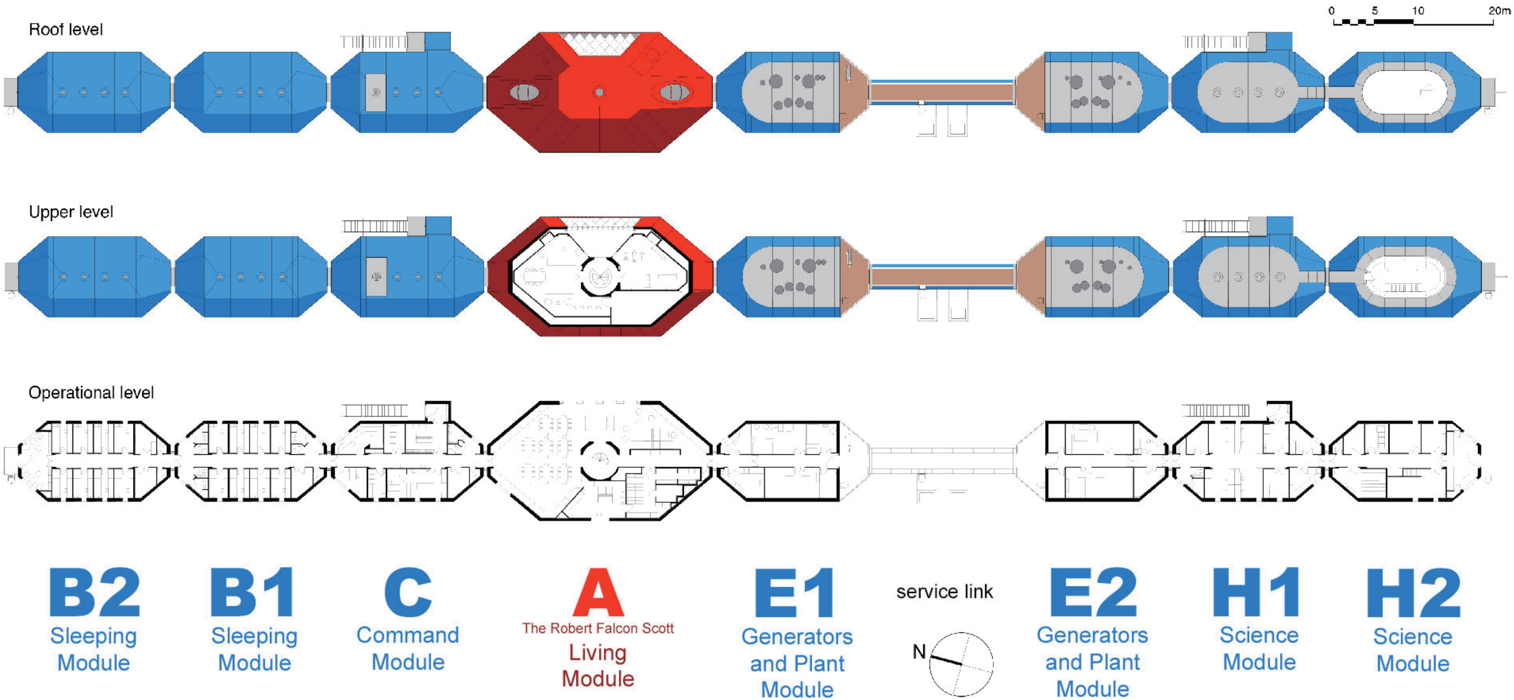
Lower. FMARS2007 Expedition pod floor plan.

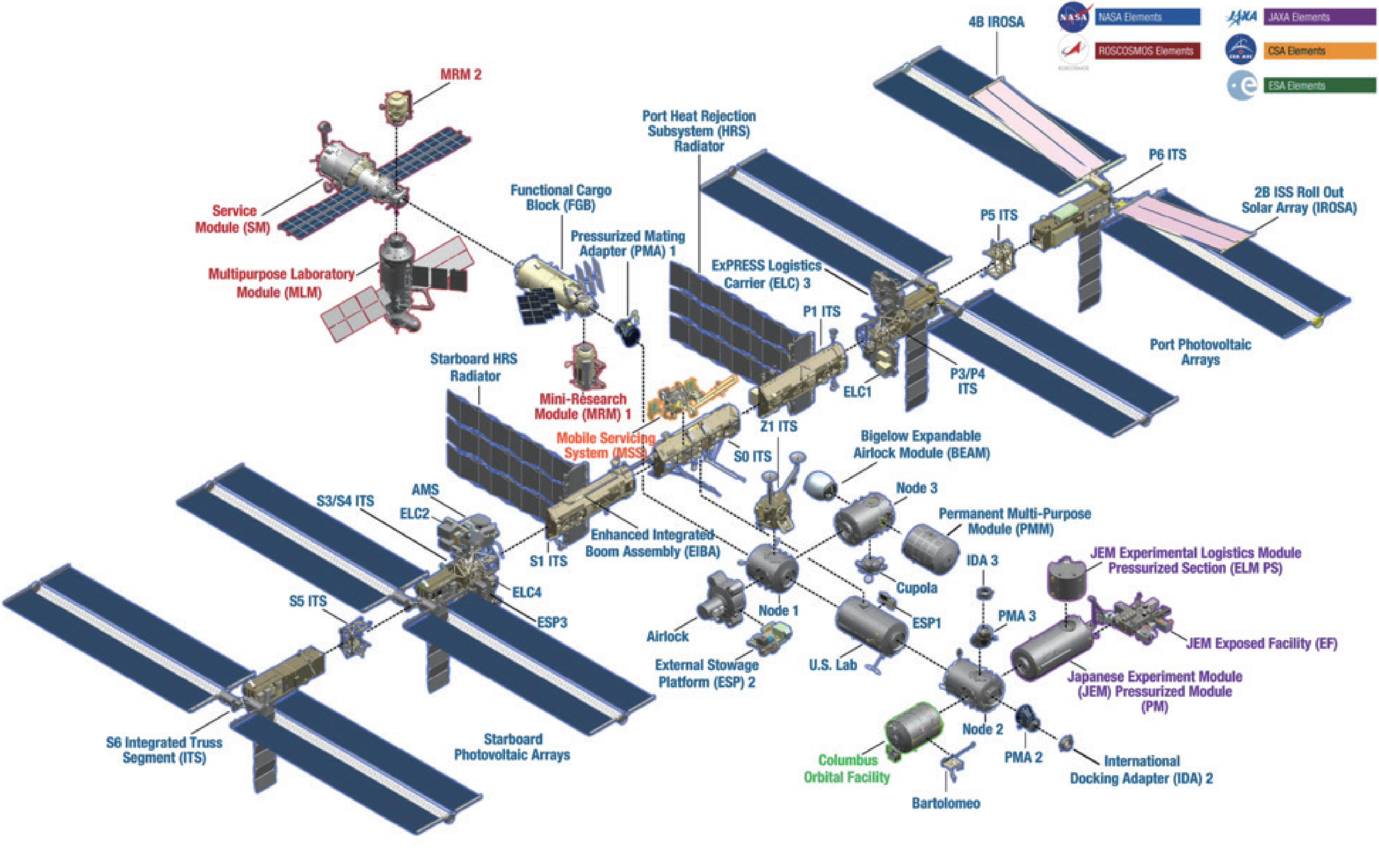
Created by M. Bamsey, et al., in "Four-month Moon and Mars crew water utilization study conducted at the Flashline Mars Arctic Research Station, Devon Island, Nunavut," *Advances in Space Research* 43 (8): 1257.

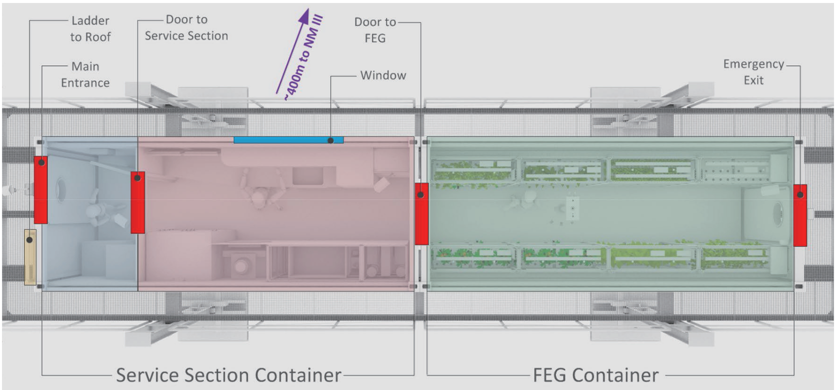
term of the furniture, the compact design inside the habitat exploits the potential of every inch by means of folding. Systems and subsystems were arranged in a particular manner to allow the circulation of matter. Especially for air and water: These most essential resources are expected to go through two stages of processing, one by human body, and another by the mechanical infrastructure. From breathable oxygen to carbon dioxide and from fresh water to wasted water, a station is expected to discern types of gas and liquid by means of piping. On the ISS, used water can be purified and became drinkable again.[12] In Antarctic, the British Halley VI had its service amenities beneath the floor and above the ceiling. It should be noted that close loop is not usually the requirement for space and polar stations, even though it is highly preferred. Many stations nowadays have a semi-closed flow of matters. Halley VI melts snow for drinking, and the wasted water will be collected and treated in a special tank.[13] To minimize the water usage, the station incorporated special shower mechanics and vacuum drainage that achieved one eighth of per capita water consumption of normal European homes.[14] Similarly, the crew of FMARS2007 expedition in Arctic also had to collect water from nearby lake and ephemeral streams.[15] On the ISS, the water and food were ferried to the station, and human waste is either discharged into space or sent back to Earth.[16]

Harnessing the flow of matter is one set of challenge, securing the energy supply is quite another. Stations in the isolated environment must be prepared with contingency plans in case of black out. Hostile surrounding of the technosphere draws equivalency between energy supply and life support. In the instance of the forementioned EDEN ISS, the designers require at least two back-up units installed to the station if such a portable greenhouse is to be realized in the future. Four-hundred meters North

Halley VI Research Station - Layout




NASA Elements
ROSCOSMOS Elements
JAXA Elements
CSA Elements
ESA Elements
4B IROSA
MRM 2
Service Module (SM)
Multipurpose Laboratory Module (MLM)
Functional Cargo Block (FGB)
Pressurized Mating Adapter (PMA) 1
Port Heat Rejection Subsystem (HRS) Radiator
ExPRESS Logistics Carrier (ELC) 3
P1 ITS
P5 ITS
P6 ITS
2B ISS Roll Out Solar Array (IROSA)
Port Photovoltaic Arrays
P3/P4 ITS
ELC1
Starboard HRS Radiator
Mini-Research Module (MRM) 1
Mobile Servicing System (MSS)
Z1 ITS
S0 ITS
Bigelow Expandable Airlock Module (BEAM)
Node 3
Permanent Multi-Purpose Module (PMM)
AMS
S3/S4 ITS
ELC2
S1 ITS
Enhanced Integrated Boom Assembly (EIBA)
ELC4
ESP3
S5 ITS
Cupola
IDA 3
JEM Experimental Logistics Module Pressurized Section (ELM PS)
Node 1
Airlock
ESP1
PMA 3
JEM Exposed Facility (EF)
External Stowage Platform (ESP) 2
U.S. Lab
Japanese Experiment Module (JEM) Pressurized Module (PM)
S6 Integrated Truss Segment (ITS)
Starboard Photovoltaic Arrays
Columbus Orbital Facility
Node 2
PMA 2
International Docking Adapter (IDA) 2
Bartolomeo



Upper. Internal structure of Neumayer Station III. Created by Alfred-Wegener-Institute. Image courtesy of AWI.

Lower. The inside of EDEN ISS. Created by Volker Maiwald, et al., in "From ice to space: a greenhouse design for Moon or Mars based on a prototype deployed in Antarctica," *CEAS Space Journal*, 13 (1): 18.

Left. Halley VI's Modules. Created by Hugh Broughton Architects. Image courtesy of Hugh Broughton Architects.

Right. The International Space Station's modules. Created by NASA. Image courtesy of NASA.

of the EDEN ISS, its commanding body, Neumayer station III incorporates varied sets of power supply. Three out of four diesel generator was used in normal occasions, while the last one is only used as emergency backup.[17] The use of diesel engines will be substituted by wind turbines in the years to come. On Halley VI, two sets of generator modules are added to the complex to maximize the chances of survival. Some temporary stations in Arctic also have two mutually independent mechanical systems for fire prevention – the station is likely to rely on its own for days before any rescue. The essential idea of safety redundancy is to increase tolerance to system malfunctions, whether induced by human error or mechanical failure. At the New Zealand’s Scott base, a waste-fueled heating system is added to the complex with other independent backup power sources.[18] Nowadays in Antarctic, a lot of stations are equipped with an emergency power plant that only starts in the blackout to earn a few hours for people to bail out. It is not just the power system, though, needs extra back-up, other systems should also be designed to handle a range of misalignment. In 1997, a failed resupply mission at Russian Mir almost destroyed the entire station. A cargo ship was guided and operated manually from Mir, giving that docking technology was owned by Ukraine after the disintegration of the USSR. The collision caused catastrophic leak in the module, and sealing the leak is involves disconnecting the power cords.[19] Cutting off the power supply to the gyroscope caused the station to spin out of

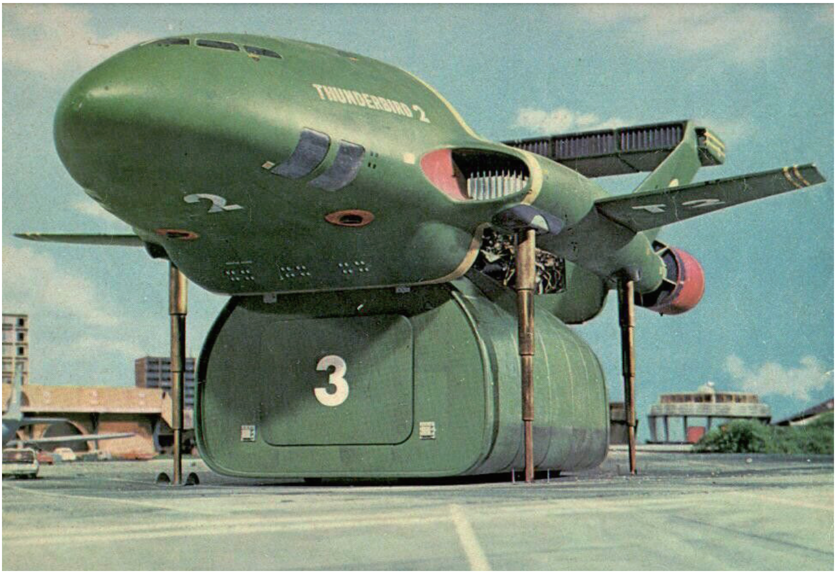
Upper. Rendering of the redeveloped New Zealand Scott Station in Antarctic. Image courtesy of Hugh Broughton Architects.

Lower. Installation of back-up generators of Halley VI station. Image courtesy of BAS.

control – the crew managed to bring Mir back to relative stability by using onboard engine, but how often can such a miracle be replicated throughout the history? The U.S has a different, if not opposite, philosophy of redundancy from Russians: A certain system must not fail.[20] While the American engineers struggle to prove their device is safe, the Russian engineers could relax as they are only asked to prove their device not safe.[21] At NASA, they have a famous saying that "Failing to plan is planning to fail;"[22] although it is quite suffocating that the total control to details could not eliminate all hazards, it is still worth awhile doing something than waiting to see what could happen in the middle of nowhere. It is the American principle that currently dominates the ISS in terms of temperature and atmosphere control.[23] This requires multiple backup units to achieve, and it comes at a cost of increasing payload. Alternative solutions such as regenerative processing of water and air is considered for a more sustainable mission.

Although it remained seemingly far-fetched to build a Mars colony nowadays, many proposals, as well as science fictions, have already produced a common picture of a streamlined outpost in the hostile desert. The Mars environment is indeed comparable to North and South poles in terms of the storms.[24] [25] Sands will likely to accumulate on sides of the building and render the entire structure inaccessible. Replacing "sands" with "snow," one can imagine the challenge of a typical station in the polar region on Earth. When Hugh Broughton and Michael Wright teamed up for Halley competition, they were given a booklet named "Lesson Learned" to gain insights of the previous success and failures in British Antarctic expeditions.[26] Drifting snow is one of the eternal hazards in Antarctic, which can pile up to 1.2 meters per year.[27] The first of the franchise, Halley I, was used for a decade before it was buried under snow.[28] The crew must find their way out from windows. Halley II was designed with drifting snow in mind by adding reinforcement to the structure, but later it was proven to be vulnerable compared to snow weight.[29] The station was only occupied for 6 years. Halley III was designed to be buried under the snow, but the poor thermal insulation of the walls causes the snow to melt and freeze, and thereby distorting the structure.[30] Halley IV solved the thermal problem by adding interlocking wood panels on the roof, which was damaged by wind.[31] Halley V was built on a platform with adjustable height, thus completely avoided snow accumulation; the issue is that the iceshelf it was anchored on is shifting towards the sea. Based on the previous experiences, BAS wanted its next station to address the snow, wind and iceshelf problem. Halley VI inherited the adjustable pillars from Halley V, and there is a ski at the bottom of each pillar so the module can be towed by bulldozers. The shape of the modules, inspired by *Thunderbird 2*,[32] encapsulated the amenities in an aerodynamic manner to allow the snow to bypass the station instead of blocking its doors. In this sense, wind tunnel has been used to test the performance of the New Zealand's Antarctic station, which was designed by Hugh Broughton, after his victory of Halley VI. Canada Space Agency commissioned a Mars analogue mission in its far North in 2007, and the station was shaped to be a cylinder, like the Concordia stations in Antarctic – both had a tremendous alleviation of wind pressure. There are different approaches to tackle drifting snow. The National Science Foundation Office of Polar Programs (NSF-OPP) funded the construction of a station that can be dismantled and relocated on a biennial basis to avoid snow blockage.[33]

But back to Mars or moon, the cylindrical shapes is perhaps a delightful byproduct of rocketry. Round edge is deemed most desirable for containing a pressurized internal: The pressure is expected to be identical along its periphery. On the other hand, the launch of rocket or station modules must consider Earth atmospheric condition, the maximal use of the cylindrical space inside the heat shell is, by definition, a cylinder, too. The EDEN ISS experiment has paved the way for future space planation, and the designers have proposed a greenhouse mounted in a launch envelope provided by NASA.[34] In the 1950s and 60s, both American and Soviets have serious study of their moon base. Both *Project Horizon* and Zvezda (also called Barmingrad by Glushko),[35] employed cylindrical modules, buried or exposed. The later was planned with 9 inflatable



Thunderbird 2 and its iconic extendable legs. Image coutesy of scalemates.com

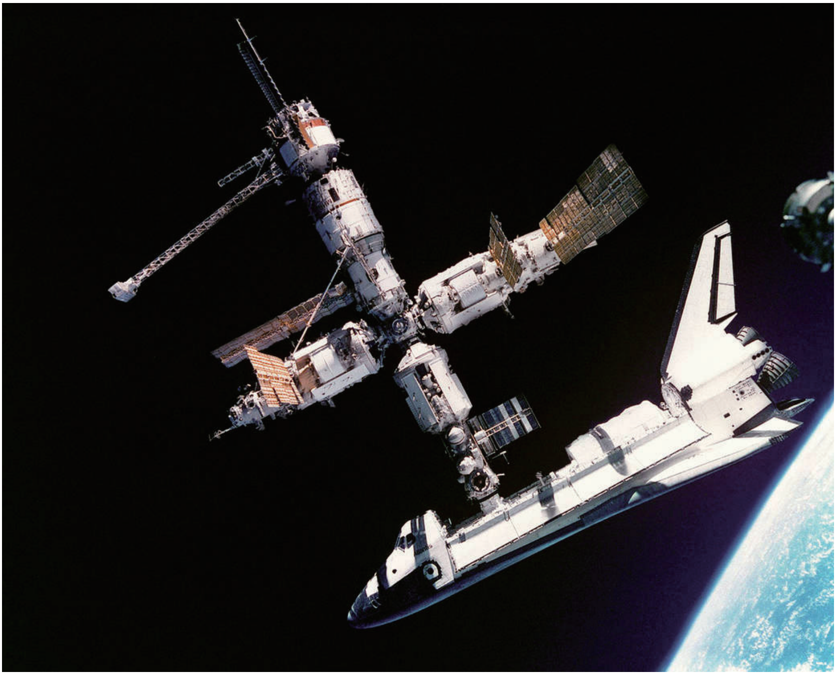
Upper. Halley I station (1956-1968). Photo by George Hemmen. January 1957. Image courtesy of BAS. Archive reference: AD6/19/3/C/Z6

Lower. Halley II station (1967-1973). Photo by maurice Sumner. circa 1967. Image courtesy of BAS. Archive reference: AD6/19/3/C/Z25

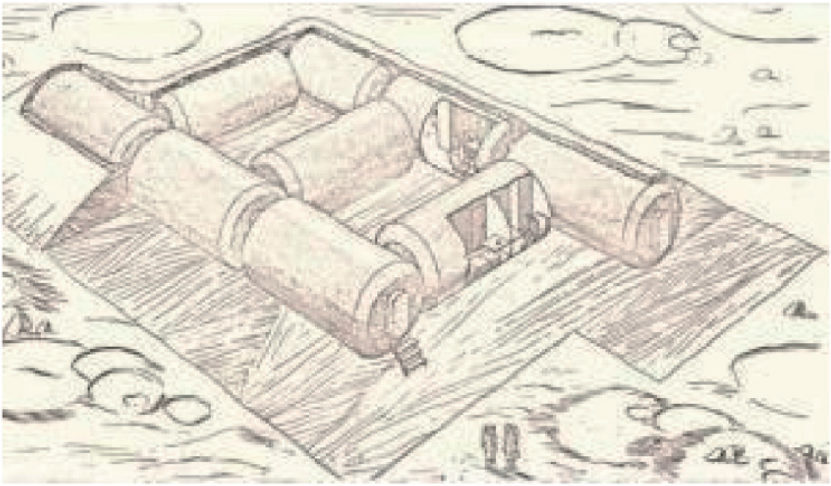
Upper. Halley III station (1973-1984). Photo by Andrew Alsop. Image courtesy of BBC. "Halley VI: Dropping in on the British Antarctic Survey," March 4, 2016.

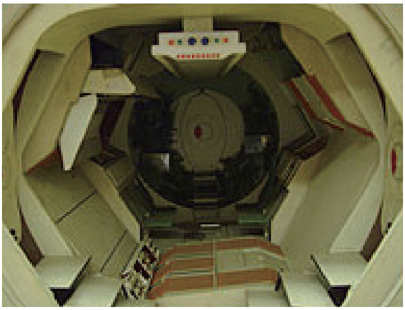
Lower. Halley IV station (1983-1993). Photo by Doug Allan. 1985. Image courtesy of BAS. BAS image library ID: 10004222.

Halley V Station (1993-present).Photo by David Maxwell. Summer, 1989. Image courtesy of David Maxwell and Cool Antarctica.com



The Soviet/Russian Mir Space Station. Photo by NASA. June, 1995. Image coutesy of NASA.





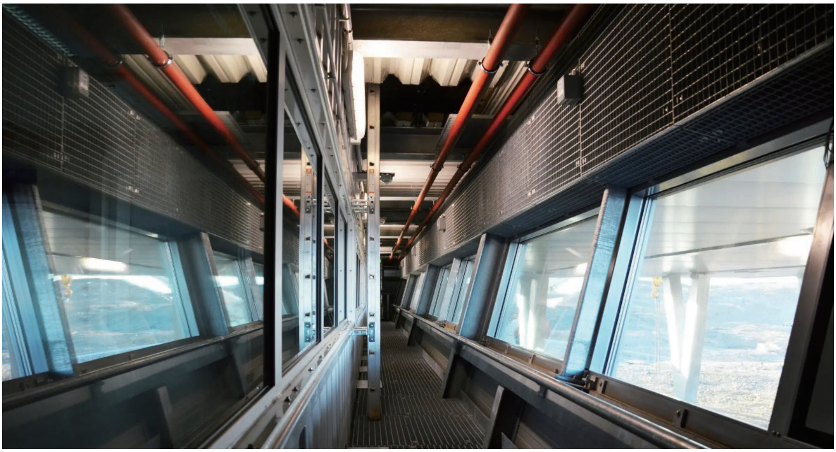
Upper. Sketch abou the moonbase Zvezda. Imgae courtesy of Barmin Design Bureau of General Engineering.

Lower. Mock-ups of Zvezda moon base in Russia. Photo by Anatoly Zak. Image courtesy of Russian Space Web.com.

modules with a radius of 3.3 meters, the compressed air would be injected into the 4.5-meter-long module to reach a final length of 8.6 meters.[36] The "sandwiched" wall consists alloys on the both ends and a layer of foam in between to keep their cosmonauts safe from radiation, heat, and meteoroids.[37]

Smaller vehicle is another feature of a station, though they were usually overshadowed by the main architecture. These vehicles are necessary in the cases such as scouting, transportation, and even emergency evacuation – it is hardly economical to bet all the money on safety. In the Arctic, the FMARS2007 expedition crew uses snowmobile to collect liquid water for daily use.[38] To retrieve samples further away from the landing site, Apollo 15, 16, 17 all carried a lunar rover folded in the spacecraft.[39] Neumayer III station is sitting on the giant pit excavated in the snow; the pit is covered by a roof on the ground level. A ramp is paved out of snow for accessing the garage, and the exit is controlled by a lid. The vehicles are valuable assets and they must be protected from the harsh conditions. Neumayer III station's garage hosts ten snowmobiles and other specialized machinery for disposal.[40] Although Halley VI does not have an underground parking lot, separate garages were built on ground. Most interestingly, Halley VI even has a flight control tower that coordinates the air traffic nearby. The ISS followed Mir design by preparing Soyuz capsules as lifeboats. They are used in cases of emergency medical condition – or other critical situations like the time when Mir was caught on fire due to its peculiar way to generate oxygen. Space shuttles used to be the way to bring astronauts back home before the final decision to decommission them all: This left the Soyuz the only reentry vessel before the Dragon spaceship. Furthermore, integrating means of transportation to the structure might be an option to save cost. The ISS used the unpressurized Progress cargo ship as one source of repositioning and maneuver.[41] On the ground, the Bharati station of India recycled ship containers that arrived with the component. A big portion of the station was built from the metal sheets cut from the containers.[42]

The under-snow garage of Neumayer Station III.Photo by Reinhard Sibberns. circa 2009. Image coutesy of AWI.



Upper. Indian Bharati Station in Antarctic. Image courtesy of National Center for Polar and Ocean Research.

Lower. Note the container panel inside the station. Image courtesy of The New York Times.

The Progress spaceship are used as an engine of the ISS. Photo by NASA. April 12, 2021. Image courtesy of NASA. Archive ID: ISS064-E-057795

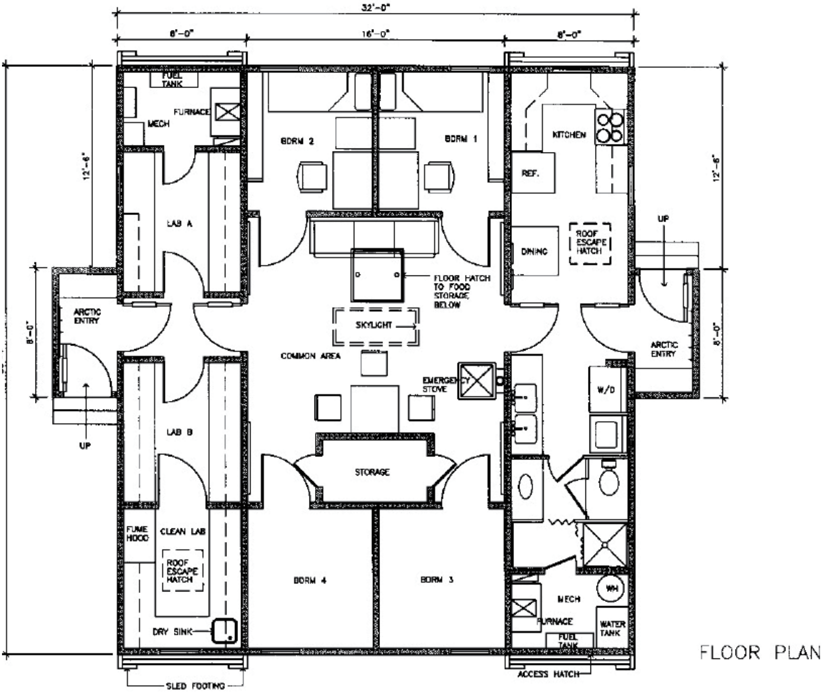

ПРОГРЕСС
Ю.А. ГАГАРИН

Living Is Not Surviving

The material aspect of living – or at least prolonged stay – in the extreme environments have been studied to a great deal, and the shadow kingdom of psychology is visited more often in the recent years to study the behavioral change in the confined environment. The earliest notes on such a matter can be traced back to the heroic age of polar exploration. Documents from the early twentieth century often describe a fearful situation which one is not stranded alone, but with the others.[43] The social pressure was enormous by realizing "I am trapped with other people and there is no escape." Diaries from the early polar expeditioners were used to study this phenomenon: Richard Byrd, the American Antarctic hero wrote that the small details like chewing food for a number of times before swallowing it can drive people insane.[44] Psychologists called it "irrational antagonism" while experienced travelers call it "polar cholera."[45] The emotion of desperation in the confined habitat is contagious, and without further interference, the mission will likely end as a failure, or worse, a disaster. Fortunately, researches have isolated the stressors such as restricted mobility and the lack of privacy: Specific environmental design can neutralize these stressors to an extent. Another major cause of psychological stress is sleeping disturbance. The lengthy day and night in polar regions had profound impacts on the crew's sleeping cycle. ESA sponsored an analogue study of sleeping at Concordia station. Shortened and fragmented sleep led to fatigue and raspatory disorder.[46] If not taking account of breathing issue, which is likely induced by high altitude of the station's location, weakness could compromise the one's ability to evaluate the situation and respond in a sensible way. The past experience and neuro-imagery have revealed the considerable level of degradation in the crew's cognitive performance, and adverse symptoms can last up to six months postflight.[47] An extended duration of stay in space and polar regions is also a prolonged battle between architectural design and human defects – the human body is not designed for those extreme domains in the first place.

To overcome the sleeping disturbance, Halley IV has its lighting scheme dedicated to simulate the normal day and night.[48] Its sleeping cabins can accommodate two people, but during the overwintering session, only one people would occupy the room to assure privacy.[49] One stress reliver that was tested effective is the possibility of personalization. In the NSF-OPP sponsored Arctic exped-ition, the four participants reflected a degree of confine-

Double bunker inside the living quater of Halley VI. Photo by James Morris. Image courtesy of Hugh Broughton Architects.



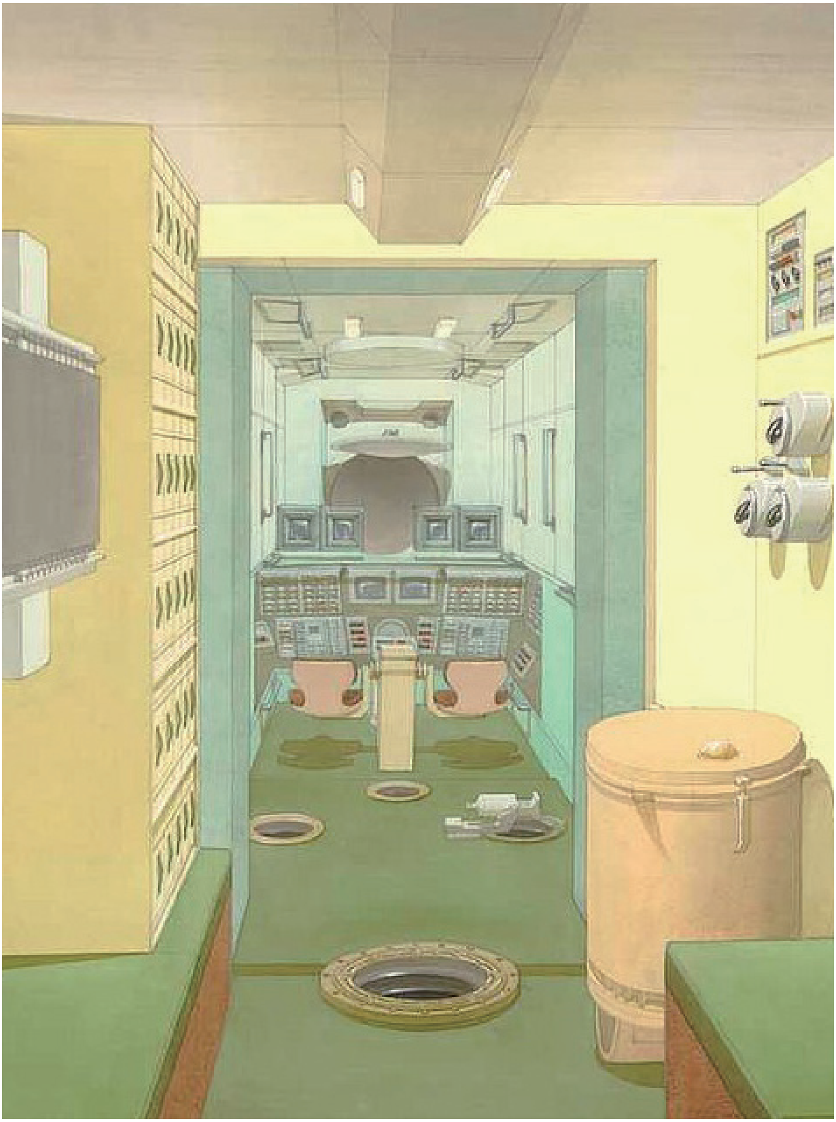
NSF-OPP 1997/1998 Arctic Expedition site, floor plan. Created by Xiaoying Winston Yan and Marijane E. England. Image courtesy of Xiaoying Winston Yan and Marijane E. England. “Design Evaluation of an Arctic Research Station: From a User Perspective.” *Environment and Behavior* 33 (3): 455.

ment in the beginning, but later it was less reported when they started to create their own handicrafts or furniture. [50] The metal wall surely causes a degree of anxiety for its implication of containment. Decorating the station could therefore nurture a feeling of home and, more importantly, a sense of control. Privacy or personal space is crucial to promote the sense of security because it provides one with a retreat from social interaction. Better sound insulation and adjustable lighting can help to create such a personal space. In the end of the study, some over-winter occupants expressed a degree of satisfaction to architectural design because it is “a home away from home,” something Galina Balashova wished to build for the Soviet cosmonauts.

As a trained architect, Balashova always holds a unique view on space settlement than her engineer colleagues. She was assigned the job to design the interior of the Soyuz capsule by Korolev in the early 1963.[51] Balashova formulated the idea that a successful space architecture is the one that provoke the feeling of Earth living, and that is what the Soviet did when she was appointed the head architect in OBK-1.[52] It should be pointed out at this point that, even though extreme architectures are works of fine engineering – and conventionally regarded as mechanical or mathematical task – the needs of architect’s gesture could make a difference between “surviving” and “living.” As the Soviet’s first space architect, also a highly ranked female architect, Balashova has the sensitive understanding of spatial interaction and orientation,[53] something that is not mandatory for an engineer. The trick she applied is using different colors in the interior of spacecraft to give the cosmonaut a sense of direction or up and down. It was revealed many years later that spatial cognition is vulnerable in the micro-gravity condition, and this defect would jeopardize the mission by compromising the astronaut’s ability of complex way-finding. Using colors

The early design of Soyuz capsule. Created by Galina Balashova. Image courtesy of Galina Balashova.

The later design of Soyuz capsule. Created by Galina Balashova. Image courtesy of Galina Balashova.



The design of Mir Space Station cockpit. Created by Galina Balashova. Image courtesy of Galina Balashova.

Upper. Mir Space Station cockpit. Photo by NASA. January 19, 1997. Image Coutesy of Digital Public Library of America. Archive code: S81E5634 - STS-081 - Interior views of the Mir space station Base Block module

Lower. Chris Hadfield plays guitar on Mir station. 1995. Image courtesy of NASA.

to rationalize the living space is also applied on Halley VI: its eight modules are each subscribed to a color to ease the process of spatial orientation. Blashova, on the other hand, turned out to the be only architect in OBK-1, and she was marginalized after the death of Korolev in 1966.[54] Nevertheless, the color scheme was used on Soyuz capsule, Salyut station, and Mir station. The cosmonauts were pleased with the color, and so were the Americans during the Apollo-Soyuz docking: compared to the tin-can they operate, the small Soyuz looks like a hotel.[55] Balashova had engaged in the designs of the Soviet's lunar program

The Astronaut exercising on a treadmill while strapped. Photo by NASA. Image courtesy of NASA. Archive ID: ISS032-E-01170.

which died out due to the failure of rocket technology, and Balashova's lunar module was thus never realized. Green color is perhaps one of the icons of the Soviet spacecraft, New Zealand also introduced its icons in Antarctic. The New Zealand Scott station, designed by Hugh Broughton, included Maori decoration that promote its cultural and natural heritage in the middle of white desert.[56]

Gym equipment might become a desired feature of the longer missions in the extreme architecture. Unlike living back home, the demand of physical exercise cannot be simply satisfied by jogging around the station. The heavy outfit will make people's movement clumsy and limited. In fact, Halley VI has regulations such as only authorized outdoor activities can be permitted giving the risk of being lost[57] – a little like the ISS. The Soviets have studied the human physiology in space after they sent people into space. In 1972, they have gathered extensive evidence that human bone has a 1% -2% decalcification rate per month in space[58] – thanks to the longer and longer missions. it appears that the smaller station it is, the more necessary the gym equipment came to be to prevent health degradation. It is, however, still unclear how much exercise help in space;[59] the samples are simply too narrow to perform a controlled experiment so variables can be then isolated. Halley VI has its second floor on the dining module dedicated to recreation, and that includes physical exercise. Onboard the ISS, the gym equipment is provided for the crew to complete their daily dose of sport. Biosphere 2, in contrast, does not include gym equipment. It is, though, big enough to make commuting an exercise, besides the farming duties that already consume a lot of energy. There we can establish a trade-off relationship between habitat size and gym equipment: A larger settlement or more gym equipment.

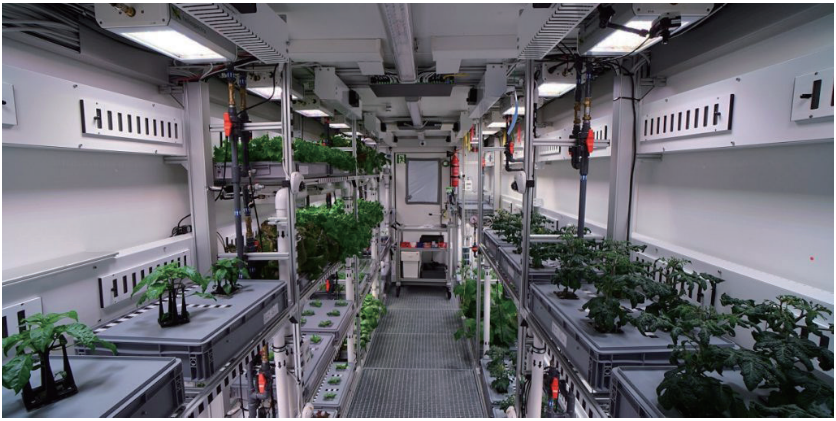
Upper. The fridge is full of booze. Photo by Anthony Lister. Image courtesy of Cool Antarctica.com

Lower. bar from a different view point. Photo by James Morris. Image courtesy of Hugh Broughton Architects.

Right. Initial design of Halley VI's communal module, note that the bar is located on the left corner of the image. Created by Hugh Broughton Architects. Image courtesy of Hugh Broughton Architects

Alcohol can be another stress reliver. Not only did the Biosphere 2 crew brewed their own beer, both Antarctic and Arctic team either increased the consumption of such beverage or produced alcohol from their limited supply - another work of fine science.[60] Whilst FMARS2007 crew in the Arctic had to balance beer production and food consumption,[61] a whole range of booze is visible at Halley VI's bar. Although alcohol is officially banned in the space operations, it also seems that the history of alcohol in space is just as long as human space exploration. Before Neil Armstrong set the first foot of man on the moon, his comrade “Buzz” Aldrin took a little sip of wine – the first liquid ever consumed on moon.[62] While people are still debating whether it is applicable to have alcohol on Mars missions under psychological prescription,[63] Russians have already developed an appetize for drinking in space – from a medical point of view,[64] or not. Sexual companionship has remained unspoken yet critical to mission's success.

The closed loop of matters, on the other hand, was studied in early days by the United States and Soviet Union as a means to generate unlimited oxygen and fresh water in space. Americans' bio-ecological approach of life-support took place in the 1960s.[65] In O'Neill's 1974 paper on space colonization, agriculture facilities are built for supplying the colony with fresh food.[66] He was not the first one to seriously discuss space agriculture: Ten years ago, at the conference on nutrition in space, biologist Max Kleiber came up with the idea of space ranching. As an expert on metabolism, he proposed the astronauts to feast on rat meat for higher energy density and relatively easy breeding.[67] Long story short, NASA eventually favored the mechanical solution.[68] The American government re-instate its support to bioregenerative life-support system in the 1970s, though, without granting it priority.[69] The Soviet Union had a rather continual track of study in such as field but never had its application in space. In the Bios-3 laboratory they built in Siberia, hydroponic plantation and algae to purify the air and water.[70] It was still not a closed loop for that proteins (aside of vegetables produced in the lab) were imported and solid human waste were exported.[71] Both countries tried to design complete life support with single species of algae and both had failed,[72] this might hint that plantation with more diverse selection of species will have a better chance of successes. The Biosphere 2 was the first close loop ecological system: By incorporating different biomes, it produced and regenerated vital air and food for survival. Landscapes such as marshland played irreplaceable role in purifying animal waste. The American Amundson-Scott station has a part of the building devoted for farming: The crew have harvested various food such as lettuce and cumber since then. In 2018, EDEN ISS test platform was deployed near the German Neumayer III station in Antarctic, the twenty-meter-long shipping container has two separate modules inside: The service



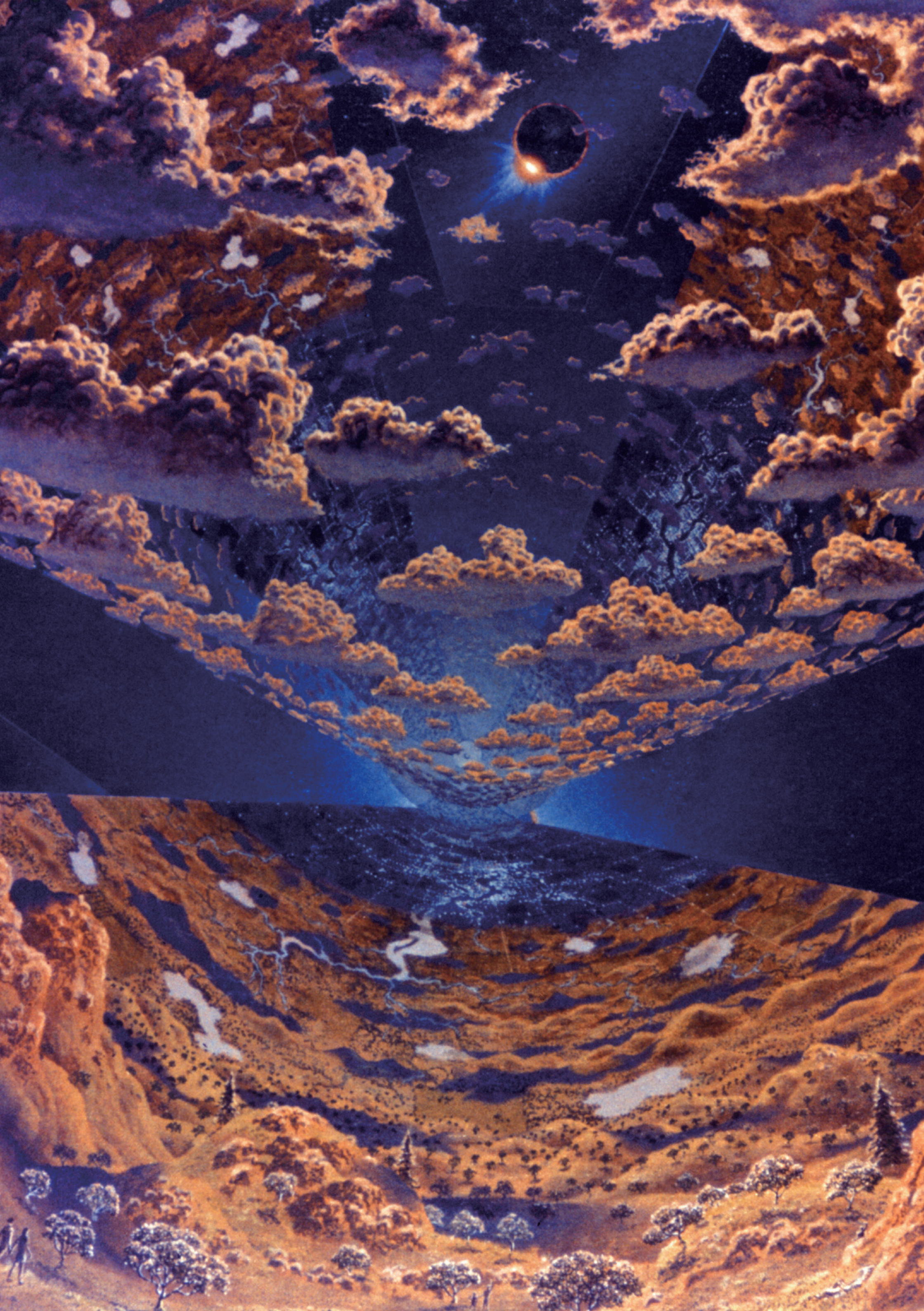
Upper. The farm of EDEN ISS. Photo by Volker Maiwald, et al., in “From ice to space: a greenhouse design for Moon or Mars based on a prototype deployed in Antarctica,” *CEAS Space Journal*, 13 (1): 18.

Lower. Volunteers inside the Lunar Palace 1 laboratory. Photo by Beihang University. 2018. Image courtesy of Beihang University.

section and greenhouse.[73] The project was funded by ESA to study the close-loop life support in the future space exploration, the first of its kind in the Antarctic. EDEN ISS was equipped with automated air conditioning system where carbon dioxide collected from the living unit will be injected into the greenhouse.[74] The goal was 1000 ppm – almost unbreathable to human, but likely to boost the agricultural yield. Similarly, the manipulation of lighting and atmosphere in O'Neill's agricultural cylinder are expected to boost production.[75] Although EDEN ISS could not provide all calorie needed, it can supply vitamin and antioxidants that cannot be stored for too long.[76] That being said, to provide the crew with full spectrum of nutrients, more plant and animal species must be introduced onboard, and hence a larger internal space in the end.

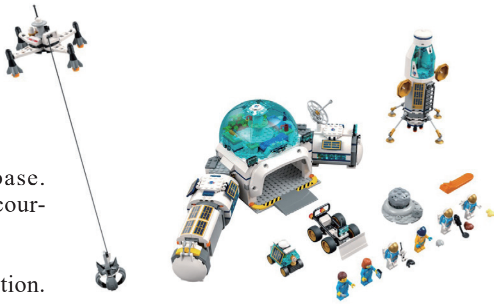
EDEN ISS is not the only regenerative life support experiment sponsored by ESA, it cooperated with the member countries in their Antarctic to test the grey water recycling technology, namely "MELiSSA" project.[77] China also has similar project: The Moon Palace program. It was a small-scale (compared to Biosphere 2), closed ecosystem built in Beijing with association of the national astronauts training center.[78] There are eight volunteers inside: four male and four female, the isolated living can last up to 370 days according to the latest experiment.[79] Returning to the discussion of size, a larger habitat may outperform the smaller ones in risk mitigating. To Biosphere 2, one of the pressing issues is the leaking of air to the outside. The team calculated that the leak through a one-millimeter square hole will have to be balanced

An independent space ecosystem in O'Neill's cylinder. Illustrated by Don Davis. circa 1975. Image courtesy of NASA. NASA ID: AC75-1920.



by the replenish of the atmosphere for every 80 days.[80] The atmospheric replenish rate is inversely related to the size of the interior: on the ISS, it requires 463 designed atmosphere to be replenished every year if such as a hole exists.[81] Gerard O'Neill and his team did another set of math when they were designing the space colony. They estimated that it would take 300 years for the atmosphere to completely escape from their space settlement.[82] A breach, in this case, would not be catastrophic and immediate, but a slow, fixable process. On a sidenote, O'Neill's initial idea of space settlement is a cylinder situated at the Lagrange point in the Earth-moon system, it rotates to create artificial gravity and has nothing to do with aerodynamics.

In summary, the same design guidelines are commonly found across the Arctic, Antarctic, and space architectures. Features such as Aerodynamic shape, modular design, environmental and waste control, smaller vehicles, and safety redundancy are universally applied. Meanwhile, the recent psychological studies revealed the necessity for humanizing the internal environment: That includes personalization of space and stress-relieving mechanisms. The longer mission requires a greater safety redundancy and self-sustainability, and the bioregenerative means of supply is expected for such querulents – greenhouses could soon be an indispensable part of habitation. The extreme architectures have shown a historical trend of enlargement based on utilitarian concerns, and the future extreme architectures will likely to follow this trajectory. The resemblance between the architectures in the seemly detached domains is perhaps best characterized by the concept of "Convergent evolution," a term that biologists use to describe the phenomenon when two architectural typologies begin to exhibit similar features under similar evolutional pressure. Reflecting from the children's toy, such resemblance havs been “educating” people about the architecture since a very young age.



Upper. LEGO 60036 Arctic base. Photo by LEGO. 2014. Image courtesy of LEGO.

Middle. LEGO 60227 Space station. Photo by LEGO. 2019. Image courtesy of LEGO.

Lower. LEGO 60350 Moon base. Photo by LEGO. 2022. Image courtesy of LEGO.

[1] Ruth Slavid, *Ice Station: The Creation of Halley VI: Britain's Pioneering Antarctic Research Station* (Zurich: Park Books, 2015): 13.

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[22] Mary Roach, *Packing for Mars: The Curious Science of Life in the Void,* Kindle edition (New York: W.W. Norton, 2010): 155.

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We Choose to Go to The Moon

The Soviet Union is in favour of a radical lowering of the level of military confrontation in the region. Let the North of the globe, the Arctic, become a zone of peace. Let the North Pole be a pole of peace. We suggest that all interested states start talks on the limitation and scaling down of military activity in the North as a whole, in both the Eastern and western hemispheres. [1]

---- *Mikhail Sergeyevich Gorbachev*

But why, some say, the moon? Why choose this as our goal? And they may well ask why climb the highest mountain. Why, 35 years ago, fly the Atlantic? Why does Rice play Texas? We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.[2]

---- *John Fitzgerald Kennedy*

On September 12, 1962, President Kennedy made this address at the baseball arena of the Rice University: Throughout the rest of the twentieth century, it was thought as one of the monumental moments of the Space Race and even the Cold War. On its webpage of the online Kennedy Presidential Library, the speech has been translated into thirteen languages and put into the public domain. [3] "We Choose to go to the moon," as a catchphrase, not only recalls people's collective memory of their President's charmful Boston accent, but also constitutes the slogan that successfully encapsulates the national ambition and perhaps American culture – to an extent. As a political legacy, the speech provides an opportunity for us to peek into that particular age.

As President Kennedy was promising the landing of Americans on moon by the end of the decade, the Soviets were busy smuggling missiles into the American backyard. The consumerism ethic reshaped the country's economic landscape, where a mainstream was established by Coca-Cola, MacDonalds, TV, and anti-communism. Tensions were built up between military campaigns or even within – Sino-Soviet split snapped some cracks in the Khrushchev's grand narrative of the ultimate victory, and President Kennedy himself died early enough to avoid being criticized by the youth who became sick of fighting VCs in the jungle. Not long ago, former colonies of the global empires started to claim their independence, a few more countries, other than the U.S, mastered the art of atomic bomb. The second phase of human exploration is signified by armed ideological rivalry. Although the confrontations had climaxed several times, no real wars were waged in the space and polar regions. Cooperations and competitions in those places have persisted till this day, and this consistency may suggest that "there are things that bever change in human history." We are probably the species who crave for conflict as much as sugar and salt. The first quote was extracted from the Murmansk speech made by Mikhail Gorbachev. Twenty-five years later after the Rice University Address, the international society was again at a turning point. Decades of rivalry exhausted the national wealth; reconciliation or truce, the offer of a peaceful Arctic seemed to transcend the geopolitics. For the extreme architectures, the two speeches boil down our motivations to the fundamental realism and idealism – and allow me to reiterate the purpose of this research.

Then why the space? Why the Arctic and Antarctic? The history of architecture in these domains is as brief as merely decades, and it takes only one, two at most, urban blocks to accommodate all of these structures. The value of those architectures can be found in themselves, such as the engineering and technological solutions; and it can be found in our daily life because of the technical spin-offs and the "answers" we found. As the previous chapters have demonstrated, the evolution of architecture is catching up with that of engineering when a station is expanding into a settlement. It does not mean that the earlier constructions were not bounded by site conditions like architectures, instead, they respond to similar requests as we are seeing today. A successful architecture answers to its site, and a site is more than a land parcel. Political, cultural, and economic settings may shape the forms and functions that is prospected from the bare ground. To our subject matter, the tangible conditions, or physical constraints, are derived from the environmental hostility: Temperature, scarcity, and isolation. The techniques to cope with these challenges have been discussed in the third chapter. The similar physical surrounding fostered a specific approach, regardless of specific places. This process of assimilation of form and functions fascinated me as we can see different architectural typologies resembles one another along the course of history. As it has elaborated in the last chapter, the “convergent evolution” is found among these extreme architectures due to the resembling evolutional pressure. Besides the possibly inspiring cross-disciplinary analogy, another question needs to be asked: Why are space and polar regions of Earth considered to exert “resembling evolutional pressure” to the architectures?

This inquiry would be difficult to answer without referring to the intangible conditions, namely: Geopolitical struggles, socio-economic shifts, and cultural movements. These are the factors that invisibly guide the development of extreme architectures, construct and disseminate their public images. The purpose of this section is thus two-folded: First, to track down the intangible site conditions that make the architecture as they are; and second, to track down the conditions that were “just right” to make the architecture possible. The discussion will be divided into two chapters due to the extensive coverage of the events and topics. In this chapter, a range of political activities, international and domestic, will be investigated for how they establish the narrative of the polar region and space. Science and colonialism sentiments will be reviewed alongside each other. Measures of propaganda will be studied for they directly associate the image making and dissemination. In the end, social reforms will be juxtaposed with the extreme architecture to show the transitions.

The Game of Science

Having noticeably a lot more to unfold about the Rice University Address – such as the utilitarian approach on fresh knowledge and pressures from strategic adversary – the fundamental reason for human to dedicate formidable efforts to build structures in space and Antarctic is the possibilities they open up to. There are unknown treasures that can in turn solve our “Earthly problems.” Science is the main motivation: We want to know more about ourselves, and the answers are hidden in the sky and buried under ice. The studies in polar regions and space constitute a considerable portion of Earth science, the multidisciplinary subject that teach us the past of our home planet as well as its future.

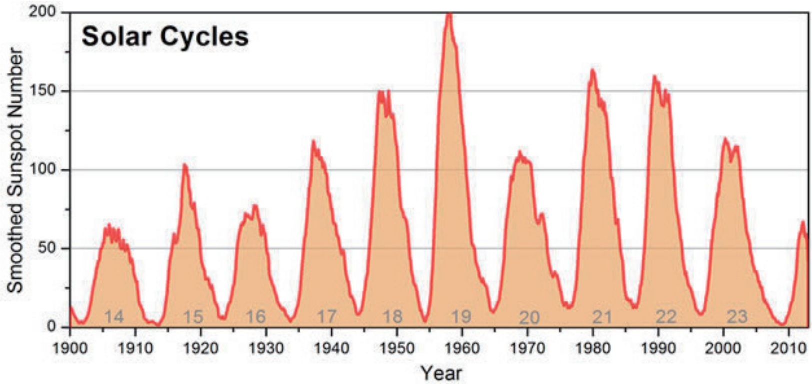
International Geophysical Year (1957-1958) has resulted in rewarding scientific outputs. The discovery of continual ocean ridges and the van Allen layer and the calculation of the Antarctic icecap have refreshed our understanding of nature. Besides what happened on land, the launch of Sputnik proved the feasibility of tele-communication via satellite technology, which is now inseparable from our daily life. The natural phenomena in these domains have been frequented by the braves for their magnificence. The forementioned American scientist-statesman Lloyd Berkner wishes to take advantage of the new technologies and would not want to wait twenty-five years for the third International Polar Year. The sunspot activity was predicted to reach its peak by 1958 – missing that, people had to wait for another eleven years. To better prepared for the observations, sixty-seven countries were given one year in advance to build up the stations.[4] Sunspot, among many other signatures of Sun’s energy fluctuation (such as flares and corona), received the most notice. It is visible to naked eyes when the spot is large enough, and it lasts for roughly two weeks.[5] It has been an ancient inquiry whether the sun could influence the organic life on Earth: Its religion and worship is notable across the civilizations, but it was not until the midst of nineteenth century when scientists discovered connection between sunspot and solar energy.[6] It was discovered that the greatest perturbation of Earth magnetic field is always coincided with the large sunspot.[7] The interaction between solar emission and Earth magnetism produces beautiful aurora borealis (or australis if it is seen in the South): One of the reasons for people to travel to the high latitude. Meanwhile, technicians were puzzled by its manipulation on radio transmission. There is certainly some sort of mechanism between the two, but remained unsolved until the turn of the nineteenth century. The Norwegian Physicist Kristian Birkeland collected data of the magnetic field in the Arctic, and deduced that the peculiar illumination was the product of solar emission colliding with the Earth atmosphere.[8] It might be too advanced at the time that it was quickly forgotten; this explanation was finally celebrated fifty years later when people of the atomic age are better prepared during the IGY.[9] It appears that the polar regions and space are associated long before the IGY, it was the Space Race that officially rendered this relationship plainly visible to many.

Sunspots create natural attractions as much they lead to social tragedy. In 1926, the Soviet scientist Alexander Chizhevskii (also known as Tchijevsky) published his theory titled “Investigation of the Relationship between the Sunspot Activity and the Course of the Universal Historical Process from the V Century to the Present day,” or Physical Factor of Historical Process in short. Unlike his idol Konstantin Tsiolkovsky, his work was demonized by the Bolshevik as “non-Marxist”[10] at best – if not anti-revolutional. In his article, he regards the energy fluctuation of the sun, reflected by sunspot activity, as the predominant factor that

Upper. Clean air of Antarctic makes it a lot easier for astronomical obeservations. Photo by Keith Vanderlinde. August 5, 2008. Image Courtesy of National Science Foundation.

Lower. Alexander Chizhevskii and his chart on historical periods. Image courtesy of Solar Activity and Perturbations in Economy and Society. Alexander Chizhevsky (1897-1964).

drives major historical events.[11] The peak of political and military movement in all human societies coincides with the maximum excitement of sunspots.[12] This research is by no means to evaluate Chezhevskii's theory from a historical point of view – in fact Chizhevskii has consulted books and astronomical records of many countries to establish the correlation; both his writings and his logics denied the

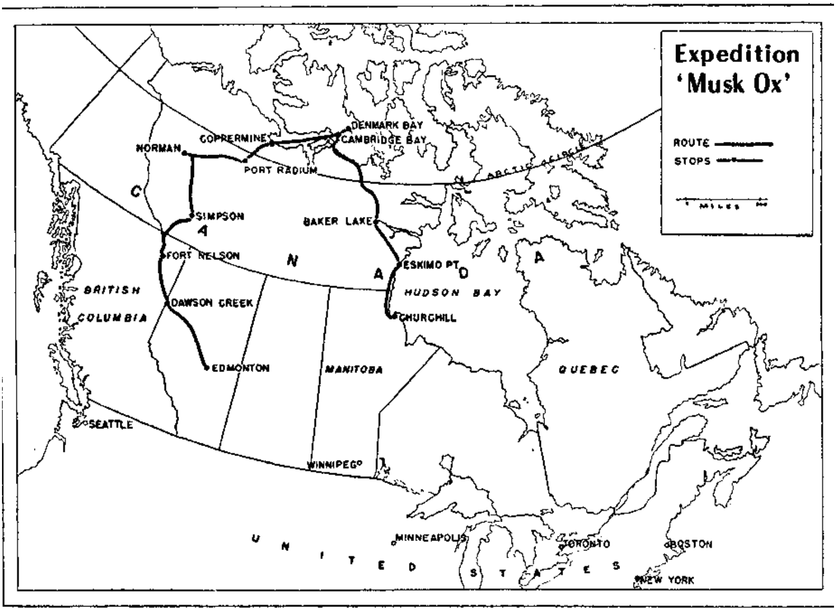


Upper. There exists a period of approximately 11 years for the Sun to reach another active peak. Chart by National Oceanic and Atmospheric Administration. Image courtesy of NOAA.

Lower. The Explorer 1 satellite with van Allen in the middle and von Braun on the right. Photo by NASA. Image courtesy of NASA.

communist ideal of anthropogenic development of history. By risking oversimplifying his texts, it was the idea like "we should abolish the effort to guide the course of history" or "even man full of historical knowledge will make the same mistakes like those of the past" that eventually got him into trouble.[13] Like many intellectuals of the time, he was later sent to Gulag for his ideological convict.[14] Another Soviet scientist of the time, Vladimir I. Vernadsky published Biosphere in the same year when Chezhevskii published his Physical Factor of Historical Process, but the former enjoyed larger audience in the world thanks to the thaw of the political frost between the East and West. Despite the importance of its concept and the time of the publication, the book Biosphere was unavailable in English until 1985.[15] Mark Nelson, co-founder of Ecotecnic, had to fly to Siberia alone to seek inspirations from the Russian Bios-3 lab.[16] He was welcomed by Oleg Gazenko, the director of Bios-3 at the time, who also trained the Soviet space dog Laika before it died on the orbit.[17] By the time, the design work of Biosphere 2 has begun, and there was no better place to learn about the close ecosystem other than the Soviet Union.

In 1963, underground – by ground I mean ice – springs were found in the Canadian Arctic as a result of extensive land survey project.[18] Canada and its Southern neighbor have grown enormous interest in the Northern territory: It was hardly visited, rarely mapped, and potentially bountiful. Right after the world war, in 1946, Canada organized the Musk-Ox operation that sends a group of troops to the North for a 5000-kilometer maneuver exercise.[19] The aim was simple: The Canadians and Americans were interested if human can endure the fatal condition with adequate resupply by military aircraft, which are scheduled to drop food and mail.[20] The equipment failed in many occasions but the mission was a success – at



Upper. Musk-Ox Exercise route. Map by R. M. Kark, R. R. M. Croome, J. Cawthorpe, D. M. Bell, A. Bryans, R. J. MacBeth, R. E. Johnson, F. C. Consolazio, J. L. Poulin, F. H. L. Taylor, and R. C. Cogswell. Figure 1. In "Observations on a Mobile Arctic Force. The Health, Physical Fitness and Nutrition of Exercise 'Musk Ox', February-May 1945." 1947. Image Courtesy of Sematic Scholar.

Lower. Men into Space comic book cover with Bonestell's illustration. March, 1960. Image courtesy of Comic Book Plus. Index: 1083-Men into Space.

least it proved that the Northern frontier is indeed survivable if aided by modern science technology. Interestingly, it echoes the *Men into Space* comic book cover: Illustrated and signed Bonestell, it writes “Scientists-soldiers explore tomorrow’s frontiers.” Even for a survey ship as Enterprise in the Sci-Fi series Star Trek, it was equipped with defensive shield, laser cannon, and devastating photon torpedoes.

Before the idealistic auras over the Arctic had evaporated, noble quest of knowledge was often found on news besides the sour and bitter expressions of Northern strategy. Canadian Arctic has since this point been integrated into its nation-building rhetoric as “the true North strong and free.” If disregarding the military background, this operation is more of a large-scale human experiment. The stations in the North and South poles are assigned with more missions that includes a psychological component because of the ICE environment. In fact, the Scientific Community on Antarctic Research (SCAR) has a team set up to select the suitable candidate for Antarctic missions, with psychological criteria included.[21] Using the polar stations as the bases for spaceflight simulation may expose issues like the deterioration of mental state before the actual flight takes place. Incidents of rebellion, physical assault, and sexual harassment are certainly not strange in the Antarctic over-wintering.[22] These unscheduled social experiments provide valuable lessons to the design of long duration spaceflight in the future. The crew members of the Biosphere 2 were well-aware of such a risk before the experiment officially began, but the experience still deepened their understanding of such psychological phenomena. “Humans are the most unstable elements in the ecosystem. Have courage,”[23] says Yevgeny Shepelev before the Biosphere 2 experiment. Note that he is the first man who stayed over twenty-four hours in the close ecosystem.

[24] What was warned happened anyway. The interpersonal skirmish began as teasing, an exercise, then a dysfunctional family meal, then side-picking where the eight was divided into two groups of four.[25] There is one group of "true scientists," and one group of obedience who answers to the project administration, which was regarded by the "true scientists" to be ignorant on what they were doing.[26] On a retrospect, it is perhaps too bold to assert on what is true science as the crew was embarking on a new field of study – knowing how to rare tomatoes does not guarantee a healthy workplace culture. Even so, none of the crew attempt to sabotage the mission. First, their mere survival depends on the well-functioning of the facility; and second, like the Soviet astronauts, the members were also under moral burden from the school visits.[27] Nevertheless, the ICE experience was reported to benefit the majority of the polar over-winterers mentally and physically after they finished the mission.[28]

According to the plate tectonic theory – confirmed by the discoveries made during the IGY– Antarctic drifted away from the other mass continents. It was located in the tropic zone and was once habited by robust rain forests and animals,[29] which now have turned into fossil remains. The research of the polar meteorology is not restricted to the current timeframe, it also reveals our planet's geo-

Upper. 8 expeditioners inside Biosphere 2 laboratory, Mark Nelson is on the left corner. Image courtesy of IDMB. "Spaceship Earth."

Lower. The Russian scientists at Biosphere 2 lab in 1989. Image courtesy of Mark Nelson. *Pusing Our Limits: Insights from Biosphere 2* (Tucson: University of Arizona Press): 15.

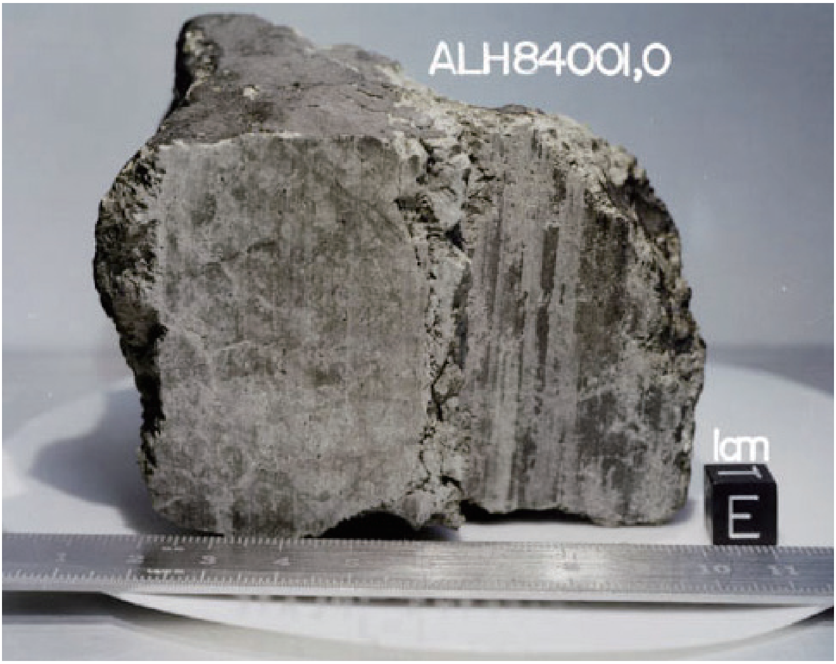
Upper. Vostok Station in 2001, with most of its structures burried under snow. Photo by Todd Sowers. October 11, 2001. Image courtesy of NOAA. Wikimedia commons.

Lower. The new Vostock (under construction). Image courtesy of Arctic and Antarctic Research Institute.

logical history. By sampling the ice core from the iceshelf, data such as Carbon dioxide and concentration of different oxygen isotopes reveal the prehistoric climate information. For example, the technique of Marine Isotope Stages (MIS) dwells on that water with heavier oxygen isotopes require more energy to escape the ocean in form of vapor.[30] When the global temperature drops, glaciers grew on land and extract lighter oxygen isotopes from the ocean because the heavier ones are more likely to remain put.[31] The periodical fluctuation of heavier isotopes therefore function as the thermometer that measure the temperature of Earth's past. When complemented by other evidence that trapped in ice, say volcanic ash, geologists can then draw a bigger picture of the prehistoric world. In 1974, the Soviets began to drill into the ice at their Vostok station located at the geomagnetic South pole. The ice samples were examined for its continual record of the weather and volcanic eruptions in the past 400,000 years.[32] It was not until the 1994 that Russian pierced through three kilometers thick of ice and discovered the largest subglacial lake. The lake was named after the station, and it is estimated to be as large as Lake Ontario.[33] In addition, the flowing water under the snow and underground springs are given more academic attention in the recent years. The polar regions on Earth are thought to be similar to the ground environment on Mars, and the latter is likely to run liquid water under its red skin giving the similar hydrological features.[34] In this sense, Antarctic and Arctic are regarded as the natural laboratory of planetary analogy. The landforms and climate resemblance of the Earth poles and Mars suggest a degree of comparability: If a cave is discovered with various species of bacteria in Antarctic, who could say there does not exit such a niche on Mars?

It was not only the planet's past we are increasingly informed about: People have wondered thousands of years on the origin of life, and Antarctic was found to provide a unique clue. In 1984, a Mars meteorite (or ALH84001 by NASA) was picked up on a snowmobile ride in the Allen Hills of Antarctic.[35] Its spotlighted study afterwards was pushed by serious scientific inquiry due to the claims that it contains evidence of biological processing.[36] The biogenic hypothesis was at best controversial after its publication in 1996. The substance that is regarded to be the trace of biological origin was argued to be reproducible by abiotic means.[37] However, the planet of Mars may had been capable to support life before: Its landform of channels and deltas suggests the water bodies that once covered its surface. In the end of 1970s, Viking rovers landed on Mars and performed a series of soil tests with the equipment they carried along.[38] Mars enjoyed incomparable amount of public attention because of its similarity to Earth – they both have active climate and season, and they both have roughly twenty-four hours in a day. This comparison is, to a degree, uncanny or even scary because it implies a deadly ending for our home planet.

And there is no "abandon ship" – planet Earth is our lifeboat in the universe. Perhaps Earth is too vast to exaggerate the damage of a small misconduct. On the ISS, there is no space for geopolitics among the astronauts. Everyone must agree on the fact that only cooperation can keep all alive. It is true that human is biologically bounded to feel pressure in the ICE environment, but the fear of indiscriminate destruction of all is powerful enough to keep sanity in the crew – it is either a win-win or all-lose scenario. Onboard the ISS, everyone is expected to take on small tasks outside one's expertise, just like all people at Halley V must work together to rise the station's platform.[39] On the other hand, geopolitical struggle is usually performed with a basic unit of nation, which might be too narrow to address the common threat of climate change



Upper. Mars Landform. Photo by *Curiosity* rover. January 30, 2018. Image courtesy of NASA.

Lower. The Mars rock picked up in Antarctic. Photo by NASA. Image courtesy of NASA. Archive ID: S94-032549 up in North, even for the Arctic states. The North was hardly the mainstream topic in Canadian society,[40] unless it is about Russia. The Dew line not only sketched the country's military territory, but its cultural hierarchy as well: from South to North, civilization is gradually replaced by savage.[41] In 1996, the Ottawa Declaration set up the Arctic Council mainly as a forum instead of a governing body. Military affairs are deliberately excluded from the agenda because there is a more prestigious forum built for it: Unofficially known as A3, including the United States, Russia, and Norway.[42] All Arctic States (or A8: the United States, Canada, Russia, Denmark, Greenland, Norway, Iceland, and Sweden) are concerned about the military expansion within the circle, especially Russia and Canada. The two, however, instead of building up real military standoffs, are satisfied by exploiting the others' advancement in Arctic to mobilize their similar initiative: Suddenly everyone is re-militarizing the Arctic.[43] However, nobody wants a real war and the conflicts are to be mitigated by international conventions such as UNCLOS, which was not even ratified by the U.S congress.[44]

When political tension must be diffused, science is then filled right into the void. In 2004, Canada announced $69 billion federal budget for sea floor survey:[45] A good reason to reactivate the stations indeed. Science enthusiasm is not to be blamed, but either addressed when discussing climate change in the high latitude region. Arctic has an understandably fragile ecosystem, and the drastic change in the sea ice volume is a price to be paid by all

Chinese science fiction *The Wandering Earth* plots the story that humans use gaint nuclear engines (see in the poster) to push Earth out of the solar system. Movie poster. 2019. Image courtesy of IDMB.


郭帆
刘慈欣
流浪地球
A FRANTGWO FILM
THE WANDERING EARTH
2019·大年初一

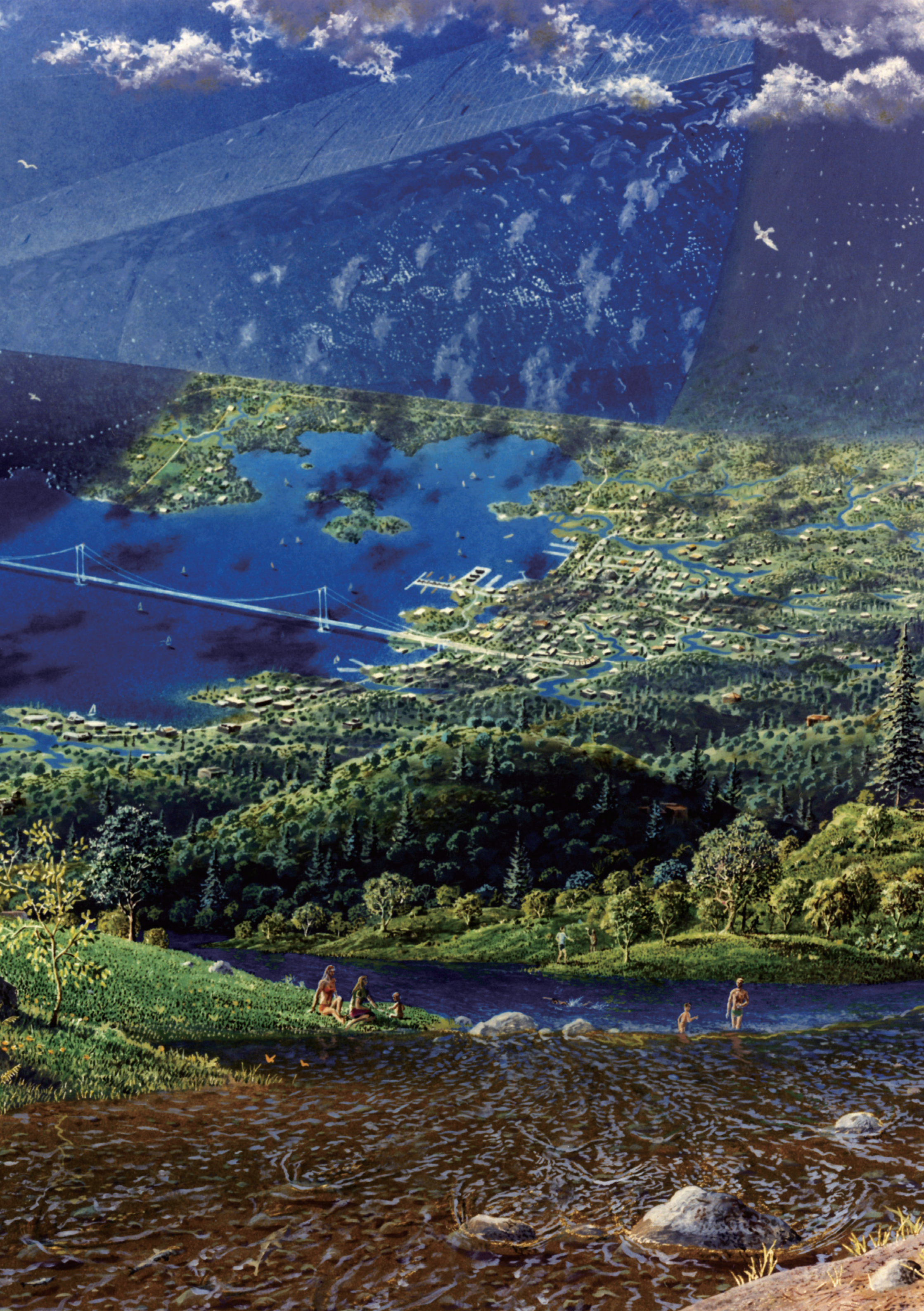
live on Earth. Not even all human beings are invited for cooperative governance – If there is such a mechanism at all. Warming in the Arctic attracts eyes of the non-Arctic states for the potential storage of natural resources. Russia, for example, has detected 66% of natural gas in its Economic Exclusive Zone (EEZ), and has viewed Arctic as its source of national wealth and influence in the new century.[46] The classic clash of geopolitics cannot escape the competition for resources, and the Arctic game might as well fit into the World Game developed by Richard Buckminster Fuller in 1969 – confrontation is permitted, but one loses the game if he triggers the firearm first.[47] As a philosopher, his realism is based on a simplified and even idealized world like Chezhevskii's historical model and Club of Rome's roadmap, the war-phobic setting is both his wish and a political consensus. As an architect, he adores the project of Biosphere 2 enough to share his engineer with the team.[48] In a closed ecosystem of Biosphere 2, humans are playing the role of keystone animal that balance the population of the other species.[49]The eight people held the right to decide what is excessive and what is needed; and as it turned out, who are "you" and who are "us." Unlike the geopolitical dramas or any socio-ecological experiments, the world peace is not a game that we can afford to lose.

The Struggle of Peace

Gerard O'Neill would be given the same question: Who gets to live in his space colony? As an independent habitat, his space cylinder contains more than a typical suburban-like community and natural landscape, but also its unique economy built upon its closed ecosystem. There are agricultural sectors in the separate cylinder right next to the living ones, and the calculation estimates that for every hectare of farm, the agricultural produce can support 143 people with a diet of 3000 calories.[50] As a rationalized world, only a limited range of animals will be introduced to the colonies: Interestingly enough, birds are welcomed but insects are not.[51] The physicists may underestimate the importance of insects as pollinators or birds' pray, ecologists may argue the otherwise. In 1975, the space colonization went public through the conference and summer study, the concept soon attracted the biologists like Odum brothers, H.T Odum and Eugen Odum. The two were the supporters of bioregenerative life-support system for the space program in the 1960s, but NASA eventually favoured the mechanical approach.[52] Eugen Odum's work has been consulted by the 1975 summer study for the regenerative ecosystem design,[53] while his brother H.T Odum approved Mark Nelson's Ph.D. twenty-three years later as the chair of committee.[54] The colonization of space will begin with sending workers into space for the construction of factories and small stations, they will then move on to the construction of larger habitats once they have established an industrial system to process space materials[55] – and it is (supposedly) feasible with the 1970's technology.[56] The ecological limit of a space colony is 200,000 people; the larger ones with a sixteen kilometers radius can host as many as seven hundred million.[57] Moon mining and asteroids harvesting will supply the colonies with raw materials, and space farming with adjustable season maximize food production. The settlers in space will enjoy complete independence as its economy is separated from that Earth: O'Neill even envisioned a unique culture to be developed in space.[58] His space colonization is expected to have some people living in the paradise, and meanwhile those who remain on Earth are relieved from pollution, famine, and wars. However promising, the engineer-minded group either overlooked or avoided the debates regarding the right to live in those paradise.

It is a strikingly difficult question to respond to, giving that O'Neill was already troubling himself by distancing the students from the campus protests and anti-cultural movements.[59] The condemn on racial segregation were not farfetched to the professors and students at all, and O'Neill's topic that somewhat embellish the act of colonization may only provoke more storms in the turbulent time. Although it was the cost that officially terminated the proposal in the end, the sensitive implication might have caused the series of rejections in the beginning – before Physics Today agreed to publish his article in the September of 1974. The America society was at a transitional stage when the government, as the public authority, was challenged, so were the men as the authority at home. Progressivist ideas such as gender equality flooded the west with the socialism superiority in the space conventions.[60] Valentina Tereshkova, the first woman who flied to space, was assigned with perhaps a more "tactful" job as the cultural ambassador of the Soviet Union.[61] She never returned to space, but her story and public appearance is powerful enough to trigger NASA's discomfort. Khrushchev

A paradise in O'Neill's cylinder. Illustrated by Don Davis. circa 1975. Image courtesy of NASA. NASA ID: AC75-1883.



called her “our Valia,” and dispatched her to the World Woman Congress, which was conveniently held in Moscow in the same month of her flight.[62] As a feminism role model, she was portrait as one of the millions of Soviet girls who are respected for their math and engineering ability. NASA applauded Tereshkova but defended by downplaying the heroism: She was less trained and educated, and we can send a chimp to do her job in the space.[63] A disgraceful response for sure, NASA was criticized for its discrimination against women for years.[64] But the chimp insult was not limited to Russians. The early spaceflights were not piloted, but more or less a ballistic projection. When NASA was testing the life support system, it did not matter what or who gets to shot into space: A dog, rabbit, monkey will do the job as well – maybe expect woman, unfortunately. So when Alan Shephard, the first Mercury astronaut, was threatened (or teased) by the launch director that his seat was to be given to a chimp, he was upset enough to throw an ashtray at the director’s head.[65] The liberation of woman has now been associated with the regime: In the Soviet Union, 40% of Ph.D. recipient in chemistry are women, while in America that percentage was 5%.[66] It was at this time when the national institutions in the U.S decided to promote women involvement in science and engineering when many of them already work outside home. As a reflection of the Space Race, the technological competition is inseparable from cultural competition, at least from the propaganda point of view. The common practice of media would render the achievements in the space or polar exploration as the solid proofs of one’s political superiority.

O’Neill was right that the culture does appear to be unique in celestial realms. The Antarctic Treaty System (ATS) prohibits the military operations but permits military establishment and personnel, as long as they serve for

Upper. Valentina Tereshkova before climbing into her space capsule. Photo by Roscosmos. June 14, 1963. Image courtesy of Roscosmos.

Lower. Sally Rider, the first American woman in space. Photo by NASA. June, 1983. Image courtesy of NASA.

science purpose.[67] Article III mandates that all scientific observations will be made freely available, so that the countries without a station in Antarctic could access the same data. Article IV froze the territorial claims in the way that country already asserted claims will not renunciate the claims or enforce the sovereignty, and the other countries will not deny such claims or propose new ones.[68] It is worth mentioning that only four of the eight countries that insist territorial claims over Antarctic actually locate in the Southern hemisphere, and none of the African countries joined this game despite the geographical proximity. The Soviet Union found itself in the middle of moral dilemma: It inherits the right of discovery, hence the ownership, from the Russian empire. But the communist regime must denounce and abolish imperialism, including the Russian empire it defeated. The best solution is perhaps to internationalize the Antarctic affairs without internationalizing the territory. Like the others, the Soviet Union saw the continent as the last untouched natural treasure, and potentially national interest. When it promoted mining in Antarctica in 1972 in the name of common benefit, it also stressed that only authorized natural extraction is to be executed.[69] Therefore, unlike the "use it or lose it" logic in the North pole, the underlying political setting in the South is interpreted as: "if I cannot monopolize it, neither shall anyone else." The international conventions or treaties became the restraint and weapon at the same time, and the superpowers turned out to be the most law-abiding participants.

The construction of Mirny station in the Australian sector triggered unrest to its claimant. The fear that the station can be converted to military use is contrasted by the following transparent exchanges of crews and information with the American stations,[70] leaving all accusations to be ungrounded. In the 1980s, scholars were concerned that the Antarctic territorial disputes may be ignited again after 1991 because the Article XII fixed the effective period to be thirty years,[71] and the treaty was enforced in 1961. From today's point of view, it is clear that none of the treaty states wanted to forfeit their rights in Antarctic or let the stronger states to consolidate their factual occupation; a consensus is easily established to maintain the status-quo.

In the same year, Madrid protocol is added as a treaty amendment: The treaty is refreshed and peace is kept. The red empire has weakened in the past years that the English translation of Biosphere's introduction was traded with a bottle of Scotch Whisky by Mark Nelson before the rest of the Russian experience was imported to America.[72] Keeping Antarctic in this way is the optimal choice despite that the restoration of Russian nationalism has removed the ideological obstacle for territorial claims. In the recent years, the British Halley VI station was positively rendered as a masterpiece of fine engineering, especially for the Sci-Fi appearance in the middle of the white desert. What most of the articles have not mentioned is that Halley VI rests in the overlapped section of the Argentina and UK sector. In addition, the construction team had a brief stop at the Falkland Islands.[73] It was perhaps inspired by the idea that long-term stay and scientific research can be exploited for affirming the practical control, Antarctic stations are motivated to evolve from a station into a settlement that support a larger crew and longer mission.

The Outer Space Treaty (OST), or UN resolution 2222 (XXI) ("Treaties on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including Moon and other Celestial Bodies") reflects the similar spirit of the Antarctic treaty. In fact, almost every clause of the OST can find its respondent in the ATS. For


FESCO

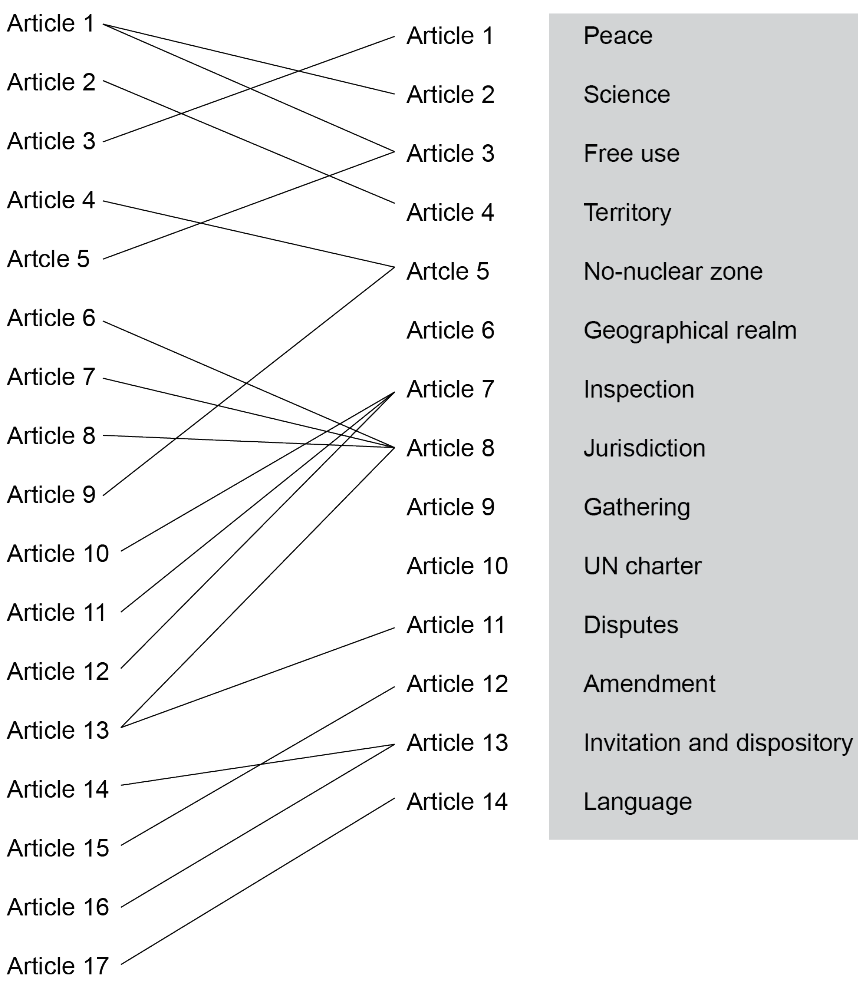
Upper. Halley VI's living module assembled in Cape Town, South Africa. Photo by Dave Southwood. Image couetesy of The Architectural review.

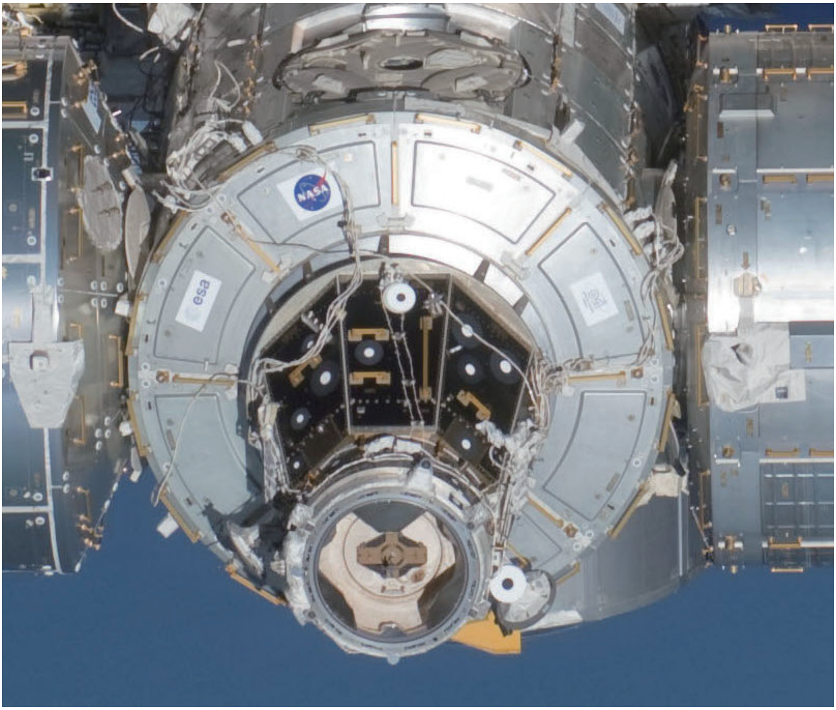
Lower. Like the ISS, Halley VI's parts were delivered by A Russian ship. Photo by BAS. Image courtesy of Karl Tuplin. "Halley VI: An Antarctic Research Station," Presentation slideshow, 37.

Right. American nuclear submarine USS Toledo surfaced in Arctic. Photo by US Navy. March 4, 2020. Image courtesy of Marine corps Times.com example, Article I in the OST is corresponding to the Article I and II of the ATS in terms of peaceful use. The OST Article II and ATS Article IV both prohibits the territorial claims and practices of sovereignty. And the OST Article IV is equivalent to the ATS Article V for no-nuclear policy. Some of the clauses are partially reflected, such as the OST Article V, X, and XI are similar to the ATS Article III for the free access of the astronauts and obligation to provide support in emergency – including commandeering foreign spacecrafts if necessary (which is demonstrated in the 2014 film Gravity). However, the free share of information among the participating countries is not guaranteed in space. The copyright of a discovery made on the International Space Station, depending on the contract, is determined among the member countries.[74] The data collected in the European module Columbus is thus equivalent to the collection of the same data on the European soil: The ESA members will then decide which country owns the result.[75] In 2011, the U.S congress pass the Wolf Amendment, which banned the cooperation, of any sort, between NASA and China National Space Agency (CNSA), unless it is specially authorized by the congress.[76] It is popularly interpreted as the “ISS Chinese ban.” Ten years and two weeks later, China launched its own space station, Tiangong, also known as the Chinese Space Station (CSS). Since 2017, ESA and CNSA have been training the astronauts together and the ultimate goal is to fly the European astronauts to the Chinese station.[77] During the joint training, Samantha Cristoforetti, an Italian female astronaut, had a chance to wear the Chinese spacesuit and practice her Mandarin.[78] After the Chinese moon rover retrieved lunar soil, the samples were shared with the international partners,[79] except for NASA – the cooperation was banned anyway. The irony lays in the way that how international is the ISS when China is excluded, and how Chinese is Tiangong with the European and Russian shareholders? Whether it

Outer Space Treaty
Signed on December 19, 1966

Antacrtic Treaty
Signed on December 1, 1959

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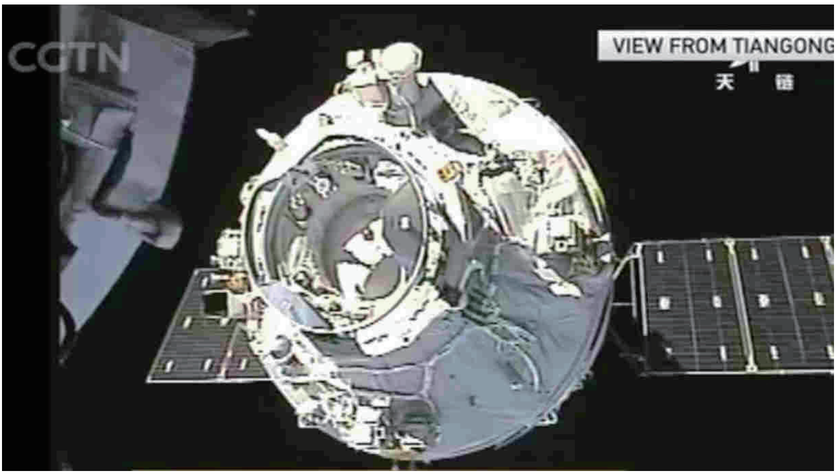
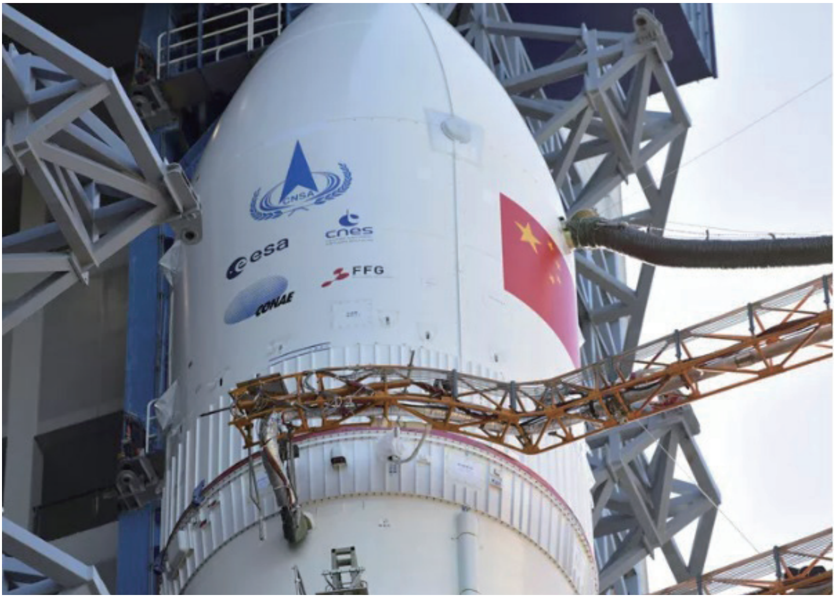

CGTN
VIEW FROM TIANGONG



Upper. ISS docking hatch seeing from shuttle Endeavor, note that it was the second last mission of space shuttles before they are grounded for good. Photo by NASA. Noven 28, 2011. Image couetesy of NASA.

Lower. Chinese cargo ship Tianzhou has the compatible docking technology with the ISS. Photo by CNSA. Image courtesy of CGTN.

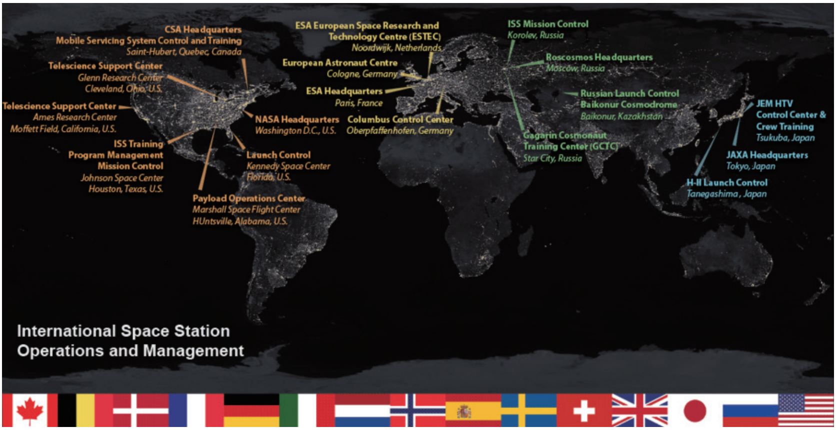
Right. The Chinese Tianwen-1 mission and its international partners. July 17, 2020. Image courtesy of CNSA.

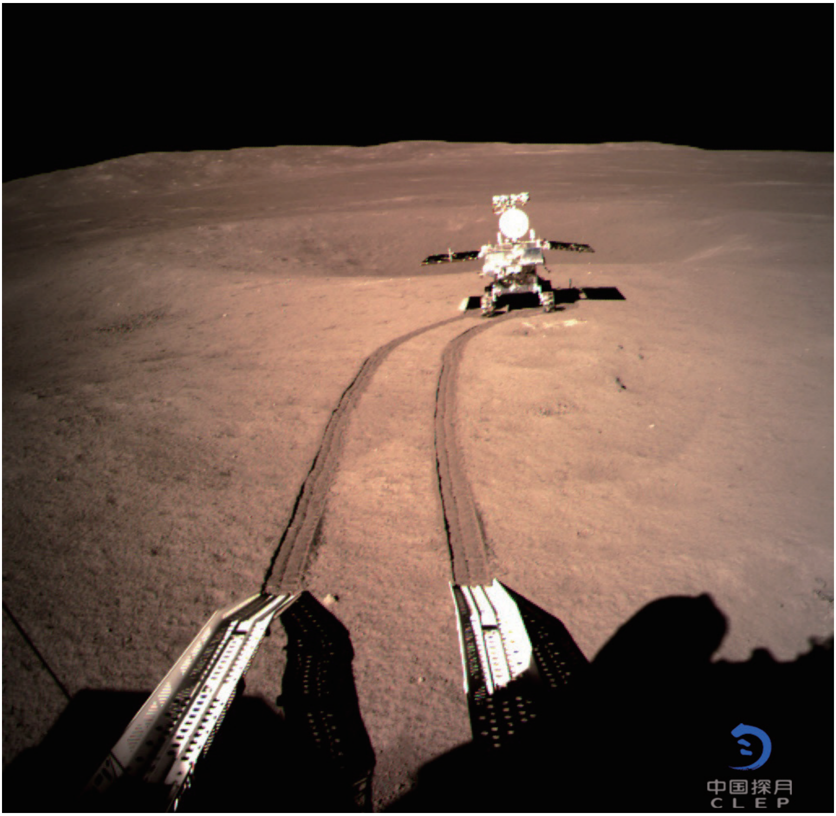
is cosmonauts, astronauts, or taikonauts, the space crews were culturally differentiated when it is essentially the same profession. It is technologically feasible for another Soyuz-Apollo docking between Tiangong and ISS, but the issue is not technological at all.

Like the Antarctic Treaty, the Outer Space Treaty was effective in demilitarizing the space. The formation of NASA in 1958 was inspired by the Soviet national space agency that specifically coordinate the civilian space programs.[80] Sputnik was simple but a global sensation. Firstly, humans can send their artifact, or even a dog, to "heaven;" and secondly, that artifact can be a nuclear warhead. Rocketry was certainly not new, but its military potential was not fully exploited before the end of the second world war. Werner Von Braun developed V-2 rocket for Nazi army, but it was only effective to a target that is roughly the size of London. On the other hand, the nuclear bombardment of Hiroshima and Nagasaki have significantly lowered the requirement of accuracy. The combination of two revolutionized massive destruction, and Americans have good reasons to worry about Sputnik. The carrier rocket was R-7, the two-stage rocket that provides propulsion for the ICBMs.[81] The Soviets did not want to stress this fact - one of the popular myths about the Soviet space program is that the launch site locates in the Kazakhstan city of Baikonur, while the real site is three hundred kilometers away at Tiura-Tam.[82] It is regarded as the example

Upper. ISS international partners. Photo by NASA. Image courtesy of NASA.

Lower. Chang'e-4/ Yutu lunar rover at the South pole of moon. Photo by Chang'e 4 landing pad. January, 2019. Image courtesy of CNSA.


CSA Headquarters
Mobile Servicing System Control and Training
Saint-Hubert, Quebec, Canada
Telescience Support Center
Glenn Research Center
Cleveland, Ohio, U.S.
Telescience Support Center
Ames Research Center
Moffett Field, California, U.S.
ISS Training
Program Management
Mission Control
Johnson Space Center
Houston, Texas, U.S.
ESA European Space Research and
Technology Centre (ESTEC)
Noordwijk, Netherlands
European Astronaut Centre
Cologne, Germany
ESA Headquarters
Paris, France
NASA Headquarters
Washington D.C., U.S.
Columbus Control Center
Oberpfaffenhofen, Germany
Launch Control
Kennedy Space Center
Florida, U.S.
Payload Operations Center
Marshall Space Flight Center
HUntsville, Alabama, U.S.
ISS Mission Control
Korolev, Russia
Roscosmos Headquarters
Moscow, Russia
Russian Launch Control
Baikonur Cosmodrome
Baikonur, Kazakhstan
Gagarin Cosmonaut
Training Center (GCTC)
Star City, Russia
JEM HTV
Control Center &
Crew Training
Tsukuba, Japan
JAXA Headquarters
Tokyo, Japan
H-II Launch Control
Tanegashima, Japan
International Space Station
Operations and Management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of the Soviet secrecy that on the one hand, it needs to register the launch site for the first human spaceflight record following the international convention,[83] and on the other, the Russians wish to diverge the media exposure away from its Intercontinental Ballistic Missiles (ICBM), which share the same launch pad with Yuri Gagarin at the time.[84] The success of Sputnik urged the Soviet decision makers to schedule of space launches on public holidays to maximize propaganda effects.[85] However, the celebration must be carefully coordinated to paint a innocent face of the Soviet space program, even though Sergei Korolev, the director of OKB-1, reports to the minister of defence while pretending to work under the Academy of Science in the public.[86]

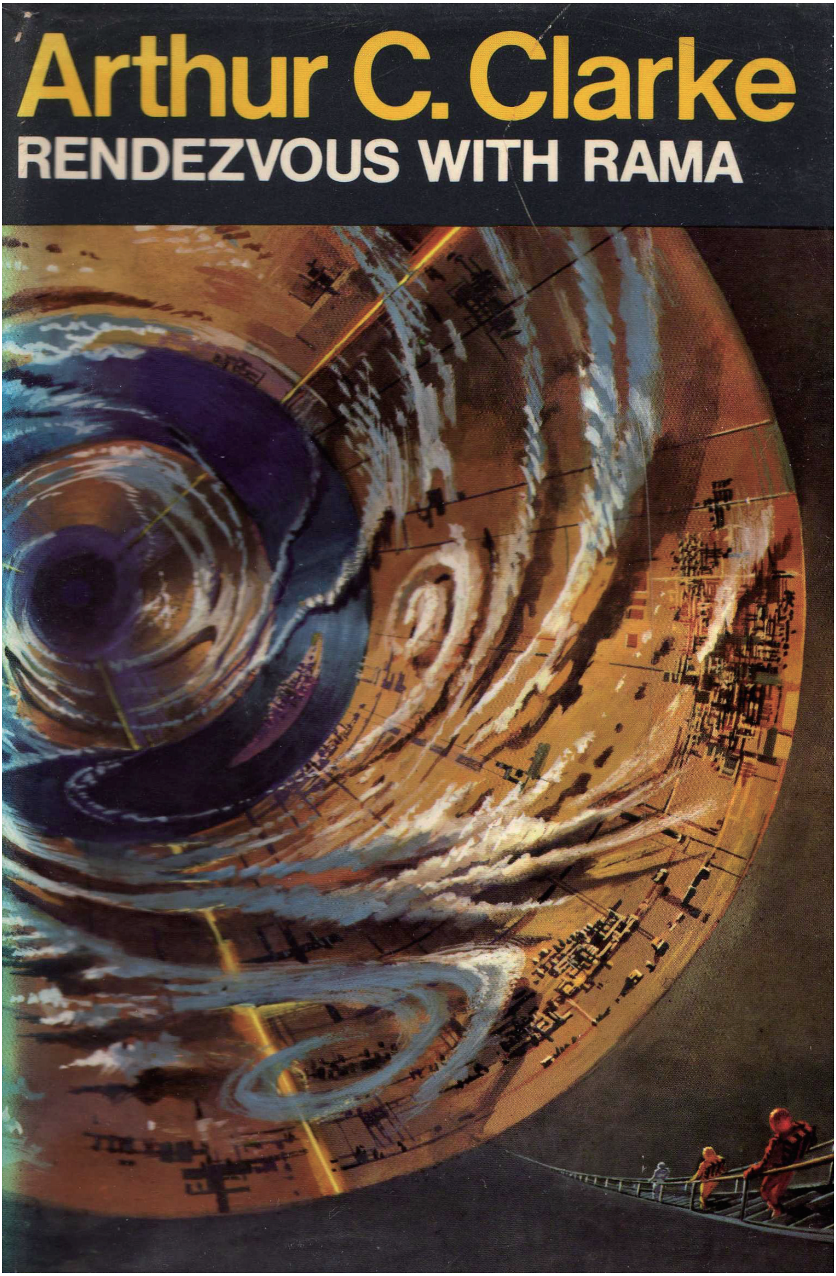
A Soyuz capsule launched from "Baikonur" facility. Photo by Bill Ingalls. April 9, 2021. Image courtesy of NASA.

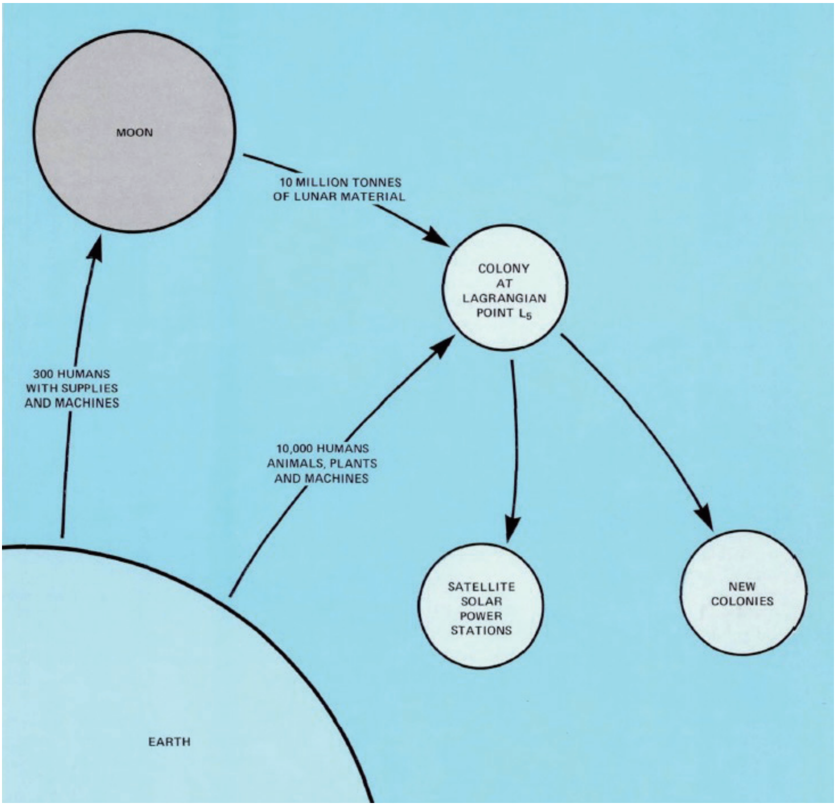
Streamlined Politics

Colonial sentiment is not the only accusation that crippled O'Neill's space expansionism. In 1975, it has estimated that building a series of space cylinders would cost American taxpayers $1400 billion (of 2005's value),[87] equivalent to spending Apollo scale of fund every year in the next four decades, with a slim chance of success. If it was ten years ago, J.F. Kennedy might give this plan a brief consideration (if not have been assassinated) before giving up; whereas in the 1970s, this budget sentenced space cylinders an instant death. Apollo was promoted in a different historical moment: The Bay of Pig invasion was a humiliation for both the president and his country (five days after Gagarin's flight), considering the deterioration of his health, the United Stated and Kennedy desperately need a victory. Three weeks before the Gagarin's spaceflight, President Kennedy expressed his intension in front of the NASA director, James Webb (the namesake of the space probe), on scrapping the Apollo program.[88] The Soviet space achievement suddenly enable him to perceive the long-term value of Apollo he did not see. As a man who cares about his public figure and changes custom-made suits and shirts several times a day,[89] Kennedy understands mass media and is willing to pay billions of dollars for a TV spectatorship of moonshot. But in 1970, five years before the summer study, President Nixon chose the least expensive plan for NASA's next move: Re-useable space shuttles and small station stood out among the manned flight to Mars and a space station on lunar orbit.

O'Neill found it to be increasingly difficult to have his project taken seriously as an achievable engineering project instead of some popular fantasies of the time like *Rendezvous* by Arthur C. Clark, which also featured the cylindrical space habitat. Clark was one of the "space boosters" in the 1950s with Werner von Braun and Chesley Bonestell, together they produced a range of works to promote space station among the public. In 1961, after his story Island in the Sky, Clark hypothesized a space station at Lagrange point so it is gravitational stabilized.[90] The concept of settling at the Lagrange point was pioneered by early fictions, and it was also incorporated in O'Neill's design. To make a difference, the physics professor argues that the fantasies like those of Clark's had no mechanism, unlike his project which worked out the strength of walls and height of clouds in the cylinder.[91] He calculated the optimal position for his cylinder: The L4 or L5 point between Earth and moon – hence the organization's name, *L5 society,* set up by O'Neill and his followers in 1975 to popularize the idea of space colonization. Unfortunately for O'Neill, space colonization was at this point inevitably sliding to the side of science fiction, something O'Neill had tried to keep a distance from. On the other hand, NASA seemed to comply to the minimalism trending by switching its iconic "meatball logo" to the "worm logo." The Nixon's plan was again reduced to space shuttle, and the station would have to wait for another thirty years – adopting a simpler logo at this moment implies that NASA might have forgone its promise and ambition.

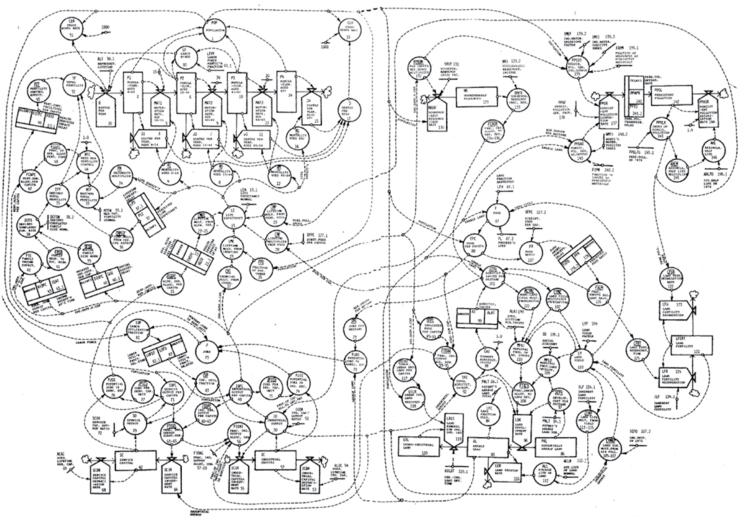
"Meatball" logo and "Worm" logo of NASA. Created by NASA. Image courtesy of NASA.

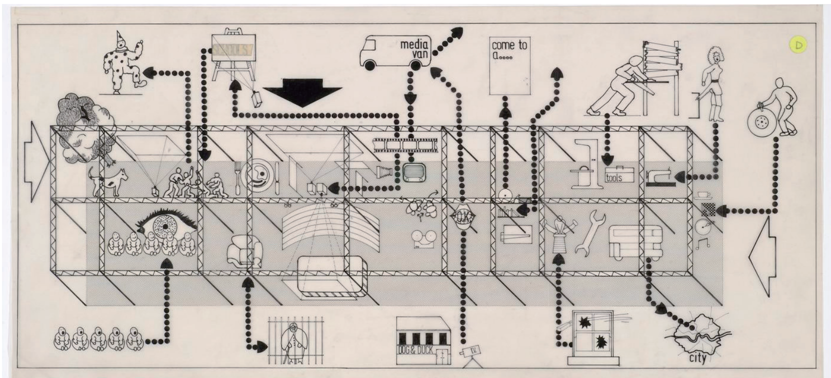

Arthur C. Clarke
RENDEZVOUS WITH RAMA



Right. Optimal position of O'Neill's space colony. In "Space Settlements: A Design Study." Edited by Johnson, Richard D. and Charles Holbrow. (Honolulu: University Press of the Pacific, 2004): 3

Left. A space cylinder on the book cover of *Rendezvous with Rama*. Illustrated by Bruce Pennington. Published in June, 1973. Image courtesy of ISFDB.





Upper. The Club of Rome’s algorithm (World3 model) that anticipates development results according to inputs. Created by The Club of Rome. 1972. Image courtesy of Rossexodams.com

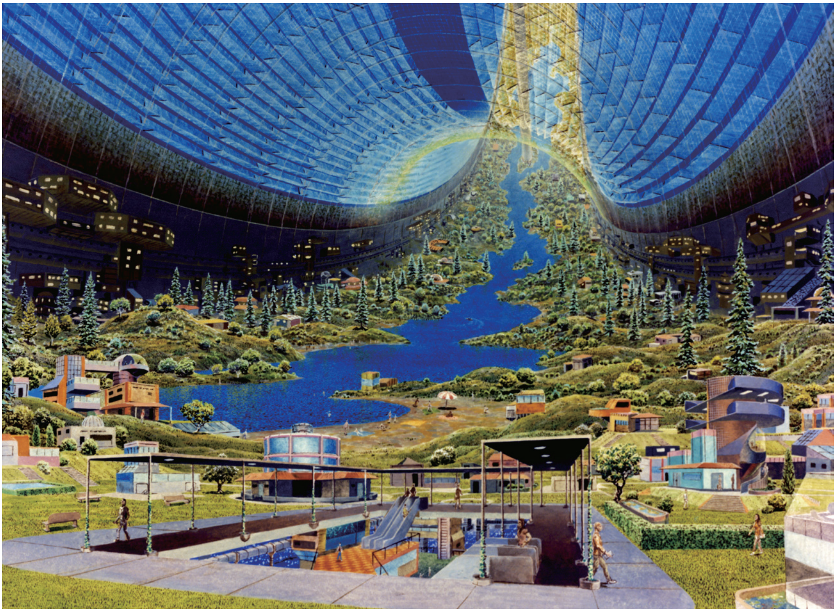
Lower. Diagram of the feedback inside Inter-Active Centre. Drawing by Cideric Price. circa 1977. Image courtesy of Canadian Centre for Architecture. Archive reference: DR1995:0252:621.

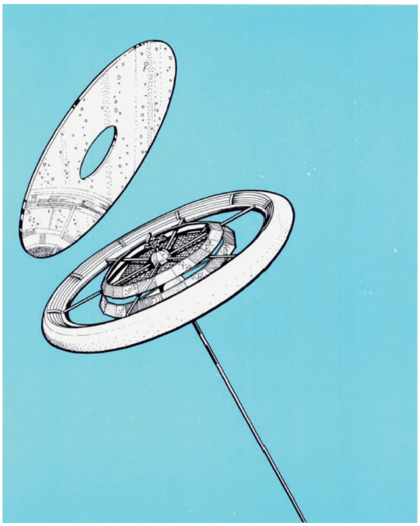
O’Neill shared the same ambition with NASA, and possibly the same concern. Like many of his peers, O’Neill has familiarized himself with the popular theory that there exists a limit to economic development. Humanity was haunted by war, pollution, hunger, and shortage; and the uncontrolled rate of population growth is approaching to a ceiling that our planet Earth can ever support. In his 1974 paper, he referred to the Club of Rome’s “The Limits to Growth,” a report that employed a large number of charts and diagrams to show scenarios of inevitable collapse of human civilization. Mistakenly or not, he wrote “The Limits of Development” in the reference, which nevertheless scrutinize the matter from a different perspective: Our civilization’s development can break through the limit by immigrating to space. Colonization in this sense is not as idealistic as “what we want,” but realistic as “what we must do.” Fifty years ago, Konstantin Tsiolkovsky built up a similar plot in his fiction that Earth would be consumed by the expanding sun, and the only way to survive on a civilizational scale is to flee into deeper space.[92] The desperation embedded in his story is reflecting the early twentieth century Russia, where people’s ordinary life was ravaged by wars and revolutions. The communist authority appreciated Tsiolkovsky’s space utopia for the educational purpose and ideological preference.

Building a utopia on Earth is not an easy task, and the Soviet censorship body, Glavlit, was established after the Bolshevik revolution to defend their country from the bourgeoise cultural corrosion.[93] Glavlit infiltrated into all levels of media apparatus and helped to secure the total information control within the Soviet Union.[94] A question should be asked here: Is a highly designed utopia also highly controlled? From the former chapters we learned that flow of matters and energy must be carefully coordinated with the extreme architectures –

certainly, safety redundancy allows a degree of variation, but the station's self-reliance is designed on the basis of sophisticated and explicit circulation of life-necessities like air, water, food, and waste. It is therefore impossible to avoid this interrogation whether O'Neill's space cylinder will impose a certain way of living. If discarding the sensitive question of whom these cylinders are designed for, the inquiries like "how many carrots and meat can a resident purchase," and "what type of home is one permitted to live in" could easily trigger psychological discomfort. It seemed that neither O'Neill nor NASA had an agreement whether the space settlement should have a specific look: During the conference, O'Neill worried that too many public attention and debates would not produce any solid results, and he prefers a smaller group of experts that make things happen.[95] On the other hand, he worked more often with Don Davis in the later phases to create pictures that insinuate open endings; they wished to provoke thinking and imagination. NASA had a different approach: It cooperated with another illustrator, Rick Guidice, a trained architect, to show more credibility of their design.[96] In the NASA's official publications, the space settlement was painted in a manner of architectural renderings: Something ought to be built as it is. The ambivalence within the group was soon ended by the social reforms of the 1970s – by the waves of deregulations and retraction of government. NASA reacted by giving up its big promises and rounding up the sharp corners of the letters.

In 1977, another summer study was organized around O'Neill's space settlement, only that this time the discussion is focused on the ring-shaped station, or taurus.[97] The design can be traced back to the late 1929, when Herman Potocnik envisioned a space wheel of thirty meters, and it was enlarged to be seventy-six meters by von Braun in 1952.[98] The idea of space station was given





Upper. Various housing inside 1977 space ring. Illustrated by Don Davis. circa 1975. Image courtesy of NASA. NASA ID: AC75-2621.

Lower. Space ring from the 1977 summer study. In "Space Settlements: A Design Study." Edited by Johnson, Richard D. and Charles Holbrow. (Honolulu: University Press of the Pacific, 2004): 2.

serious study by Nazi German, and it is later imported to the United States by operation paperclip along with the other Nazi military assets such as Werner von Braun. As the student of Hermann Oberth, von Braun inherited the enthusiasm of space station. Oberth once suggested building a canon to “launch” people to the moon.[99] Although the idea was commonly introduced as a joke, von Braun was “canonized” for making moonshot possible by the development of Saturn V rocket. In 1974, von Braun established the National Space institute – it later merged with the *L5 society* in 1987 as the National Space Society (NSS).[100] In contrast to O’Neill’s prospectives that space colonization is the agency to mobilize social change, the NSS set forth the objective “to promote social, economic, technological, and political change in order to expand civilization beyond Earth, to settle space and to use the resulting resources to build a hopeful and prosperous future for humanity.”[101] Its doctrine insists that human must solve the issue on ground before stepping into space, and it can be summarized as “we are not ready.” In the Soviet Union, voice of criticism toward the space program can be traced as early as Gagarin’s flight, as people raised suspicion of Gagarin’s rapid promotion through military ranks while they were waiting for cars, refrigerators, and universal housing.[102]

As it turned out, people not only nurtured a negative view on space exploration, but very much all the gigantic and utopic urban experiments in their cities as well. These megaprojects encountered growing magnitude of resistance from citizens. Intellectuals like Jane Jacobs were enraged that city planner held little respect to the small elements of the city, nor do they understand urban life. In her phenomenal book *The Death and Life of Great American Cities*, Jane Jacobs attributed the livelihood and vividness of urban live to the small business in the mix-used blocks.[103] The big corporations, on the other hand, are more independent from the urban interactions but consumed a lot of space. The megaprojects – public transportation or skyscraper complex – destroyed the healthy urban environment and replaced it with homogenous fabric in the name of progress. The term progress is loosely defined: Owning a suburban home, a car, a TV, and a refrigerator is progressive; travelling to space, moon, North and South pole is progressive; liberating women and race of colour from oppression is undoubtedly progressive; saving Earth from pollution

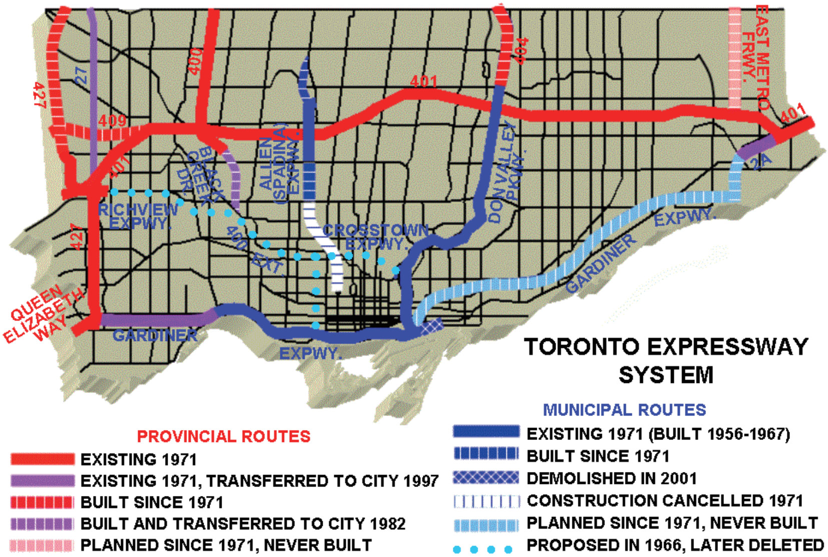
Jane Jacobs in front of her house, North of Bloor-Spadina intersection, Toronto, 1968. Photo by Frank Lennon. Image courtesy of University of Toronto: Uof T News.

and over-extraction is, again, progressive. The ultimate goals can be mutually-intelligent, the measures are sometime contradictive – which “progress” are we trying to accomplish, and who is in charge? Jane Jacobs and many others protest against totalitarians who weighed their “greater good” more important than the others and impose their masterplans from high above. The grand narration of capitalism and communism justifies the social, economic and cultural interventions from the authority. More importantly, it unifies the society with a common promise. In the west, the postwar consumerism ethic was established that buying is not just a privilege, but a duty for every citizen to fight communism.[104] Keynesianism policy and G.I Bill created a myth of full employment and an expanding middle-class. In the East, the combination of Sputnik (1957), universal housing (1957), and de-Stalinism have fueled up the hope that Khrushchev claimed the attainment of communism by 1980.[105]

Megaprojects of the 1960s seemed to favor the terraced structure; the designers envisioned a community cohabiting a monstrous brutalist architecture and guaranteed equal access to air and sun light. Expectedly, the 1977 summer study featured such terraced housing in

Upper. Spadina Expressway cancelled in 1971 due to fierce protests led by Jane Jacobs. Map by James Alcock. May 8, 2006. Image courtesy of James Alcock. Wikimedia commons.

Lower. Students protesting Spadina Expressway in front of University College, University of Toronto. Unknown Photographor. March 18, 1970. Image courtesy of University of Toronto. Heritage Uof T ID: heritageutarms:4881

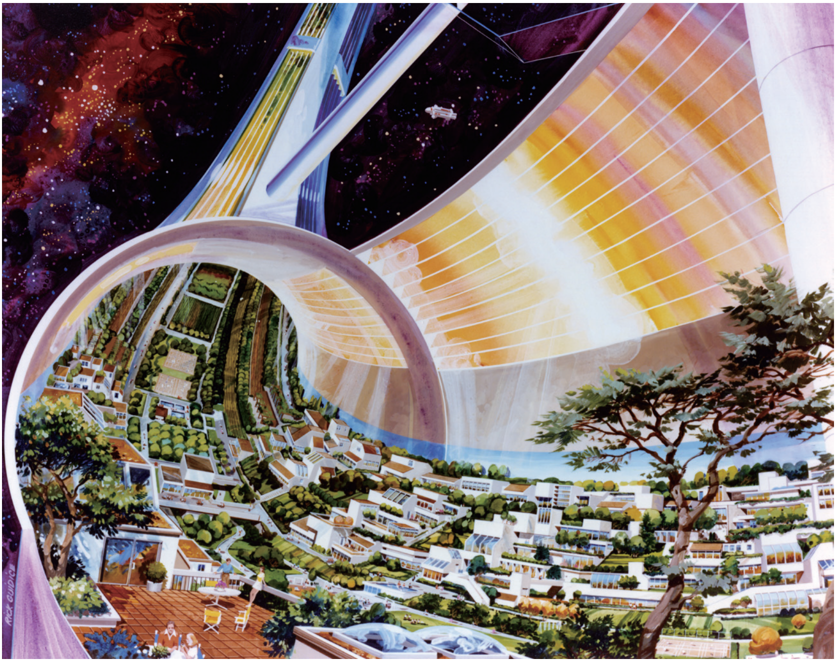

TORONTO EXPRESSWAY SYSTEM
PROVINCIAL ROUTES
EXISTING 1971
EXISTING 1971, TRANSFERRED TO CITY 1997
BUILT SINCE 1971
BUILT AND TRANSFERRED TO CITY 1982
PLANNED SINCE 1971, NEVER BUILT
MUNICIPAL ROUTES
EXISTING 1971 (BUILT 1956-1967)
BUILT SINCE 1971
DEMOLISHED IN 2001
CONSTRUCTION CANCELLED 1971
PLANNED SINCE 1971, NEVER BUILT
PROPOSED IN 1966, LATER DELETED
427
27
400
401
404
409
EAST METRO FRWY.
2A
BLACK CREEK DR.
ALLEN (SPADINA) EXPWY.
DON VALLEY PKWY.
RICHVIEW EXPWY.
CROSSTOWN EXPWY.
400 EXT.
GARDINER EXPWY.
QUEEN ELIZABETH WAY

Upper. Andrews Building, Univeristy of Toronto Scarborough. John Andrews, Toronto, 1966. Image courtesy of UTSC.

Lower. Habitat 67'. Moshe Safdie, Montreal, 1967. Photo by Wladyslaw (user name). September 15, 2008Image courtesy of Wladyslaw. Wikimedia commons.

Upper. Kafka's Castle. Ricardo Bonfill, Sant Pere de Ribs, 1968. Photo by Ricardo Bofill. Image courtesy of Ricardo Bofill Taller De Arquitectura.

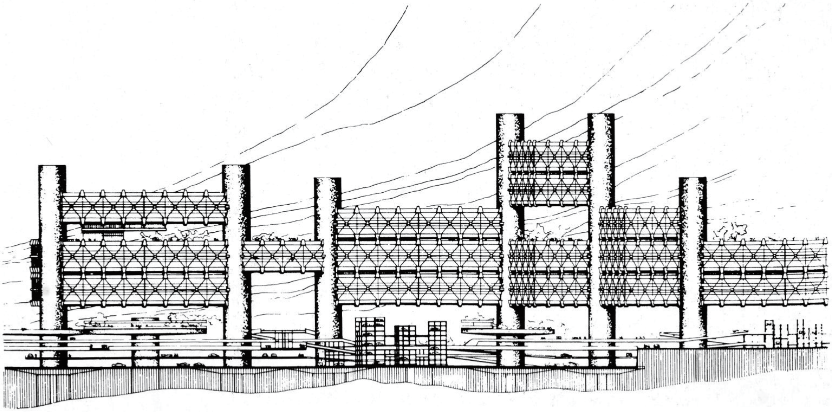
Lower. Golden Mile Complex. DP Architects, Singapore, 1973. Photo by Sengkang (user name). August 2007. Image courtesy of Sengkang. Wikimedia commons.

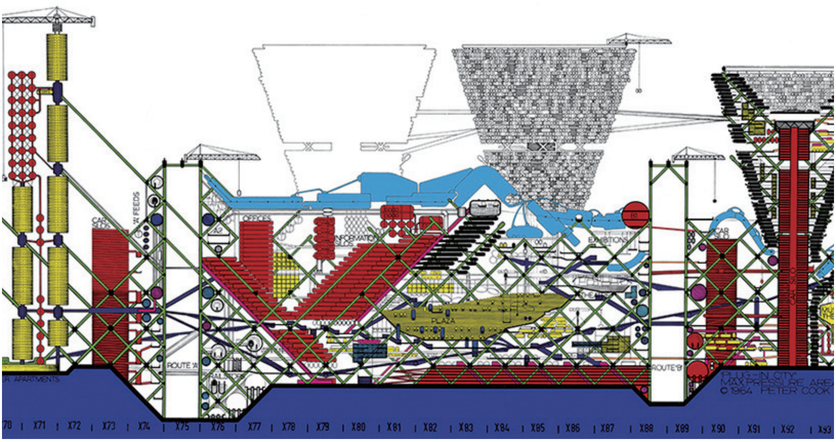


the space taurus. If more, some projects were programed to update themselves to accommodate new demands. Although it was never built in real life, the 1961 *Fun Palace* revolutionized architecture with cybernetics concept: A building can respond to real-time feedback and readjust itself. Concurrently, a group of young Japanese architects publish their Metabolism Manifesto, in which they regard cities as living organisms and metabolic process shall be fostered by architectural means.[106] In the United Kingdom, Archigram produced many drawings that diptych cities with complex mechanical systems and flexible modules, and sometimes mobile by themselves. It is fascinating to see that some of those ideas were realized today. Nowadays, many extreme architectures are installed with automated environmental control; the valves that decide "stop" and "go" function like logic gates: They execute commands and modify the system with feedback. If the entire station is viewed as a computer, Cedric Price's *Fun Palace* was, to a certain extent, realized. And not to mention that Halley VI is a modular and movable settlement in itself. However, as much as the designer wanted them to last, the megastructures were short-lived in the history with debatable reputation. By the 1970s, Keynesian societies found themselves in a difficult situation where rising

Upper. Jeanne Hachette Housing. Jean Renaudie, Paris. 1973. Photo by Léopold Lambert. circa 2014. Image courtesy of Léopold Lambert. "Ivy-sur-Seine: The Architecture genius of Renée Gailhoustet & Jean Renaudie in Paris Banlieues."

Lower. The terraced architectures inside 1977 space ring. Illustrated by Rick Guidice. circa 1975. Image courtesy of NASA. NASA ID: AC75-1086-1.





Upper. "City in the air," typical Japanese metabolism. Created by Arata Isozaki. 1960-1961. Image courtesy of North Carolina State University. Library accession number: 104758.

Lower. Plugin City of Archigram. Created by Peter Cook. circa 1963. Image courtesy of Archigram Archive. Archive reference: 060-004-NM01.

production cost and emerging international competition have exhausted the momentum for mass production. Stagnation in the Soviet Union rendered the attainment of communism an empty promise: People were still waiting to be assigned with an apartment,[107] but abandoning such a promise in the Brezhnev era surged the feeling of betrayal. In the United States, the Watergate scandal disenchanted people from their government, and it is worsened by the Apollo 15 postcard scandal. So much of the government big talks – it became hard to sell the grand narrations to the public, and so were the megaprojects. The eventual recession of megaprojects has multiple causes: The senescence and decease of the master-planners like Luis Khan (1974) and Le Corbusier (1965), exacerbation of economic hardship, and emergence of diverse interests. But perhaps the most fatal of all is the maturation of the civic society, the very thing that megaprojects were built to serve.

Depletion of public support in large government investments slowed down the pace of further explorations in space and polar regions, but never brought the programs to a complete halt. “In a society where the public has little trust in government, business, and media, as documented by the Pew Research Center, the need for enemies takes on greater prominence. As long as the United States persists in finding enemies, it will need and use propaganda – and the host and cold wars that follow.”[108] Years of cozy relationship between the United States government and defence industries had nourished a booming business of lobbying (or “advertisement”). The search of the next strategic threat has become a path dependence for the military complex to win defence contract. Prior to the second world war, one could hardly find a military industry in the United States, but it soon grew into a concerning existence that President

Eisenhower had to warn the American public about its "grave implication" in his farewell address.[109] By the time he transferred his position to Kennedy, the military establishment has acquired immense influence in economy and policies for its shear size and millions of workplaces it directly associates.[110] President Kennedy was not at the liberty to risk the moon landing by removing the military industries from the supplier list. The Apollo landing module was built by Grumman,[111] the same company who produced F-14 fighter jet for U.S Navy. Boeing built the Carrier rocket Saturn V as it gambled its future on 747 Jumble Jet.[112] Meanwhile, its B-52 bombers were carrying nuclear weapons on the regular patrol at any given time. The Lunar Roving Vehicle (LRV) was contracted to Boeing as well for $ 19 million, but the final cost was two-fold of the budget for four cars[113] – seventy-five million worth of today's dollar per each, more than a hundred Royce Rolls Phantom combined. The air raid drills on school campus since the 1950s turned out to be the successful fear-mongering anti-communist propaganda. Although the Soviet people were tired of the tedious coverage of their space triumph and standardized communist rhetoric, they were still cheered by the Gagarin's press conference that western journalists were given non-essential information about the highly secret space program.[114] When is the next launch? At the time when it is necessary. People would laugh in front of TV about the whimsical

Upper. Gumman F-14 "Tomcat." Photo by Stephano Orsucci. July 18, 1988. Image courtesy of Stephano Orsucci. Planespotters.net

Lower. Boeing B-52 Stratofortress. Photo by MILSPOT (user name). March 9, 2022. Image courtesy of MILSPOT. Planespotters.net serial number: 464445.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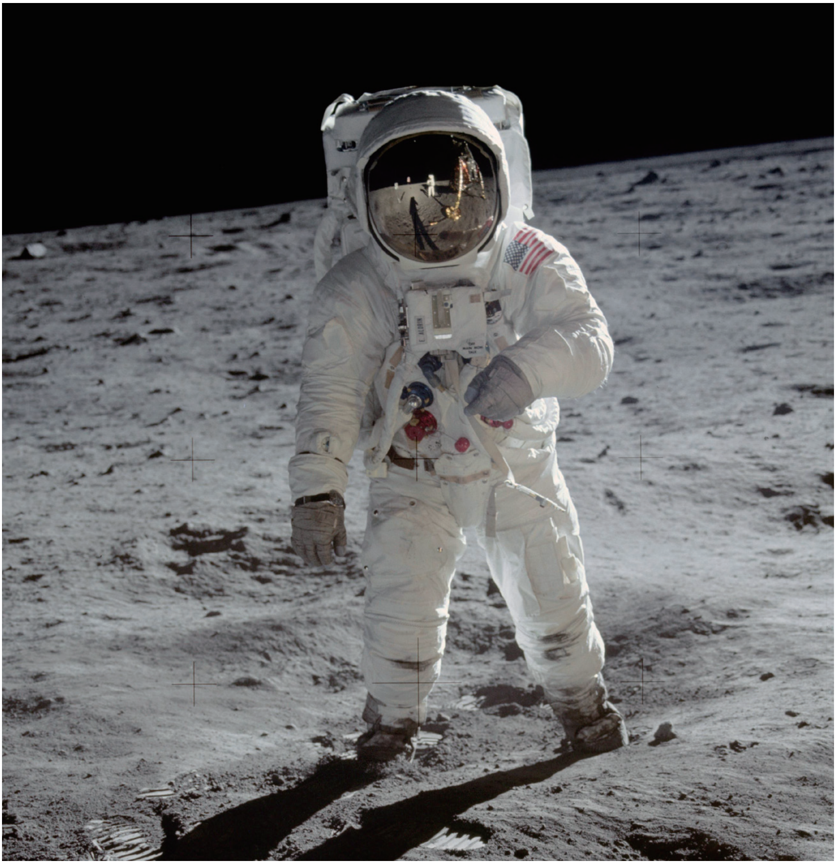
bureaucratic nonsense from their cosmonaut – if they actually own a TV. Cultural aggression infiltrated aspects of life throughout the Cold War, a permanent station in space and polar regions is more than a shelter: They are the national assets to demonstrate technological prestige, and the icons that pinpoint the country's resolute to stay on the moral high ground. Perhaps wining the Cold War restored American's national pride and ambition, or its defence industry acquired a new target, NASA switched back its "meatball" logo in 1992,[115] when the construction of the international space station was underway.

Following the political and economic crisis in the 1970s, social reforms were undertaken: One of the signals of neoliberalism is the sophistication of government's public-relation strategy in exchange of welfare set-back. Softened communication replaced the commanding tune. The Apollo-Soyuz docking in 1975 signifies a geopolitical turning point. Since 1977, the picture of Russian figures was painted in a positive way in the Star Trek series: The Russian genius, Chekov, is an indispensable crew member of the starship Enterprise. Ten years later, another Russian protagonist, Gorbachev, expressed his willingness to create a zone of peace in Arctic. On a microscopic scale, Cadillac abandoned its symbolic tailfins that somewhat signifies a pseudo-aerodynamism. A few years earlier, the manufacture of Apollo spacesuit was contracted to International Latex Corporation, which thrived on woman underwear.[116] Spacesuit are not only the extension of the extreme architectures, they are also extreme architectures themselves. The A7L spacesuits – the soft, puffy, white ones that iconize the entire genre – won the competition among the hard suits. Softened architecture coincides with the softening governance – a triumph of soft over hard, or femininity over masculinity. The Artemis Plan, named after Apollo's twin sister, aimed to return to the moon.[117] And in 2019, President Trump challenged NASA to land first woman on moon by 2024.[118]

Oil crisis forced the car manufacturer to reconsider the designs, and smoothed edges were implemented on new models for true fuel-efficiency.[119] The call for more transparency and inclusiveness is answered in Arctic and Antarctic stations. For example, Halley VI offered its crew member a big gathering space in the middle. This chapter discussed the intangible site conditions of the extreme architectures, with a particular interest on political factors. We can see the coexisting of scientific curiosity and geopolitical drama – often packaged and exhibited in the struggles between idealism and realism. Political tension and international convention are both restraint and motivation to promote the permanent stay in the forsaken places. The social movements have the power to reshape people’s opinions on the government spendings on explorations, and propaganda plays an irreplaceable role to keep the program ongoing. The development of civic society and issues of Keynesianism engendered a shift in public aesthetics where megaprojects and grand narrations became less attractive. Even though some of the megaproject concepts are later realized in the extreme architectures, the adaptation is based on renewed political agenda that is different from their original settings. Personally, I see the nostalgic quality in the extreme architectures. They seem to belong to an alternative universe – a future that never happened. If we are to distill that aura of infinite optimism, what is left for the nostalgic future? There are frameworks of colonialism and anti-colonialism, Keynesianism and neoliberalism, and there are agendas that tell us what to do; but what do we want from the explorations? What is driving human to endure the unlivable conditions besides the simple impulse of curiosity?

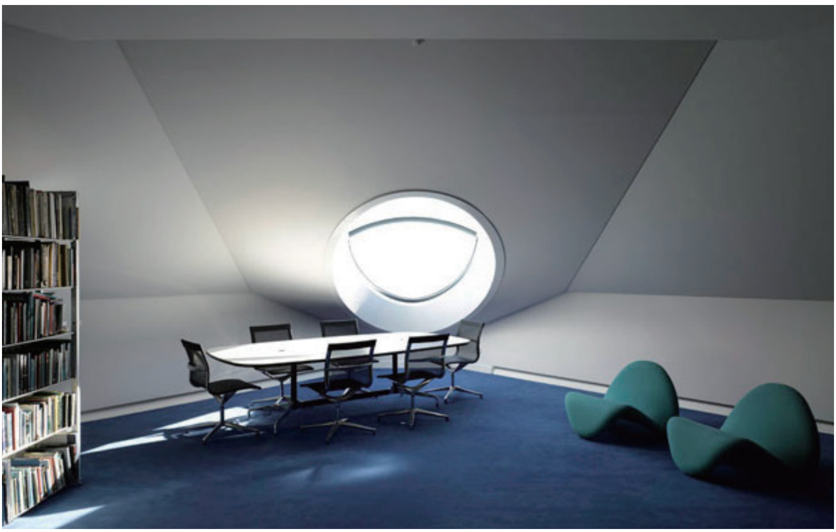


Upper. Cadillac tailfins that used to dominate the car design. Photo by Paul Popper. October, 1, 1958. Image courtesy of Paul Popper/Getty Images.

Lower. Colours are carefully tuned for the study area, curves are softened, too. Photo by James Morris. Image courtesy of *Abitare*.

Left. Buzz Aldrin walks on moon surface. Photo by Neil Armstrong. July 21, 1969. Image courtesy of NASA. Archive ID: AS11-40-5903


1959 CADILLAC COUPE



[1] Gorbachev S. Mikhail, “Speech in Murmansk at the Ceremonial Meeting on the Occasion of the Presentation of the Order of Lenin and the Gold Star to the City of Murmansk,” speech transcript, Brentsinfo Online Archive. Original Speech delivered on October 1, 1987. Accessed on February 7, 2023. https://www.barentsinfo.fi/docs/gorbachev_speech.pdf

[2] John Fitzgerald Kennedy, “Address at Rice University on the Nation’s Space Effort,” transcript, John F. Kennedy Presidential Library and Museum. September 12, 1962. https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-at-rice-university-on-the-nations-space-effort

[3] See the descript and options of the transcript at https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-at-rice-university-on-the-nations-space-effort

[4] Claude A. Piantadosi, *Mankind Beyond Earth: The History, Science, and Future of Human Space Exploration* (New York: Columbia University Press, 2012): 55.

[5] Alexander L. Chizhevskii, 1926, “Physical Factor of Historical Process,” trans. Vladimir P. de Smitt, *Cycles* 1971: 13.

[6] Ibid.

[7] Ibid.

[8] Claude A. Piantadosi, *Mankind Beyond Earth*, 55.

[9] Ibid.

[10] Alexei Kojevnikov, “The cultural Spaces of Soviet Cosmos,” in *Into the Cosmos: Space Exploration and Soviet Culture*, ed. Andrews, James T. and Asif A. Siddiqi. (Pittsburgh, Pa: University of Pittsburgh Press. 2011): 17.

[11] Alexander L. Chizhevskii, 1926, “Physical Factor of Historical Process,” 15-16.

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[13] Ibid, 12. Note that these is only summarization of his idea, not exact words.

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Once upon The Time in The Future

Space: The last frontier. There are the voyages of the Starship Enterprises. Its five-year mission: To explore strange new worlds. To seek out new life and new civilizations. To boldly go where no man has ever gone before. [1]

---- *Star Trek*

This is a present from a small distant world, a token of our sounds, our science, our images, our music, our thoughts, and our feelings. We are attempting to survive our time so we may live into yours. We hope someday, having solved the problems we face, to join a community of galactic civilizations. This record represents our hope and our determination, and our good will in a vast and awesome universe.[2]

---- *James Earl Carter Jr.*

On July 29, 1977, President Carter wrote this letter to the hopefully alien recipient in the universe, as shown in the second quote. It was digitally stored on Voyager I spacecraft: As a part of golden record carried on board, the message can be deciphered by the manual engraved on the surface. Besides the president's letter, the pictures of animals and their sounds, and greetings in various languages were added as a friendly gesture.[3] The probe was launched in September; it took a year and half to reach Jupiter, and another year and half to pay a visit to Saturn.[4] In 1990, Voyager I sent out the last pictures of solar system and moved on to the deeper space. In 2012, it finally left the solar system and became the first interstellar object of human being. The problems on Earth are still far from being solved as of today, but the explorations in Antarctica and space continued nonetheless. There are different motivations behind this, and as we have seen in the last chapter, geopolitical struggles and military confrontations are keep human stationary in the distant domains. Scientific mission initiated the programs, and is often, if not always, supplemented by the political dramas. Even driven by pure curiosity, these programs, especially those of space, must justify themselves for the cost of great national fortune– usually iterated in utilitarian view on fresh knowledge.

"We sail on new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for progress of all people. For space science, like nuclear science and all technology, has no conscious of its own."[5] This is another excerpt of President Kennedy's Rice University Address. He advocates in plain words for the acquisition of knowledge as a continuation of human development. The United States must join the Space Race because only the winners can decide whether the new knowledge will be used for peace and progress. Propaganda of different sides can argue who is the winner, though the history of science shows that the progress is shared in a larger demographic group across borders. Can we all forgo the ideological disputes and share the benefits of science research? Can all human be united in explorations of our planet's past and future? A positive answer to these questions is perhaps only a wishful thinking but a frequent setting for science fictions. The first quote is the remark from the TV series Star Trek. The story took place in the world where the entire Earth was unified under the common leadership, so the only border human can transgress is the mysterious universe.

In 1970, Ernst Stuhlinger, who was then in charge of NASA's Mars mission, replied to a Zambian nun in response to her interrogation why spending millions of dollars on space exploration while a lot of children are starving to death. "The voyage to Mars will certainly not the direct source of food for the hungry. However, it will lead to so many new technologies and capabilities that the spin-offs from this project alone will be worth many times the cost of its implementation."[6] In the Dr. Bush's 1945 report, he credited science advancement and application as one of the reasons that there is no famine in the United States from 1900 to 1940 when its population almost doubled.[7] The redistribution of the food, on the other hand, is a different matter of international cooperation, as Stuhlinger noted: "Efficient relief of hunger, I am afraid, will not come before between nations have become less divisive than they are today."[8] There are political borders on Earth – the frontier of a state's farthest jurisdictional stretch – contrasted by the shifting frontier of exploration: Arctic in the 1940s,[9] Antarctica in the 1950s, and space in the 1960s. Two types of frontiers: One static, as the sovereign border, and one dynamic, as Dr. Bush's report title (Science: the endless frontier), creates the tension for narration. This is the basis of this chapter. The first chapter that deals with history focused on mirror images of elsewhere, this chapter will then move on to the mirror images of elsewhen, the alternative reality that the extreme architectures stand for: The nostalgic futures that never happened.

The extreme architectures are mostly established as science instruments. Not only do they accommodate equipment, they are the platform to test human limits and new technologies. For the scientists, the extreme architecture shall satisfy human desire to discover. To the rest of society, it exemplifies the might and resolute to conquer the known. This chapter will focus on the cultural factors – another agent of intangible site condition – of the extreme architectures. Notions of progress will be discussed alongside the ideological contest. Technological sublime and Manifest Destiny will be investigated as a cultural phenomenon and compared to colonial sentiments. Curiosity in the exploration will be analyzed from a psychological point of view. In the end, the topic of utopia will be added to the discussion for the utopic establishments of the expedition and design philosophy of the architecture involved.

Debates in Kitchen

Kitchen is perhaps the most special domestic space in a twentieth century home. Not only does it become the gathering place for the nuclear family, it is the extension of the society and often subject matter of the political and cultural narrations. Kitchen, therefore, is the theatre to observe the cultural shifts of later half of the twentieth century. Musician Bill Joel published his music video of “We Didn’t Start the Fire” in 2009, the lyric that captures the iconic incidents throughout the post-war (mostly American) history is reflected by the typical kitchen of the age since the 1940s.[10] Its most significant feature is that the characters’ performance changes with the modernization of kitchenware. Back in 1959, the dialogue between Khrushchev and Nixon in Moscow is one of the occasions that expose the power of collective culture as it captures small elements into something much bigger. The conversation between the superpower leaders, otherwise known as the Kitchen Debate, associates home appliance, especially that of kitchen, with ideological signature when a colour TV could be as American as a Cadillac. On July 24, 1959, the American National Exhibition was unveiled at the heart of Communism; a mock-up home was built to update the Soviet people of the latest American life.[11] The sparkle of competition was ignited as early as the opening address, which at the same time was fairly entertaining when two leaders were standing on the stage like stand-up comedians: Khrushchev teased the Americans several times so tension was not built up. He asked: “How long has America existed? Is it three hundred years? One hundred and fifty years of independence. Then we will say America has existed one hundred and fifty years and here is its level. We have existed almost 42 years. In another seven years we will be on the same level as America. And then we’ll move on ahead. When we pass by you along the way, we will greet you amicably like this."[12] Then he waved his hand toward the American commercial representative – people laughed, including the giggling vice-President Nixon in the back. "Then, if you like, we can stop and invite you to catch up."[13]

The Soviet Union was at the time confident enough to have Americans showing off their gadgets on Russian soil. The United States was under pressure to keep up with Sputnik satellites, and not mention that Russians built three stations in Antarctica right after the first IGY conference in 1955.[14] In 1957, Khruschev launched his massive construction campaign to provide housing for every Soviet family.[15] Single family apartment, along with new furniture and appliance, is the cultural definition of good life.[16] What's more, the de-Stalinism movement denounced the state terror and encouraged the spirit of truth-telling.[17] To many Soviet baby boomers who were born before the great patriotic war,[18] they have seen the life devastated and then greatly improved – in both material and spiritual sense – in the 1950s. The citizens were assigned new apartments on public holidays,[19] new articles would usually present it as a ceremonial event and a gift from the state.[20] Achieving communism seems to be only a matter of time through the collective life and Soviet Kitchen. Bearing in the mind that residents would be more productive if they are to live in a good environment, the Soviet archi-

Upper. Instead of "debate," this conversation is more of a casual chat. Filmed by C-SPAN. Imgae courtesy of C-SPAN.

Lower. The mock-up American kitchen in Moscow, note the robotic cleaner in the lower left corner. July, 1959. Image courtesy of Bettman Archives/Getty Images.


08-30-98 01 12:13:46
C-SPAN
July '59

tects would integrate pubic green spaces in apartment complex for recreational purpose.[21] However, the hidden implication is that home and workplace are organically connected, and there could be hardly any boundaries to separate public affair from private space. It is a challenge for the socialist planners to resolve the potential conflict between the expanding public service and private comfort. Their solution, though, is to establish a community by implementing public kitchens.[22] In the quintessential socialist masterplan, a public kitchen will serve the entire complex so workload at home would be alleviated. Refrigerator and electric stove in the apartment would grant a family considerable convenience, but the lacking of such products on Soviet market helped to fuel the enthusiasm for collective urban life. Progress was carried out in the name of Soviet people and is shared by all. Individuals, in this case, are subordinated to a common cause – not to mention that one still has to join his comrades in public lavatory and bathroom.[23]

Nixon replied in a clever way: "As far as Mr. Khrushchev's comments just now, they are in a tradition we learned to expect from him of speaking extemporaneously and frankly whenever he has an opportunity. And I am glad he did so on our colour television."[24] The argument whether America is ahead of the Soviet Union on TV technology was then ended with an agreement between the two: One's speech will be translated into native language of another so people in each country can hear the conversation on TV. Khrushchev did not have to worry about the American influence giving that only 5% of Soviet population have access to TV by 1960,[25] and many people would not be able to understand the content due to illiteracy.[26] In a broader picture, the collectivist description of good life was often found in contrast with individual dissatisfaction in the Soviet Union. The apartments were built with prefabricated

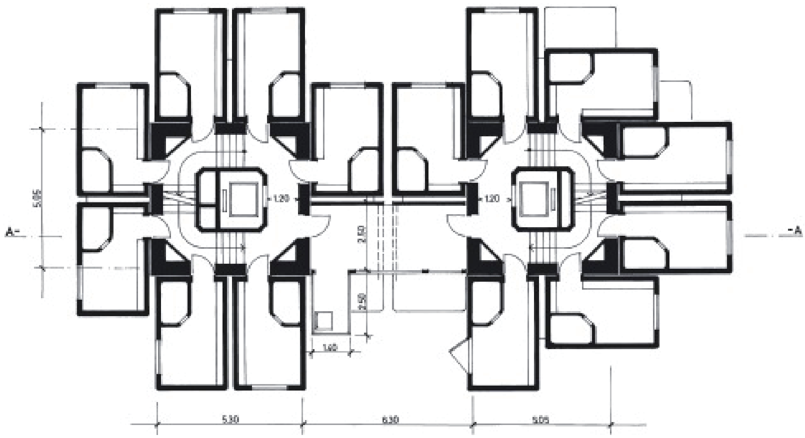
The cover of magazine *Krokodil*, April 10, 1960. July, 1959. In “Moving Toward Utopia: Soviet Housing in the Atomic Age.” Varga-Harris, Christine. In *Divided Dreamworlds? The Cultural Cold War in East and West,* edited by Peter Romijn, Giles Scott-Smith, and Joes Segal, 133–54. Amsterdam, Amsterdam University Press, 2012: 142.


НОВОСЕЛАМ - ДОСРОЧНО!

Left. *New Settlers ahead of schedule*. State Publishing House of Fine Arts. Poster. 1961. 83×56 cm. Image courtesy of SVOCOM.org. Auction Number 158.

Right. *Wedding on the street of Tomorrow*. Yuri Ivanovich Pimenov. Oil on canvas .1962. 86×80 cm. State Tretyakov Gallery Moscow.

material and standardized design: Speed of construction was the top priority,[27] leaving the quality to the second position. Despite the hasty construction and hence poor environment of the new apartments, many people were still waiting to be assigned with one.[28] When asked to design the interior of the Soyuz capsule and later the lunar module, Galina Balashova put in her understanding of the average good life: A toilet, a sofa, a shelf full of personal



Nagakin Capsule Tower. Kisho Kurokawa, Tokyo, 1972. Drawing by Kisho Kurokawa. Image courtesy of Kisho Kurokawa/ Archeyes.com

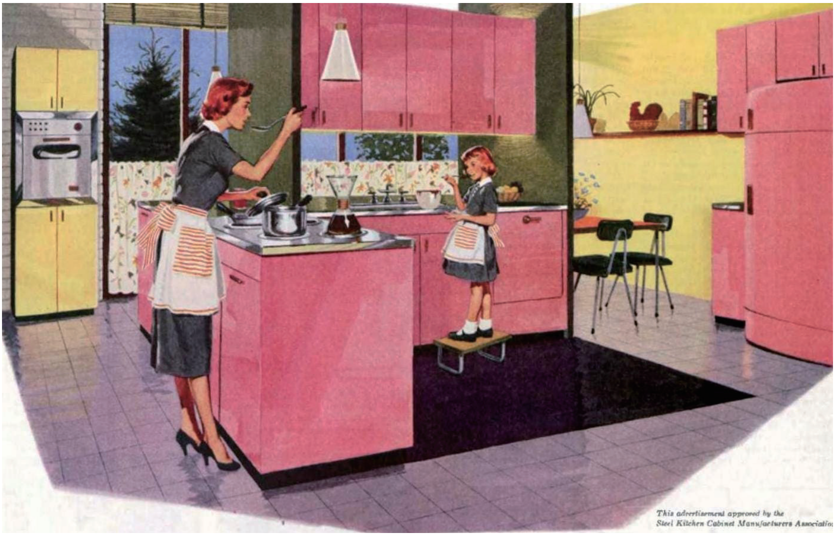
Inside the encapsulated private kingdom. Photo by Kisho Kurokawa architects & associates. Image courtesy of Kisho Kurokawa architects & associates.

belongings. Although many of the designs were not adopted in the end, her drawings reflect the very housing model – even the society – that the Soviet authority tried to provide: A cozy, highly controlled interior where one enjoys the maximum personal freedom. Interestingly, the same idea has driven Kisho Kurokawa to create Nagakin Capsule Tower. To demonstrate the freedom in the encapsulated personal-kingdom, the residents are broadcasted with pornographic videos through the TV.[29]

Compared to the Soviet Union, home appliances such as TV and refrigerator in the United States played a major role in cultural shaping. By 1960, 86% of American homes have a TV.[30] And by 1944, 85% of American homes have a refrigerator.[31] Owning a set of those electronics is the symbol of healthy middle-class; if more, the contribution one can make to keep the country's economic wheel spinning.[32] The introduction of electric appliance in the kitchen enriched the family life, but also complicated the gender dynamics. Like a TV, a refrigerator challenged a man's masculinity – a degree of insecurity is stemmed from his incapability to understand the functions in in the machine,[33] and that machine's power to satisfy the housewife. As kitchen remained to be a sexualized space at home, a man could see himself illiterate and lagging behind an increasingly automated America[34] – he may even feel difficult to cook coffee or bake potato at their own home. Commentator would argue that, for example, a

Upper. Not a single male figure was displayed in the 1955 kitchen commercials. Poster by John and Earline Brice. Image courtesy of Jones & Laughlin Steel/ Plan59.com

Lower. Deep Freeze Refrigerator commericial, 1955. Image courtesy of RETRO-A-RAMA.com


This advertisement approved by the
Steel Kitchen Cabinet Manufacturers Associatio


it's a freezer! it's a refrigerator!
crisper

refrigerator not only empties a man wallet, but the wasting the country's resource on nonessential products when the communists were building ICBMs.[35] As a bread earner, why buying the expensive machine that will surely harm your role? A man must find a balance between his mechanical authority and social parameter.[36] Meanwhile, the integrated kitchen flourished in the consuming market where a refrigerator is somewhat hidden among the drawers with dish washer and oven. One may take it as the cue that manufacturers finally yielded by making refrigerators invisible – or it is simply a futuristic cliché that a compact kitchen in a flush façade fits better on rockets or nuclear icebreakers. Perhaps a traditional male character is supposed to be ignorant in the feminized kitchen: Women's feedback was gathered so the industry could update the kitchenware design.[37] In Sweden, amenities and floor plans were rationalized according to woman body. In the Soviet Union, architects design pull-out shelf so a housewife can prepare meal while remaining seated.[39] Despite the fact that modern kitchen is oriented around women, soon enough men would find out that their spouses are equally uncomfortable about the situation.

It is debated whether technological improvements in kitchen were intended to liberate woman from the unpaid works, or to boost their willingness of staying at home, or both.[40] Feeling being grounded at home, many American women wish to devote their energy in something they enjoy, and oftentimes they are warned by the unpleasing figures of the Soviet women's overworked body. As a reaction to the Soviet propaganda about woman's participation in labour market, American press would present the Soviet Union's shortage in consuming goods (make-ups and clothes) and the authority's disapproval of "feminine beauty" as the "cost of communism."[41] In September of 1959, two months after the Moscow exhibition, the Soviet

Luna 2 impacts the moon surface, leaving the first trace of human civilization outside Earth and its orbit.[42] Before Americans could perform the same stunt three years later with Ranger 4,[43] their response is subtle yet influential: By the end of that month, TV show *Men into Space* finally met the audience. In the story, the astronauts were portrait as a group of "brave, stable, rational, hetero-, cis- family men working in the military."[44] The women on the other hand, were typical worrying but supportive house wives living in suburb detached houses. In the aftermath, the show was successful as it opened a new age of TV series. Even though it was aimed for children, *Men into Space* attracted many adult audience as it incorporates real engineering problems in the plot.[45] Unlike many cheaply made space series, *Men into Space* has pressure suit borrowed from Air Force, and sets designed by Bonestell.[46] The popular-

American definition of good life. circa 1965. Image courtesy of Camerique Archive/Getty Images.

Upper. Pressure suit for U-2 spy plane pilots. Photo by U.S Air Force. Image courtesy of U.S Air Force. Wikimedia commons.

Lower. *Men into Space* poster, with McCauley in a "spacesuit." Photo by PBS Television. September 11, 1959. Image courtesy of PBS Televsion. Wikimedia commons.

ity of its themed toys and board games resembles a similar cultural industry in the Soviet Union, where a range of collectable items were made of space symbolism.[47] The story of *Men into Space* is for sure fictional, but the American lifestyle it glorifies is real. The protagonist Colonel McCauley lives with his family in a house; he is honest and brave, and enjoyed activities with his son.[48] He was shaped as the role model for the 1950s manhood – like many TV characters of the time who are distinctively good or evil[49] – the actor of McCauley even found this role too earnest to be true.[50] In the eleventh episode, when a wife was invited to join the team in space, she hesitated and said she does not know anything about space and science.[51] McCauley explained that it is exactly why they wanted her: To see how an average housewife, without scientific training, manages her life in space.[52]

This image of a stereotypical housewife was compared to that of Valentina Tereshkova, who filed a longer distance than all American male astronauts combined.[53] While the writers in the United States enjoyed criticizing the Soviet women's bodily appearance, they did not attempt the same approach on female processionals in science and technology.[54] "Russian Blonde in space" was the new Soviet female character adopted in American media, though Tereshkova has brown hear in reality. As a general cultural appropriation, Tereshkova redefined femininity for Americans: A woman can be pretty and achieving at the same time. The Cold War nationalism has henceforth combined with feminist objective organically. As a part of scientific program, Tereshkova was attached by numerous equipment to monitor the impact of spaceflight to a female body.[55] Zvezda moon base was still under development, and the data collected from Tereshkova flight is practical for designing the environment for future Soviet couples and families on moon.[56] However, Tereshkova is perhaps

an exception in the Soviet Union woman liberation movements. Cosmonauts before and after her was still predominantly a male profession.

"We are three strong, healthy girls and also gay and bright, and willing to undergo any hardships that you yourselves undergo."[57] These are the words in the letter sent to Earnest Shackleton from three girls who applied to join the 1914 Endurance expedition. "We have been reading all books and articles that have been written on dangerous expeditions by brave men to the Polar-regions, and we do not see why men should have all the glory, and women none, especially when there are women just as brave and capable as there are men."[58] The application was declined for the obvious reason: A journey lonesome and unpredictable as such will barely keep men from insanity, and who are there to protect ladies? For years, women are banned from working in Antarctica for their presumed inability to handle crisis. The first female scientist in Antarctica is Maria Vasilyevna Klenova, who joined the Soviet Union's 1955 expedition that set up several stations. Like the forementioned British girls, she was initially rejected to participate the expedition; she then had to confronted the highly ranked officials as a professor, not a woman, before she was admitted later.[59] Back from her flight, Tereshkova was described by Khrushchev as a daughter figure[60] – by promoting a particular intimacy, the Soviet leadership can

Upper. Valentina Tereskova in spacesuit before taking off. June 16, 1963. Image courtesy of Sovfoto/Universal Images Group via Getty Images

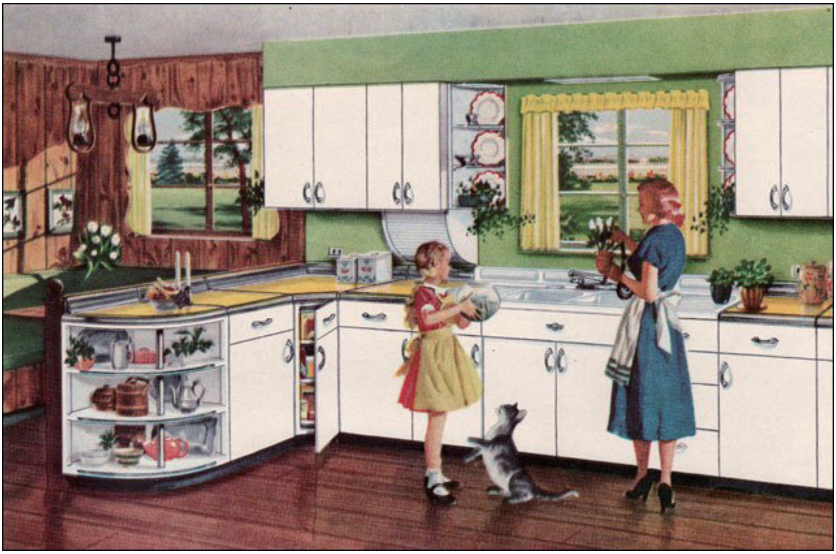
Lower. Maria Vasilyevna Klenova, the marine scientist. Image courtesy of P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences. Научная Россия.

catch a break from their cultural ambivalence. When addressing Bykovsky, who was breaking the record of longest spaceflight but overshadowed by Tereshkova's mission at the same time, Khrushchev used formal titles.[61] Traditional family value was still highly regarded in the Soviet Union: Women were largely stranded in the low- or mid-level jobs even though they were more educated; work positions that required extensive thinking were occupied by men.[62] It appears that Tereshkova was detached from her public figure like Gagarin. The two, as well as Colonel McCauley, were more of the products of the myth-making apparatus in the East and West.

About the time when indoor kitchens were occupied by women, American men began to exploit barbecue, the outdoor kitchens, in their practice of masculinity. The myth of postwar barbecue culture in America was tightly associated with one's American-ness. Living like an American is a measure of defence during the age of massive espionage when the enemy is absorbed into the crowd. Grilling beef on coal in the backyard is a picture one can find a deep resonance with the early American pioneers.[63] Besides, magazines of the 1950s would pronounce barbecue as a male job – indeed, it safeguards "his" dignity as the family provider, while women were assigned works of preparation and clean-up.[64] Having friends and neighbours invited or not, making barbecue is

Upper. Females preparing food for barbecue. Image courtesy of Vintage Everyday at vintag.es

Lower. Male are preparing outdoor kitchen. Cover of *How to Build and Plan Your own Outdoor Kitchen*. Popular Mechanics Comapny, 1953. Image courtesy of Hennepin County Library.




HOW TO BUILD AND ENJOY YOUR OWN
BRANCH'S
OUTDOOR
KITCHEN
ANC
A POPULAR MECHANICS Book
By Tom Riley
75¢ $1.00 IN CANADA
Build These.
GRILL ON WHEELS
COOKERY TOOLS
INFRARED BARBECU

A renewed gender norm in 1950s America. Photo by Dennis Hallinan. January 1, 1965. Image courtesy of Dennis Hallinan/Getty Images. Editorial number: 86062161.

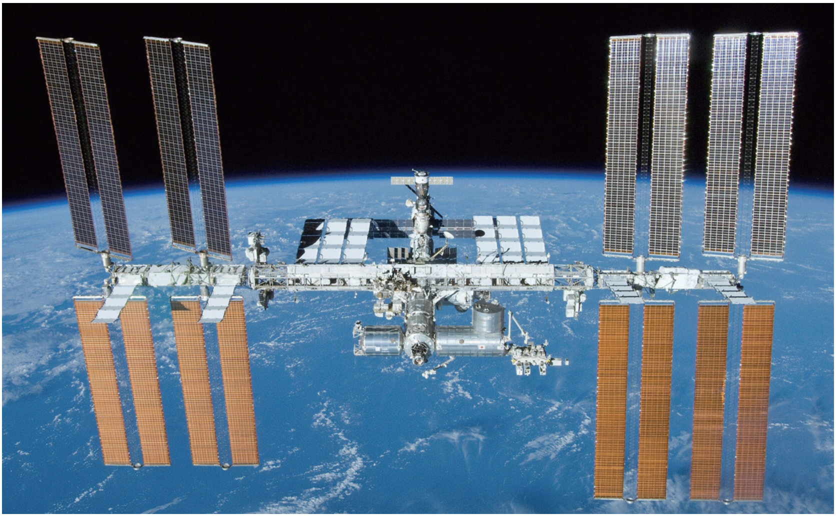
thought to reunite the family and country as a whole. This unity, however, is not said to be created from obedience of its citizens: Men can build the stove in their own way instead of following the manuals brick by brick.[65] In a world of political witch-hunting by HUAC, to what extent the personal freedom is truly enjoyed when one must demonstrate the American quality? No matter it is space, Arctica, Antarctica, the Soviet Union, or the United States, the individual freedom is always mediated by a massive structure – call it technosphere, government, and internet algorithm. Rejecting megaproject and grand narration only make them less visible. When celluloid film first thrived, it was estimated to have great propaganda potentials as a mass media – the art of working class. It is among the bombardments of various visual and acoustic information that the audience are mobilized by distraction – as Siegfried Kracauer described in the cult of distraction, "rivet the viewer's attention to the peripheral, so that they would not sink into abyss."[66] The emergence of TV was initially deemed a challenge to movies, but later realized as a more powerful tool for its private nature. The processed information enters every home, and subsequently every mind in front of screen. The softened speech and inclusive rhetoric are ironically supplemented by invisible mechanisms, signifying – perhaps even celebrating – the control society, where gates and credentials between disciplines have been immaterialized;[67] and one is always finding himself somewhere "in between."[68] Compared to our terrestrial societies, the extreme architectures in celestial domains, namely space and polar regions, are showcasing the honesty in architecture for its environmental control. There are doors and pipes we see, and we know what is keeping us confined but alive at the same time.

A Technological Sublime

Are we essentially addictive to progress (whatever it stands for)? The notion of progress has different implications on public stage compared to personal level. As we have seen in the history, the general progress made available for the majority is usually a tool for public mobilization at best, if not an excuse of brutal intervention of personal life. On the other hand, the individual pursuit of ideal way of living can challenge, or even subvert the grand narrations: The recession of megaprojects since the 1970s testifies the maturation of the civil society. And yet, progress is continually reinvented in the past decades as if there is a destiny of any sort. Restoration of the original NASA logo, current Mars Race, and promotion of polar expeditions in the third world countries are examples of this momentum. It seems that there exists an undercurrent that mediates two types of progress, so that humanity is always moving along a direction – there are always people volunteered to embark on the unimaginable task of before, like living in the unlivable places.

The appreciation of the extreme architectures is stemmed in two ways. The first and most direct of which, is the technological complexity of the structures. Architects and engineers heavily labored the redundancy of the technospheres, which granted a degree of tolerance on nature- or human-induced errors on a practical level, and aesthetic inspiration on the art level. In some cases, complexity is expressed by a space crowded with mechanical or hydraulic components like the photos of Mir station or the International Space Station. The exposed cords and buttons showcase the colloquial sense of technology, even though the functions are largely unknown to the spectators – in a similar manner when people use the umbrella term “rocket science” in the discussion of aeronautical explorations. The nostalgic interpretation of manageable technology resembles the early computers: They are huge and "rusticated," and the logic control of the electric current is somewhat perceivable. The artistic representation of this sentiment creates a structure that looks technologically advance, and the builders seem to have a grip of what they are doing. Asymmetry is another way to prescribe how technologies are piled up in a functionalist way. Being loyal to the real needs, the dwellers would add new elements to the established structure in the most sensible way, and visual beauty is not necessarily guaranteed. In case of the ISS and Halley VI, the asymmetry suggests the prioritization of functions and the potential for further expansion. The rustication and asymmetry all imply a degree of imperfection, something manageable by the mortals themselves. And more importantly, the imperfection invites further modification, rendering the structure "approachable."

Meanwhile, the development of civic aviation and minimalism might affect the art in the way that streamlined surface became a desirable feature on the habitats. If the rustication entails manageable environmental control – such as the Lloyd's Building in London – then a flush façade symbolizes the sophistication of that control. In cases of the Saturn V rocket and Halley VI station, many essential components are hidden under a flawless skin: The system rejects any direct intervention due to its automation. The technological perfection claims autonomy: Now have the structure operated in a separate logic which is only understood by a few. By this time, the vacuum tubes of electronics have been largely replaced by semiconductors; the computers are scaled down until it can be fit in the pockets. The spread of personal computer and smart phone cause an increasing public illiteracy on the modern life: Where is the signal? Why is my screen frozen? Why does every website nowadays ask for cookie,



Upper. Females preparing food for barbecue. Image courtesy of Vintage Everyday at vintag.es

Lower. A combination of smoothing and rustication on the South African Antarctic station. Image courtesy of XinaBox and SANAP.

and what is the “cookie?” Psychological unrest is triggered by the secrecy and incomprehensible mechanism, but the massive adoption of such mechanism is by itself is an engineering achievement. No matter it is the supersonic jetliners or the internet, our modern society is full of the items that we can be proud of and knowing nothing about at the same time.

It always fascinates me that the combining the two types of technological complexity echoes the aesthetics of sublime. The fundamentalist sublime is generated by natural landscape, where one is overwhelmed by vastness, powerfulness, and magnificence. Edmund Burke argues that sublime is constituted by two elements: The terror of powerless or vulnerability in front of great danger – which is not imminent threat to one’s safety, and the grip of astonishment followed by pleasure and awe.[69] By the same token, a comparison between the exterior hostility and indoor hospitality of the extreme architectures is an embodiment of power and magnificence. And exposure of mechanical systems (the rusticated-ness) reflects the struggle of control and comprehension. The two types of complexity complete each other when creating the technological sublime: The awe of the developed parts begins with the reading and reasoning of the under-development parts. Even for a perfect celestial body such as *Death Star*, designers had to show the unfinished hemisphere where internal is visible – a degree of understanding and control is established. Similarly, the spaceships in the Star Wars, such as the *Millennium Falcon* and star destroyers have their flush façade and rustication displayed together; the mainly smooth surface of the *Enterprise* from Star Trek is also decorated by asymmetry of the little bumps. The polar stations, in general, have the load-bearing columns underneath the aerodynamic envelope. Natural sublime paved the way for technological sublime, as argued by David E. Nye, through his studies the spectatorship of the great technological achievements and transformations. The technological complexity of extreme architectures must be culturally processed so it could be established as a part of the "religious feeling" of sublime.[70]

The United States is the best example of studying technological sublime in popular culture. It is a society that feast on sublime and deemed it more necessary than Europeans: Sublime played the indispensable role in its culture and is incorporated into the culture since the early nation-building stage. Commerce in the Europe is detached from the soil, while the agriculture in America is inseparable from the landscape.[71] Intellectuals of the time have promoted the sense of nation built-upon on the land, including its resource and diverse sceneries.[72] The vast and fertile lands in the new world facilitate the not only independence of individuals, but also the feeling of patriotism. The freedom of the young nation is strongly associated with the natural majesty. In fact, Ralph Waldo Emerson took a step further and claimed that the young country without a past is fully open to the future and immense opportunities[73] – the past, though, is substituted by the sublimes that defines American collective memory. This tendency is acknowledged by David E. Nye in his book that "Americans often favorably compared their technological achievements to those of ancient world."[74] The technological sublime in the society is continually refreshed like the natural sublime during the west-ward movement in the nineteenth century. After railways and TVs, Apollo moon landing was again toiled for public engagement in the United States. On July 16, 1969, millions of Americans journeyed to Florida to see the launch, to experience the trembling of ground, smell of fuel and swamp, and fearsome roar of engine.[75]

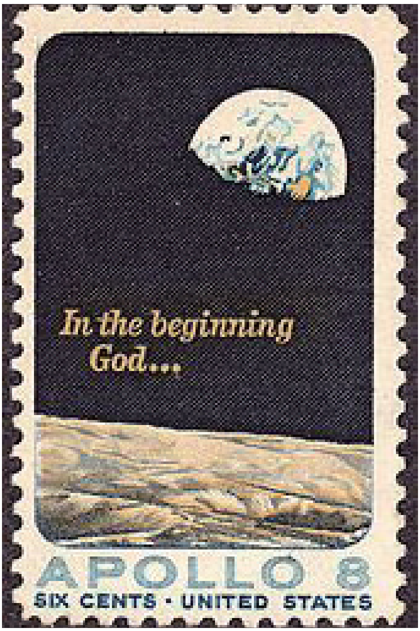
Upper. People cheering the launch of Apollo 11. Photo by Michel Y. Tizious. Image courtesy of Space.com

Lower. People cheering Space X's Starship launch, note the t-shirt says "Occupying Mars" on the man in the back. Filmed on April 17. Image courtesy of Space X via YouTube.

Many visitors burst in tears while the rocket lift-off, “here are the characteristics of the sublime: Irresistible power, magnificence, complexity, and a journey into the infinite reaches of space.”[76]

Another way to appreciate the extreme architectures resides in the concept of “frontier.” The built structures are located beyond the periphery of civilization; they are the outposts of lonely adventurers. A common condition for both sublime and frontier is the risk one has to undertake. The terror, or negative pleasure of sublime relies is triggered by risk, while the risk on the frontier guarantees novelty of discovery or encounter. Although what motivated Russians to flee toward frontier, as written in Tsiolkovsky’s fiction, may appear to be different from Manifest Destiny of America, they both attribute a quality of corruption to the old world. In the American case, the frontier is a dynamic concept as it is pushed toward the “West:” To gain more independence from the economic control of the East coast, which resembles European, the old world.[77] If fearing the corruption of individualism is a shared sentiment of pioneers, the desire of vast resource drives people to follow, and spread of civilization along the railway and telegraph summarize this complete cycle. The industry and representative government along the Atlantic coast forced some people to move west-ward for space of living and development,[78] the business and enforcement of law followed the footprint, and urbanization process began – another group of people then took off for the further West, hence the continual expansion of across the continent. Often sugar-coated by the spirit of enterprise, adventurous and many other qualities, frontier – in a cultural background of Manifest Destiny – means untouched potentials. In 1960, a Princeton professor, Freeman Dyson, came up with an idea that is now popularly referred to as “Dyson sphere.”[79] A giant structure engulfing the entire star like our sun to enable the maximum exploitation of its energy. Note that he supported O'Neill's study of space colonization when it was little known.[81] With the development of California, the last piece of frontier vanished on the U.S soil, and new frontiers are invented. In 1947, Arctica was claimed as the last frontier, followed by Antarctic during the International Geophysical year. Science fiction Star Trek set the *Starfleet Academy* in San Francisco: The end of the "Old West."[82] This is where students – the future starship commanders will depart for space, the "last frontier," where they will encounter new species and civilizations.[83] Interestingly, some may find an uncanny resemblance of between the city symbol of Wenchang (where locates the China's southmost and newest space launch center) and that of Starfleet. It is hardly convincing that the city explained the figure as a visual reappropriation of the Chinese character "wen," the first word of the city's name. The word addresses the city and it literally means "culture" – introducing cultural in space, as the staff explains. Nonetheless, this is exactly what frontier means in the US context; we can see the transcultural aesthetics of frontier at least.

The city logo of Wenchang, China. Created by Quanli Design. Adopted June 19, 2016. Image courtesy of Quali Design.



Upper. *Across the Continent: "Westward the Course of Empire Takes its Way."* Frances Flora Bond Palmer, James Merritt Ives, Currier and Ives. Hand-colored lithograph on wove paper. 1868. Collection of Mr. and Mrs. Paul Mellon, 1985.64.160.

Lower. A retrospect from the new frontier. Illustrated by Bureau of Engraving and Printing. May 5, 1968. Image courtesy of U.S Post Office. Wikimedia commons.

It was not only the West frontier that ends on the Pacific coast of California, but the natural sublimes as well. It creates the opportunity for cultural excitement to organically combined the two: Freedom of navigation and exploration in the vast and unhabitable environment but supported by complex technology. The drawing of a cocktail party in the space cylinder shows O'Neill's definition of such a freedom. In the North and South pole, although the stations are largely stationary, scientific equipment kept pushing back the boundary of unknow. In a more casual case of extreme architecture, individuals can travel in their mobile homes that enable camping in

American Progress. John Gast. Oil on canvas. 1872. 40×29.2 cm. Autry Museum of the American West.

the out-of-reach places in the national park. Interestingly enough, when the first generation of extreme architectures settled down in the 1950s and 1960s, mobile homes also thrived in the post war consumption market due to the construction of interstate highways; cup holder was at this time commonly introduced to cars as an example of domestication of automobile interior.[84] The public mobilization with technological sublime and frontier rhetoric is not only found in the United States. The extreme architectures evoke the deep emotion which transcends the realm of progress. Instead, the sublime, curiosity, and enterprise are hardwired in human brains regardless of culture. Perhaps the United States took the most effort in creating the artificial magnificence and selling the idea of Enterprise: It was given as a name to American navy combat vessels (one of which is the world's first nuclear-powered aircraft carrier), the prototype of space shuttle, and starship in the fiction. In 2004, when British Antarctic Survey (BAS) was calling for designs of its next generation of Antarctic station, it chose to collaborated with Royal Institute of British Architects (RIBA).[85] The later held the open competition and helped to write the briefs; the unique event soon attracted wide attention from the society – including Hugh Broughton, who was then nobody and joined out of curiosity.[86]

Upper. *Enterprise*, the prototype for all space shuttles test flight. Photo by NASA. September 26, 1977. Image courtesy of NASA. Archive ID: ECN-8611.

Lower. *USS Enterprise*, the world's first nuclear aircraft carrier. Photo by Rob Gaston. June 14, 2004. Image courtesy of U.S Navy. Wikimedia commons.


NASA
Enterprise
United States


THE FUTURE BEGINS
STAR TREK
MAY 8

In the other cultures that we shared the planet with, extreme architectures play the same role for public engagement. Socialist realism in the Soviet Union is established in 1934 as a cultural guideline:[87] It favors the expression of vastness and the might of working class and industry. Despite the aesthetic theory and the name, it is by no means reflecting reality as it is, but a tool abused for propaganda purpose[88] – a more brutal social engineering compared to that of the United States. The massive housing and space achievements during the Khrushchev era fit conveniently in the socialist realism framework, though it was abolished along with the Stalinism. Like the Apollo 15 mission's TV experiment, the Chinese space agency broadcasted the entire process of descending and landing, and roll-out of the lunar rover Yutu (a moon-living bunny in Chinese mythology) during the Chang'e mission (a fairy who enjoys the companionship of Yutu in the same story). Inspired by the story of Biosphere 2, I made myself a much smaller ecosystem inside a plastic container when I was about the fourth grade. The premature project was later joined by some friends, and we recorded what happened inside the box. The experiment soon became the class sensation, classmates would come over to the Biosphere 3 lab to have a look of the miniaturized "replica." The experiment turned out to be a failure – it was sabotaged anonymously (someone smashed a hole on the top), and two turtles inside the "pound biome" eventually passed away and emitted a strong odour. The grass, however, grew much taller giving the open access to the classroom oxygen. Discarding the unnecessary animal cruelty in this case, my fiends later grew up to be engineers of several kinds. I suppose some early

Enterprise (NCC-1701). Star trek movie poster. 2009. Image courtesy of IDMB.

enlightenment can be so profoundly influential despite the short-lived attempt – like both Biosphere 2 and 3.

“What was once the furthest outpost on the old frontier of the West will be furthest outpost on the new frontier of science and space.” President Kennedy in his Rice University address again rendered the American culture of frontier plainly visible. If more, the obsession of “being the first” in the Space Race, and not just the Moon Race, captures yet another aspect of Manifest Destiny: Its Zionist sentiment. America must win and will win the competition; and any new Race to any possible frontier. Dr. Vannevar Bush titled his report Science: The Endless Frontier for a good reason: America has so far developed the technologies that enable it to win the war and improve

My “Biosphere 3” project fifteen years ago. 2008.

the living quality of its people. The positive feedback geared by the industrial power fuels the exceptionalism. The issue is, America was not the only culture that claimed the proxy of a certain divine truth, and either was the Soviet Union. Progress may be defined differently to (or within) these missionary states, but there lies something the humanity holds in common: The worship of the power and the braves.

Viva La Vida

By the time when AEG turbine factory was revealed to the public, the world was slowly transformed by electricity: Guglielmo Marconi's radio made the civilized world a smaller place, and Thomas Edison's light bulb disrupted people's sleeping cycle for good. The water turbine powers the new gadgets that proclaim the upcoming modernity, so the AEG factory that produce the turbines was undoubtedly an industrial temple for its glorification of the electric power, and its reappropriation of classic language in modern architecture. A future is opened up, yet a hundred years later, the world is still undergoing electrification. The economic giants of today aim to achieve the carbon-neutrality by the mid twenty first century, and electricity was promoted as a clean power to substitute the fossil fuels. It is not to question "to what extent the former commitments have been lived up to," either it is to judge the pseudo-progress aesthetics of the past. What it reflects, however, is our "future mania" – usually interpreted as (blind) optimism toward future. In her article "Selling Space Colonization and Immortality," Rayna E. Slobodian argues that colonizing space reflects fundamental human instinct of preservation, in other words, the pursuit for immortality. Devoting to something that is happening tomorrow can thus relief today's anxiety of the final eternity. Like many people who raises doubts against space exploration – or any "non-essential expenditure" of tax payer's money – Slobodian worries that the space race is merely a game for the rich but not the under-represented and under-privileged.[89] Apart from biological and cultural enthusiasm, the Space Race satisfy people's innate desire to preserve self-existence, in a similar manner as they built monuments, architectures, or anything that last considerably longer than the builders themselves.[90]

Five days before the launch of Apollo 11, David Bowie released his song Space Oddity. Inspired by the Apollo sensation and the movie 2001: Space Odyssey, the song was about the last conversation between the astronauts (Major) Tom and the ground control before the connection was lost. The song is thought to be one of the greatest rock music, and was recoded again in 2013 by the Canadian astronaut Chris Hadfield onboard the International Space Station. The lyric was modified in the Hadfield's version and the desperation in the original song was replaced by a feeling of tranquility: "Here am I floating in my tin can. Last glimpse of the world: Planet earth is blue, and there nothing left to do."[91] According to Hadfield himself, Bowie adores this version[92] – the song about space travel made it to space after all. At the point when retuning home becomes impossible, Major Tom feels peace by realizing that he is part of a noble quest on behalf of humanity, and immerses himself in Earth's beauty. NASA experts call this particular psychological phenomenon as Space Euphoria: A sense of invincible but exceptional tranquility, and feeling like a king for being literally atop of everyone.[93] It was during the early of the 1960s when Americans misled-edly believed that only a one way trip to moon could defeat the Russians.[94] The problem is not about selecting the candidates – the world never run out of people for such a daring feat – but how to keep him alive on the moon surface for a year or two when the ground team figured out how to take him home.[95] Similarly, in a 2007 interview with Valentina Tereshkova, who by the time was already 72 and a Russian politician, she said a trip to Mars is a dream of all cosmonauts, and she is ready to board the spaceship without a returning capsule[96] – assuming she can pass the physiological screening.

A piece of construct or artifact plays the same role. Prior to the International Geophysical Year, a silvered

glass ball was airdropped to the geographical South pole along with the construction materials for the Amundsen-Scott station.[97] It was mounted on top of a bamboo pole not far from the station; a "sphere" on a "pole" is thus denoting the "pole" of another "sphere," a much larger one. Aside the humor in the wordplay, the namesake of the station was the first two pioneers who reached the South-most point on Earth: Roald Amundsen and Robert Scott. The station itself is a monument to commemorate the dreadnought spirits of the heroic age, and hence the continuation of them before the Americans. The ceremonial glass ball, however, was dislodged from the base and cracked on ground during the 1977 reconstruction of the station; to preserve the cultural value deemed so necessary, the staff at McMurdo station painted a bowling ball silver and brought it to Amundsen-Scott station that is over 1350 kilometers away (roughly the distance from Milan to Gothenburg).[98] In the 1990s, the ball was replaced by another one made of metal, and the current one is made of "unbreakable plastic."[99]

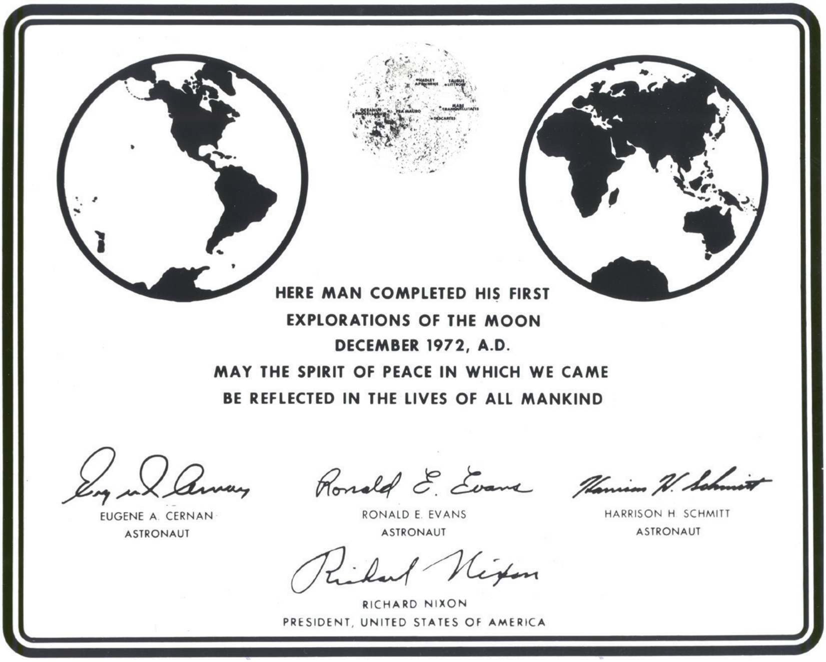
In 1973, after the defeat of Moon Race and launch failures of the N-1 rocket, the Soviet Union finally had its Lunokhod 2 touched down on moon surface. In addition to the new equipment it carried, a series of plate, engraved with Lenin's face, was brought on the rover.[100] Its cousin Lunokhod-1, launched three years before, was laterally

Upper. Valentina in 2007. Photo by Mikhail Metzel. May 22, 2007. Image courtesy of MIKHAIL METZEL/AFP via Getty Images

Lower. Chris Hadfield playing *Space Oddity* onboard the ISS. Filmed by Chris Hadfield. Music video uploaded on May 12, 2013. Image courtsy of Rare Earth YouTube.


GEOGRAPHIC SOUTH POLE
AVERAGE TEMP MINUS 56°F
ALTITUDE 9186 FEET
ICE THICKNESS OVER 9000 FEET


BASSETT, CHARLES A. II
BELYAYEV, PAVEL I.
CHAFFEE, ROGER B.
DOBROVOLSKY, GEORGI T.
FREEMAN, THEODORE C.
GAGARIN, YURI A.
GIVENS, EDWARD G., Jr.
GRISSOM, VIRGIL I.
KOMAROV, VLADIMIR M.
PATSAYEV, VIKTOR I.
SEE, ELLIOT M. Jr.
VOLKOV, VLADISLAV N.
WHITE, EDWARD H. II
WILLIAMS, CLIFTON C. Jr.



Upper. A sphere on a pole, which stands at the pole of aother sphere. Image courtesy of Bill Spindler. southpolestation.com

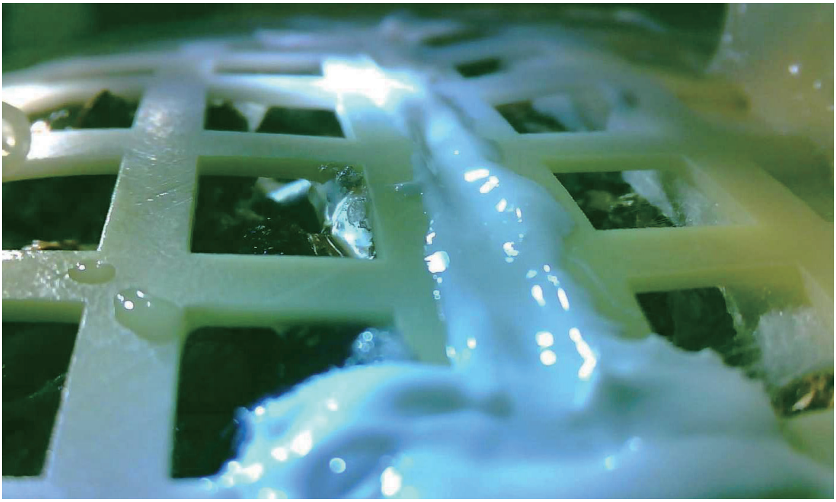
Lower. Extraterrestrial monument dedicated to the fallen astronauts. Photo by NASA. August 2, 1971. Image courtesy of NASA. Archive ID: AS15-88-11894.

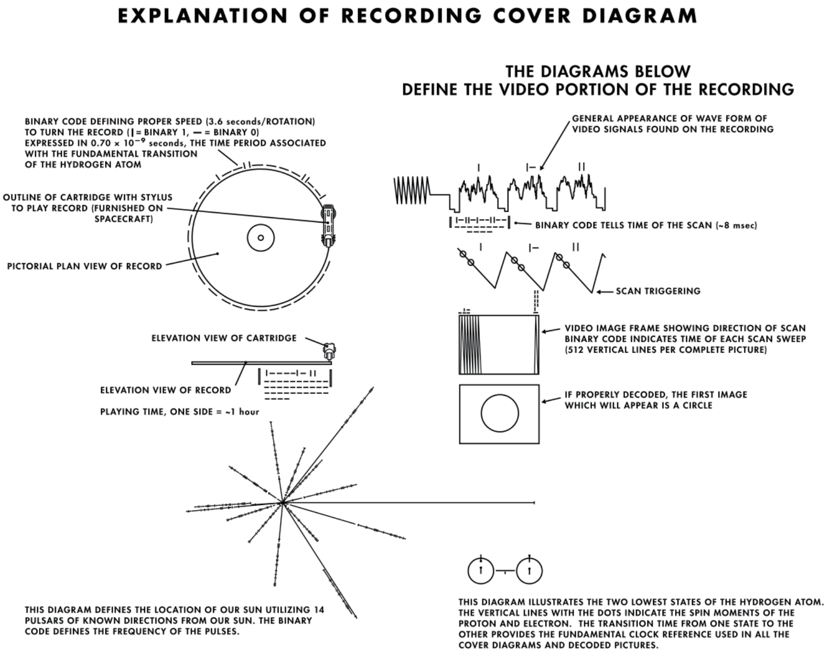
Right. Apollo 17 plaque left on moon surface. Photographic replica by NASA. December 13, 1972. Image courtesy of NASA. NASA ID: S72-55169.

auctioned to a private owner in 1993.[101] The location cannot be determined since 2010,[102] but owning a monument on moon does guarantee exceptionality of an individual person. It may appear to be an ideological aggression on a neutral territory, but it was already by then a common practice: Apollo-15's crew placed a commemorative plaque and a minifigure Fallen Astronaut on moon surface in respect to the astronauts who dedicated their lives in pursuit of space exploration.[103] Seventeen months later in December, 1972, the Apollo-17 mission left behind another plaque to conclude the entire Apollo program.[104] The plaque contains the wish for a peaceful world, and is signed by three crew members and President Nixon – who reopened the diplomatic relationship with China in the beginning of that year, but was at this point troubled by Watergate Scandal. Nixon eventually resigned from his chair two years later, but his name stays on moon forever. In January 2019, China's lunar rover landed on the South pole of moon. What is so special about this mission is that a microecosystem was delivered to moon: A micro-ecosystem composed of plant seeds, silkworm egg, and nutrient soil in the box.[105] It is the first time the other Earth-bound lives, other than human, expand the living realm to another celestial body: An iconic continuation of Earth life beyond Earth. On the NASA website, people of the world have chance to

Upper. The leaves are growing inside the micro-ecosystem sent to moon, the "alien." Photo by CNSA. January, 2019. Image courtesy of CNSA via CGTN.

Lower. Manuals (for aliens) on deciphering the *Voyager* record. May 12, 2013. Image courtsy of NASA Jet Propulsion Laboratory. Image courtesy of NASA. Wikimedia commons.

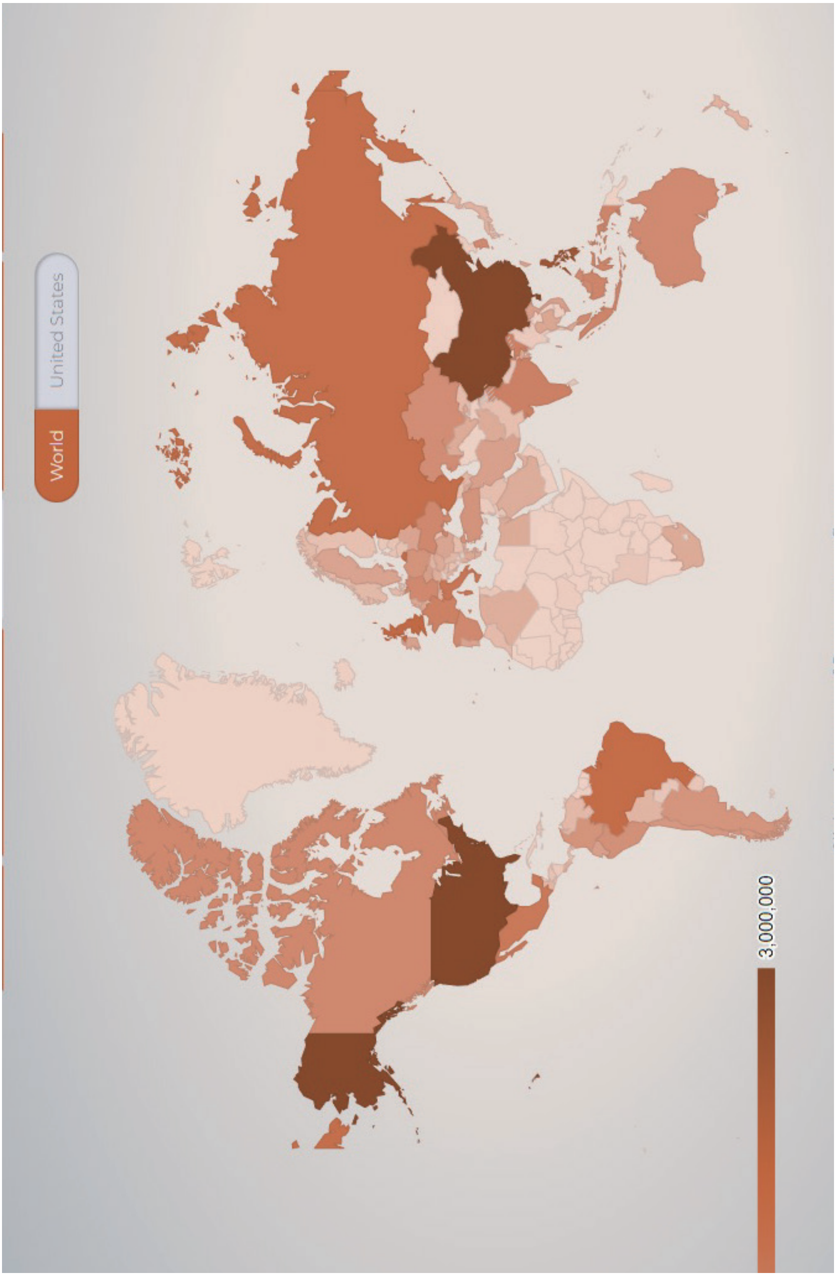



EXPLANATION OF RECORDING COVER DIAGRAM
THE DIAGRAMS BELOW DEFINE THE VIDEO PORTION OF THE RECORDING
BINARY CODE DEFINING PROPER SPEED (3.6 seconds/ROTATION) TO TURN THE RECORD (| = BINARY 1, — = BINARY 0) EXPRESSED IN 0.70 × 10⁻⁹ seconds, THE TIME PERIOD ASSOCIATED WITH THE FUNDAMENTAL TRANSITION OF THE HYDROGEN ATOM
OUTLINE OF CARTRIDGE WITH STYLUS TO PLAY RECORD (FURNISHED ON SPACECRAFT)
PICTORIAL PLAN VIEW OF RECORD
ELEVATION VIEW OF CARTRIDGE
ELEVATION VIEW OF RECORD
PLAYING TIME, ONE SIDE = ~1 hour
GENERAL APPEARANCE OF WAVE FORM OF VIDEO SIGNALS FOUND ON THE RECORDING
BINARY CODE TELLS TIME OF THE SCAN (~8 msec)
SCAN TRIGGERING
VIDEO IMAGE FRAME SHOWING DIRECTION OF SCAN BINARY CODE INDICATES TIME OF EACH SCAN SWEEP (512 VERTICAL LINES PER COMPLETE PICTURE)
IF PROPERLY DECODED, THE FIRST IMAGE WHICH WILL APPEAR IS A CIRCLE
THIS DIAGRAM DEFINES THE LOCATION OF OUR SUN UTILIZING 14 PULSARS OF KNOWN DIRECTIONS FROM OUR SUN. THE BINARY CODE DEFINES THE FREQUENCY OF THE PULSES.
THIS DIAGRAM ILLUSTRATES THE TWO LOWEST STATES OF THE HYDROGEN ATOM. THE VERTICAL LINES WITH THE DOTS INDICATE THE SPIN MOMENTS OF THE PROTON AND ELECTRON. THE TRANSITION TIME FROM ONE STATE TO THE OTHER PROVIDES THE FUNDAMENTAL CLOCK REFERENCE USED IN ALL THE COVER DIAGRAMS AND DECODED PICTURES.

put down their names in hope that they would be carried to Mars in the 2026 mission. A “free ticket” to Mars will be given once the registration is finished: A successful advertising of the space program indeed, but how many chance in one’s life can he or she be remembered as a part of human history?

Although it tuned out that Gagarin’s Vostok-1 capsule displayed during the 1961 aviation day was only an artistic approximation due to the secrecy in the Soviet space program,[106] the model hung under the helicopter did provide the Soviet people a grasp of their success in space. In fact, it embodies the socialist realism practices: Artists try to see the life as it was becoming instead of what it actually is.[107] The difference between the manifest destiny of communism and undergoing socialist construction led to both the reality of “in-progress” and intuition of “enroute to.” The unfinishedness of the projects underlines the propaganda strategy of this period: The exploitation of “contemporary.” The housewarming images titled “toward communism” usually focus on the moment when a family is about to move in to the new home instead of the family already living there. Two messages are conveyed here: First, everyone as ordinary as “these people” also have chance. And second, what is incomplete will be completed, and as long as the status of completion is not indicated, there is always hope. If Slobodian’s model dictates that devoting to a coming future is the way to escape contem-

Despite the geopolitical adversay, two main groups that signed up for this activity are from China and the U.S. Map by NASA (as of 7:12 am, June 19, 2023). June 19, 2023. Image courtesy of NASA.


World
United States
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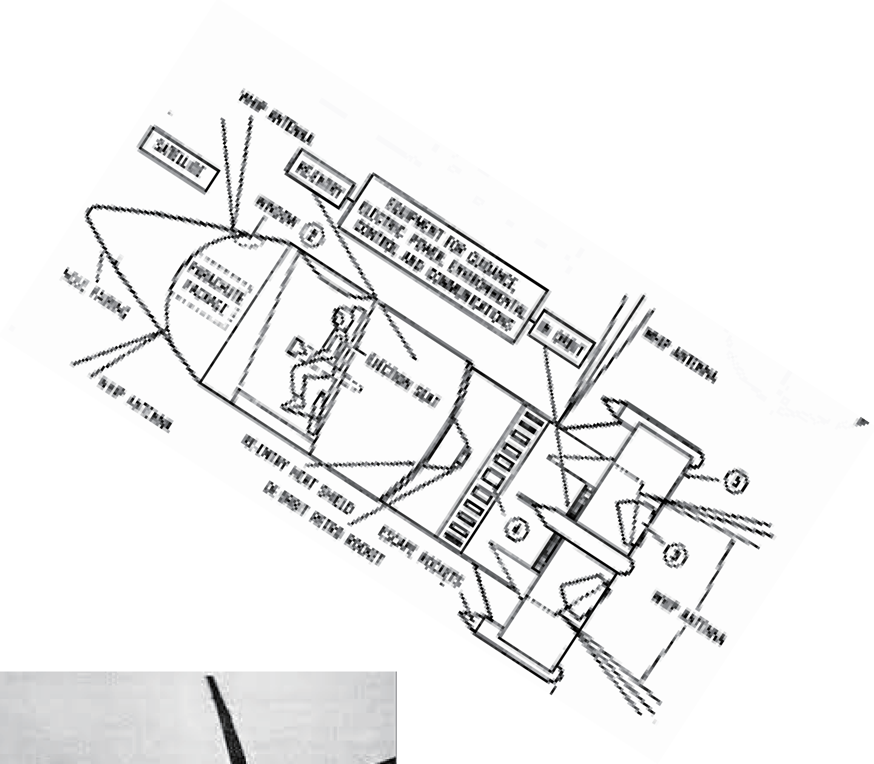
porary anxiety, then the Soviet technique reversed this process: An extracted picture of contemporary implies a designed future. Unfortunately, for the Soviet people, the “enroute to” stayed the same when “in-progress” slowed down during the stagnation era. The growing tension of the two contributes to the public feeling of betrayal and disillusionment in the 1970s. Nevertheless, it proved that the sentiment of “enroute to” can be forged separately from the real condition. From the perspective of visual analysis, the imperfection of the architectural texture invites further perfection, and hence a more ideal future condition such as expansion and new components. On the other hand, since the extreme architectures in Antarctica does not require absolute aerodynamic efficiency, the sharp edges and big obstructions are not necessarily hidden. The imperfection signifies a degree of vulnerability, but makes the architectures “relatable” at the same time. Not only does it reinforce the sublime, in which a small artificial structure is enduring the harshest environment, the evolution of the ice stations reminds us of the life process elsewhere. When looking at these stations, from wood huts to high-tech containers, they have persisted for generations in the most remote place, and there is hardly any reason to deny it will not continue to do so.

From the Khrushchev’s housing program or the modern kitchen design, from the Biosphere 2 lab to Nagakin Capsule Tower, and from polar stations to space colonies, the work of architecture reflects human’s fundamental impulse for construction. It was not just the rationalization of the world during the enlightenment, but since

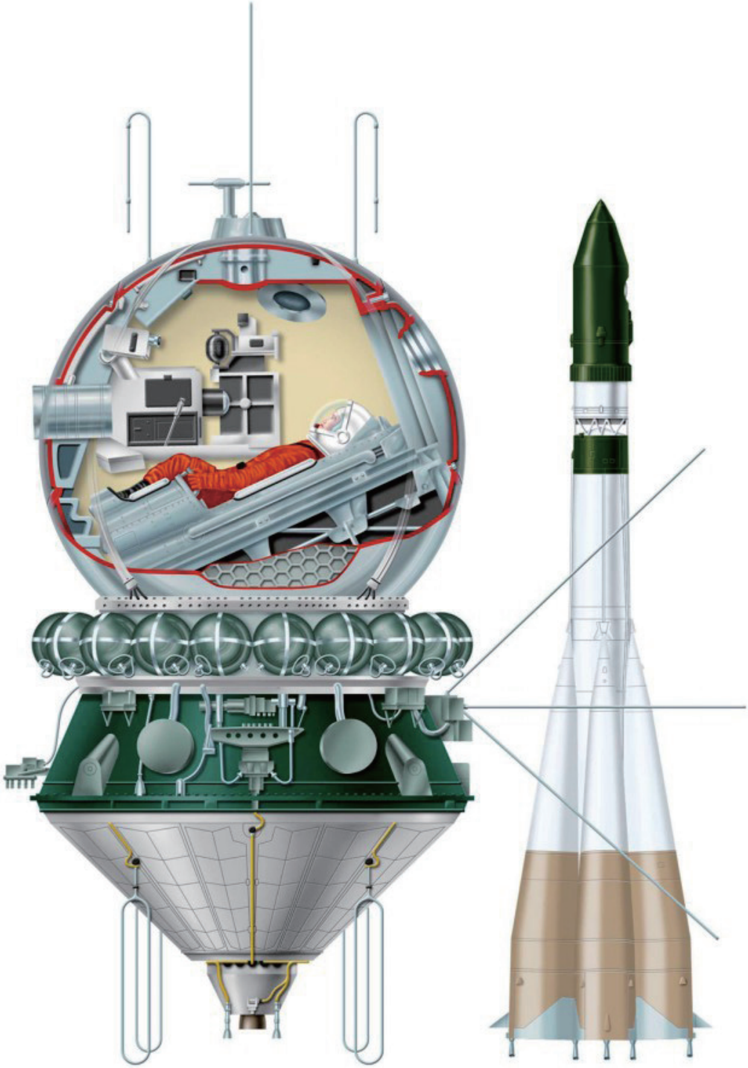
Perhaps it is in our genetics that we want to believe in progress, whatever it is. Illustrated by Feihao Zhang. Januray 18, 2023.


CHOOSE TO BELIVE
Буран



Upper. Speculated structure of Soyuz capsule. Image courtesy of svengrhan.pp.se. “Soviet Space Deceptions - not so many after all!”

Lower. Fake Soyuz capsule during the aviation day parade. In *Into the Cosmos: Space Exploration and Soviet Culture*. Edited by James T. Andrews and Asif A. Siddiqi. (Pittsburgh, Pa: University of Pittsburgh Press: 2011.): 73.



Soyuz structure in reality. Illustrated by Mark Franklin. Image courtesy of Mark Franklin Arts Technical Illustration. Vostok.

the primitive hut of the ancient times, architecture has been an inseparable aspect of human civilization. It is a production of the interactions between we the mortals and the physical world. Through architecture we paise the uncontrollable power: Temples of the past became weather stations and hydro-electric dam of today. Through architecture we reproduce the alternative reality: Lamps replaced sun, fans replaced wind, ceiling replaced tree canopy, and water hose replaced river. It seems that in the limited life, we build the architectures so we could have a little spiritual grip on the outer world. If more, we modify the world with the means of architecture, and the architectures modify our way of living in return. Is not it true that when we are designing the new space or ice stations or simply kitchens, we are also designing a life inside?

Let us reframe the architectures since the antiquity as a range of small worlds. They are the mimic of the ideal world, a utopia, and what haven been constructed are perhaps the defect ones, but kept improved throughout the time with new techniques and skills – something we acknowledge as “progress.” And nothing is more “progressive” than building a miniaturized celestial world out of our terrestrial realm. In this chapter, the term “progress” is examined in many cases. A series of cultural movements since the 1950s have shown that progress is interpreted differently by individuals and groups. To the extreme architectures, the progress narrative is often based on the technological sublime they represent and the new frontiers they guard. Psychologists pointed out that human’s fear of death, or discontinuation of self-existence, have long motivated people in devoting to a greater construct for achieving immortality. Exploration of polar region and space offer such opportunities for us to be remembered as a part of history. The study of the extreme architectures has always brought us back to our Earthly societies; one is inevitably influenced by another. There is also a duality in the extreme architectures: Behind the rational language of design and construction, there is irrational anxiety and worship.

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[20] Ibid.

[21] Ibid, 138.

[22] Ibid, 147.

[23] Ibid, 134.

[24] See the video: C-SPAN, “Nixon-Khrushchev Kitchen Debate,” short film, July 24, 1959. C-SPAN archive. Last accessed on March 14, 2023. https://www.c-span.org/video/?110721-1/nixon-khrushchev-kitchen-debate

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Beyond The Horizon

“明月几时有，把酒问青天。不知天上宫阙，今夕是何年？”

English translation:

“When is the moon clear and bright?
I toasted to the azure sky.
I wonder in the palace of heaven,
What year could it be at this moment of time.”[1]

---- *Shi Su*

Written a thousand years ago in China, this excerpt of poem captures the author's mixed emotion regarding the moon – why is it always so beautiful when families are separated? Like many other civilizations, people in China often devote the most genuine feelings to the celestial beings. There is always this riddle whether one should keep on the noble quest into the unknown, or cherish the companionship of the loved ones. As chapter five has debated, propaganda or cultural narration can be quite detached from personal experience, which should be studied alongside the official records for sake of a bigger picture. The study of extreme architecture should therefore be approached from these two perspectives. The later section of this poem expressed the author's wish to enjoy the moonlight with his brother who is in a great distance – as if the two are somewhat connected by the moon. In a similar manner, the extreme architectures in the celestial domains are never isolated from the terrestrial world; this is one of the main discoveries of this research.

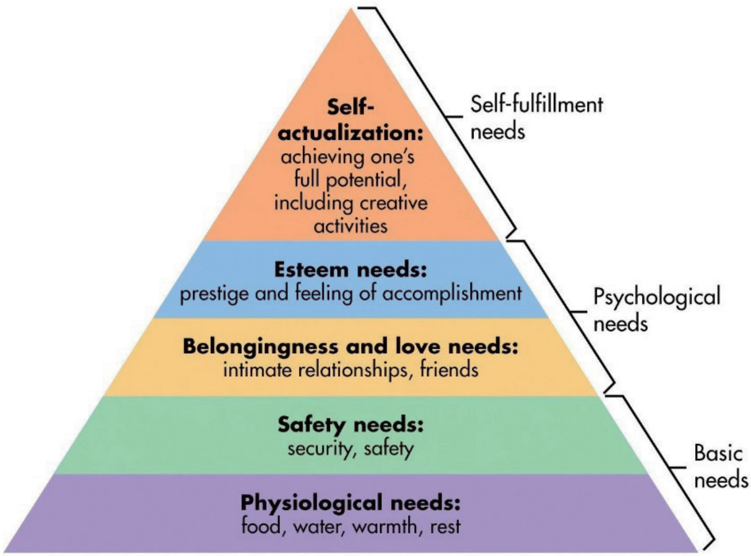
Since the middle of the last century, human started to expand the realm of activities into the formerly forbidden domains. Modern technology of transportation and communication profoundly changed the travel to Arctic, Antarctic, and space: Heroic era of the North and South poles expeditions is ended by a guaranteed return to civilization, and space travel is no longer a fantasy. This research focuses on the extreme architectures built since the 1950s in those three distant domains. The technical features, cultural images, social movements, and political applications are analyzed. This forms the foundation of my definition of "extreme architecture:" They are the settlements placed in the extreme environments such as Arctic, Antarctic and space, where scarcity and remoteness push architectures to a limit; and they are built with multifaceted initiatives during the Cold War. With a quick glimpse, the structures in desert, mountain top and deep sea could also fit in the category; however, they do not satisfy the quality of “briefness” and “extremeness.” These places have been frequented or even habited for a long time, and the environment are not as harsh as popular culture may have imagined. Nevertheless, the Biosphere 2 lab, which was constructed in the Arizona desert, is referred to for multiple times in the research due to its technical connections with the extreme architects. Owing to the framework established here, this research is likely the first one that embarks on the systemic comparison between Arctic, Antarctic, and space settlements.

What We Have Been through

As a part of the historical study, I traced the explorations and developments of people in Arctic, Antarctic, and space. Such an analysis provides us with a thorough examination of the extreme architectures in terms of their economic and political background. The division of historical periods is based on the iconic events that set the general theme. Unlike a history book, history itself does not have any page numbers; and it is the interpretation that translates a sequence of incidents into communicable stories. By risking it too audacious and generic, I divide the explorations into four phases according to the technological advancement and geopolitical condition. The first phase lasts until the end of the 1940s. On technological level, it is characterized by fantasies and early experiments on new gadgets like radio communication and rocketry. The geopolitical situation shifts from colonial competition to military confrontation, and finally the dissolve (at least weakening) of the old colonial powers. Space travel at this time became theoretically feasible with the rocket tests during the world war. Expeditions to the North and South poles became manageable. The humanity was at this point ready to leap into the celestial domains. The second phase ranges from the 1950s to the 1960s. It is characterized by growingly intense adversary between two super powers and technological maturation. Space Race and Polar Race forced countries to build stations in the forsaken places. Meanwhile, the domestic societies were undergoing transformation and a mainstream was built with strong state intervention (i.e., propaganda). Despite the ideological and military tensions, no major wars were waged between the superpowers giving the unaffordable consequence. The third phase expands from the 1970s to 1980s, where the societies were going through another transition. Economic hardship and following public objections forced the governments to readjust their positions on international (and domestic) relationships. International competitions were more replaced by cooperation: Signified by the Anti-Ballistic Missile Treaty and Soyuz-Apollo docking, three years apart in the early 1970s. Although the development in the polar regions and space slowed down, it did not stop completely. The last and the current phase began from the 1990s when the Cold War abruptly ended. More international players joined the polar and space explorations, and the general tune of peace allowed more international cooperations in station construction. It should not be discarded, however, that competition persists between countries, and some intellectual argues that the Cold War never ceased. The new rounds of Polar Race and Space Race require longer duration and larger crew; when reflected in architectural design, larger settlements are expected for future missions.

The reason that this research is undertaken from a an "architectural perspective" instead of an "engineering perspective" (which is more commonly taken) is the multidisciplinary nature of architecture itself. As it has shown in this research, the architectural discussions often involve the other disciplines, such as megaproject and social movement, besides the interweaving between material engineering, psychology, ecology, etc... The architectural gesture becomes increasingly significant as the settlements expand in size and population. Pure engineering is no longer sufficient to cope with the complex social interaction and psychological challenges. In contrast, architectural design dwells on sensitive spatial conditioning and emphasizes on living quality – not possibility. To borrow the concept of Maslow's Hierarchy of Needs, methods of engineering may satisfy the basic needs for physical security, but it was the architects' role to manage the abstract ideas such as intimacy, accomplishment, and goal. In such a spirit, I propose the Arctic, Antarctic, and space stations to be the subjects of architectural study: With understanding the difference between "surviving" and "living." Modular construction and streamlined shape are a common feature found on the extreme architectures. Rationalization of internal space by a series of gates and comprehensive control of matter and energy is another condition. There must be safety redundancy to tolerate contingencies. Smaller vehicles may be added for emergency exit and personal mobility. To adapt to prolonged stay, privacy and flexibility for personalization in living space should be considered. Adequate measure of spatial orientation is desirable for human cognitive function. Physical exercise should be included not only to keep the crew in shape, but also to rehabilitate people for long term confinement. Close loop of matters, or in other words, bioregenerative life support system could be a long-term solution for the settlement's sustainability (economic and material wise) and resilience. These new components will require a larger space to accommodate. Since the beginning of the second phase, the architectures began to resemble one another across the domains in terms of function and form. The biological concept "convergent evolution" can be borrowed to describe this phenomenon: Two architectural typologies would develop similar traits when placed under similar evolutionary pressures.

Evolutionary pressure is another way to say "site condition," which, in this case, includes the tangible ones, like the physical surroundings, and intangible ones, the political and cultural image the governments strive to create and sell to their people. The chapter "We Choose to Go to The Moon" focuses on the political factors that motivate the continual expeditions. Science inquiries are common rhetoric to brand the expensive activities, if not to sugarcoat the military aggressions. As we have seen in the experience of Alexander Chezhevskii, science cannot escape the politics. In some instances, scientific investigation usually paved the way for future military application; while in the others, science is used as cover-ups of the later. Even for the seemingly pure science experiment, such as Biosphere 2, politics found its disguise as interpersonal conflicts. Scientific inquiries grant us with considerably deeper understanding of our home planet, and many countries acknowledged the common objective to avoid wars – at least in Arctic, Antarctic, and space. The desire for a longer stay to formalize occupation is thus both scientific and political. To keep military conflicts from expanding to the "celestial domains," international treat-



Architectural design of the extreme architectures is focused more on the upper three needs as it deals with person-person relationship. Image courtesy of simplepsychology.org ies were signed and enforced. However, the treaties, agreements, and declarations also resulted in layering of the governance over the international territories. There is always a more prestige club with an already-prestige club, and this “stratigraphy” limit the technical transfer on the extreme architectures – as a cost of peace. Meanwhile, the extreme architectures have long been used as propaganda material for ideological warfare; they are the national assets to demonstrate resolute to settle on the moral and technological high ground. Depletion of national funds and public support during the stagnation of the 1970s has slowed down the pace of exploration. No matter it was the environmental control in the extreme architecture or the Fordism-Keynesianism control in the welfare societies, new government investments, usually in forms of megaproject (like Toronto’s Spadina Expressway), hit the riff in the matured civil society. Grand narration, or big talks, of government was far less convincing at the brink of transformation. Controls in the society must be reformed and executed in a more subtle way. In a similar manner, the extreme architectures would have to balance between the mission and personal comfort. Incorporating gathering place and recreational area is a result of such a change in design. We should also note that despite the lacking of public enthusiasm, the support for explorations is – to a degree – supplemented by continually-refreshed military concerns. It is not to assert that the expeditions are dominated by the war-mongering defence industry, instead, it is the continuation of the Cold War momentum and enemy-searching practice that keep the scientific activities ongoing.

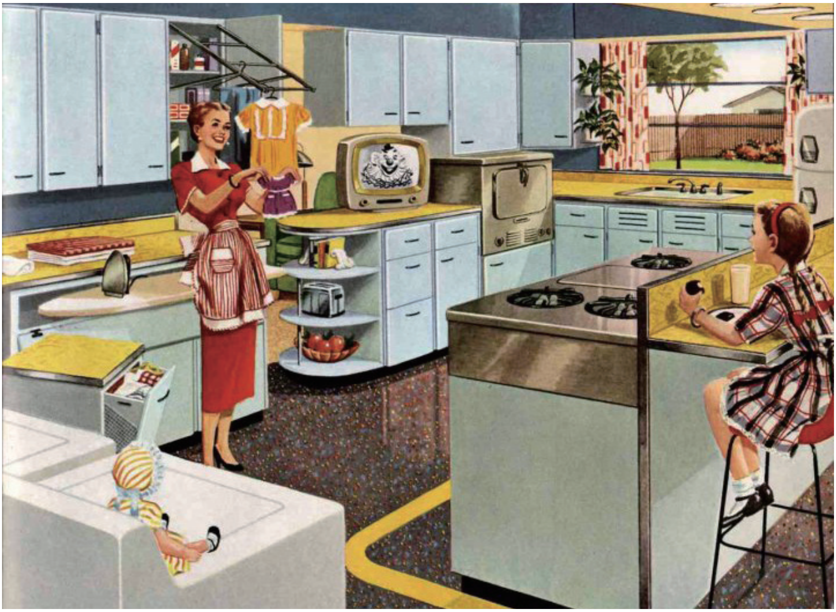
The first part of chapter “Once upon The Time in The Future” extended the discussion of megaprojects’ recession. Themed under the title of “Debates in Kitchen,” the advancement of technology at home and distant domains introduced new cultural challenges. Progress is an umbrella term that includes many contradictory practices – collective progress can be very different from that of individuals. Gender equality is one of the most argued matters regarding what kind of progress is really actualized. Kitchen, in this background, becomes the arena of ideological competitions. Both collective and individualistic notion of progress has fostered new architectural designs of the time: No matter it is Nagakin Capsule Tower in Tokyo, mobile homes in fields, or Soyuz capsules in space, the compacted living space is a retreat from the tedious "community building" narratives. The softened tones in propaganda, or relaxed regulations can be regarded as a degree of feminization in the terrestrial societies, while this wave of transformation arrived much later in the celestial worlds. Also in the fifth chapter, the extreme architectures, built or fantasized, are evaluated with methods of visual analysis. There is no surprise that the extreme architectures insinuate a sublime image. The aesthetics of technological sublime is, on the one hand, created by the tension between harnessing and loss of comprehension; On the other hand, it is defined by the level of public mobilization as a quasi-religious power. It is not just the American culture of Manifested Destiny that appreciate the idea of "frontier," but a transcultural worship of power and lust for new resource and knowledge among every human-being as well. Like many doubts raised against the national space programs, criticism or even rejection of the notion "innate curiosity" of some intellectuals often attribute the noble space quest as a product of hierocracy: It only fulfills the "preservationist" desire of the privileged people. By putting oneself at the frontier of exploration is as much as building a monument giving that both exploration and monument last longer than our mortal lives. Therefore, beside the power and rewards, the expeditions are also pushed by the anxieties of people to "stay" beyond their biological countdown.

Extreme Architecture As…

Practically speaking, the ice and space stations are employed in public mobilization. The technological sublime would trigger awe of the average citizens. However, the debates regarding the worthiness of these structures are as long as the history of structure themselves. And this is the very reason that the discussions of extreme architectures often involve the movements in our reachable societies. One could feel compelled to believe in a shallow promise, but when displaying the extreme architectures as the solid evidence, somehow the story is more convincing. Maneuvering in the space of collectivism within capsules is quite similar to extreme architectures in the forsaken environments. Therefore, extreme architectures are the connections between individual and mass society. As bridges between oneself and a greater world, we may see their shadows in our daily life: Cup holder in our cars or the Bonsai plants on our balcony.

Now let us take one step further. When designing the extreme architectures, we are imposing a way of living inside - the spatial orientation, the control of diet and waste, and social interactions. But is not it also true that we have been practicing such a design in other disciplines, too? Rationalization of kitchen space is a way to formulate a desired way of cooking and eating, and that agreements and treaties permits only a set of activities. Now there have been quite a lot of examples on AI-aided design of space habitats; based on the precedents and data fed to the machine, we can acquire the somewhat optimal layout of the habitat. Yet from an architect's point of view, there seems to be a fundamental gap between machine learning and architectural design. Structural integrity is essentially a material-material relationship, survival is a human-material relationship, but life inside those extreme architectures is a human-human relationship. With enough examples, machines can perhaps master the former two, but there are always new things to learn when we push the architecture to the frontier of civilization; can AI also mediate the unprecedented sensitive “entanglement” between people? Here I recall the recent LUNARK analogue experiment in Arctic, the architects who lived inside their small station decide that human being is what it takes to make a home.[2] The world itself is beyond management, but the advancement in scientific discoveries allows human to exert some control of the surrounding environment. Understanding the fundamental laws of the world paves the way for constructing a smaller copy, which then directly or indirectly engages the investigation of new knowledge. Extreme architectures, in this sense, is a self-propagating existence. There are people like van Allen and Chezheviskii who push forth the boundary of comprehension, and there are people like Broughton and O’Neill who expand the realm of human civilization. It is hard to argue which group come first because, as discussed, they take turns in the history.

Rationalizing the world is similar to rationalizing the architecture, in both cases we wish to have a gripe of our fate and security. Building a home may resemble the process of creation: The roof replaces tree canopies, water hoses replace river, and air conditioner replaces winds and rains. Environmental control empowered human on a metaphysical level, and this might have been the earliest technological sublime – if following our framework above. And architecture is a way of human to both interact with the world and modify it, so a better version can be built. But what is this better version? We have seen many instances that our best efforts are paid in vain when building the massive urban infrastructures. Megaprojects are sold in the utopic pictures but usually received in a dystopic way. Even in a space paradise of O’Neill, who gets to live



Upper. Rationalization of kitchen space. Kitchenmaid blue kitchen commercial. 1953. Image courtesy of retrorenovation.com

Lower. Note the curb-line on the kitchen in this Glocoat Kitchen Corp commercial. 1946. Image courtesy of retrorenovation.com

Upper. Yellow lines in the middle of nowhere. Image courtesy of rare-gallery.com.

Lower. Are we essentially living in a bubble made of our rules? Movie scene. 2001: A Space Odyssey. 1986. Image courtesy of The LIFE Picture Collection/Shutterstock.

in comparably better lighting condition could easily surge political turbulence. It reminds people of the slavery three hundred years ago: Who lived in the mansions and who lived in shed? But we kept designing the utopia with better solutions, which soon will be obsolete in the foreseeable future. On the architectural scale, reinforced concrete replaced clay and brick, and it was to be replaced by synthetic materials in some cases. On a social scale, capitalism replaced feudalism, and it was argued to be replaced by socialism, which, again, is to be replaced by communism. Extreme architecture perhaps best represents the tendency of human to build utopia. First of all, it is built with promises that the life inside will improve compared to the former ones; and more importantly, they promise to make our terrestrial world a better place.

Now has this research arrived at a point to stop, but the development in the extreme environments continues as it always has been. With so many related topics to explore, I hope this research could form a basis for further progression of not just me, but the others as well. Along the course of inquiry, we saw the fiercest combat between humans but also the sincerest wish for peace in Arctic, Antarctic, and space. Perhaps we will never stop fighting each other, or perhaps someday in the distant future, humans could let go of all the bias and hatreds, and step into a new realm that is then not so extreme at all. Someday, our civilization can all dream the un-dream-able, reach the unreachable, and live the un-live-able.

The Primitive Hut. Charles Dominique Joseph Eisen. 1775. Frontispiece of Marc-Antoine Laugier: Essai sur l'Architecture 2nd ed. Image courtesy of Wikimedia commons.

[1] I personally translated the first four lines. The original text can be found at: Chang Yungting, “The Project Gutenberg eBook of 水調歌頭 ,” ebook, Project Gutenberg website, November 2, 2008. Updated on January 4, 2021. Accessed on May 16, 2023. https://www.gutenberg.org/cache/epub/27123/pg27123.html

[2] The entire expedition log can be found at: Saga Space Architects, “The Expedition,” web entry, Saga website. Last accessed on May 29, 2023. https://saga.dk/projects/lunark/expedition

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Appendix

Stations and timeline

Polar and space stations

	Antarctic					
	First station in	Active stations	Share Stations	Territorial Claim	South Hemisphere	First Station in
Argentina	1904	13	0	Yes	Yes	
Austrailia	1954	4	0	Yes	Yes	
Belarus	2007	1	0	No		
Belgium	1957	1	1	No		
Brazil	1984	1	0	No		
Bulgaria	1988	1	0	No		
Canada						1957
Chile	1951	12	0	Yes	Yes	
China	1985	4	0	No		2003
Czech Republic	1989	2	0	No		2014
Denmark						1906
Ecuador	1990	1	0	No		
Finland	1988	1	0	No		1949
France	1950	1	1	Yes	No	2003
Germany	1976	6	0	No		1991
Iceland						1975
India	1985	2	0	No		2008
Italy	1976	1	1	No		1997
Japan	1957	2	0			
Netherland	2013	1	1	Yes	No	1995
New Zealand	1956	3	1	Yes	Yes	
Norway	1949	2	1	Yes	No	1967
Pakistan	1991	1	0	No		
Peru	1989	1	0	No		
Poland	1959	1	0	No		1957
Romania	1986	1	0	No		
Russia	1956	7	1	No		1932
South Africa	1960	2	0	No		
South korea	1988	2	0	No		
Spain	1988	2	0	No		
Sweden	1949	2	1	No		1903
UK	1944	4	1	Yes	No	
Ukrine	1994	1	1	No		
Uruguay	1984	2		No		
USA	1941	5	2	No		1973

Arctic				Space		
Active stations	Shared Stations	Territorial dispute	North Hemisphere	First station in	ISS contribution	Astronauts
				1998	Yes	2
				1998	Yes	1
13	0	Yes	Yes			9
1	0	NO		2021	No	6
1	0	NO				
9	0	Yes	Yes			
3	0	NO				
1	1	NO		1998	Yes	4
2	1	NO		1998	Yes	4
1	0	NO				
2	0	NO				
1	0	NO		1998	Yes	5
				1998	Yes	11
1	0	NO		1998	Yes	2
3	0	Yes	Yes			
4	0	No				
10	0	Yes	Yes	1998	Yes	57
					Yes	1
					Yes	1
					Yes	1
2	0	No			Yes	2
					Yes	1
3	0	Yes	Yes		Yes	161

1775		Sails in the South seas returned without the discover of Antarctica	James Cooke
1798		*Essay on the Principle of Population*	Thomas Robert Malthus
1821		First circumnavigation in Antarctica made by Russian	Bellingshausen
1836		US congress authorized the exploartion of huge hole in Antarctica	John R. Reynorlds
1869		Publish of "The Brick Moon"	Edward Everett
1882		First International Polar Year	IPY
1911	Dec (11)	Roald Amundsen made it to the South Pole	Roald Amundsen
1912	Jan (18)	Robert F. Scott's made it to the South Pole	Robert F. Scott
1914		Ernest Shackleton's *Endurance* expedition	Ernest Shackleton
1920		Publication of "Vne zemli" first detailed and scientific treatment of space habitat	Konstantin Tsiolkovsky
1920	Feb (9)	Sign of Svalbard Treaty	Svalbard Treaty
1926		Vernadsky's book *Biosphere*	V.I. Vernadsky
1926		Alexander Chizhevskii's essay *Physical Factors of Historical Process*	Alexander Chizhevskii
1929		First flight to Antarctica	Richard Byrd
1929		Publication of the idea of whele shaped station of 30m in diameter	Potocnik/ Hermann Noordung
1931		International Council of Science Union was founded in Brussel	ICSU
1932		Second International Polar Year	IPY
1934		Rescue of Chelyuskin in Arctic	Nicolai Komanin
1936		Publication of "Mountains of Madness" which combined the hypothesis of plate tecton	Howard Philips Lovecraft
1938		Korolev was arrested for anti-Soviet activities	Korolev
1941	Mar (11)	Lend-Lease Act ratified at the US national congress	USA
1942		Publish of "Venus Equilateral" early fiction of space settlement at Lagrange point	George O Smith
1942	Mar	KMS Tirpiz tried to intercept Arctic convoy	Nazi Germany
1942	Jun	The loss of Arctic convoy PQ-17	Allies
1944	Jul	Bretton Woods Agreement	
1945		Launch of Arctic Institute of North America (AINA)	Canada, USA
1945	Jul	Vannevar Bush's report "Science: The Endless Frontier"	Vannevar Bush
1945	Jul (16)	First nuclear explosion with fissional material (Atomic bomb)	
1945	Jul (18)	New York Times quote the report of Hitler's refuge in Antartica	New York Times
1945	Sep	Unexpected surrender of Nazi submarine near Antartcica	Newspapers in Buenos Aries
1946		US navy supported Antarctic expidition	Richard Byrd
1946	Mar (15)	Iron Curtain Speech	Winston Churchill

1947	Oct (30)	Sign of General Agreement on Tariffs and Trade	
1948	Apr (3)	Beginig of Marshall Plan	
1948	Jun	Berlin Blockade	
1949	Jan	Founding of COMECON	
1949	Apr (4)	Founding of NATO	
1949	Feb (10)	Soviet Geopgraphical Society made its assertion	USSR
1950		Founding of the National Science Foundation	USA
1950	Jun	Breaking out of Korean War	
1950	Jun (9)	Soviet Union addressed the memorandum to the other 7 countries	USSR
1952		International Council of Scientific Union proposed extensive set of geophysics studies	ICSU
1952		International Social Science Council was founded in Paris	ISSC
1952		Publication of "The Island in the Sky" suggesting putting stations at the Lagrane point	Arthur C Clark
1952	Nov (1)	First nuclear explosion with fusional material (Hydrogen bomb) at Enewetak Atoll	
1954	Feb (24)	President Eisenhower approved DEW line project	Eisenhower
1955	May (14)	founding of Warsaw Pact	
1955	Aug (8)	Soviet (Presidium) Politiburo approved the launch of satellite	USSR
1955	Aug (18)	TASS communique was set up	USSR
1956		Halley I was built as first gen of British Antarctic station	British Anatrctica Survey
1956		US navy supported Antarctic expidition	Richard Byrd
1956		National Interstate and Defense Hiways Act	US congress
1956	Feb	20th congress of Soviet Union Communist Party	
1956	Feb (13)	Soviet Union built its first base in Antarctica, Australian sector	USSR
1956	Jun	Suez Crisis	
1956	Jun	Poland protest	
1956	Oct	Hungaryprotest	
1957		Khrushchev promised every family a separate apartment	Khrushchev
1957	Jul	Beginig of International Geophysical Year	International event
1957	Oct (4)	Launch of Sputnik 1	USSR
1957	Nov (3)	Sputnik 2, space dog Laika, the first life huan sent to space	
1957	Dec	Soviet built another station at the geomagnetic pole	USSR
1958	Jan (31)	US launchd its first satellite	USA
1958	May (3)	US send notes of its proposals to 11 countries	USA

1958	Aug	World's first nuclear submarine *Nautilus* passed north pole	USN
1958	Oct (1)	Found of NASA	NASA
1958	Dec (13)	UN resolution 1348 (XIII), founding of UN Office for Outer Space Affairs (UNOOSA)	
1958	Dec	End of Internatinal Geophysical year	International event
1958		Candian Polar Continental Shelf Program begins	PCSP
1959		A study of Project Horizon: a military outpost on moon	USA
1959		NASA launched its Meatball logo	NASA
1959		CIAM dissolved	
1959	Spring	NASA anounced the Mercury Seven astronauts	NASA
1959	Apr (9)	Frank Lloyd Wright died	
1959	Summer	America National Exhibition in Moscow	USSR, USA
1959	Jul (24)	Kitchen debate	Nixon & Khrushchev
1959	Sep (13)	Luna 2 impacted moon, first artificial marker on moon	USSR
1959	Sep (30)	TV series *Men into Space*	CBS
1959	Oct (15)	Conference was held in Washington D.C	USA
1959	Dec (1)	Sign of the Antarctic Treaty in Washington DC	11 initiating countries
1960		Freeman Dyson came up with the idea of Dyson Sphere	Freeman Dyson
1960		Publication of Metabolism manifestation	Metabolism
1961		Fun Palace	Cederic Price
1961		Book *Metabolism* published	Max Kleiber
1961	Jan (11)	President Eisenhower's farwell address	Eisenhower
1961	Apr (12)	Launch of *Vostok*, first human in space	Yuri Gagarin
1961	Apr (17)	Bay of Pigs Invasion	USA
1961	May (5)	First Mercury manned flight	Alan B. Shepard
1961	May (25)	J.F. Kenney set the goal the land on Moon by the end of the decade	Kennedy
1961	Jun (23)	Enforcement of the Antarctic Treaty	11 initiating countries
1962		A study of Zvezda/ Barmingrad moon base	USSR
1962	Feb (20)	First US astronaut in space orbit	John Glenn
1962	Apr (26)	Ranger 4 impacted moon, first organic material on moon	USA
1962	Sep (12)	President Kennedy's Rice University adress	Kennedy
1962	Nov	Cuba Missile Crisis	
1962	Dec (13)	UN resolution on legal principle governing space exploration	UN

1962	Sep (27)	Publish of "Silent Spring"	Rachel Carson
1963		Archigram Pug-in city	Peter Cook
1963		Earliest report of perennial spring in the Canadian high Arctic	PCSP
1963	Jun (16)	First woman in space	Valentina Tereshkova
1963	Oct (13)	UN resolution of complete disarmament in space	UN
1964	Nov (28)	Mariner 4, first imaging of Mars	USA
1965		Publication of "Spome" idea	Isaac Asimov
1965	Mar (21)	Ranger 7 impacted on moon, first lunar flight broadcasting	USA
1965	Jun (3)	First American EVA, Gemini 4	Howard H. White
1965	Mar (18)	First extravehicular activity, Voshkod-2	Alexi Leonov
1965	Aug (27)	Le Corbusier died	
1966		Korolev died from a colon surgery	Korolev
1966		Beginning of Star Trek	
1966	Feb (3)	Luna 9, fisrt soft landing on moon	USSR
1966	Mar (16)	First space docking	Gemini VIII (Gemini-Agena)
1966	Dec (19)	UN Outer Space Treaty	UN
1967		Halley II was put to use (steel-reinforced roof)	British Anatrctica Survey
1967	Jan (27)	Three astroanuts killed in Apollo trianing	NASA
1968		*2001: A Space Odyssey* movie released	
1968		Publication of *General System Theory*	Ludwig von Bertalanffy
1968		Publication of *The population Bomb*	Paul and Anne Ehrlich
1968		Prague Spring	
1969	Jan (4)	First Soyuz docking	Soyuz-Soyuz
1969	Mar (3)	First Apollo docking	Apollo 9
1969	Jul	First moon landing	Neil Armstrong
1969	Summer	American ship *SS Manhattan* sailed in Arctic to test the Northern shipping passage	USA
1970		US Air Force closed down the chimpanzee colony, the end of chimp college	USAF and NASA
1970	Mar	Osaka World Expo	
1970	Apr (24)	China's first artificial satelite	
1970	Sep (12)	Luna 16, first robotic probe on moon	USSR
1970	Nov (10)	Luna 17/ Lunokhod 1, fist moving vheicle on moon	USSR
1971	Feb (5)	Apollo 14, first boradcasted moon experiment	USA

1971	Apr (19)	Launch of the world's first space station, *Salyut 1*	USSR
1971	May (19)	*Mars 2* , first probe to reach Mars surface	USSR
1971	Jul (30)	Apollo 15, first moon car and moon postcard scandal	USA
1972		Amendment of Antactic Treaty CCAS	ATS
1972		Human bone decarbonization study reveals 1%-2% per month	
1972		Publication of *The Limits to Growth*	Club of Rome
1972	May (26)	Sign of Anti-Ballistic Missile Treaty	USA, USSR
1972	Oct	Completion of Nagakin Capsule Tower	Kisho Kurokawa
1972	Dec	Last moon landing	Gene Gernan
1973		Halley III was put to use (burried tube)	British Anatrctica Survey
1973		Founding of the Institute of Ecotechnics	Institute of Ecotechnics
1973		Oil crisis	
1973	May (14)	Lauch of Skylab	NASA
1974		Project Zvezda/Barmingrad terminated	USSR
1974	Mar (17)	Louis Khan died	
1974	Jul	Recovering of the Soviet Submarine K-129 and sea burial of its sailors	CIA
1974	Sep	*Physics today* published O'Neill's article on space colonization	O'Neil's team
1975		NASA calculated that it would cost 1400 billions to built an O'Neil space settlement	NASA
1975		NASA launched worm logo	NASA
1975	Summer	NASA's 10 week design Study	NASA and Stanford
1975	May (7)	"Space Manufacturing Facilities" conference held at Princeton University	O'Neil's team
1975	Jul (17)	First docking between the US spacecraft and the Soviet spacecraft	Apollo-Soyuz
1975	Aug (20)	*Viking 1* , first Mars rover	NASA
1977		Werner von Braun died	Werner von Braun
1977		Beginning of Star Wars	
1977	Sep (5)	Launch of Voyager 1	NASA
1978		President Carter donated 500g Apollo moon rock to China	Jimmy Carter
1979		China carries out open and reform program	
1980		The attainment of communism predicted by Krushchev	Khrushchev
1980		Amendment of Antarctica Treaty CCAMLR	ATS
1981		Book "Hitler Survival Myth" by	Donald McKale
1981	Apr	First flight of space shuttle	NASA

1982		Falkland Island war	UK; Argentina
1983		STS-7: first American woman in space (second woman in space)	Sally K. Ride
1983		China joined Antactica Treaty	ATS
1984		NASA was authorized to build a new space station	NASA
1984		Halley IV was put to use (exposed tube)	British Anatrctica Survey
1984		China's first Antarctica Station	
1984		Biosphere 2's design started	Biosphere 2
1984		Discovery of ALH84001, the meteroite from Mars and contains life	
1985		China became ATCP	ATCP
1986	Jan	Loss of the Space shuttle *Challenger* with its 7 crew members	NASA
1986	Feb (19)	Lauch of modular space station Mir	USSR
1986	Apr (26)	Chernobyl nuclear disaster	USSR
1987		Construction begins	Biosphere 2
1987		First international conference on closed ecological systems and biospherics	London, Royal society
1987	Oct	Gorbashev's phrases on "Arctic as a zone of peace"	Gorbashev
1988		Amendment of Antarctica Treaty CRAMRA	ATS
1989		Second international workshop on Biosphere 2	Moscow; Krasnoyarsk
1989		President Geroge Bush Sr. announced first manned mission to Mars by 2017	George Bush
1989		Second interntaional conference of closed ecological system and biospherics	IBP lab, Krasnoyarsk
1988	Oct	MELiSSA concept was published	MELiSSA
1990	Jan (24)	Hiten, the fist probe other than those from the US and USSR	Japan
1990	Feb (4)	Last photo of the solar system sent from Voyager 1	NASA
1991		1984 space station initiation was replaced by *Space Station Freedom*	NASA
1991		Halley V was put to use (legs that elevate station from ground)	British Anatrctica Survey
1991		Amendment of Antarctica Treaty Madrid Protocal	ATS
1991		Settlement of Russia-China border disputes	Russia, China
1991	Jun	Arctic Environmental Protection Strategy	
1991	fall	US Congress ratified Cooperative Threat Reduction program	USA
1991	Sep (26)	Beginning of the close experiments at Biosphere 2	Biospherian crew
1991	Dec (26)	Collapse of the Soviet Union	USSR
1992		NASA switched back to the Meatball logo	NASA
1992	Apr	Third international conference in Biosphere 2	Biosphere 2

1993		Space Station Freedom was scaled down again into *Space Station Alpha*	NASA
1993		US and Russia decided to build a space statino jointly	US, Russia
1993	Sep (26)	Ending of the close experiments at Biosphere 2	Biospherian crew
1995		First shuttle/Mir docking	Roscosmos & NASA
1995		Biosphere 2 changed into a flow-through system	Biosphere 2
1996		Last international workshop on Biosphere 2	London
1996	Sep	Sign of Artcic Militray Environmental Cooperation (AMEC)	Norway, Russia, USA
1996	Sep (19)	Formation of the Arctic Council, Ottawa Declaration	Arctic States (A8)
1998		Mir was decommissioned	Roscosmos & NASA
1998	Jan (29)	International Space Station Intergovernmental Agreement signed	15 countries
1998	spring	CTR was linked with AMEC	USA
1998	Nov (20)	Launch of the first core module of the ISS	ISS
1998	Dec	STS-88 *Endeavor* mission: delivering modules of the ISS	NASA
2001		China Joined WTO	
2003	Feb	Loss of the space shuttle *Columbia* with its 7 crew members	NASA
2003	Oct (15)	China's first manned space lunch	
2003	Dec (15)	First Chinese in space	
2004		BAS initiated compitition for new British Antarctic station design	British Anatrctica Survey
2004		Canadian federal budget announced $ 69 billion for Arctic seabed surveying	Canada
2004	Jan	President Bush announced new space program	Bush
2004	Dec	Congress granted FAA additional authority over private space initiatives	US Congress
2005	Aug	Space shuttles are gounded after the flight of *Discovery*	NASA
2005		Concordia Station opened and FGWRS development begins	MELiSSA
2005		Canadian Space Agency funded an expansion for M.A.R.S. within CARN framework	CSA
2006		Biosphere 2 was owned and managed by University of Arizona	Biosphere 2
2007		Russia planting flag on seabed of the magnetic North	Russia
2007	Mar	Fourth Interntaional Polar Year	
2007	Apr	CSA sponsored FMARS2007 exipedition for analogues study of water utility	CSA
2007	Oct (24)	Chang'e 1 made China the world's third moon mapping country	China
2008	May (28)	Ilulissant Declaration	Arctic Ocean States (A5)
2008	Sep (27)	China's first spacewalk	

2011		The end of space shuttle program	USA
2011	Apr (2)	China's experiemntal space station Tiangong 1	
2011	Apr (15)	Wolf Amendement	
2012		Halley VI was put to use (movable station)	British Anatrctica Survey
2012	Jun (17)	Voyager left the solar system	NASA
2013	Feb (15)	Halley VI was officially launched	British Antarctic Survey
2014		Russia designed a 3-stage lunar program to build moonbase	Roscosmos
2014		Russia's annexation of Crimea	Russia
2015	Mar	EDEM ISS project started	ESA
2016	Apr	NASA hybrid traning begins	NASA, Neumayer III
2017		China hosts its first ATCM conference	ATCM
2017	Nov	EDEN ISS construction finished	ESA
2018		Spain initiated the design for its new station in Antarctica	Hugh Broughton Architects
2018		Returning to Moon surface in 10 years	NASA
2018	Nov	Space Settlement Summit, NSS curated	National Space Society
2018	Jan	EDEN ISS experiments began	ESA, Neumayer III
2018	Jun	Merge of ICSU and ISSC into International Science Council, based in Paris	ISC
2019	Jan (3)	First artificial object on the back of the moon	
2019	Marc (26)	President Trump challeged NASA to land the first woman on moon by 2024	NASA
2020		Construction of Australia's David station in Antarctica	Hugh Broughton Architects
2020	Sep	NASA releases Artemis plan	
2021	Apr (29)	Launch of Chinese Space Station	
2022	Apr	Demolition of Nagakin Capsule Tower	
2022	Nov (16)	Launch of Artemis I unmaned test	NASA
2023		Construction of New Zealand's Scott station in Antarctica	Hugh Broughton Architects
2032		Fifth International Polar Year	WMO

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Master's Thesis

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