Emergent Alternative Home 2050

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May 2013

Submitted towards the fulfilment of the requirements for the Doctor of Architecture Degree.

School of Architecture
University of Hawaiʻi

Doctorate Project Committee
David Rockwood, Chairperson
Luis Longhi
James Dator
Andrew Brittain

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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment as a Doctorate Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

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Abstract

Designing for a time beyond the immediate future has potentials for new dialogues. This approach challenges the designer to reconsider the point of departure, societal, contextual and other dynamics, techniques and available materials. Endeavors such as this also promote the opportunity to envision architectural inventions, and new concepts better suited for future. My project aims to find a prototype home for the future 2050, envisioning a design solution for a tropical urban environment.

A series of chronological scenarios across a selected time line investigates the preferred future home. An architectural genealogy and emerging techniques suitable for the context are presented to solidify the overarching theme.

My design proposal provides the necessary proof or evidence for this doctorate project, and tests my hypothesis for a synthetic organic *Emergent Alternative Home 2050*.

Biotechnology, nanotechnology and biomimetic manifestations propagate a reductive, performative, and generative design. In turn, this leads to investigation of accurate, efficient, near intelligent, mass fabricated, low cost materials, components and systems. Self-assembly, flexibility and positive environmental footprint are forecasted for the future home 2050.

Chapter I: Introduction

1.1. Doctorate Project Statement

1.1.1. Focus

The focus of this doctorate project is to find a suitable solution for tropical urban home, 2050. This exploration of *"home"* entails physical and tangible aspects. In addition to a comparative study of selected precedents, an analysis of driving forces, emerging trends, future opportunities, and challenges are investigated in formulating a final design prototype for this project.

1.1.2. Background and Overarching Theme

The definition of "home" is subjective and personal. Home is often considered the fundamental unit of our contemporary society and the basic unit of the city, essentially the building blocks of urbanity. Home can be described as a destination that we (humans) frequently return to rejuvenate ourselves.

The image below displays a future forecast for humanity by Ian Pearson.[1] The targeted population of this investigation is forecasted to be a non-augmented, aging, human society without extensive genetic, cybernetic, or mechanical augmentations. In a

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[1] Future Human Evolution, "Future Visions," Future Human Evolution, http://www.futurehumanevolution.org/future_post_human_futures.php (accessed May 2, 2013).

society propelling towards augmentations, they are considered to be vulnerable and disadvantaged.

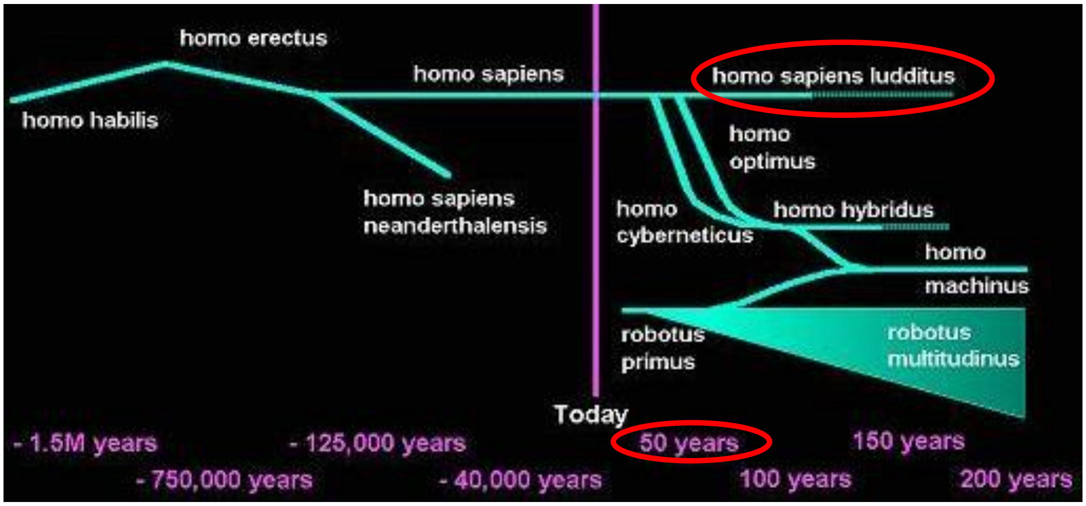

Figure 1 Forecast of a future of humanity (by Ian Pearson)

The Koppen-Geiger climate classification system defines mega-thermal climate as characteristically hot and wet, with temperature constantly over 18°C, high humidity, and heavy precipitation over 60mm during most part of the year. *Emergent Alternative Home 2050* is a prototype intended for mega-thermal climates. Based on temperature, mega-thermal climate is subdivided into the equatorial climate; having little or no temperature variations, and tropical climate; having no seasonal variations throughout the year. However, in this paper acronym “tropical” is used as a synonym for term “mega-thermal.”

The Proposed prototype is designed for 2050 mega cities, such as Belem and Rio de Janeiro (Brazil), Georgetown (Guyana), Paramaribo (Surinam), Kinshasa-Brazzaville

(Congo), Lagos, Ibadan and Port Harcourt (Nigeria), Kolkata (India), Colombo (Sri Lanka), Dhaka (Bangladesh), Jakarta (Indonesia), Kuala Lumpur (Malaysia), Bangkok (Thailand), Ho Chi Minh (Vietnam), Manila (Philippines)Port Moresby (Papua New Guinea).

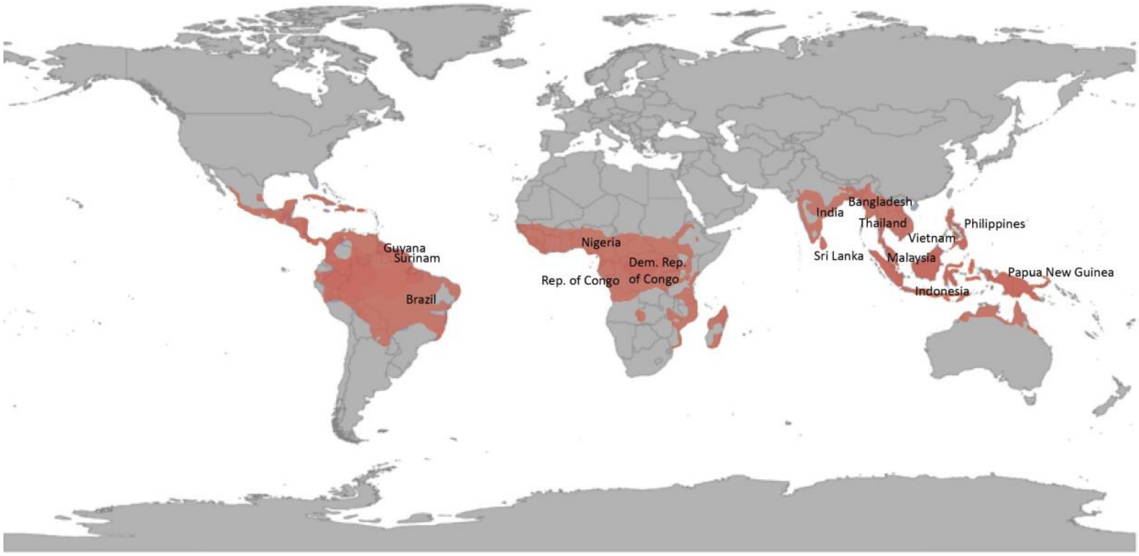

Figure 2 Potential project sites

1.1.3. Hypothesis

Advancement in biotechnology is instigating the exploration of human genomics and synthetic life. Digitized biology translations are assumed to facilitate artificial post humans and "harvestable beings."[2] This doctorate project hypothesizes that as humans become more inorganic, the *Emergent Alternative Home 2050* becomes organic, likely facilitating architectural evolution. The term "organic" can be defined as having the characteristics of an organism, living plants or animals. The advent of synthetic live materials that have characteristics of an organism may redefine the term "organic."

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[2] Walter F. Parkes et al., *The Island*, Universal City, CA: DreamWorks Home Entertainment, 2005.

The physical construction of home in 2050 is assumed to have undergone a paradigmatic shift, from assembly of huts from natural material, to building of shelters from manipulated materials, and to printing of habitats using code generated synthetic materials. By 2050, it is anticipated that the habitats will be generated employing synthetic organic material, resulting in habitable synthetic organic environments.

In conjunction, biomimetics is proposed as a technique to minimize use of resources and integrate other desirable functionality, promoting efficiency and flexibility that enables growth or reduction according to user need. It also encompasses "maximum use of functions provided by nanotechnology."[3] Nanotechnology refers to the scale at which the organic nanoparticles and proposed techniques are applied.

The *Emergent Alternative Home 2050* proposes a positive environmental response and a new typology for the human habitat. It surfaces as an assertive, performative initiative to a negative environmental condition. At the macro level, similar to the natural plants, the proposed synthetic environment will absorb greenhouse gas emission, assist in reestablishing the lost vegetation, and reset the water cycle.

In addition, it is also a working mechanism that extracts inorganic material and converts them into organic compounds through a bio-chemical re-coding process. At the end of life, synthetic organic materials are programmable for controlled decomposition.

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[3] Sylvia Leydecker, *Nano Materials in Architecture, Interior Architecture and Design* (Berlin: Birkhäuser, 2008), 56.

In essence, this investigation proposes application of synthetic organic or biomaterials according to biomimetic principles to create a preferred *Emergent Alternative Home 2050*.

1.2. Goal

My doctorate project argues for a desirable human habitat for 2050. The long-term vision and preparing for optimistic future(s) are exceedingly important in the profession of architecture. Architects, as creators of physical spaces, carry a responsibility towards the society to avoid unfavorable future conditions. Therefore, as a student of architecture, I recognize the ethical and moral implications of my project's vision.

In this proposal I attempt to meet the "triple bottom line" for sustainable industry: *economically viable*, *environmentally compatible*, and *socially responsible* architecture; in other words, value creating architecture that use eco-efficient products and processes to prevent pollution and depletion of natural resources and behave in an ethical manner.[4] This project considers (human) survival existence in a likely synthetic or technologically highly modulated environment. A trendy sustainable solution is not intended in its place; instead, according to biomimicry principles, a technologically advanced prototype is attempted.

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[4] Organisation for Economic Co-operation and Development, "The Application of Biotechnology to Industrial Sustainability—A Primer, Working Party on Biotechnology, Directorate for Science, Technology, and Industry, Committee for Scientific and Technological Policy,"(2002), quoted in Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 340.

I agree with Leydecker that technological advancement will facilitate new fundamental architecture or change contemporary solutions.[5] Efforts are being made to capture these potentials. Simultaneously, technology advancements offer a gateway to unlock our shrinking profession. An example would be the advancement of biology, offering new knowledge that leads to development of advanced materials. In turn, additional opportunities requiring specific skill sets could create new branches to the architectural profession.

In Thomsen's *Visionary Architecture: From Babylon to Virtual Reality*, he describes how visionary architecture permits exploration of concepts and connections between various other fields. The professional contribution of this doctorate project is to demonstrate potentials and benefits of making interdisciplinary connections[6] between architecture, biology, sociology and future studies. I believe that interdisciplinary research explorations comparable to this paper create new knowledge, and new opportunities, to further expand connections across the disciplines. Moreover, the architects may become the leaders of such future collaborations.

In addition to an interdisciplinary approach, forecast oriented planning has the potential to extend the scope of architects, in terms of adding value for services, in envisioning the future. Deep qualitative investigations over longer periods may lead to

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[5] Sylvia Leydecker, *Nano Materials in Architecture, Interior Architecture and Design* (Berlin: Birkhäuser, 2008), 33.

[6] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 153.

additional professional compensations, and reduced professional liability after the completion of the building.

Besides serving as a doctoral research paper, this project will facilitate my own extension of knowledge and opportunity to study, envision, and experiment potential application of new technologies such as biomimetics, nano-materials, and generative architecture.

Generative architecture is differentiated from the traditional blueprint architecture. Generative architecture, in essence, is code generated geometry. I argue that in the future, "*home(s)*" will be generated according to this technique. Similar to coding in DNA, generative software constructs designs using codes. Plug-ins such as the Grasshopper extension to Rhinoceros software is a contemporary example that is widely in use today. Mula is a user- friendly emerging software that could be used by laymen. Bentley Systems is a leading company vesting their interest heavily on generative software.

The targeted audience of this paper includes students, architects, governing bodies, nonprofit organizations, commercial enterprises, researchers, and material scientists concerned with the design, construction, and organization of the built environment.

1.3. Scope and Limits of Research

The initial research investigation and partial documentation was conducted during the first part of my doctorate project (D.Arch I). The latter part (D.Arch II) was undertaken in spring 2013, to further the initial findings and to propose a design prototype solution.

Macro-scale issues are investigated in an effort to find micro-solution(s) using advanced future technology. The primary scope of this project entails the conceptual design of a living pod for a single human being in the year 2050. An outline urban context is presented to facilitate an understanding of the contextual conceptualization of the future locality conceived in *Emergent Alternative Home 2050*. Limited discussion for social spaces is also accommodated.

The following information is included in this document:

1. Precedent studies
2. Design program
3. Design process
4. Preliminary conceptual experimental modeling
5. Explorations of relevant technologies
6. Demonstration of relevant materials and systems

Thomsen, in his book *Visionary Architecture: From Babylon to Virtual Reality*, points out that visionary architecture escapes typical mundane pressures, such as construction cost and material properties, and availability of building sites.[7] In 2050, it is forecasted that due to high population, that the mega cities of my project sites will experience a shortage of land. In response to this phenomenon, the proposed project occupies airspace and existing built surfaces. Emerging technologies are anticipated; however, financial feasibility, and deep investigation into economics is circumvented, because such hypothesis is beyond the scope of this paper.

In a forecasted future context, detail investigation on code and regulations would be a separate investigative topic. Hence, code and regulatory conformity is not considered in this conceptual project. Confrontation with varying governance factors are outside the periphery of this project. They have been avoided, so as to not to limit the potential design outcomes that this doctorate project aims to highlight.

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[7] Christian W. Thomsen, *Visionary Architecture: From Babylon to Virtual Reality*. (Munich: Prestel-Verlag, 1994), 116.

1.4. Research Methodology

1.4.1. Forecasting

The basis of my hypothesis follows the principals and the methodologies of the University of Hawaii at Manoa Future Studies alternative future(s) forecast theory. In this paper, forecasting methodology is selected to investigate the *Emergent Alternative Home 2050* under their basic parameters, applied to an urban architectural context.

For manageability, Manoa Future Studies methodology focuses foresight studies in future time milestones in 50-year increments. Accordingly, my doctorate project adheres to this principal, hence the title, *Emergent Alternative Home 2050.*

It must be noted that these future(s) are forecasted, and not predicted, using quantitative and qualitative methods. Preference is given to qualitative methodologies such as the Delphi consensus method.

For the purpose of this paper, the future(s) are considered plural according to the Manoa school of thought. The Future Studies methodology defines four primary categories of alternative future(s): continued growth, post collapse (or new beginning), disciplined (or sustained) future, and a transformed future. Although the forecasted future scenarios may not necessarily become manifest, the possibility exists for any one of them, or a hybrid, to occur. My research focuses on creating a preferred future of home.

1.4.2. Logical Argumentation

In this paper, scenarios are built using logical arguments based on literature reviews. These methods include scanning emerging issues, current trends, and patterns.

The literature review has been carried out via applicable peer-reviewed books and articles, multiple futuristic motion pictures and video files, web articles and lectures, conferences, and debates, etc.

Furthermore, an extended review facilitates an investigation on the notion of home, architectural history and tradition, organization of social structure, influencing trends, environment, culture and their relations.

1.5. Design Methodology

1.5.1. Biomimicry

This paper utilizes biomimetics technology transfer strategies and methods[8] described by Gruber to achieve a desirable design prototype. Agreeing with Barnett, I propose Biomimicry as an appropriate design methodology with the arguments, "Nature has been housing its creatures for three and a half million years"[9] and Wilson's "all living phenomena are obedient to the laws of physics and chemistry."[10] Biomimetics is the attempt at imitation of nature's methods and structure to achieve a preferred design solution. (See Glossary)

Benyus further elaborates:

1. "Nature runs on sunlight
2. Nature uses only the energy it needs
3. Nature fits form to function
4. Nature recycles everything
5. Nature rewards cooperation
6. Nature banks on diversity

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[8] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 262.

[9] Sean William Barnett, "Biomimetic Dwelling, Urban Living in a Built Environment Modelled After and Integrated with the Natural Environment" (master's thesis, University of Minnesota, 2006), 1.

[10] Edward O. Wilson, "Systematics and the Future of Biology," PNAS 102 no. S 1 (May 3, 2005), 6520-6521, doi:10.1073/pnas.0501936102, published on April 25, 2005, http://www.pnas.org/content/102/suppl.1/6520.full.pdf+html (accessed May 2, 2013).

7. Nature demands local expertise
8. Nature curbs excess from within
9. Nature taps the power of limits"[11]

1.5.2. Case Studies

Although seemingly a part of logical argumentation and trend analysis, in this paper case studies are considered a distinct methodology. A genealogy matrix of homes has been carried out to aid in forecasting the architectural potential of *Emergent Alternative Home 2050*.

This research methodology facilitates a comparative analysis of context, time, technologies, components, systems and processes. It also enables an extrapolation of trajectories adopting current and emergent future technologies, such as biomimetics, nanotechnology, and advanced materials, including their harvest and methods to create an efficient, organic home.

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[11] Janine M. Benyus, *Biomimicry, Innovation Inspired by Nature* (New York: Perennial, 2002).

Chapter II: Contextual Framework

2.1. Introduction

This chapter investigates the contextual characteristics of the future 2050, through scenario creation. In accord with Manoa Future Studies methodology, the emerging context is framed using research investigation of key driving forces, and trend forecasting. A summarized matrix of scenarios highlights the key drivers that project a preferred alternative future for 2050.

For the design of *Emergent Alternative Home 2050*, the year 2050 is considered “present,” while the year 2030 is considered the “past” and the year 2070 to be “future.” Because this doctorate project investigates the development of a future design prototype for the year 2050, the following scenarios are theorized according to my research and are true to the above statement for better contextual understanding.

2.2. Driving Forces

History has shown that certain intense manifestations lead to new ways of living.

The projected scenarios are primarily shaped by the following key components:

- Technology
- Economy
- Human population
- Family dynamics
- Demographics of the population
- Natural and built Environment

2.3. 2030 Scenario

Technological advancements will play a primary role in shaping 2030 context. Technology, economy and population will continue to grow rapidly. A notable change in these 2013's third world or emerging world economies will be their rise as corporate giants in 2030.

A society that is predominantly driven by monetary compensations can be called a high-yield economic society. The 2030 society will reflect the dynamics pertinent in a high-yield economic structure, and a reduction in fertility rate across the population will be observed. Due to economic reasons women and men of reproductive age will consider having a reduced number of children. As a result, the family demographics will change to small families and ultimately shift to single offspring families.

Biotechnology induced medical and pharmaceutical advancements will aid in healthier, longer lives for people in 2030. In reference to such a trend, the population demographics will reveal that the overall population is aging. (See Appendix B)

Large urban cities will be essential to support 2030's growing population. Moreover, considering the longer life span and the demographics of the growing population, new constructions and infrastructure will need to be extended to all non-urban settings to handle the housing needs. The project sites will be dominated by mega cities. All open spaces will be encroached by high capacity mega-structures.

Together with the population increase, the built environment will account for near complete exhaustion of the natural environment by 2030. It will raise enormous complex environmental issues. In order to prevent extinction of diverse plant, animal and human life, and the water cycle, improvement to the environment will be urgently called for.

2.4. 2050 Scenario

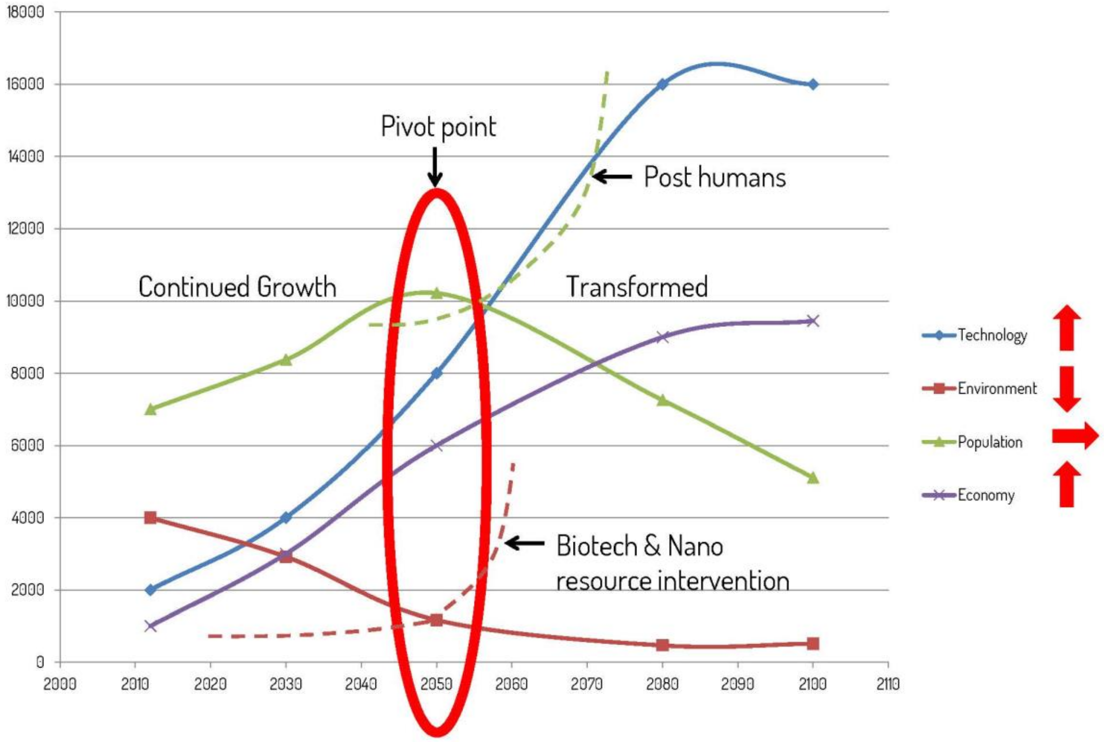

Figure 3 Emergent Alternative Home 2050 driving forces

The year 2050 will be a pivotal point in history. Technology, as we know it in 2013 will reach its peak in 2050, becoming the fundamental supporting structure of this period. This is comparable to the classical music peak in the European classical era. The ability to complete tasks quickly, efficiently with the least amount of effort, minimum and diverse use of materials will be its characteristics. The internet, silicon devices, interactive and mobile technology, touch screens, 3d extrusions, have been the forefathers of this era. Ubiquitous, immersive technologies will be their advanced counterparts. These technologies are digitally codified, robotically or manually controlled for the well-being of humans.

The economy of the tropical world will level with the economically developed world. A shift from corporate giants to smaller, individual private organizations will be seen, especially in high tech, genetic, research and experiment laboratories. The pressure and incentives to invest in research, to understand and improve bio-diversity has been high even before 2050. Technological innovations already enforced will not only bring in advanced knowledge and techniques, but will also institute successful organizations and the financial leaders of this era.

In 2050, strict population control parameters will be enforced to curtail the 2013's projected population growth. Due to these measures, global and local populations of my project sites will be in a controlled plateau in 2050. These extreme population control measures will be voluntarily accepted by the 2050 society. For example, implants against fertility will be the norm, and sole individuals without any offspring, its result. In the absence of a nuclear family, the community becomes the smallest societal structure.

The advancements in biotechnology, nanotechnology and genetics will further slowdown the process of aging. Humans will live up to 150 years of age. Their cognitive capacities will stabilize, comparable to that of a healthy 60 year old person from 2013.

Memory enhancements through non-extensive medical procedures will be utilized for this purpose. Alternative means of creating life and extending life through technology induced extensive augmentations will also be experimented in 2050. Cyborgs,[12] post-humans, and early testing of synthetic designer adults will be modeled in laboratories. Post-humans will be attempted to create beings that maintain their physical and cognitive agile youth form, while cyborgs as well as stable, synthetic designer life will be attempted to be complete newly created. New cyborgs will be considered expendable, while the synthetic designer population will be highly valued. Importantly, the outcome of such experiments is expected to create efficient beings, and have programmable, controlled life spans.

Among investigating and testing techniques to repair the endangered environment, a genetically modified, codified, controlled environment technique will champion. This invention will incorporate synthetic organic life and biomimetic architecture. It will demolish the existing old built environment. The energy that is created during the disintegration process will be captured, and stored for human use. The demolished materials will be processed, enabling up-cycling to innovative biodegradable products. As a component of an innovative human habitat described below, it will activate a new organic or synthetic addition to the biosphere. In turn, this technique will improve the carbon dioxide storage by newly created synthetic organic

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[12] Nate Lanxon, "Practical transhumanism: five living cyborgs," wired.co.uk, posted on September 4, 2012, http://www.wired.co.uk/news/archive/2012-09/04/cyborgs (accessed May 2, 2013).

plants, and re-establishing the water cycle conditions. The resultant new synthetic organic elements will aid in establishing a network of organic human habitats.

In theoretical essence, the proposed means of transforming the built environment is a reductivist building strategy. This approach erodes away the older, inefficient, static, inorganic, built environment by implementing biodegradable, minimal, human dwellings or pods, thus creating a higher percentage of synthetically intervened organic diversity in their place.

2.4.1. The Technology Peak

Mobile, user friendly, affordable digital technology and design communication will be the product of 2030's rapid growth of technology. Open sourcing, mass media and other data sharing networks will be credited for this accelerated growth and the ubiquitous availability of digital information. In his book *Bio-inspired Innovations and National Security,* Armstrong *et al.* support my theory and potential application of these technologies in the third world of 2013: "Biological products within an increasingly digital world and global economy can be acquired more easily by countries that are lagging behind scientifically."[13]

In 2050, not only will the enhanced information exchange facilitate many potential efficiencies, it will also drive diverse applications of technology at a scale

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[13] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 339.

previously unimagined. Biology continues to rapidly evolve propelling advancements in biotechnology and nanotechnology. Research is quickly progressing, seen in the use of nano-tubes, synthetic cells, DNA coding and biomimetics. A technology peak that is copious with intelligent, interactive, collaborative robotic services will spring in 2050.

Future trend forecasts for biotechnology include: synthetic biology, bio-energy, bio-materials, biologics (biopharmaceuticals), biomechantronics, biomimcry, genomics, proteomics, bioplastics, 'green chemistry', biocatalysis, bioimaging, biosensors.[14]

The early generative design approaches in 2013 that facilitated mass customization, polymorphism, and tessellation, together with biotechnology and nanotechnology will lead architecture to become an advanced, generative, autonomous process in 2050. Material decomposition, reconfigurations will also be facilitated by the advancements in biotechnology, genetics and nanotechnology.

The following examples illustrate selected precedent technologies that are abundantly available in 2050 in the design and construction industry. Technologies such as 3D extrusion of surfaces or 3D printing will be inexpensive because of this abundance.

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[14] Gary Golden, "Carbon Capitalists of the World Unite! The Future of Carbon's Bio-and Nano-based Wealth Creation; Bio Industrialism," posted on December 22, 2009, http://www.garrygolden.net/2009/12/22/carbon-capitalists-of-the-world-unite-the-future-of-carbon-based-wealth-creation/ (accessed May 2, 2013).

Domestic 3D Printer[15]

Commercial 3D Printer[16]

SeatSlug – First 3D Printed Bench Rael San Fratello Architects[17]

3D printed concrete bench[18]

Honeycomb morphology[19]

3D printed wood[20] (Integrated, generative design based on biomimetic approach)

Figure 4 Abundant technologies in 2050

2.4.2. Tropical Third World Economic Shift

The fastest growing economies of the world in 2013 are located in the tropics. This can be explained with population growth, demographics and resource distribution. Primarily, these countries continue to have a high percentage of working population. Secondly, financial investments, income from workers in foreign countries sending

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[15] Shopingblog.com, “3D Systems Demonstrates Cube, $1,300 Personal 3D Printer, on CNN,” entry posted on April 2, 2012, http://www.shoppingblog.com/3d-systems-demonstrates-cube-1300-personal-3d-printer-on-402201211 (accessed May 2, 2013).

[16] “3d printing,” http://farm4.static.flickr.com/3083/2728141800_1bfd77e805_o.jpg (accessed April 5, 2012).

[17] Andrew Michler, “SeatSlug – First 3d Printed Bench at a Low Cost / Rael San Fratello Architects,” eVolo, posted on SEPTEMBER - 24 – 2011, under “3d printing,” http://www.evolo.us/architecture/seatslug-first-3d-printed-bench-at-a-low-cost-rael-san-fratello-architects/ (accessed May 2, 2013).

[18] Andrew, “Impressive 3D-Printed Curved Concrete Shapes,” posted on March 15, 2012, “under 3d printing,” http://www.makerbot.com/blog/2012/03/15/impressive-3d-printed-curved-concrete-shapes/ (accessed May 2, 2013).

[19] Design-canvas. BlogSpot, “& Honeycomb Morphologies: The Honeycomb Morphologies Project is based on the desire to form an integrated and generative design strategy using a biomimetic approach to architectural design and fabrication,” Design-canvas. BlogSpot blog, entry posted on July 1 2010, under “generative biomimetic approach,” http://design-canvas.blogspot.com/ (accessed May 2, 2013).

[20] David, “The Year of 2011 in 3D Printing,” i materialize blog, entry posted on December 19, 2011, under “3d printing,” http://i.materialise.com/blog/entry/the-year-of-2011-in-3d-printing (accessed May 2, 2013).

remittances back, information and infrastructure growth, resource availability, flexibility in macro-economic policies and extended education to rural communities and women are other contributors to their economic growth.

Business Insider published the fastest economic growth trends for next 40 years.[21] Year over year growth rate are projected as: Nigeria 8.5%, India 8%, Iraq 7.7%, Bangladesh 7.4%, Vietnam 7.5%, Philippines 7.3%, Mongolia 6.9%, Indonesia 6.8%, Sri Lanka 6.6%, Egypt 6.4%. This extrapolated continued growth of economy will draw high migration to their urban centers and as well as create new urban landscapes.

By 2050, not limiting to that and being mostly contained in the tropical belt, these countries will continue to over harvest resources causing natural environmental depletion. The efforts to rectify their potential effects will create a paradigmatic shift in wealth distribution. The corporate wealth from 2030's will be distributed among individual private organizations such as high tech, genetic research companies.

2.4.3. <u>Controlled Human Population Plateau</u>

The world population continues to increase rapidly. This is particularly true for the tropics. UN demographers indicate 8 to 11 billion global population for 2050,

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[21] Business Insider: Money Game, "The 10 Fastest Growing Economies of the Next 40 Years," http://www.businessinsider.com/fastest-growing-economies-2011-2#10-egypt-1 (accessed May 2, 2013).

whereas the Population Reference Bureau indicates 9.4 billion.[22] (See Appendix A) Over the next forty years, 2.3 billion population increase is projected. It is expected that 97% of the increase will be in the less developed regions, with 49% of it in Africa."[23] This could be partly due to advanced healthcare permitting low infant mortality and longevity. Year 2050 can be designated as "Long life and small family and … a completely new world."[24]

A global cross sectional study projection indicates that the current world population is dangerously close to, or according to some, has passed the carrying capacity of the earth. The images below indicate the global population density and global urban extent respectively.[25]

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[22] Robert Engelman, "Population Growth Steady in Recent Years," WorldWatch Institute, Vital Signs: Global Trends that Shape Our Future, posted on Sep 17, 2009, http://vitalsigns.worldwatch.org/vs-trend/population-growth-steady-recent-years (accessed May 2, 2013).

[23] Harvard School of Public health, "World population to Surpass 7 Billion in 2011: Explosive Population Growth Means Challenges for Developing Nations," posted on July 28, 2011, http://www.hsph.harvard.edu/news/press-releases/2011-releases/world-population-7-billion.html (accessed May 2, 2013).

[24] TED, "Hans Rosling shows the best stats you've ever seen," filmed Feb 2006, posted Jun 2006, TED2006 video file, http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html (accessed May 2, 2013).

[25] NASA SEDAC, "NAGDC: Population, Landscape, And Climate Estimates (Place), v2 (1990, 2000): Global Population Density," NASA SEDAC: CIESIN Columbia University, http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v2/maps (accessed May 2, 2013); CIESIN Columbia University, "The World: Urban Extents of Settlements greater than 5000," CIESIN Columbia University, World Data Center for Human interactions in the Environment, posted on November 2, 2006, http://sedac.ciesin.columbia.edu/wdc/downloads/maps/population/GRUMP/Urban_Extents_World.pdf (accessed May 2, 2013).

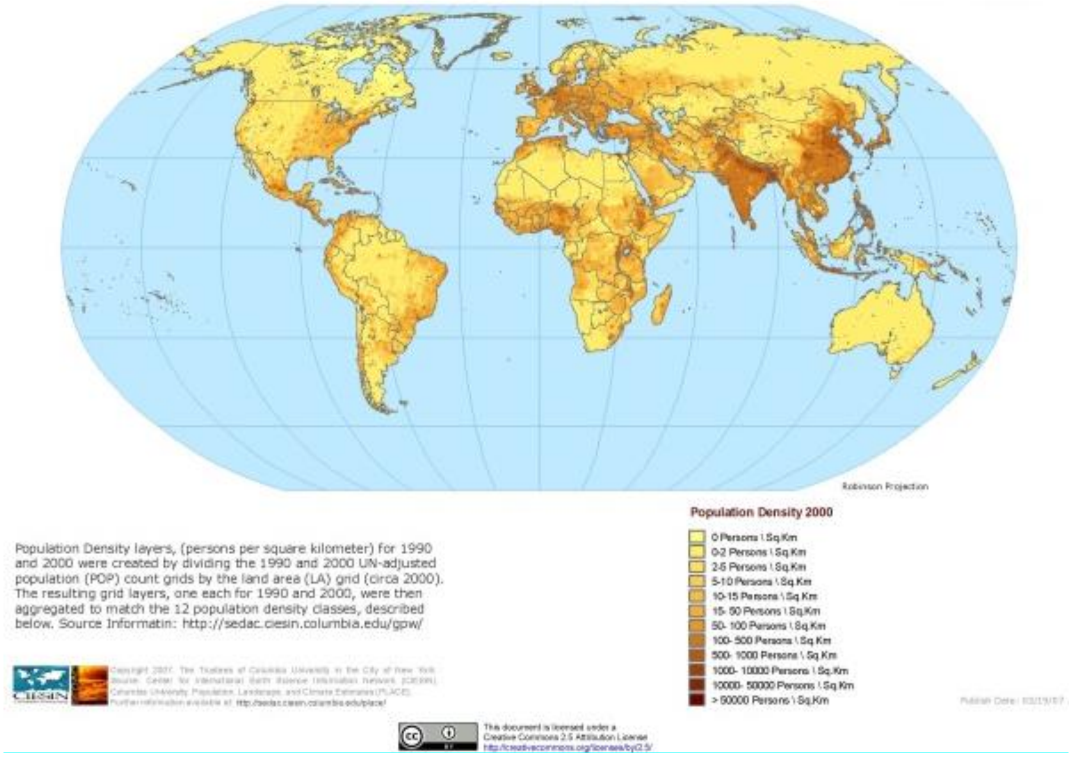


Figure 5 Global population density (1990/2000)

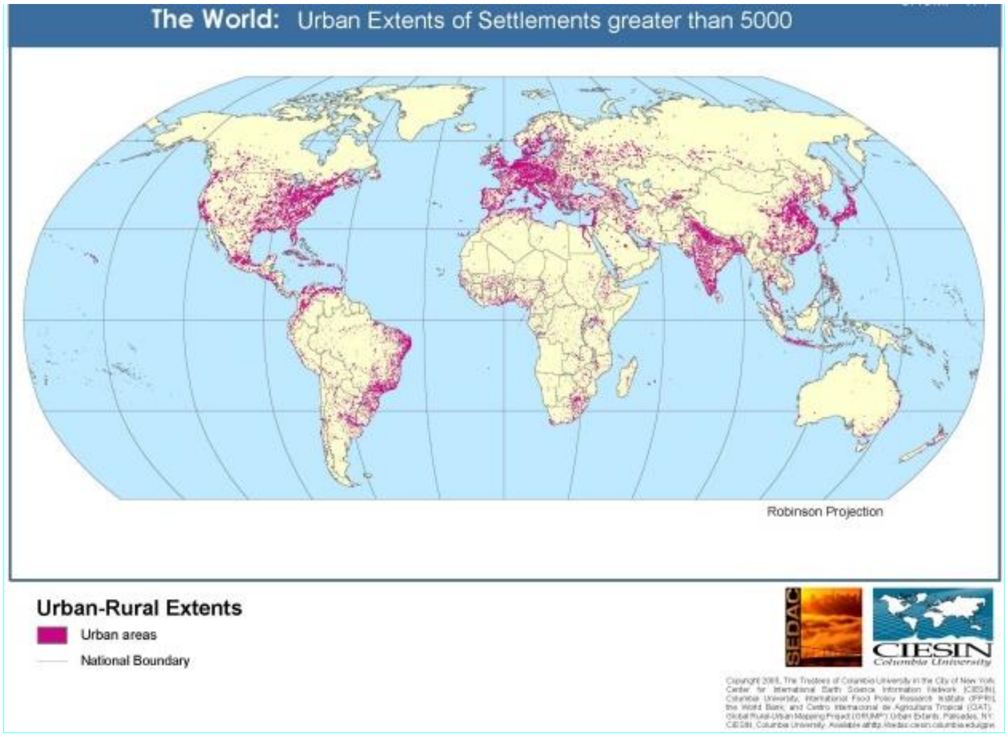
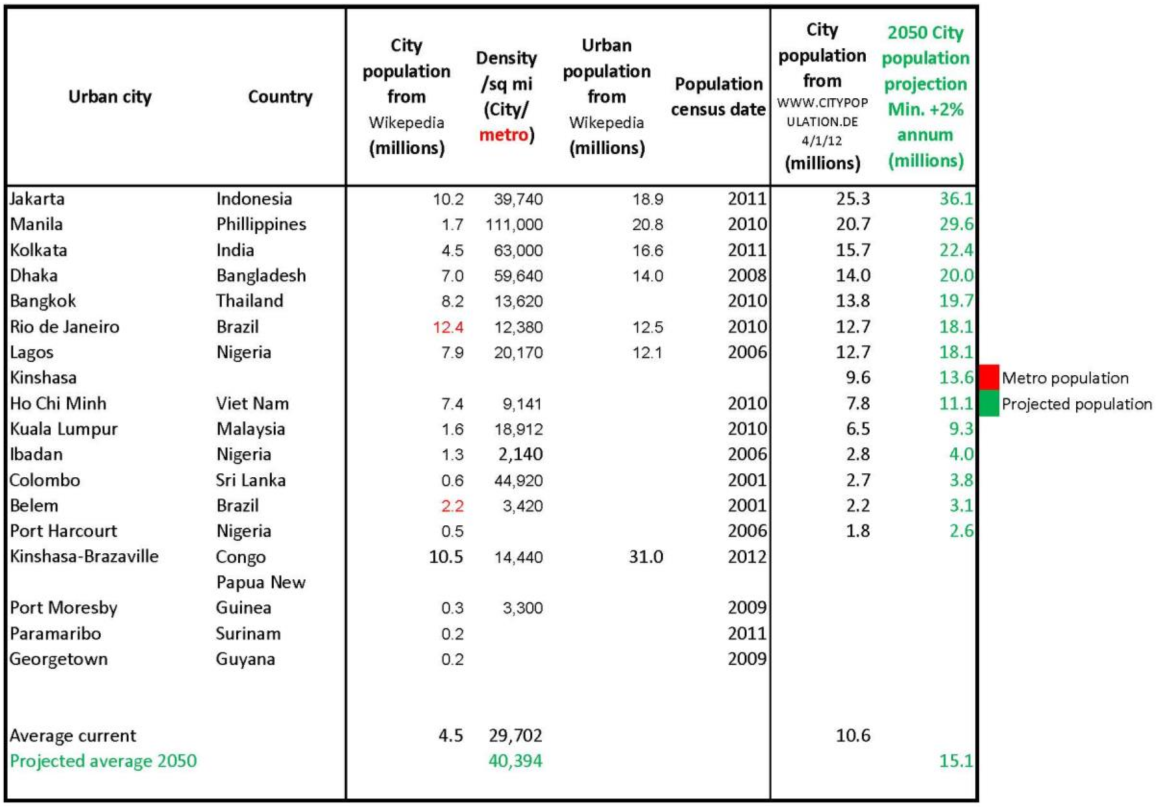


Figure 6 Global urban extent (2005)

The following chart shows an analysis of statistical figures from the Websites *City Population*[26] and *Wikipedia.* A projection of 2% minimum growth per year is applied in anticipating their peak in 2050. The calculations used are the most recent data for the urban contexts of my proposed project sites.



Urban city	Country	City population from Wikepedia (millions)	Density /sq mi (City/ metro)	Urban population from Wikepedia (millions)	Population census date	City population from WWW.CITYPOPULATION.DE 4/1/12 (millions)	2050 City population projection Min. +2% annum (millions)
Jakarta	Indonesia	10.2	39,740	18.9	2011	25.3	36.1
Manila	Phillippines	1.7	111,000	20.8	2010	20.7	29.6
Kolkata	India	4.5	63,000	16.6	2011	15.7	22.4
Dhaka	Bangladesh	7.0	59,640	14.0	2008	14.0	20.0
Bangkok	Thailand	8.2	13,620		2010	13.8	19.7
Rio de Janeiro	Brazil	12.4	12,380	12.5	2010	12.7	18.1
Lagos	Nigeria	7.9	20,170	12.1	2006	12.7	18.1
Kinshasa						9.6	13.6
Ho Chi Minh	Viet Nam	7.4	9,141		2010	7.8	11.1
Kuala Lumpur	Malaysia	1.6	18,912		2010	6.5	9.3
Ibadan	Nigeria	1.3	2,140		2006	2.8	4.0
Colombo	Sri Lanka	0.6	44,920		2001	2.7	3.8
Belem	Brazil	2.2	3,420		2001	2.2	3.1
Port Harcourt	Nigeria	0.5			2006	1.8	2.6
Kinshasa-Brazaville	Congo	10.5	14,440	31.0	2012		
Port Moresby	Papua New Guinea	0.3	3,300		2009		
Paramaribo	Surinam	0.2			2011		
Georgetown	Guyana	0.2			2009		
Average current		4.5	29,702			10.6	
Projected average 2050			40,394				15.1

🟥 Metro population
🟩 Projected population

Figure 7 Population comparisons of potential (urban) project sites

The fertility rate is falling and a population peak is forecasted for 2050. Depletion of global resources demands population control. The society voluntarily complies with this notion to prevent catastrophic failure due to overpopulation.

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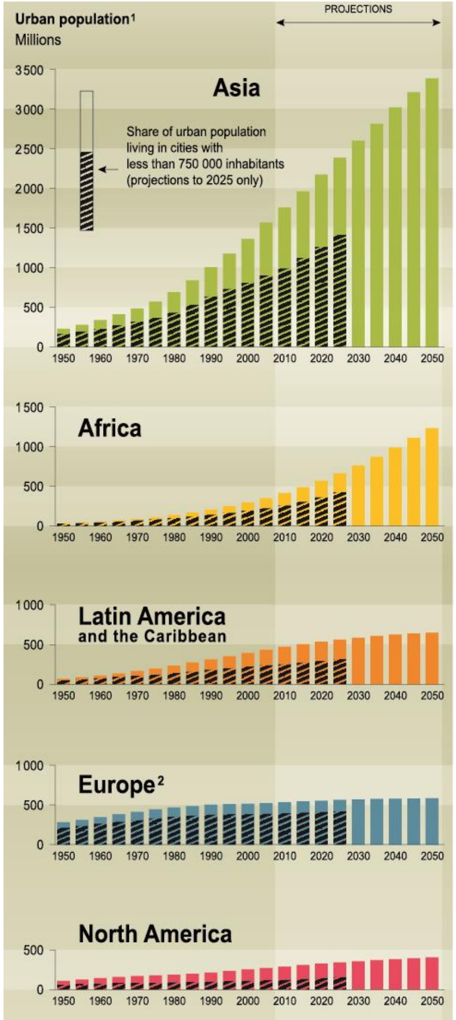
[26] Thomas Brinkhoff, "City Population: Population Statistics for Countries, Administrative Areas, Cities and Agglomerations – Interactive Maps – Charts," http://www.citypopulation.de/ (accessed April 1, 2012).

The image below illustrates the global urban trend from 1950 to 2050.[27] (Also see Appendix A)



1 - The definiton of "urban area" varies from one country to the next.

2 - Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Channel Islands, Croatia, Czech Republic, Denmark, Estonia, Faeroe Islands, Finland, France, Germany, Gibraltar, Greece, Holy See, Hungary, Iceland, Ireland, Isle of Man, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, The Netherlands, Norway, Poland, Portugal, The Former Yugoslav Republic of Macedonia, Moldova, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom.

Urban areas of Oceania – not included here for legibility reasons – are projected to reach 38 millions of people by 2050 (currently 25 million).

Source: UN Population Division, *World Urbanization Prospects: The 2009 Revision.*

Figure 8 Urban trends

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[27] European Environment Agency, "Historical urban population trends and projections by world regions (1950- 2050), showing the share of cities with less than 750 000 inhabitants: Urban trends," created on Dec 10, 2010, posted on Dec 13, 2010, http://www.eea.europa.eu/data-and-maps/figures/urban-trends (accessed April 6, 2012).

2.4.4. Family Dynamics Shift

Early decades of the twenty-first century industrial market-based economy endorsed lower fertility rates.[28] Dator *et al.* in their article "What futures for families?" and Stevens in his article "What future for the family?" indicate many supporting theories for reduction in fertility .[29]

The images below illustrate a globally set trend for small families. (See Appendix C) When dependent on scarce resources, "family of one"[30] seems the most efficient organization. Hence, this paper assumes and adopts a "family of one"[31] for unrestricted freedom for mobility and economic efficiencies. This is in contrast to agricultural societies in which women are more sedentary and able to have more children.[32]

Hans Rosling attributes to this social change as the precursor to economic change seen in Asia in 2013.[33]

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[28] Jim Dator et al., "What futures for families?" (2007), 11, 14.

[29] Jim Dator et al., "What futures for families?" (2007); Barrie Stevens. "What future for the family?" OECD, posted on December 21, 2011, http://oecdeducationtoday.blogspot.com/2011/12/what-future-for-family.html (accesses March 21, 2013).

[30] Dator, 19.

[31] Dator, 19.

[32] Dator, 7.

[33] TED, "Hans Rosling shows the best stats you've ever seen," filmed Feb 2006, posted Jun 2006, TED2006 video file, http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html (accessed May 2, 2013).

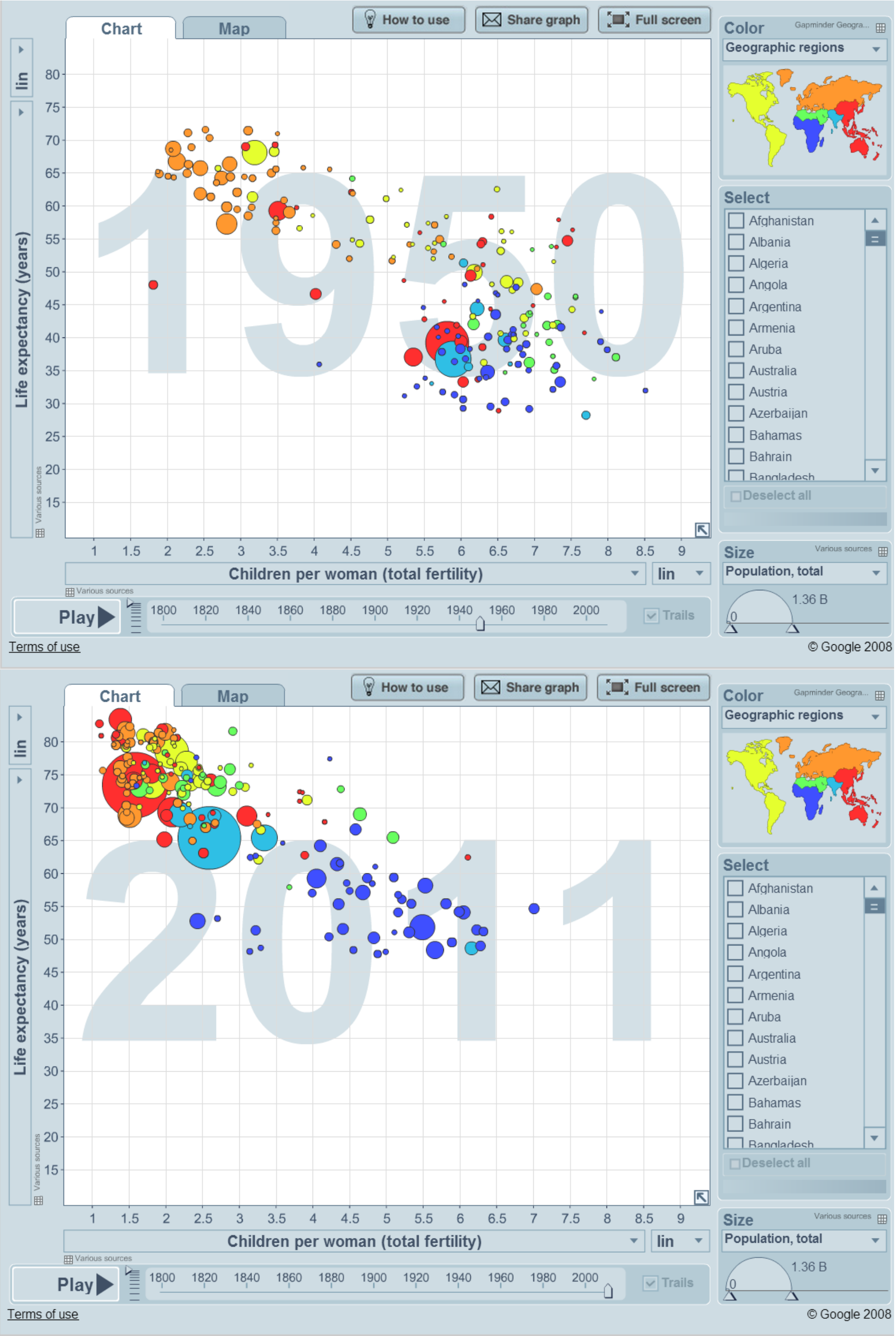

Figure 9 Family size trend comparison[34]

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[34] "Gapminder for a fact-based world view, Gapminder World," http://graphs.gapminder.org/world/ (accessed May 2, 2013) quoted in TED, "Hans Rosling shows the best stats you've ever seen," filmed Feb 2006, posted Jun 2006, TED2006 video file, http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html (accessed May 2, 2013).

2.4.5. Demographics Shift to an Older Population.

After the population explosion in the 1930's, the population control methods enforced in 1970[35] are now resulting in aged societies in many places such as South-Korea, Japan, certain areas in Europe etc.

"By 2050, 32 countries are expected to have more than 10 million people aged 60 or over, including five countries with more than 50 million in that category: China (440 million), India (316 million), the United States (111 million), Indonesia (72 million) and Brazil (64 million)."[36] As well as in 2050, 22% of the expected world population will be 60 years and over.[37] UN data for 2050 projects that the aging population follows a (declining from 2025-2030 2.8%) 1.8% growth rate of people over 60 years of age compared to (declining from 2045-2050 0.7%) growth rate of 0.3% total population growth.[38] (See Appendix B, Figure 8) However, in 2050, technology facilitated medical advancement is expected to play a major role in extending the life expectancy by about 50 years compared to today's measures.

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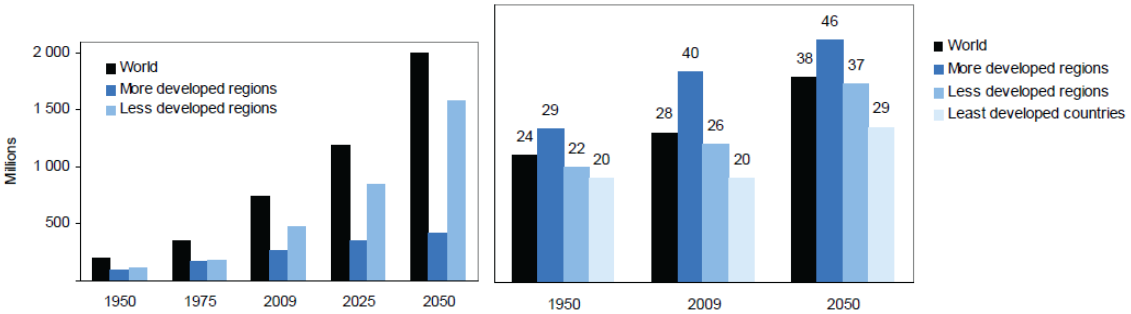
[35] Jim Dator et al., "What futures for families?" (2007), 5.

[36] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

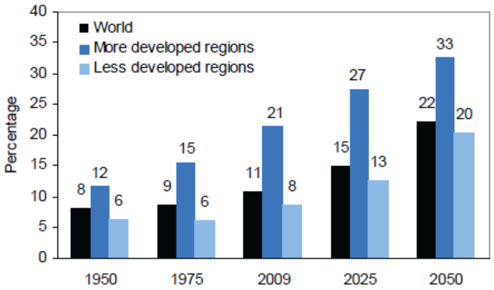
[37] UN, http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

[38] UN, http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).



Population aged 60 or over: world and development regions, 1950-2050

Median age of population: world and development regions,1950-2050



Proportion of population 60 or over: world and development regions, 1950-2050

Figure 10 Population demographic statistics and forecasts

Shown above are the global population demographic forecasts.[39] (Also see Appendix B)

Recently enforced population control resulting in no human offspring strategy drives population demographics further into an aging society. In turn, the demands on architectural habitat, shifts from family to individuals. The smallest unit of the society has also shifted from family to the community. This paradigm shift challenges many aspects of our concept of home as well as our familiar notions of habitation.

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[39] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Moreover, ethical choices such as the selection for a non-augmented continued human existence, in the not too distant future, as a "family of one"[40] will create a vulnerable aging society by 2050. Humans will be less competitive compared to their future post-human or clone counterpart such as Cyborgs and synthetic designer adults.

2.4.6. Environment Restoration

In 2030, continuingly growing populations will mean rapid consumption of finite resources[41] of our planet. Trend analysis points out that about 20% of the population (mostly from developed countries) consume up to 80% of these resources (mostly from less developed countries of 2013). An example is Nigeria, which is the highest exporter of oil in Africa; nonetheless, over 70% of its population lived in poverty.[42]

Furthermore, most of the raw materials for fabricated goods originate in the tropics.[43] Owing to deforestation, over harvesting in agriculture, industrialization and petrochemical related activities such as transportation cause high carbon emissions. In

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[40] Jim Dator et al., "What futures for families?" (2007), 19.

[41] Richard Heinburg, "End of Growth," book launching and public speech at University of Hawaii, 2011.

[42] "HOME," YouTube video file, posted on May 12 2009, http://www.youtube.com/watch?v=jqxENMKaeCU (accessed May 2, 2013).

[43] Rainforest Conservation Fund, "Drastic reduction of human population growth," http://www.rainforestconservation.org/rainforest-primer/6-conservation-of-tropical-rainforests/a-means-of-conserving-tropical-rainforests/1-drastic-reduction-of-human-population-growth (accessed May 2, 2013).

short, global environmental conditions will worsen rapidly from 2013 to 2050. The image below shows the global ecological footprint in 2007.[44]

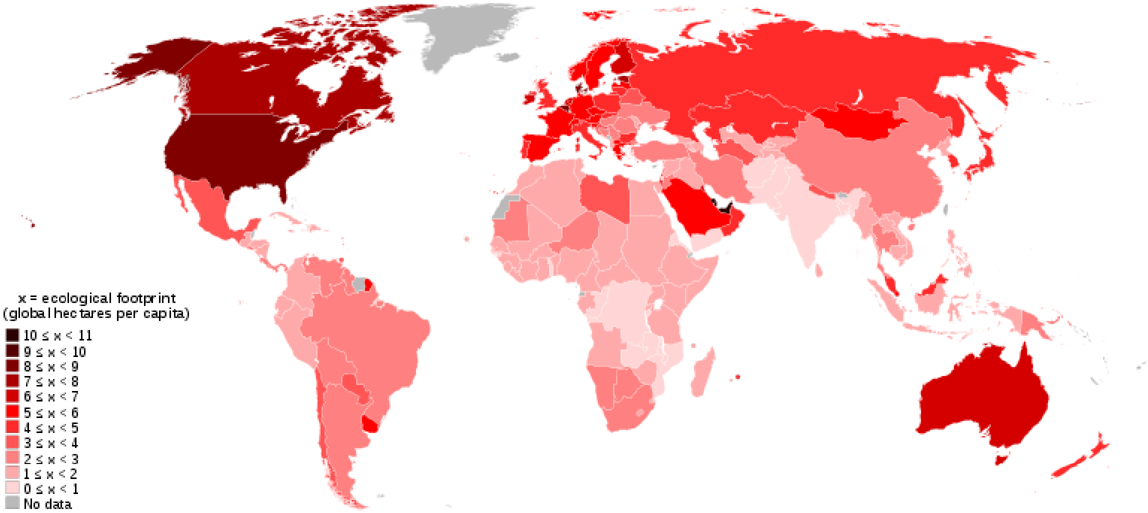

Figure 11 Global ecological footprint (2007)

The images below illustrate the remaining global tropical rainforests in 2011 and carbon dioxide storage by plants during winter in the Northern Hemisphere in 2010.[45] This shows the lowest level compared to higher levels in the summer. (Not shown here)

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[44] "World map of countries by ecological footprint (2007)," http://en.wikipedia.org/wiki/File:World_map_of_countries_by_ecological_footprint_(2007).svg (accessed May 2, 2013).

[45] Mongabay, "Where are rainforests located?" http://kids.mongabay.com/elementary/002.html (accessed May 2, 2013); Mr. Reid, "Yearly Variation in the storage of CO_2 by plants," WordPress, http://wordpress.mrreid.org/2011/08/11/storage-of-co2-by-plants/ (accessed May 2, 2013).

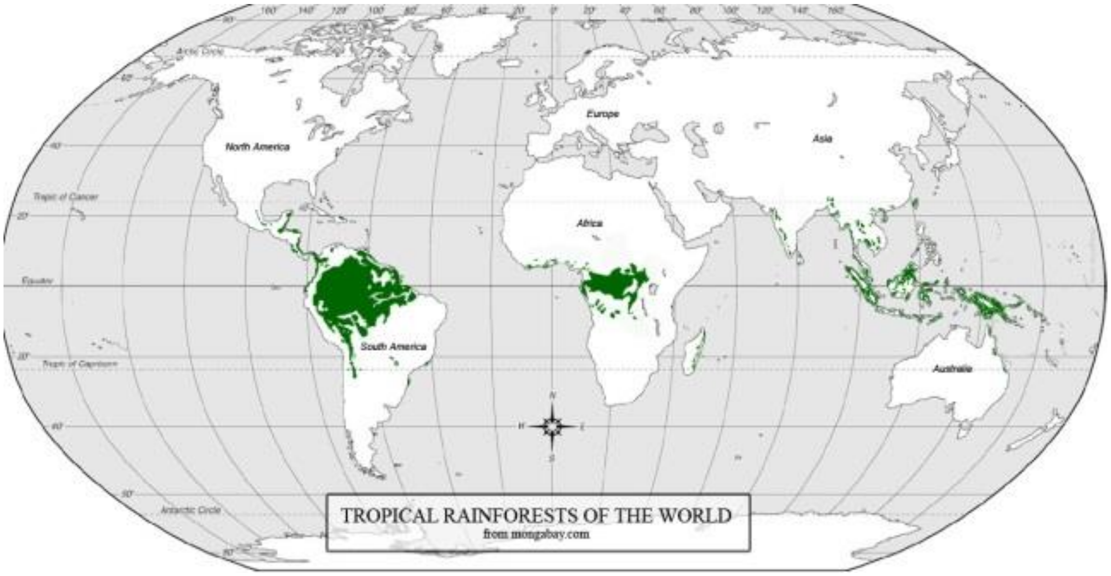

Figure 12 Tropical rainforests (2011)

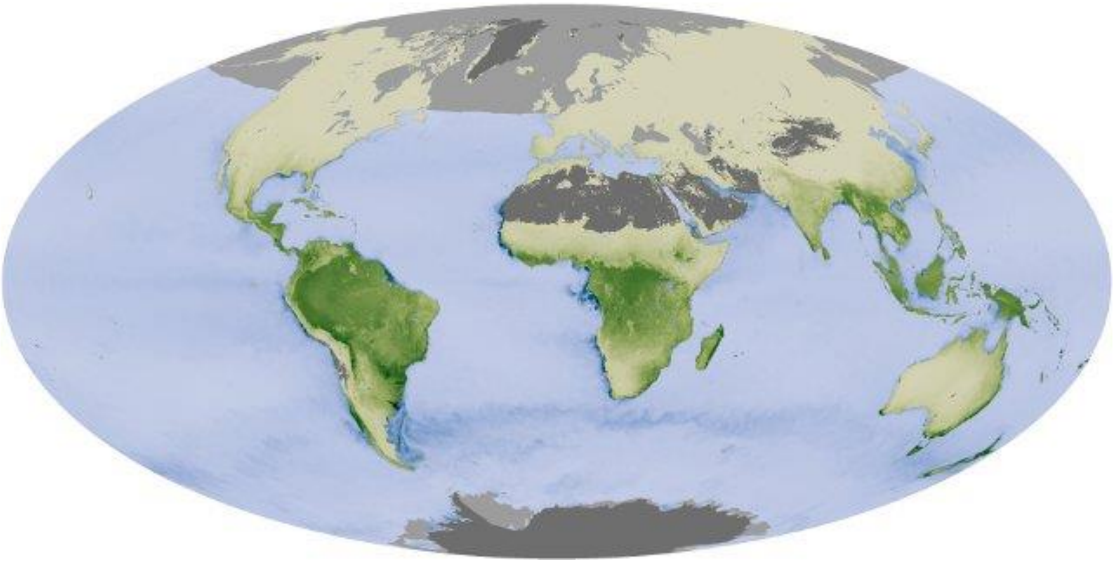

Figure 13 CO^2 Storage by plants

The Images below display global particulate matter pollution concentration increase from 2000 to 2030.[46]

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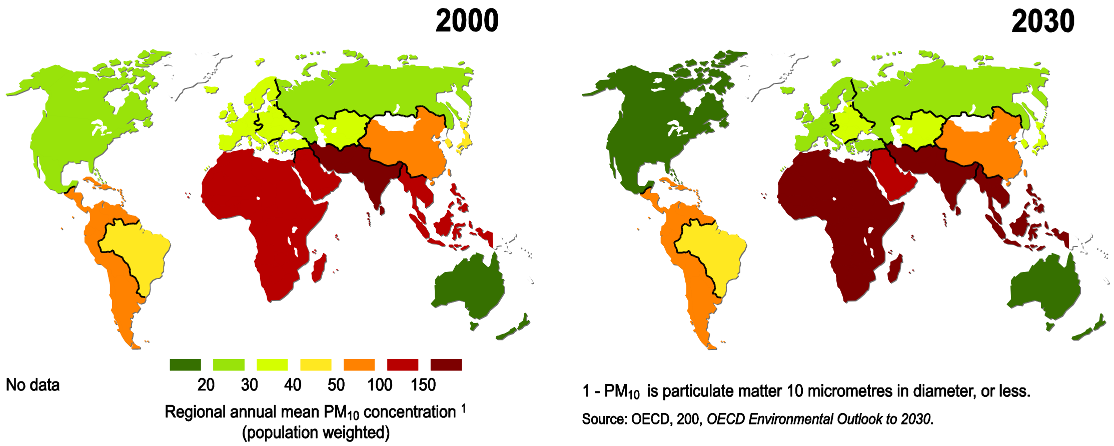
[46] European Environment Agency, “Particulate matter pollution: 2 comparable maps showing current (2000) and projected (2030) PM10 regional concentrations (population weighted),” crated on Dec 17, 2010, posted on Dec 17, 2010, http://www.eea.europa.eu/data-and-maps/figures/particulate-matter-pollution (accessed April 6, 2012).



1 - PM_{10} is particulate matter 10 micrometres in diameter, or less.

Source: OECD, 200, *OECD Environmental Outlook to 2030*.

Figure 14 Global particulate matter pollution (2000, 2030)

Not only do we consume extravagant quantities of resources, we have also manipulated our natural environment to form artificial built environments with diverse cultures.[47] In doing so we have nearly "destroy(ed) the creators work."[48]

Year 2050 will be an era dedicated to environmental restoration. Funding from high tech and research organizations, together with their expertise skill sets, will continue to allow for experimenting with new techniques to regenerate the organic diversity, especially plant life. The urgency for re-establishing the water cycle is imperative for survival.

In 2050 all open spaces will be exploited for building. Shortage of land for habitation will force new habitats to occupy existing surfaces for survival.

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[47] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 8.

[48] Eugene Viollet-Le-Duc, trans. BenjaminBucknall, *The Habitations of Man in All Ages*. (London: Sampson Low, Marston, Searle, & Rivington,1876), 14.

2.5. <u>2070 Scenario</u>

2070 will embark on new paradigms of technology previously unknown.

An economy driven by private individual organizations will begin to create two classes of beings. They will be the high maintenance transformed Moghuls (haves), and low maintenance peasants (have-nots). The Moghuls or augmented beings will have enhanced physical and intellectual capacity, as well as exclusive access to resources. Peasants will have minimal access to resources and will create lesser impact on resources. Peasants will live under basic conditions and circumstances. Their choice of basic lifestyle will be a reflective spiritual one.

The population is transformed and is highly diverse. The designer babies and post-humans dominate society. Cyborgs will be especially useful in research, exploration and inhabiting extreme condition in different parts of the universe and outer space. Intelligent selection or designer babies will predominate that of natural selection.[49] Natural "inferior" human beings will not be highly acknowledged and will eventually decline. Controlled cloned adult population will replace them. Hence, the population demography will fluctuate in variety as well as their age.

In contrast to today's view, decisions such as to abide to cloning procedure may become moral obligations rather than ethical issues, passing the gift of life in a rapidly

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[49] "Future of Biotechnology Panel (Part II)," YouTube video file 43:45, posted on May 6, 2010, http://www.youtube.com/watch?v=Z9_bO-LQK14 (accessed May 2, 2013).

declining human population beyond 2050. Alternative choice will also exist, such as the turn to human machine interfaces or other genetic augmentations. The phenomenon of potential transformed post-humans are acknowledged, yet not included in the time frame 2050 used in this research.

Supported by the technology peak of two decades ago, the sidelined minor group of peasant beings will take charge and coordinate the regeneration of the synthetic organic environment. Therefore, the synthetic organic biodiversity will be continuously recreated with control. A multifunctioning system was initiated in 2050. It will continue to facilitate dynamic architecture, which has the ability to grow and exchange. The resultant outcome will be that the synthetic organic growth takes over the older built environment, which was present prior to 2050. This will be the structural and systemic backbone of the living system for the humans as of 2050. This network will continue to grow utilizing the existing structures, while building a scaffold along their façade. Once established, the system will initiate extracting of material from the existing structures to form new organic morphologies, over the existing built environment. This process will invigorate the synthetic organic diversity and reduce the inorganic built environment, while up-cycling its material to preferred organic elements. Concurrently, it will maintain the basic morphology of the original structures with additional linking to neighboring structures. The *Emergent Alternative Home 2050* is a key vehicle for improved environmental conditions for future 2070.

FORECASTED CONTEXT

	2030 SCENARIO	2050 SCENARIO	2070 SCENARIO
KEY DRIVING FORCES	RAPID TECHNOLOGY GROWTH	TECHNOLOGY PEAK	TRANSFORMED TECHNOLOGY PARADIGM
	3^{RD} WORLD CORPORATE ECONOMY GROWTH AND LEVELING WITH DEVELOPED WORLD	3^{RD} WORLD ECONOMY SHIFT TO INDIVIDUAL PRIVATE ORGANIZATIONS i.e. HIGH TECH, GENETIC RESEARCH COMPANIES	3^{RD} WORLD ECONOMY CREATES TWO CLASSES OF INDIVIDUALS HIGH MAINTENANCE MOGULS AND LOW MAINTENANCE PEASANTS
	POPULATION GROWTH	CONTROLLED POPULATION PLATEAU	TRANSFORMED POPULATION
	FAMILY DYNAMICS SHIFTING TO SINGLE OFFSPRING	COMMUNITY TAKES OVER THE PLACE OF FAMILY FOR INDIVIDUALS WITHOUT OFFSPRINGS	SHIFT TO CYBORGS, DESIGNER BABIES, CLONES AND POST HUMANS INFERIOR HUMANS NOT ACKNOWLEDGED
	AGING POPULATION	AGED POPULATION, NO REPRODUCTION	CLONE ADULT POPULATION MIX
	NATURAL ENVIRONMENT DESTROYED DOMINANT URBAN BUILT ENVIRONMENT	BUILT ENVIRONMENT BEING DEMOLISHED VARIOUS ENVIRONMENT REPAIRING TECHNIQUES BEING TESTED NEW SYNTHETIC ORGANIC LIFE BEGINS	BUILT ENVIRONMENT IS TRANSFORMED OLD MORPHOLOGY PRESERVED UNDER THE NEW SYNTHETIC ORGANIC ENVIRONMENT

Figure 15 Summary of overall contextual shifts in the presented scenarios

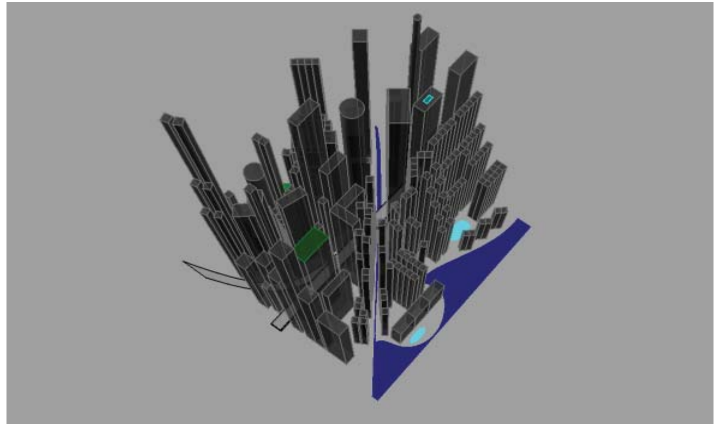
PROPOSED ENVIRONMENT RESTORATION

2030 SCENARIO

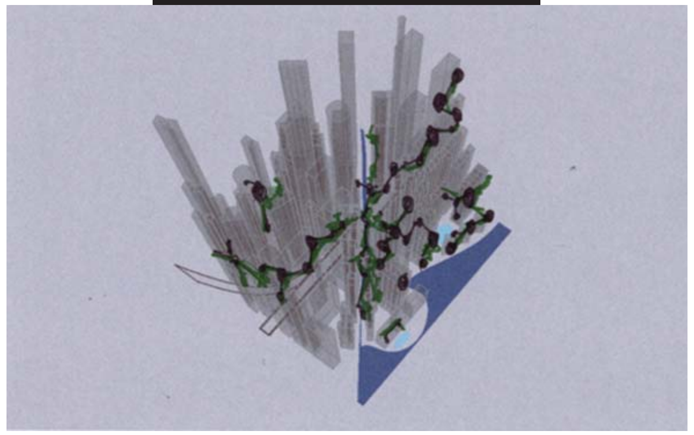
2050 SCENARIO

2070 SCENARIO

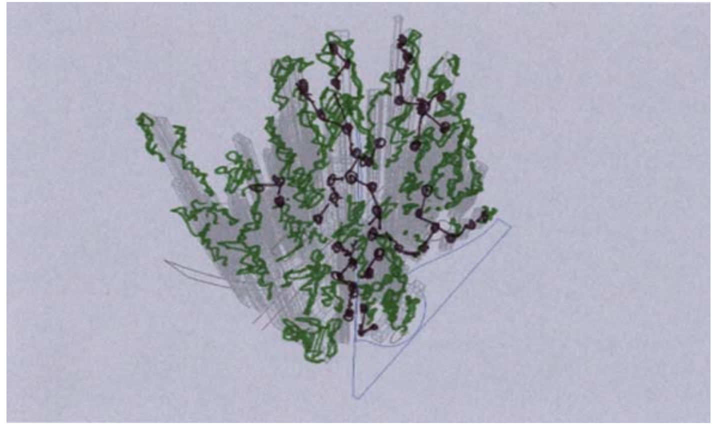
MACRO ENVIRONMENT
PLAN & ARTIST VIEW



DOMINANT BUILT ENVIRONMENT



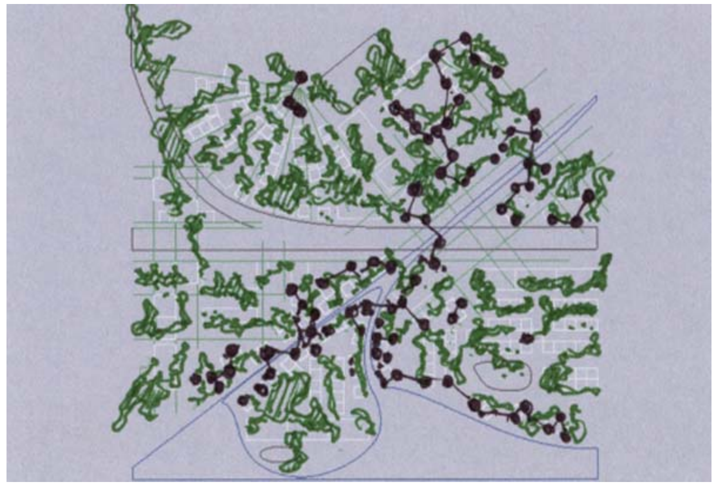
DESIGN INTERVENTION



TRANSFORMED QUASI NATURAL ENVIRONMENT

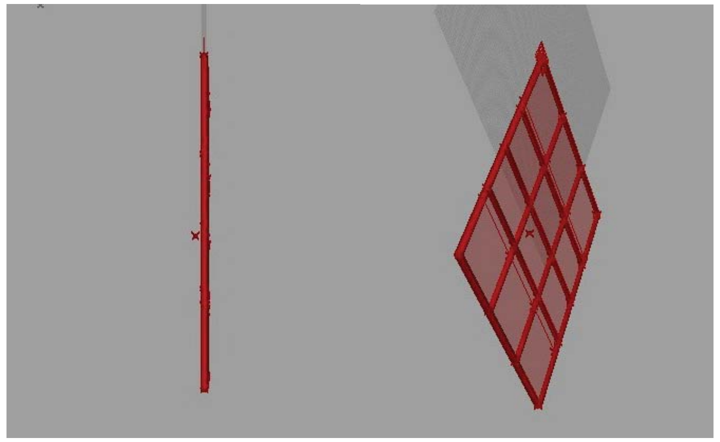
NATURAL ENVIRONMENT EXHAUSTED

SYNTHETIC ORGANIC ENVIRONMENT INITIATED

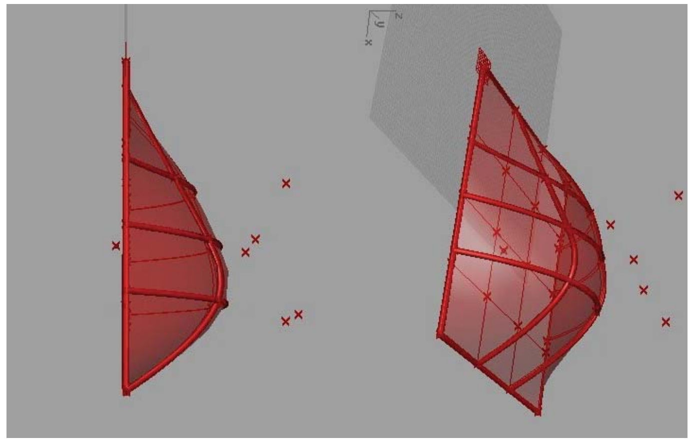


SYNTHETIC ORGANIC ENVIRONMENT TAKES OVER

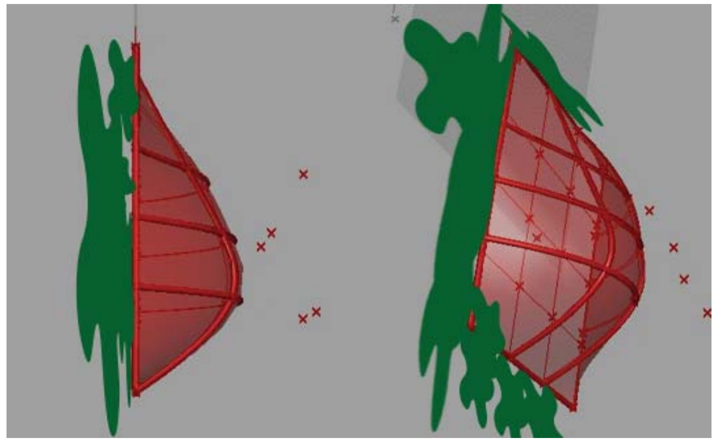
MICRO ENVIRONMENT
ELEVATION & ARTIST VIEW



EXISTING BUILT SURFACES



DETACHABLE & INFLATABLE CONCEPTUAL POD



CO-EXISTENCE WITH SYNTHETIC BIODIVERSITY

Figure 16 Built environment shift to synthetic organic (quasi natural) environment

2.6. Concluding Summary

The *Emergent Alternative Home 2050* is founded on technology and environment as the primary governing factors; advanced technologies such as biotechnology and nanotechnology are assumed to be available at low cost due to their abundance. The population will have peaked in 2050. Going beyond the traditional family life, humans may be cloned or will have a singular existence (similar to projections by Ray Kurzweil). 2050 society will primarily be a collection of single individuals supported by minimal resources.

The projected economic growth is expected to direct migration towards the urban centers. The need is seen for developing and applying advanced technologies which seek to leave a minimum environmental impact, and reverse the current negative impacts on the tropical environment.

The *Emergent Alternative Home 2050* is proposed as an offshoot grounded on developmental biotechnology and biomimetic engineering concepts. In the design process, material systems are proposed as generative drivers and not as derivatives of standardized building systems and elements.[50] This biomimetic architectural prototype design is targeted for potential mass application, accommodating the aging populations in tropical mega cities.

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[50] Achim Menges, "Polymorphism," *Architectural Design*, 76, 2, 2006, 78, 87.

A biomimetic approach is deemed a suitable for a resource scarce future, where doing more with less is important. The rapidly depleting natural environment necessitates the use of “biomimicry in industrial biotechnology,”[51] facilitating these “grand improvements”[52] by the mid-century. Essentially, the future technologies will drive the *Emergent Alternative Home 2050*.

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[51] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 340.

[52] Armstrong, 340.

Chapter III: Emerging Technology

3.1. Introduction

This chapter investigates the potential opportunities and rising issues in terms of enabling materials and techniques that has the potential to facilitate the *Emergent Alternative Home 2050*.

My research pursuing materials for the *Emergent Alternative Home 2050* steered me to investigate natural biological materials and methods. A trend analysis illustrates their potential to emerge as synthetic generative materials in the design and construction industries.

Biotechnology, biomimetics and emerging materials, systems and methods including their characteristics are discussed in this chapter.

3.2. What are the Potential Materials and Material Characteristics?

The biomaterials listed below are anticipated for military and national security applications within the next 20 years (2030) or so.[53] They have the potential to excel structurally, and functionally.[54] Such military applications often quickly become ubiquitous technologies. In *Bio-inspired innovations and national security,* Armstrong *et al*. summarize potential materials and material characteristics:

- Environmentally benign polymers that adapt to environment
- Atomic level control of structure, biocompatible function, with range and color change control, self-assembly and biodegradability
- Catalysts conforming changes under ambient conditions
- Computation of hierarchical structure under ambient conditions
- Lightweight materials that convert and or conserve energy
- Adaptation or function and evolution of micro and nano-devices
- Self-repair lubricants
- Adhesives, membranes with transport control, multifunctional materials, smart materials, sensors and responses

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[53] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), xx.

[54] Armstrong, 141.

In elaboration, Armstrong *et al.* outline invaluable insight for potential biomimetic, and bio-inspiration developments. Although at the moment some may not be directly associated with design and construction industry, examples [55] include:

Bone:

Development of structural mimics made of hydroxyapatite crystals and polyethylene composites that mimic bone structure and properties. (Strong, brittle composite of varying ductility) Sensing and self-healing properties are yet to be achieved.

Soft tissue properties:

The mechanical properties of collagen systems that change with the state of hydration, the ability of individual fibrils to self-assemble to form larger fibers, which in turn become highly elastic.

Intervertebral disc's ability to convert structural compressive stresses into tensional stresses, this is achieved through its hierarchical structure. This method promotes divergent application of individual materials in organisms.

The performance of the aortic valve that opens and closes nonstop, 60 times per minute over the life time is an example of material non-fatigue.

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[55] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 142-144.

Exoskeletons/Invertebrates:

The Insect exoskeletons provide inspiration for fiber-reinforced structural composite to achieve net shape control during production. Fiber-reinforced composites are ideally produced in net shape than in bulk and cut. For instance, precise reproducible composites from Bess bug shell. Using single-fiber thickness per layer, with helical orientation, results polymer matrix composites closer to net shape.

Nacre's or mother of pearl's impact strength is another example. It is made up of layers of brittle platelets of mineral aragonite, (a calcium carbonate) separated and held together by sheets of elastic biopolymers (acidic macromolecules, silk-like proteins, and b-chitin). It is a tough and resilient composite that combines the strength of the mineral and the ductility of the polymers. In addition, single layer, hexagonal mineral platelets are staggered with mortar like biopolymer which is useful in preventing crack formation. Biologically, certain mollusks secrete this structure as a layer that protects the mother of pearl (layer inside) or to form the pearl by encapsulating a foreign object.

Among others, Barnacle's high intensity (that can damage naval vessels), cementing adhesive properties are investigated to find possible superior adhesive for marine application. Another is a proteinaceous adhesive form when mussel extract of iron from the surrounding seawater curing takes place by cross linkage.

The banana slug's versatile slime is an adhesive application used for lubrication, and for self-protection. This is claimed as the strongest adhesive found in nature.

Bio-mineral ceramics:

The ceramic industry that is dependent on sol-gel process method, is looking to bio-chemical build or grown method. Bone and shells are examples of controlled and methodical build or growth. Added benefits will include room temperature sintering, packing density, near perfect ceramic particles, in desired conformations.

Simultaneously, in other cases bio-chemical control additionally produces the surrounding matrix material. For instance, Abalone shell, a soft organic component is generated to guide the growth of calcium carbonate plates. Its level of control is 10 nm for the scaffolding of 200nm for the mineral plates. (Approximately, respectively 0.001 and 0.02 times the width of human a hair). The diatoms of a single cell algae produces self-assembling organic scaffold that facilitate directed synthesis of silica shell.

Imitation of both biomechanical and biochemical aspects of biological process will offer unprecedented control over ceramic and ceramic composite structure and function.

According to Armstrong *et al.* future materials that are currently in research include the following:[56]

- Advanced Fibers (Silk and Spider Silk)
- Resilin

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[56] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 145-149.

- Multifunctional coatings
- Artificial cell
- Octopus
- Dry Adhesion and the Gecko, Mosquito and Water glider
- Plants

Furthermore, Valdes and Valdes discuss aerogel as a potential Bio-inspired material.[57]

3.2.1. Advanced Fibers (Silk and Spider Silk)

The silkworm cocoon of Bombyx mori is a one continuous fiber of about 10 micron diameter single fiber about 1,000 meters length. That is an aspect ratio of 100 million. This fiber is of high strength, and known to offer ballistic protection. Silk worms are relatively easily farmed.

Fossil evidence shows that spiders were spinning silk as long as 380 million years ago. The first applications of spider silk date back to 1800's. Among its uses are fishing lines by Australian aborigines.[58]

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[57] James J. Valdes and Erica R. Valdes, "Bio-Inspired Materials and Devices for Chemical and Biological Defense," (Center for Technology and National Security Policy National Defense University September 2010), http://www.ndu.edu/CTNSP/docUploaded/DTP%2079%20Bio%20Inspired%20Material%20and%20Devices.pdf (accessed May 2, 2013).

[58] Vivienne Baillie Gerritsen, "The Tiptoe of an Airbus," *Protein Spotlight*, (July 2002), http://web.expasy.org/spotlight/back_issues/sptlt024.shtml (accessed May 2, 2013).

A single spider produces many different types of spider silk for variety of functions.[59] Specifically, dragline silk that supports the frame of the web, and capture silk is a fine sticky silk that catches the prey. Toughest of them is the dragline silk, a cable, about the size of the garden hose, which is able to stop an Airbus.[60] Armstrong *et al.* and Gerritsen both point out that the spider silk (made up of protein and water)[61] process in ambient condition and made of renewable resources.[62]

Figure 17 Spinneret glands on the spider abdomen (Image by Dennis Kunkel Microscopy, Inc.)

The above image shows the spinneret glands on the abdomen of a spider from which a fiber is spun. Characteristically these fibers are tougher than any that humans have made to date.

Armstrong *et al.* indicate that although having different properties, all silks are at or above the strength of Kevlar.[63] Dragline silk is both a strong and an extensible fiber.

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[59] TED, "Cheryl Hayashi: The magnificence of spider silk," filmed Feb 2010, posted Dec 2011, TED2010 video file, http://www.ted.com/talks/cheryl_hayashi_the_magnificence_of_spider_silk.html (accessed May 2, 2013).

[60] Vivienne Baillie Gerritsen, "The Tiptoe of an Airbus," *Protein Spotlight*, (July 2002), http://web.expasy.org/spotlight/back_issues/sptlt024.shtml (accessed May 2, 2013).

[61] Gerritsen, http://web.expasy.org/spotlight/back_issues/sptlt024.shtml (accessed May 2, 2013).

[62] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 145.

[63] Armstrong, 145.

According to Gerritsen, they stretch by 40% of its length and absorb one hundred times more impact than steel without breaking.[64] Moskovitz describes that the spider silk has five times the yielding tensile strength (a measure of how much something can be stretched before it breaks) of steel, and triple that of the best artificial fibers available today. The unique unmatched properties of spider silk; high elasticity and extreme tensile strength are well pointed out by Horst Kessler[65] and Randy Lewis.[66] In regard to micro structure of spider silk, Moskovitz describes its composition of protein molecules that link together in long chains. In some areas, protein chains are interlinked through physical connections, which offer stability in those regions. In other areas, the protein chains remain unlinked, giving threads their high elasticity.[67] Another interesting property of spider steel is described by Armstrong *et al.*; its ability to capture more energy than Kevlar. Dragline specifically absorbs 10 times more energy and converts it to heat.[68]

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[64] Vivienne Baillie Gerritsen, "The Tiptoe of an Airbus," *Protein Spotlight*, (July 2002), http://web.expasy.org/spotlight/back_issues/sptlt024.shtml (accessed May 2, 2013).

[65] Clara Moskowitz, "Mysterious step in spider silk-making revealed," The Christian Science Monitor, posted in May 12 2010, http://www.csmonitor.com/Science/2010/0512/Mysterious-step-in-spider-silk-making-revealed (accessed May 2, 2013).

[66] "BioSteel," YouTube video file, posted on Oct 21, 2007, http://www.youtube.com/watch?v=g6tWf-VCURs (accessed May 2, 2013).

[67] Moskowitz, http://www.csmonitor.com/Science/2010/0512/Mysterious-step-in-spider-silk-making-revealed (accessed May 2, 2013).

[68] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 145,146.

The images below show microscopic images of recombinant spider silk (left top), types of spider silk that Golden Orb Weaver spider produces (right top), and the structural properties of spider silk in regard to wind, stress vs. strain (bottom).[69]

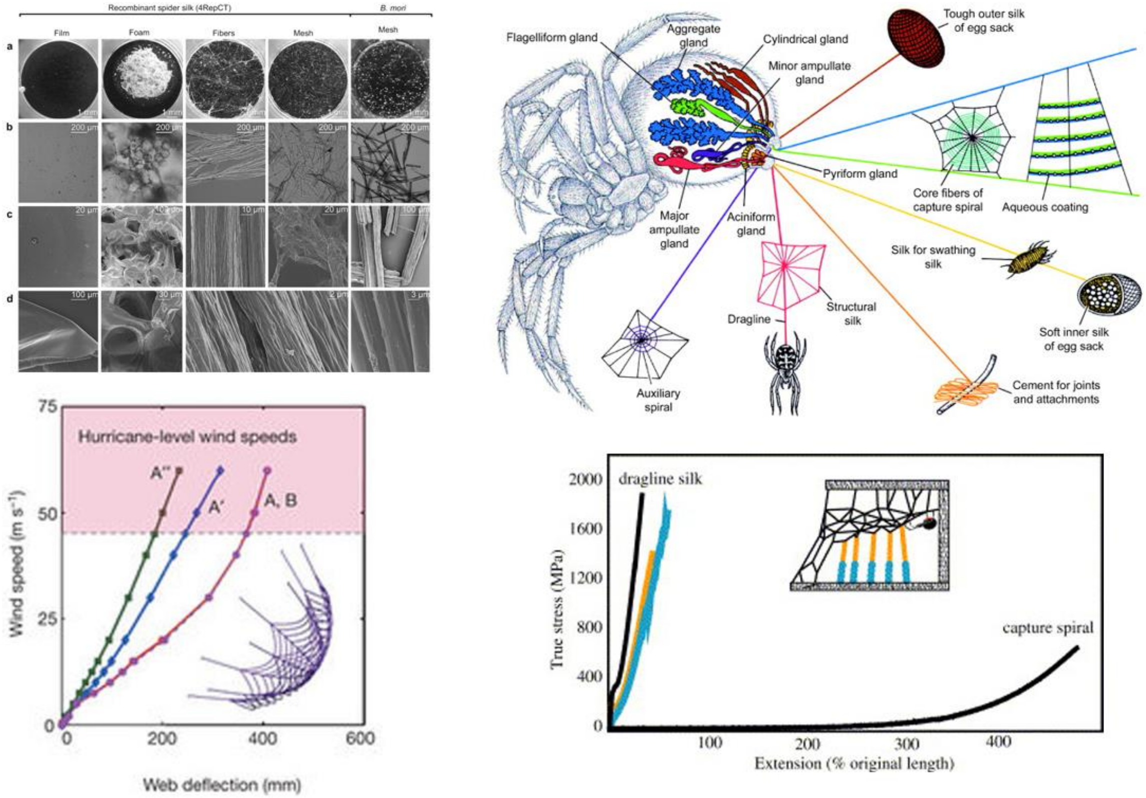

Figure 18 Recombinant spider silk, spider silk types, and their strengths

To further illustrate the characteristics of spider silk, the dragline silk from the golden orb weaver (Nephila clavipes), is made up of crystalline beta sheets modules and

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[69] Mona Widhe et al*.,* "Recombinant Spider Silk as Matrices for Cell Culture," *Biomaterials Elsevier* 31, no. 36 (December 2010), 9575–9585, http://www.sciencedirect.com/science/article/pii/S0142961210010999 (accessed May 2, 2013), Todd A. Blackledge et al., "Gumfooted lines in black widow cobwebs and the mechanical properties of spider capture silk," *Zoology Elsevier* 108, no. 1, (15 March 2005, 41–46, http://www.sciencedirect.com/science/article/pii/S094420060400073X (accessed May 2, 2013), Lukas Eisoldt et al., "Decoding the secrets of spider silk," *materialstoday* 14, no. 3 (March 2011), 80–86, http://www.sciencedirect.com/science/article/pii/S1369702111700578 (accessed May 2, 2013), Cedric Dicko, John M Kenney, and Fritz Vollrath, "β-Silks: Enhancing and Controlling Aggregation," *Advances in Protein Chemistry Elsevier* 73, (2006), 17–53, http://www.sciencedirect.com/science/article/pii/S0065323306730029 (accessed May 2, 2013).

amorphous regions. (Simple stretches of 16 to 20 amino acids) The amorphous regions provide extensibility and the crystals provide the toughness. Different silks have different concentrations of crystals giving different mechanical properties. Another property of spider silk fiber is when wet, it shrinks to as little as 55% of its original length.[70]

Contemporary investigations into spider silk primarily focuses on its stiffness, (ability to resist deflection when force is applied), strength (the force required to break it) and toughness (ability withstand impact without breaking).[71]

In the recent past, research has been successfully carried out reproducing spider silk without the spider. A genetic approach has been taken due to difficulty in farming and harvesting spider silk[72]. Cloning the genes responsible for fibroin proteins that comprise spider silk and placing them in goats has produced spider silk fibroins in their milk. This initiation can be considered as a first progressive step towards producing spider silk synthetically with similar or exceeding properties of natural spider silk.[73]

Moreover, the realization of research to design and create abiotic spider silk appears near, given that according to Craig Venter, syntactic cells are already being

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[70] Vivienne Baillie Gerritsen, "The Tiptoe of an Airbus," *Protein Spotlight*, (July 2002), http://web.expasy.org/spotlight/back_issues/sptlt024.shtml (accessed May 2, 2013).

[71] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 145.

[72] "Smart Material: Spider Silk," YouTube video file, posted on March 5, 2011, http://www.youtube.com/watch?v=nYlkJyG1Oik (accessed May 2, 2013).

[73] Armstrong, 146.

produced in the world abiotically.[74] Venter elaborates on an abiotic future biology process that makes creation of organic life possible through genomics. Further, current technology breakthroughs are rapidly developing insight at nano-scale that will create synthetic spider silk that mimics the advanced properties of natural spider silk.

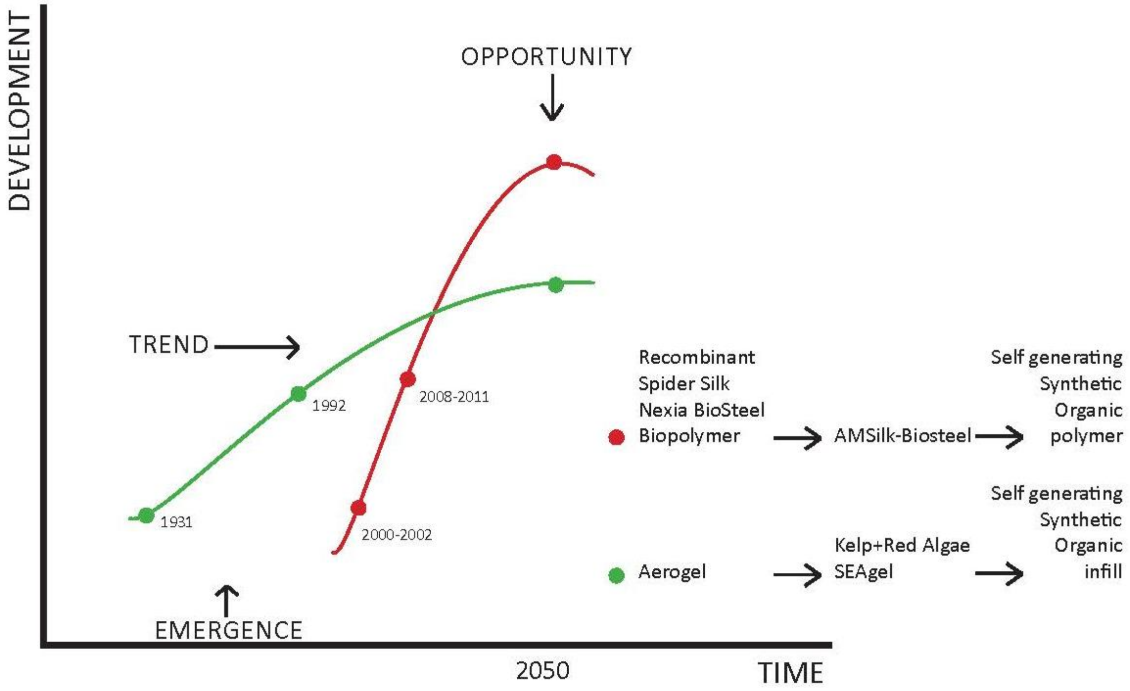

Figure 19 S-Curve; proposed major synthetic organic material manifest for 2050

In 2002, BioSteel; trademark recombinant spider silk by Nexia emerged creating many opportunities. Nexia used transgenic goats for mass production of spider silk through their milk. Its intended uses were artificial tendons and ligaments, medical sutures, biodegradable high-strength fishing lines, and bullet-proof clothing. Recombinant spider silk is eco-friendly and biodegradable, since it is made of amino

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[74] TEDx, "TEDxCaltech - J. Craig Venter - Future Biology," posted Feb 16, 2011, TED video file, http://tedxtalks.ted.com/video/TEDxCaltech-J-Craig-Venter-Futu (accessed May 2, 2013).

acids. The biomimetic process that produce recombinant spider eliminates the necessity for harsh solvents.[75]

Innovation of AMSilk's Biosteel spider silk fibers takes the recombinant spider silk to the next level. It is generated using *E. Coli* bacteria and genes from spider silk proteins.[76] This can be seen as an advanced trend for recombinant spider silk. It features characteristics similar to natural spider silk fibers, in terms of tensile strength, and the measure of the absorption of kinetic energy before its rupture.[77] The recombinant spider silk is thought to retain the attractive unique properties of natural spider silk; flexibility similar to rubber, strength and durability similar to steel. It is also lightweight. AMSilk has developed a biotechnological process that is cost effective and can be applied in large scale.[78] Proposed applications of AMSilk Biosteel include high-performance technical textiles, sports goods, and medical textiles.[79] Other potential future use of this material include bulletproof vests, fireproof clothing, finished

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[75] Anna Salleh, "Animal cells spin spider silk," ABC Science, posted on January 18, 2002, http://www.abc.net.au/science/articles/2002/01/18/461157.htm (accessed May 2, 2013).

[76] "Die spannendsten deutschen Biotech-Start-ups = The most exciting German biotech start-ups," Wirtschafts Woche, under "AMSilk," http://www.wiwo.de/technologie/forschung/medizin-waffen-gegen-infektionskrankheiten/6720996-4.html (accessed May 2, 2013).

[77] Planegg, "AMSilk entwickelt die weltweit erste skalierbare Spinnenseiden – Faser - AMSilk developed the world's first scalable spider silk – fiber: Biosteel ® fibers made from recombinant protein show similar properties as natural spider silk - fibers," under "AMSilk," posted on Mar 11, 2013, http://www.amsilk.com/news/artikelansicht/article/amsilk-entwickelt-die-weltweit-erste-skalierbare-s.html (accessed May 2, 2013).

[78] "Die spannendsten deutschen Biotech-Start-ups, http://www.wiwo.de/technologie/forschung/medizin-waffen-gegen-infektionskrankheiten/6720996-4.html (accessed May 2, 2013).

[79] Planegg, http://www.amsilk.com/news/artikelansicht/article/amsilk-entwickelt-die-weltweit-erste-skalierbare-s.html (accessed May 2, 2013).

dressings and coatings for implants and produce spider silk concrete for buildings in earthquake zones.[80]

Hsia *et al.*, shed light on laboratory production of spider silk. Their arguments are parallel to my own. They support my analysis that in the future, as resources become scarcer, new technologies will engineer high performance biomaterials. They further elaborate on the rapid developing speed, cost-efficiency and processing in accord to sustainable methods.

Hsia *et al.* propose synthetic silk production as a mass production process that can be efficient, describing a development of a low variant wet-spinning protocol that integrates recombinant spider silk proteins in bacteria on a laboratory scale. Methods such as this will propel the process of artificial silk production, leading to higher quality fibers that surpass natural spider silk. According to them the potential diverse applications ranges from body armor, surgical sutures, ropes and cables, tires, strings for musical instruments, and composites for aviation and aerospace technology.[81]

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[80] "Die spannendsten deutschen Biotech-Start-ups - The most exciting German biotech start-ups," Wirtschafts Woche, under "AMSilk," http://www.wiwo.de/technologie/forschung/medizin-waffen-gegen-infektionskrankheiten/6720996-4.html (accessed May 2, 2013).

[81] Y Hsia et al, "Synthetic Spider Silk Production on a Laboratory Scale," doi: 10.3791/4191, *PubMed* (July 2012), http://www.ncbi.nlm.nih.gov/pubmed/22847722 (accessed May 2, 2013).

3.2.2. Resilin

Armstrong *et al.* consider resilin an elastomeric protein in anthropoids, one of the most elastic known, and is capable of many millions of extension and contractions. For instance, it gives fleas the ability to jump more than 100 times their height. It stores 97% of energy in compression and recoups it in the following expansion. According to Armstrong *et al.,* this process facilitate the Cicada to chirp, flies to flap their wings nearly a million times an hour, and brittle shells to bend and revert back to their original shape.

Resilin also stretches up to three times its length without breaking. Recently research has produced pro-resilin by E.coli, although a challenge still exists for the scientists to replicate resilin in a dry system.[82]

3.2.3. Multifunctional Coatings

Recent investigations have led modification of surfaces to allow, encourage, or enhance material properties and interaction. Using bio-inspired approach and focus on Mytilums edulis mussel's ability to bond to any surface, including Teflon, has been mimicked successfully, creating a deposition of thin polymer films that withstand friction.[83]

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[82] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 146.

[83] H. Lee et al., "Mussel-Inspired surface Chemistry for Multifunctional coatings," *Science* 318 (2007), 426, quoted in Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 154.

3.2.4. Artificial Cell

In the biomedical field, the synthetic cell is sought for functioning in an environment outside of a living body. The challenges involved include the fact that cell membranes for dry applications need to be stabilized in air,[84,85] or be encased by environmentally hardened materials. Resulting contributions could include porous inorganic membranes, phosphorycholine-polymer surface technology, and polymersomes.[86]

3.2.5. Octopus

The changeability of the octopus's structure is attributed to its muscle body. Their ability to squeeze through small cracks and curl themselves into clamshell positions, as well as the orthogonal bands of muscles that provide flexibility and movement, while the constant internal volume supports octopus are of interest.

The octopus can change color, pattern and texture of its skin to match the surroundings as camouflage techniques. Octopus uses a complex chromatophore

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[84] Helen K. Baca et al., "Cell Directed Assembly of Lipid-Silica Nanostructures Providing Extended Cell Viability," Science 313 (2006), 337, quoted in Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 154.

[85] Liangfang Zhang and S. Granick, "How to Stabilize Phospholipid Liposomes (Using Nanoparticles)," Nanoletters 6, no. 4 (2006), 694–698, quoted in Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 154.

[86] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 147.

system that includes reflective iodophores as well as hue-changing cells. It can make these changes in as little as 3 seconds.

Figure 20 Octopus suckers and ink cloud

The above images show suckers and ink cloud of an octopus.[87] The suckers on its arms have chemical receptors and touch receptors which allow them to "taste" what they touch. Further, octopus uses ink clouds to interfere with the senses of the enemy.[88]

3.2.6. Dry Adhesion and the Gecko, Mosquito and water gliders

The feet of a gecko allow them to adhere to surfaces with no use of fluid adhesive. The large numbers of setae of gecko feet, each comprised of 1000 spatulae are held to surfaces by van de Waals attractions. These forces are generally considered to be weak intermolecular forces. Scientists have been successful in re-creating gecko feet adhesion using nano-fibers. By ensuring that their tips in an array can contact a surface simultaneously, adhesive powers exceeding those of the gecko foot has been

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[87] Frank W. Grasso, "Sensational Sucker: The Neural Complexity of the Octopus Organ," *Scientific American* (October 2010), http://www.scientificamerican.com/article.cfm?id=sensational-sucker (accessed May 2, 2013); Rafe Sagarin, "When Catastrophe Strikes, Emulate the Octopus," Wired (April 2012), http://www.wired.com/magazine/2012/03/st_essay_octopus/ (accessed May 2, 2013).

[88] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 147,148.

achieved. The images below show gecko feet, (top left), how gecko feet adhere onto surfaces (top right), and details of gecko feet (bottom).[89]

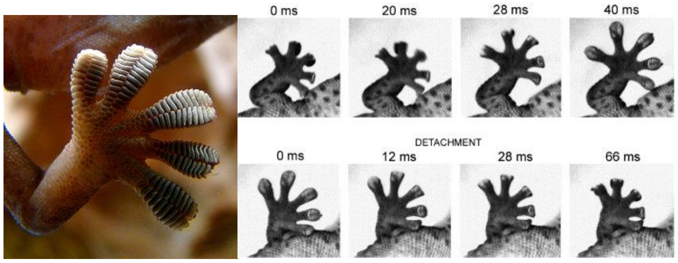

Figure 21 Gecko feet and feet attachment

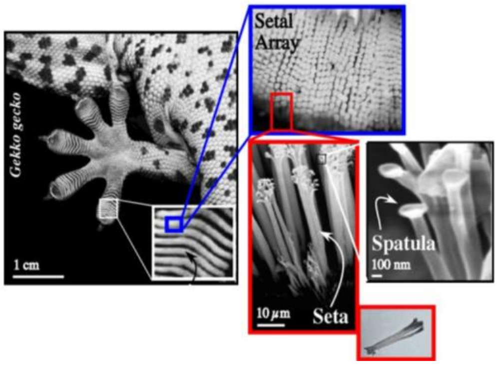

Figure 22 Gecko setae and spatulae

Mosquitoes and water gliders ability to walk on the water is well known. The hierarchical structures on their legs, the fine hairs that are grooved at nano-scale trap air to achieve this. It effectively produces cushion between the insect's feet and the surface of the water. These unusual properties associated with nanotechnology have

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[89] ScoopWeb, under "gecko foot," http://www.scoopweb.com/Template_talk:Developmental-biology-stub (accessed May 2, 2013); Huajian Gao, Xiang Wang, Haimin Yao, Stanislav Gorb, Eduard Arzt, "Mechanics of hierarchical adhesion structures of geckos," *Mechanics of Materials* 37 no. 2-3 (February-March 2005), 275‑285, http://www.cchem.berkeley.edu/rmgrp/about.html (accessed May 2, 2013).

significant potential at increased sizes. This method has only been investigated recently for practical applications.[90]

3.2.7. Plants

Lotus and jewelweed are recognized for their ability to repel water. The microscopic level roughness on these leaves reduces both the contact area of foreign particles and the contact angle of water with the surface. The result is water droplets on the leaves that roll and particles that do not adhere well to the leaves. This effect is currently in commercial use in exterior paints and textiles named as "self-cleaning" surfaces.[91] The image below shows self-cleaning properties of lotus leaf and its biomimetic product.[92]

Figure 23 Self-cleaning mechanism of lotus leaves and its biomimetic product

In her book *Nano materials in Architecture, Interior Architecture and Design*, Leydecker presents potential wide application of nanomaterial. These materials seems

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[90] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 148,149.

[91] Armstrong, 149.

[92] David Sanchez, "Biomimetic Design: Lotus Effect/Efecto Lotus," WordPress, posted on August 27, 2008, http://biodsign.files.wordpress.com/2008/08/lotusan.jpg (accessed May 2, 2013).

currently in their "*early phase.*"[93] Michael Vieth further describes nanotechnology as an "enabling technology."[94] Enabling technology can be explained as technology that helps improve existing products rather than create entirely new products.

3.2.8. SEAgel (Safe Emulsion Agar gel)

SEAgel is an advanced biomaterial that holds high potentials for 2050; especially its insulation properties are attractive for reducing heat gain in habitable spaces.

SEAgel is currently synthesized by freeze-drying.[95] It is a non-toxic, biocompatible and biodegradable aerogel made from agar. The agar forms a hydrogel which, upon freeze-drying, results in SEAgel. These products are called Biofoams.[96] According to Valdes and Valdes, Biofoams are made from agar, agarose, gelatin, algin, alginates. Gellan gum and cellulose are then added to a polar solvent, then either freeze-dried or emulsified with a non-polar solvent prior to gelation and freeze-drying. To modify the

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[93] Michael Veith, "Foreward" in Sylvia Leydecker, *Nano Materials in Architecture, Interior Architecture and Design* (Berlin: Birkhäuser, 2008), 10.

[94] Veith, 11.

[95] Wikipedia, "SEAgel," http://en.wikipedia.org/wiki/SEAgel (accessed May 2, 2013).

[96] R.L. Morrison, Biofoam 2. U.S.Patent 5,360,828, November 1, 1994; R.L. Morrison, Biofoam. U.S. Patent 5,382,285, January 17, 1995, quoted in James J. Valdes and Erica R. Valdes, "Bio-Inspired Materials and Devices for Chemical and Biological Defense," Center for Technology and National Security Policy National Defense University, (September 2010), http://www.ndu.edu/CTNSP/docUploaded/DTP%2079%20Bio%20Inspired%20Material%20and%20Devices.pdf (accessed May 2, 2013).

properties, composite-forming additives can be incorporated prior to gelling of the aerogel product.[97]

New hybrid applications formed from bio-derived polymers and silica, working with chitosan, pectic acid and alginic acid has recently been generated.[98] Similar technology is proposed to be used as synthetic organic polymer-cross-linked SEAgel composite hybrid with synthetic spider silk sandwich envelope is considered for the *Emergent Alternative Home 2050*.

From a different point of view, "*The nano-scale era of materials design redefines what we think of as a 'resource'. In this future carbon-carbon bonds can be designed to perform on par with higher cost precious metals. In this future 'carbon' emissions can be re-assembled (and resold in the marketplace) with hydrogen bonds using the metabolism of algae…'Phase One' for nano-scale materials engineering is based on materials design using: carbon nanotubes, nanoparticles and nano-sheets (graphene) in a range of applications from energy production and storage and conversion, high*

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[97] James J. Valdes and Erica R. Valdes, "Bio-Inspired Materials and Devices for Chemical and Biological Defense," Center for Technology and National Security Policy National Defense University, (September 2010), http://www.ndu.edu/CTNSP/docUploaded/DTP%2079%20Bio%20Inspired%20Material%20and%20Devices.pdf (accessed May 2, 2013).

[98] Mingzhe Wang et al., "A New Hybrid Aerogel Approach to Modification of Bio derived Polymers for Materials Applications," (In Materials Research Society Symposium Proceedings 2001gRY), 2002, 702, 77-85, doi: http://dx.doi.org/10.1557/PROC-702-U3.5.1

strength composites for light weight airplanes, cars and textiles, to new ways of building electronic devices from carbon (instead of silicon)"[99]

Hence, it is safe to assume that the above discussed materials hold the potential to become viable solutions. Inspired from these processes the material development has the possibility also to become more advanced, for instance specifically valuable in a transformed environment such as anticipated for the *Emergent Alternative Home 2050*.

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[99] Gary Golden, "Carbon Capitalists of the World Unite! The Future of Carbon's Bio-and Nano-based Wealth Creation; Bio Industrialism," posted on December 22, 2009, http://www.garrygolden.net/2009/12/22/carbon-capitalists-of-the-world-unite-the-future-of-carbon-based-wealth-creation/ (accessed May 2, 2013).

3.3. What are the Potential Systems?

3.3.1. Climatic Systems

As termed by Gruber, “Bionics or natural construction” indicates experimental designs. Particularly of interest are current conceptual potential future systems such as, “Aero Dimm, a façade darkening system, and a new kind of fabric with changing permeability inspired by stoma.”[100] Gruber indicates that in biomimetics, if the abstraction of principal is successful, that typically the application is also successful.

Doris Kim Sung present Metal that breathe.[101] This is an abotic method that has the potential to evolve to an autonomous, biotic system. It is being considered for the *Emergent Alternative Home 2050* prototype design.

“The arrangement of leaves on a twig or stem, phyllotaxis or leaf ordering, is significantly related to the avoidance of self-shading. Leaves spring from a twig or stem more or less at the same angle, but in sequence is rotated so that they are offset from each other.”[102] This system is considered for optimizing daylight for the proposed prototype pod. Below images show the phyllotaxis and its Fibonacci spiral analysis.[103]

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[100] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 254.

[101] TED, “Doris Kim Sung: Metal that breathes,” filmed May 2012, posted Oct 2012, TEDx USC video file, http://www.ted.com/talks/doris_kim_sung_metal_that_breathes.html (accessed May 2, 2013).

[102] Michael Weinstock. The Architecture of Emergence, The evolution of form in nature and civilization. (UK: John Wiley & Sons, Ltd, Publication, 2010), 123.

[103] Weinstock, 123; Wikipedia, “Fibonacci number,” http://en.wikipedia.org/wiki/Fibonacci_number (accessed May 2, 2013).

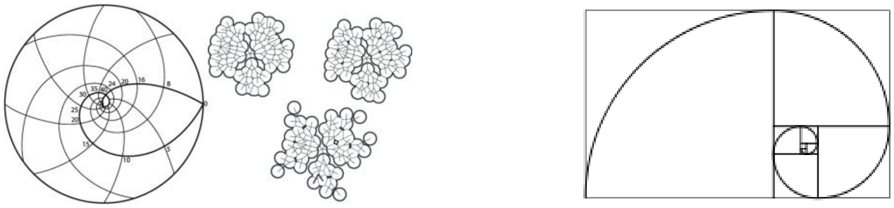

Figure 24 Phyllotaxis and Fibonacci spiral

An example of phyllotaxis is Dennis Dollens experiments with simulated digital trees that are hybridized into architecture. Dollens BioTower design displays biological form, morphology and applied mathematical attributes applied to design systems and structure. He uses generative process to demonstrate transfer of biological properties in his project BioTower (left) such as phyllotaxy (right) is shown in below images.[104]

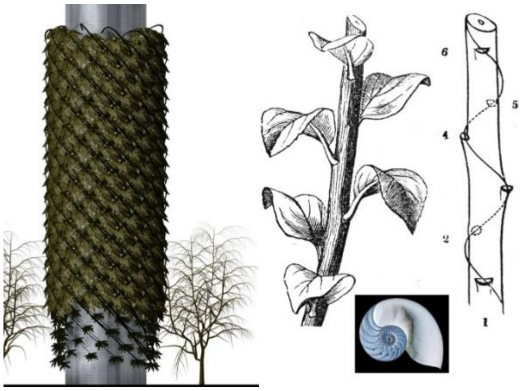

Figure 25 BioTower and spiraling biological geometry

The biological geometric spiraling patterns of plant leaves, and shell shown above (as well as flowers and bones and horns) are captured in algorithmic formulas and then digitally simulated. Dollens uses Xfrog drawings programmed to illustrate the embedded Fibonacci directional flow to apply phyllotaxy & algorithmic growth.

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[104] Dennis Dollens, Digital-Botanic Architecture eBook; eTrees, Digital Nature, & BioArchitecture, 33, 12, http://exodesic.org/TrussImages/DBA2-150.pdf (accessed May 2, 2013).

Figure 26 eTree truss

Above Image illustrates an additional example by Dollens.[105] eTree truss design, simulate tree trunks and branches that follow natural geometries. It is formulated by both the L-systems and Xfrog's proprietary growth and environmental rules.[106] eTree truss is modeled as a tree-to-truss design considering natural proportions and processes, including phyllotaxy. This system numerically models the facets of nature's growth patterns instead of direct emulation, and calculated from the biological analysis of plants and trees.[107]

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[105] Dennis Dollens, Digital-Botanic Architecture eBook; eTrees, Digital Nature, & BioArchitecture, 59, http://exodesic.org/TrussImages/DBA2-150.pdf (accessed May 2, 2013).

[106] Prusinkiewicz and Lindenmayer, 1990. Lintermann, 1998. Dollens, DBA, 2005 quoted in Dennis Dollens, Digital-Botanic Architecture eBook; eTrees, Digital Nature, & BioArchitecture, 59, http://exodesic.org/TrussImages/DBA2-150.pdf (accessed May 2, 2013).

[107] Jean, 1995. Niklas, 1994 quoted in Dennis Dollens, Digital-Botanic Architecture eBook; eTrees, Digital Nature, & BioArchitecture, 59, http://exodesic.org/TrussImages/DBA2-150.pdf (accessed May 2, 2013).

3.4. What are the Potential Methods?

3.4.1. Environmental Solutions

The Sahara Forest project can be seen as an early precedent to a future process. Inspired by the organisms adapted to life in deserts and two proven technologies were used in symbiosis; concentrated solar power (CSP) and Seawater Green houses. In essence, the methods used in this project not only produce resources such as clean water, clean energy and a sustainable food production, it recreates vegetation and is seen as a new environmental solution.[108] This scheme has gone beyond the expectations from sustainability to a regenerative design.[109] The image below displays the synergies and technology integration in Sahara Forest Project.[110]

Figure 27 Sahara Forest Project- integrates technologies, deliver synergies

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[108] Sahara Project, "Greening the Desert: A short introduction to the Sahara Forest Project and its ambitious goal to bring the green to the desert," http://saharaforestproject.com/ (accessed May 2, 2013).

[109] Michael Pawlyn. *Biomimicry in Architecture*. (London: RIBA publishing, 2011), 103,104.

[110] Pawlyn, 104,105.

3.4.2. Synthetic Solar Storage

This method is an investigation to encapsulate photosynthesis inspired energy storage, and synthetic photosynthesis. Armstrong *et al.* discuss an early attempt at understating the manipulation, utilization, and biological connections to inorganic world of electronics. He elaborates on light activated proton movement and bioelectronics actuators.[111] Although these are still in experimental stages they propose synthetic biological photovoltaic for photosynthesis[112] as a strong possibility for future renewable energy.

Moreover, the company Sun Catalytix claims that together with Nocera lab they have solved proton-coupled electron transfer photosynthesis process. Using catalysts they have mimicked this functionality in terms of production of hydrogen. According to them the process of splitting of a neutral water molecule into hydrogen and oxygen during photosynthesis is a complex and difficult bio-pathway. Since then, they claimed to have developed a photocatalyst for the production of hydrogen from diverse water sources with the intention to develop them into a commercial product. The catalyst they use are said to have 76% efficiency. According to MIT chemist Daniel Nocera, this technology has the potential to produce low-cost electricity for individual homes. The solar cell is about the size of a playing card and uses inexpensive materials like silicon

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[111] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 102.

[112] Armstrong, 154.

and inexpensive catalysts like nickel and cobalt. Placed in a gallon of water in bright sunlight, the device could produce enough electricity to supply a house in a developing country with electricity for a day.[113] With biotechnology advancements this abiotic production has the potential to be applied to a synthetic organic system as proposed in the *Emergent Alternative Home 2050.*

Photosynthesis as a primary form of energy production that sustains biological life is therefore projected, along with harvesting the energy of the sun and storage for future use according to the principals of Sun Catalytix.[114] The biochemical approaches proposed for the *Emergent Alternative Home 2050* is founded on principles similar to Armstrong *et al.,* they argue for a bio-chemical approach in biotic cells for direct usable form of energy. They discuss that the energy powering the cells is derived biochemically; in essence, biological systems operate on energy transductions in the mitochondria. Even abiotic systems performing selected cell-like functions are modeled exclusively on biotic cell architecture.[115]

Furthermore, Armstong *et al.* argue that in nanotechnology and micro-electro-mechanical systems are significantly progressing. Examples include nanocapacitors, nanowires, nontraditional solar photovoltaics, thermal photovoltaics, and biomimetic

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[113] AskNature, “Synthetic solar storage: Photosynthetically inspired energy storage & artificial photosynthesis,” http://www.asknature.org/product/highlight/nyserda+energy (accessed May 2, 2013).

[114] AskNature, (accessed May 2, 2013).

[115] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 69.

solar energy conversion. They outline a hybrid of conductive polymer technology and switching of molecules, provide an abundance of technology for powering and controlling signaling and telemetry operations in an abiotic cell. Research and technology advances will tailor universally applicable nontraditional application of power sources.[116] In conclusion, harnessing abundant solar energy in the tropical regions provokes the possibility of an autonomous or a self-maintaining system.

3.4.3. Self-Assembly

Armstrong *et al.* propose size to weight reduction applications or potential lightweight materials. Bio-inspired molecular electronics and self-assembly are seen as a method to reduce the weight.[117] The Shape Deposition manufacturing process or the technique that mix materials and mold any shape, embedding desired material via embedded sensors and actuator in the form itself[118] are properties that are proposed to be utilized in generating the proposed prototype design for *Emergent Alternative Home 2050*.

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[116] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 71.

[117] Armstrong, 154.

[118] TED, "Robert Full: Engineering and evolution," filmed Feb 2002, posted June 2008, TED video file, http://www.ted.com/talks/robert_full_on_engineering_and_evolution.html (accessed May 2, 2013).

3.5. What are the Advantages of These Techniques?

Qualities that potential biotechnology and biomimetics offer include:

- High performance materials
- Biological products are easy to transport[119]
- Biomaterials offer weight reduction and self-healing properties
- Enhancement for unprecedented mobility (people, vehicles, robotics)
- Biodegradable
- Based on nanotechnology, biotechnology, biomolecular devices they are radiation resistant [120]

Today's emerging technological trends such as nanotechnology, biomimetics, and biotechnology are rapidly unveiling new knowledge. Therefore, abundance in advanced technology in 2050 will result in lower costs. Further, due to material efficiencies the required reduction in quantities of materials, as well as energy efficiency, low maintenance, promotes high quality products at low cost.

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[119] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 339

[120] Armstrong, 154.

3.6. What are the Problems of These Techniques?

The implementation feasibility, in other words, whether new and advanced technologies will fill a niche versus broad market, determine the level of policy difficulty it may face. The technical feasibility or likeliness of proposed developments[121] is also an issue.

Perhaps more than ever, there is an environmental need to apply the emerging technology trends in the tropics or in the third world. The necessity to apply *western* technology models that have not yet stood the test of time, and the standards possibly is easily embraced by the rapidly developing urban centers of the tropics. This may be partly facilitated by not so stringent policies, and because so called "flat world."[122] However, as the developing world rises to the standards of the develop world or beyond, a game change may occur.

At present the disadvantages include high costs, unavailability of testing, statutory regulations, leading to quality control and hazardousness of their application is discussed in *Nano-materials in architecture, Interior Architecture and Design* by Leydecker.

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[121] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 340.

[122] Thomas L. Friedman, *The World Is Flat: A Brief History of the 21st Century,* (New York: Farrar, Straus and Giroux, 2005)

The challenges to biotechnology use may involve new wars, policy and law, intellectual property rights for material developments.[123]

Finding local and or regional expertise in biomimetics material and technology required to generate the *Emergent Alternative Home 2050* may become challenging.

In her book *Survivors Of The Stone Age: Nine Tribes Today* Marcus expresses that less technologically advanced people suffer in the hands of people of high technological cultures, as they push into the territory of less technologically advanced societies.[124]

Gruber indicates that following as failures of biomimetic transformations:

- " Superficial research because of disinterest, mistaken ideas
- Information from life sciences unavailable or inaccessible
- Unimaginative approach
- Unsalable phenomenon."[125]

These are only a handful of issues that may rise in 2050.

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[123] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 341.

[124] Rebecca B. Marcus, *Survivors of The Stone Age: Nine Tribes Today*. New York: Hasting House Publishers, 1978.

[125] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 261.

3.7. Concluding Summary

The technology advancements are expected to predominantly shape the *Emergent Alternative Home 2050*. Their impacts need to be carefully considered in shaping the future home. High technology homes will take dynamic, light weight, digitally generated and self-assembled characteristics. They carry the potential to eliminate otherwise needed high demand for resources and labor intensive construction.

Armstrong *et al.*, describe that at the beginning of the architecture of home utilized regionally available basic biological materials "*at the dawn of civilization, the only materials available to man were either biological or mineral, and prior to the development of tools there were limits on what could be done with rocks. … From the first fig leaf, people have been using biological materials for clothing and shelter: plant and animal fibers for threads, yarns, and rope; animal hides and fur for warmth and shelter; reeds and grasses for woven containers; and wood for supports and structures*."[126] 2050 is an opportunity to achieve a high-tech environmentally benign, autonomous architectural solution. Thus biomaterials, nano-scale technological applications using biomimetic methodologies, autonomy in architecture can be targeted.

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[126] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 141.

Chapter IV: Case Studies and Future Trajectories

4.1. Introduction

Over time, the home has gone through various changes; its function, spatial composition, structure, materiality, and fabrication have evolved. Changes in values, opportunities, and trends in societies have transformed home from hunting and gathering societies, through agriculture and industrial societies, to current information societies. For instance from a rudimentary unit that functions as a shelter from weather (i.e. caves) to today's digital center, we live, work, and virtually travel around the world and beyond.

The following case studies and illustrations demonstrate specific architectural innovations that began in the last century. They represent social, political, environmental, technological or other significant manifestations of their time and context. The fundamental inspiration and architectural design thinking that enables the *Emergent Alternative Home 2050*, originates from the following case studies. Their assembly into a genealogy map reflects the connections to the overall vision of my project, linking the past with contemporary and enabling a trajectory for future extrapolations.

These case studies are a selected few from a broader research endeavor that encompassed investigation of a number of pre-selected key seminal and contemporary precedents. Following the inquiry of precedents, themes and drives for the future trajectories were speculated, and a genealogy map was created. These investigations were carried out during my Alternative Experience in Fall 2012, under mentoring of Nataly Gattegno and Jason Johnson of Future Cities Lab.

4.2. Seminal Precedents

4.2.1. Endless House

(1924-1950)
Architect: Frederick Kiesler

Figure 28 Physical model[127]

The *Endless House* is a conceptual proposal. In the *Endless House,* all ends meet constantly,[128] unifying the different areas into a single continuum. Although the space in *Endless House* is continuous, each space-nuclei can be separated for seclusion.[129]

The architecture of the *Endless House* is not subservient to the techniques of construction. It conceptualizes a form that is analogous to the human body; with no beginning or end.[130] This house is conceived as a living organism or biotechnical design,[131] or *Biotechnique.*[132]

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[127] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 57.

[128] Dpr-Barcelona, “Endless House: Frederick Kiesler,” posted on September 21, 2009, http://dprbcn.wordpress.com/2009/09/21/endless-house-frederick-kiesler/ (accessed May 2, 2013).

[129] Frederick Kiesler, *Inside the endless house; art, people and architecture* (NY: Simon and Schuster, 1966), 567.

[130] Kiesler, 566.

[131] Jae Eun Yoon, “A Study on the Co-relationship between the Endless Space of Frederick J. Kiesler and Non-territorial Space Expression in De-constructivism Architecture,” http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/cd_donotopen/adc/final_paper/189.pdf (accessed May 2, 2013).

The Endless House embodies an innovative spatial concept in all dimensions. Its ground plan is considered only an imprint of its volume[133]. The superimposition of the intertwining routes create the symbol of infinity, as in a Klein bottle and Mobius strip, both being single and endless surfaces.[134]

Its boundaries are designed according to the scale of the inhabitant's living; shaped and formed by the process of life rather than upon code standards. *Endless house* is considered a place where people live poly-dimensionally, and it is thought to represent their sum of movements.[135] To achieve this, reinforced concrete is used in a plastic way, creating spatial formations in vertical, lateral, or in other expanding directions. Structural columns and beams are absent, in their place are light and heavier shells.[136] They create walls, floors and ceilings that flow into each other seemingly uninterrupted. Concrete is not an exclusive material for such exercise; wood, canvas, stone and paper are a few other materials that can be used to similar advantage.

Elevated into the air, the *Endless House* is designed to be independent of the ground. It is meant to be seen as "floating on the water or on sand."[137] Essentially, the *Endless House* is constructed out of interlinking pods that are supported off the ground

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[132] Maria Bottero*, Frederick Kiesler: Arte, Architettura, Ambiente* (Milano: Electa, 1996), 198.

[133] Simon Unwin, *Twenty Buildings Every Architect Should Understand* (Hoboken: Taylor & Francis, 2010), 57.

[134] Unwin, 59.

[135] Unwin, 59.

[136] Frederick Kiesler, *Inside the endless house; art, people and architecture* (NY: Simon and Schuster, 1966), 569.

[137] Television interview, 1961.

on pedestals. The middle pedestal contains the entrance. The grand stairway leads to the cloakroom and a garden storage room at the middle floor. The southern pedestal has a stair going to the kitchen and a place presumably for storage. The northern pedestal is a way into the garden. At the bottom, an external stair sweeps down under the pod from the parents room on the middle floor. At the head of the grand stairs on the middle floor is the living space with a hearth as its core. The parent's room leads off into an area with a pool in place of a bathtub. The living space also gives access to the kitchen through what appears to be the dining space. The final space on this floor comprises a combination of a bedroom/bathroom for children. Growing green vegetation is featured at various positions for relaxation. Light control and a color clock are other attributes of this house. A stair from the living room leads to another bedroom and bathroom on the top floor. From here an external stair leads to the roof.[138]

This free form structure is considered to be reminiscent of a rock carved system, created by the flow of water, or the grottos of 18th century landscape architecture. The space carves itself in the *Endless House,*[139] as a quasi-natural morphology.

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[138] Simon Unwin, *Twenty Buildings Every Architect Should Understand* (Hoboken: Taylor & Francis, 2010), 58.

[139] Unwin, 58.

4.2.2. La Maison Tropicale (The Tropical House)
Colonial Africa (1949-1951)
Architect: Jean Prouve

Figure 29 Digital model (superimposed) [140]

La Maison Tropicale was intended as a low cost prototype, to be mass produced to address the shortage of houses in tropical colonial Africa.[141] It has become a key demonstration house for its environmental adaptable qualities.

La Maison Tropicale reuses the features and principles from precedent studies and previous projects to address the environmental concerns. This prefabricated house sits on reinforced concrete piles allowing circulation of natural ventilation under the house. Features such as the interior porticos designed for shaded outdoor living, the sun breakers with pivoting slats above the railings in the passageways, and ventilation between the panel ceiling and roof, provides protection from the sun and lowers the temperature within the house.[142] The blue glass porthole façade panels further

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140 DeZeen magazine, “Jean Prouvé’s Maison Tropicale in London,” posted on January 28, 2005, http://www.dezeen.com/2008/01/28/jean-prouves-maison-tropicale-in-london/ (accessed May 2, 2013).

[141] DeZeen magazine, http://www.dezeen.com/2008/01/28/jean-prouves-maison-tropicale-in-london/ (accessed May 2, 2013).

[142] Robert M. Rubin and Olivier Cinqualbre, *Jean Prouve La Maison Tropicale* (Paris: Centre Pompidou, 2009), 31, 32.

encourages cross ventilation, and protection from UV rays.[143] Between the interior and exterior panels, sandwiched aluminum fiber blanket isolation prevents the air movement.

The research that contributed to the development of *La Maison Tropicale* spans from the post war lightweight manufacturing and construction process, to the studies aimed for oversees French colonies military huts in the late 1930's.[144] Accordingly, the main techniques used were standardization and prefabrication. Catalogues of parts based on the modularity principle were employed to cater to the transportation needs.[145] The modularity of elements, and the loadbearing façade, seemingly offers internal spatial flexibility in size and orientation, allowing customization.

The construction of this house comprised of settings, earth works, foundations, floors and assembly of prefab parts. The primary components of the house skeleton included the ridge beam, ventilation system and porticos. The cladding includes sun shields and movable walls, which create a gallery around the periphery of the inhabitable volume. All the panels (regular, windows, and doors) were constructed using the same principle. The exterior panels were made of aluminum plates, and the interior panels were customized according to client's needs and preferences; wooden battens,

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[143] Wallpaper, "La Maison Tropicale, Jean Prouvé," posted on February 4, 2008, http://www.wallpaper.com/architecture/la-maison-tropicale-jean-prouv/2084 (accessed May 2, 2013).

[144] Robert M. Rubin and Olivier Cinqualbre, *Jean Prouve La Maison Tropicale* (Paris: Centre Pompidou, 2009), 31.

[145] Rubin, 31.

aluminum or plywood, etc. Beam and purlins were connected by the gussets. The water tightness of the roof was achieved by unity of roof elements.[146]

To achieve a reduction in weight, aluminum roof components and sun-breakers with perforations were used.[147] Light weight construction facilitated the mobility of this structure.

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[146] Robert M. Rubin and Olivier Cinqualbre, *Jean Prouve La Maison Tropicale* (Paris: Centre Pompidou, 2009), 32, 97.

[147] Rubin, 32.

4.3. Contemporary Precedents

4.3.1. The Suitaloon and Cushicle

(1967)
Architect: Archigram - Michael Webb

Figure 30 Cushicle with (model) David Green [148]

The *Suitaloon* and *Cuschicle* are examples of Archigram's conceptual mobile architecture.

The *Suitaloon* is a speculative design for a personal, individual and portable dwelling unit. It essentially is an inflatable space suit[149] like clothing. It may be "worn" for transport and unpacked for occupation and is readily available at any time, or anywhere. The suit is considered to represent a return to nomadic lifestyles in pursuit of

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[148] Arquitecturas de emergenca: seminario del máster de proyectos arquitectónicos avanzados etsam - Architecture of Emergency: Masters Seminar Advanced Architectural ETSAM, "Suitaloon: Archigram," posted on Oct 18, 2010, http://arquitecturasdeemergencia.blogspot.com/2010/10/suitaloon-archigram.html (accessed May 2, 2013).

[149] Archigram Archival Project, "Cushicle & Suitaloon: Project No. 96: Michael Webb," University of Westminster, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

pleasure, increased opportunity and changes to socio-political conditions.[150] Its lightness allows portability.

The *Suitaloon* is a minimal, reductive dwelling concept,[151] where the components and the support systems are reduced to basic necessities. Conceptually, this wearable system provides all the necessary services.[152] The single open space interior creates a thermal barrier between the external environment and the wearer.

Each suit has a device similar to a key for plugging in and out.[153] This plug facilitates individuals to connect to another *Suitaloon.* Alternatively, they can also be left clipped on to the outside ready to step back in upon return. Two people can plug in to a single suit and be in a single envelope. When several of them are interconnected communities are formed within larger spaces.[154]

The *Cushicle* is a carlike mechanism that enables a man to carry a complete full service unit on his back. It inflates out when needed, and enables the user to have a comfortable environment efficiently.[155] When unpacked, the two main parts of the *Cushicle* expand out. The "armature" or "spinal" system forms the framework and

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[150] Peter Cook et al. ed., *Archigram* 1973 (reprinted NY: Princeton Architectural Press, 1999).

[151] Simon Winters, "Links and Things: My Very Own Cabinet of Curiousities blog," http://simonwinters02.blogspot.com/2009/12/mike-webb-suitaloon-cushiclevicarious.html (accessed May 2, 2013).

[152] Archigram Archival Project, "Cushicle & Suitaloon: Project No. 96: Michael Webb," University of Westminster, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

[153] Archigram, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

[154] Archigram, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

[155] Archigram, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

support for the appliances and other apparatus. The other is the enclosure, which essentially is the inflated envelope with extra skins as viewing screens. These parts can be opened and used collectively or independently.[156]

The *Cushicle* carries nutrient supplies, entertainment. The entertainment is contained in the helmet and the food supplies are carried in pod attachments. The established ubiquitous service nodes and additional optional apparatus, is considered to facilitate the autonomous *Cushicle* to develop into a system of personalized urban enclosures.[157]

4.3.2. *Il Monumento Continuo (Continuous Monument)*

(1969-1970)
Architect: Superstudio

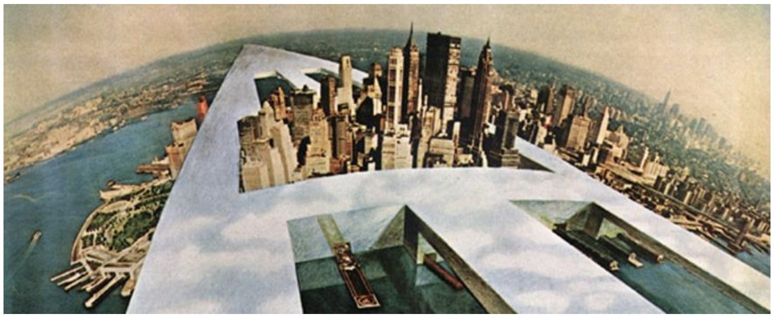

Figure 31 Representation of *Il Monumento Continuo* [158]

Il Monumento Continuo is a conceptual negative utopia[159] or dystopia[160]that is illustrated as an emerging single, continuous, uniform environment. It is characterized

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[156] Archigram Archival Project, “Cushicle & Suitaloon: Project No. 96: Michael Webb,” University of Westminster, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

[157] Archigram, http://archigram.westminster.ac.uk/project.php?id=92 (accessed May 2, 2013).

[158] Tumblr, “Continuous Monument,” http://www.tumblr.com/tagged/continuous-monument (accessed May 2, 2013).

by sparse, functional spaces, free of local identity and individual expression.[161] This is a gridded structure that takes over the planet. It is thought to be a result of malicious force of technology ,[162] global culture[163] and urban sprawl.

In essence, *Il Monumento Continuo* is a cosmic master-plan that considers everything about modern culture, disregards everything around it, frames it, and indirectly defines it; seemingly to demonstrate globalization flooding the world,[164] leaving it featureless.[165]

Il Monumento Continuo is a single architectural design that wraps the world. It can be transferred from one area to another without change. The accumulation of the basic geometric unit (white cuONbes)[166] creates the city. It is represented by a three-dimensional white gridded monolithic structure that spans[167] the surface of the earth,

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[159] Jonathan Glancey, “Anti-matter: Italy's Superstudio hated both the bland future and the twee past. Jonathan Glancey on a timeless vision,” The Guardian (2003), http://www.guardian.co.uk/artanddesign/2003/mar/31/architecture.artsfeatures (accessed May 2, 2013).

[160] CityMovement: Concerned with the issues and ideas of the contemporary city, “Tag Archives: Superstudio,” posted on April 12, 2012, http://citymovement.wordpress.com/tag/superstudio/ (accessed May 2, 2013).

[161] Glancey, http://www.guardian.co.uk/artanddesign/2003/mar/31/architecture.artsfeatures (accessed May 2, 2013).

[162] Glancey, http://www.guardian.co.uk/artanddesign/2003/mar/31/architecture.artsfeatures (accessed May 2, 2013).

[163] Martin Van Schaik and OtakarMarcel ed., *Exit Utopia Architectural Provocations 1956-76* (Munich: Prestel Verlag, 2005), 126.

[164] CityMovement, http://citymovement.wordpress.com/tag/superstudio/ (accessed May 2, 2013).

[165] Diogo Azevedo, “Super/Future: Superstudio-Life without objects,” posted in 2003, http://super-future.tumblr.com/ (accessed May 2, 2013).

[166] Azevedo, http://super-future.tumblr.com/ (accessed May 2, 2013).

[167] MoMA: The Collection, “Superstudio (Italian, est. 1966–1982): The Continuous Monument: On the River, project, Perspective,” http://www.moma.org/collection/browse_results.php?criteria=O%3AAD%3AE%3A5733&page_number=2&template_id=1&sort_order=1 (accessed May 2, 2013).

crossing megacities, mountains, oceans[168] and destroys the topography of the land. This is expressed as a system of total urbanization, a singular anonymous structure devoid of culture.

It explores the outdoor and social living on a continuous surface. It occupies the ideal living zones and leaves the rest free. *Il Monumento Continuo* stipulates no interiors.[169]

Il Monumento Continuo is considered committed to engaging the mainstream society consciously made up of responsible individuals, communities, critically aware of their natural resources and shared cultures.[170]

4.3.3. Mobius House
Het Gooi, Holland (1993-1998)
Architect: Van Berkel Bos

Figure 32 Completed Mobius House[171]

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[168] Aurelien Vernant, "Superstudio: Monumento Continuo, 1969-1970," FRAC Center, http://www.frac-centre.fr/collection/collection-art-architecture/index-des-auteurs/auteurs/projets-64.html?authID=185&ensembleID=988 (accessed May 2, 2013).

[169] Diogo Azevedo, "Super/Future: Superstudio-Life without objects," posted in 2003, http://super-future.tumblr.com/ (accessed May 2, 2013).

[170] Azevedo, http://super-future.tumblr.com/ (accessed May 2, 2013).

The *Mobius House* is conceptualized as a double torus and a Mobius loop.[172] Due to that, an unusual architectural topology of a single surface,[173] without a defined inside or outside is created. They are joined by unframed sheets of glass and concrete those simultaneously act as interior and exterior walls.[174] The double-locked torus conveys the arrangement of the two different pathways. Those trace the progress of the two inhabitants living together, yet apart, meeting at shared areas [175] at the crossing points of the paths.[176]

In the *Mobius House*, light, space, materials, program, circulation and structure appear to be in seamless integration. Daily work, social activities and individual time for the family are organized in an intertwining loop that is diagramed as a Mobius strip.[177] Mobius strip can be demonstrated by twisting a narrow piece of paper and joining the ends.[178]

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[171] UNStudio, "Mobius House," archello, posted on March 14, 2012, http://www.archello.com/en/project/mobius-house (accessed May 2, 2013).

[172] UNStudio, "Mobius House," UNStudio, http://www.unstudio.com/projects/mobius-house (accessed May 2, 2013).

[173] Werner Sewing and Erik Wegerhoff, *Architecture: Sculpture* (Munich: Prestel 2004), 98.

[174] Colin Davies, *Key Houses of the Twentieth Century: Plans, Sections and Elevations* (New York: W.W. Norton, 2006).

[175] Ben van Berkel and Caroline Bos, *UN studio: Design models, Architecture, Urbanism, Infrastructure* (NY: Rizzoli, 2006), 150.

[176] UNStudio, http://www.unstudio.com/projects/mobius-house (accessed May 2, 2013).

[177] Ben van Berkel and Caroline Bos, *UN studio: Design models, Architecture, Urbanism, Infrastructure* (NY: Rizzoli, 2006), 150.

[178] Colin Davies, *Key Houses of the Twentieth Century: Plans, Sections and Elevations* (New York: W.W. Norton, 2006).

This house is characterized by its Mobius loop that continuously winds around itself; meets, broadens and crosses over itself. The entrance is its only free extending end, which turn on its axis, then move up as a stair to the residential story. At this point it is connected to the loop. A ramp leads to kitchen, living and veranda, and a conically broadening stair turns around on itself, leading to the upper level. This level encompasses a study to the right, and two children's bedrooms and baths to the left. A descend following a twist to the left reaches the parent's bedroom, and a second study. This brings the user to where the access loop is first entered. The house structure encircles and moves around the garage.[179]

In the *Mobius House* four loose quadrants create a spatial interplay. Balance is achieved through the placement of the program within a space similar to a cross. For instance, the upper and lower studies are complemented by upper and lower bedrooms.[180]

The *Mobius House* transfers mobility through its programmatic organization, unfurling horizontality taking advantage of its surrounding environment.[181] This house employs glass and concrete in an unconventional way.[182] Folded ribbons of glass and

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[179] Werner Sewing and Erik Wegerhoff, *Architecture: Sculpture* (Munich: Prestel 2004), 98.

[180] Ben van Berkel and Caroline Bos, *UN studio: Design models, Architecture, Urbanism, Infrastructure* (NY: Rizzoli, 2006), 150.

[181] Berkel, 150.

[182] UNStudio, "Mobius House," UNStudio, http://www.unstudio.com/projects/mobius-house (accessed May 2, 2013).

concrete create unusual interconnecting spaces. They present views to landscape through, under, over, and across.[183]

4.3.4. Mosquito Bottleneck House

Trinidad Island (2003)
Architect: R&Sie(n)

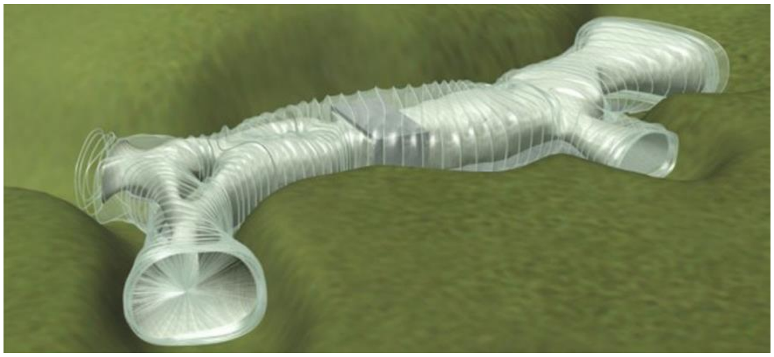

Figure 33 3D model of Mosquito Bottle Neck House[184]

The *Mosquito Bottleneck House* is a vacation home designed in an area that is infested with mosquitoes that transmit West Nil Fever virus.[185] This design illustrates a reaction to a strong negative environmental condition.

The flight trajectory of the mosquito has been translated into a tubular spiral which supports the building and its double skin.[186] Moreover, a horizontal Klein-bottle is

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[183] Colin Davies, *Key Houses of the Twentieth Century: Plans, Sections and Elevations* (New York: W.W. Norton, 2006).

[184] Suzanne Stein, “Mosquito Crossing,” SFMOMA blog: Open Space, posted on May 16, 2008, http://blog.sfmoma.org/2008/05/mosquito-crossing/ (accessed May 2, 2013).

[185] Andreas Ruby and Benoît Durandin ed., *Spoiled Climate: R & Sie Architects* (Basel, Boston: Birkhauser-Publishers for Architecture, 2004), 140.

[186] Giovanni Corbellini, Bioreboot: *The Architecture of R&Sie (n)* (NY: Princeton Architectural Press, 2010), 105.

created to trap mosquitos. Klein bottle trap can be demonstrated using a plastic bottle cut in half, then by inserting the top part turned upside down into the bottom part.[187]

The *Mosquito Bottleneck House* interior is considered a seamless continuation of the exterior. The exterior surfaces invert to become interior walls and interior volumes intertwine but do not intersect. [188] The exoskeleton forms a continuous surface incorporating façades, walls, ceilings and floors into a flowing fabric-like structure. The exoskeleton is made out of braided transparent polyamide yarn and plastic shrink film.[189]

This design captures mosquitoes and moves them through the double skin, without them contacting the inhabitants. The noise of the mosquitoes can be heard from within,[190] thus preserving the resonance between the vibrating structure and their buzzing.[191]

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[187] Corbellini, 106.

[188] SFMOMA, "R&Sie(n): Mosquito Bottleneck Project, Trinidad," http://www.sfmoma.org/explore/collection/artwork/118213 (accessed May 2, 2013).

[189] VIA, "Designer: Mathieu Lehanneur: Mosquito Bottleneck - realization of a private house in Trinidad Island," http://en.via.fr/agora-produit-16154 (accessed May 2, 2013).

[190] Suzanne Stein, "Mosquito Crossing," SFMOMA blog: Open Space, posted on May 16, 2008, http://blog.sfmoma.org/2008/05/mosquito-crossing/ (accessed May 2, 2013).

[191] Andreas Ruby and Benoît Durandin ed., *Spoiled Climate: R & Sie Architects* (Basel, Boston: Birkhauser-Publishers for Architecture, 2004), 140.

4.4. Future Trajectories

4.4.1. Alpha House

Theme: **Material logic + Envelope**
Driving Forces: Microbiology + Hygroscopic

Figure 34 Texture: Climatic responsive Hygroscope by Achim Menges at Centre Pompidou[192]

The *Alpha house* is envisioned as a climatically sensitive autonomous envelope. This house proposes a passive ventilation process. This process is induced by its internal material logic. At high humidity levels the envelope flexes, due to microbiological properties of the material. This enabling process similar to breathing will ventilate the moisture-saturated air. Notably, this process will eliminate mechanical or electrical intervention and optimize the energy performance. This climatically responsive envelope is an ideal comfort house.

Its self-supporting, light weight envelope comprises of customized paneling. This envelope will use minimal amount of material in ultra-thin veneer form. Designed for

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[192] Jennifer K. Gorsche, "Hygroscope: Meteorosensitive Morphology," A: N blog, posted on May 4, 2012, http://blog.archpaper.com/wordpress/archives/38154 (accessed May 2, 2013).

high level human comfort, *Alpha house* is a proposed as a prototype for high humid regions.

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Automobile + Precast Conc. + Machine + Transportability + **Human Comfort** + **Autonomy** + Hardware room + **Energy saving performance** + **Customized paneling** + **Operable skin** **(MAISON CITROHAN + DYMAXION HOUSE + VILLA NURBS)**

Stone Veneer + Transitional space + **Material** + **Climate** + Flat pack + Mobility + **Pliability** + Portability + **Inter connectivity** + wearable (**BARCELONA PAVILION + MAISON TROPICALE + SUITALOON)**

4.4.2. Beta House

Theme: **Reactive + Structure**
Driving Forces: Community + Informatics

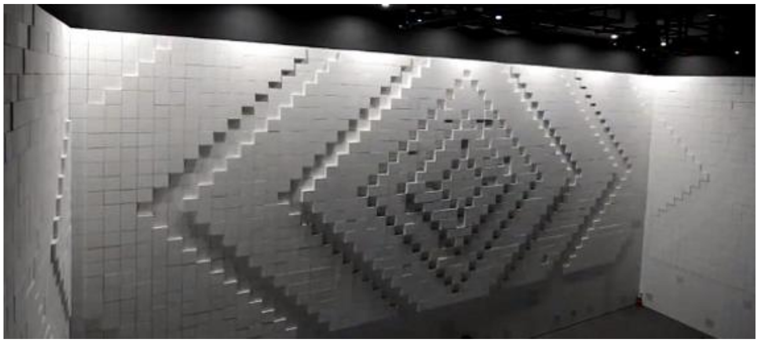

Figure 35 Texture: Hyper-Matrix Cube Wall by Hyundai Motor Group at 2012 Yeosu EXPO[193]

This smart house is envisioned as an interactive social structure. The *Beta House* proposes a dynamic design that self-configures according to the data input and reactions of a community. Live interfaces will collect information from local and remote data feeds. This digital hyper house will adjust its operable surfaces to create spatial enclosures defined by community actions. For instance, positive local weather

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[193] John, “Hyper-Matrix Cube Wall by Ja’Npasang,” Freshness, posted on September 18, 2012, http://www.freshnessmag.com/2012/09/18/hyper-matrix-cube-wall-by-jonpasang/ (accessed May 2, 2013).

information inputs and community responses cause transformation of the indoor configuration into an outdoor configuration, thereby creating an alternating indoor-outdoor living within a single structure. Beta House will expose its inhabitants to the external environment through its single dynamic architecture. The proposed integration of the house with environment will encourage healthier living.

High strength veneer materials will be framed, using standard framing construction methods. The gap between the layering of veneer will be used for required sensors, electronics and other mechanical interventions. This is proposed as an ideal prototype house for dynamic mass community living.

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Climate + Flat pack + **Environment** + Biomorphic + Conc. Plasticity + **Surface** + Negative site condition + **Fluidity** + Trap + Klein-Bottle (MAISON TROPICALE +**ENDLESS HOUSE** + **MOSQUITO BOTTLE NECK HOUSE)**

Automobile + Precast Conc. + **Outdoor living** + Site-Cast Conc. Slab tilt + Biomorphic + Conc. Plasticity + **Health** + Shot Conc.+ Live-work + **Standard** Steel **Components** + **Life Style** + **Health** + Shot Conc. + Stone **Veneer** + Transitional space + **Landscape** + 3 Dimensional transition + View + Gravity + Accessibility (MAISON CITROHAN + **SCHINDLER HOUSE** + **LOVELL HOUSE** + EAMES HOUSE + **BARCELONA PAVILION** + MAISON A BORDEAUX)

4.4.3. Gamma House

Theme: CNC Fabrication + Nomadic
Driving Forces: Robotics + Origami

Figure 36 Texture: Assembly by Parallel Robots by adept[194]

The self-assembling *Gamma house* is envisioned as a fast interchangeable system that adapts quickly to new configurations. CNC fabrication will ensure the precision, accuracy and customized components for this system.

In this house, advanced robotics will drive assembly, disassembly, as well as control the speed of their process. The origami inspired fold-ability of this structure will make it deployable as a temporary dwelling for various situations; for instance, in extreme site conditions or aftermath of disaster situations. It will require least physically intensive intervention for fabrication and assembly. This also has the potential to serve as an ideal home for less physically able individuals such as the elderly. *Gamma house* is proposed as a prototype house for temporary mass housing or housing for the elderly.

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[194] DayBreak Magazine: near-future, “Optimistic SF Stories, Bin Sorting Robots,” *DayBreak Magazine*, posted on March 21, 2010, https://daybreakmagazine.wordpress.com/2010/03/26/shine-excerpts-russian-roulette-2020/bin-sorting-robots/ (accessed May 2, 2013).

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Automobile + Precast Conc. + Machine + **Transportability** + Human Comfort + Autonomy + Hardware room + Energy saving performance + **Customized paneling** + Operable skin (MAISON CITROHAN + **DYMAXION HOUSE** + **VILLA NURBS)**

Stone Veneer + Transitional space + **Material** + Climate + **Flat pack** + **Mobility** + **Pliability** + **Portability** + **Inter connectivity** + wearable (**BARCELONA PAVILION + MAISON TROPICALE + SUITALOON)**

4.4.4. Epsilon House

Theme: **Assembly logic + Utopia**
Driving Forces: Genetics + Hydroponics

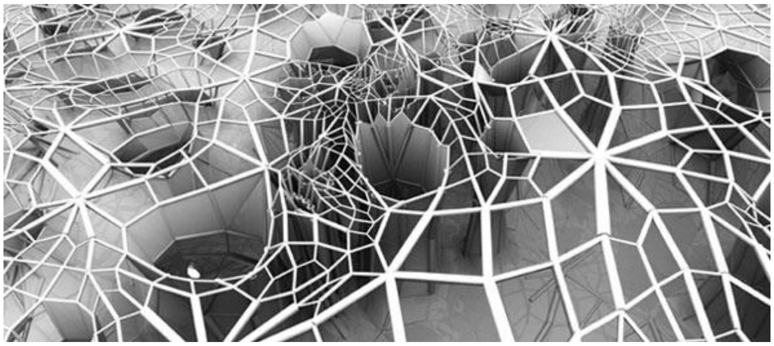

Figure 37 Texture: Geotube by Faulders Studio [195]

A modular matrix of live organisms will generate this human shelter. The *Epsilon house* has the potential to propagate to a utopian equivalent of current ubiquitous urban cities.

The main characteristic of this house will be genetical coding for performance, and creation of desired quasi-natural environments. Using principles similar and advanced to hydroponics, this concept house will assemble an environment, replace and improve the loss of biodiversity, encountered due to high population, fast global

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[195] CubeMe, "GEOtube by Faulders Studio," CubeMe, http://cubeme.com/blog/2010/09/27/geotube-by-faulders-studio/ (accessed May 2, 2013).

urbanization and resource depletion. *Epsilon house* essentially is proposed as a propagating utopian live synthetic ecology.

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Transportability + Human Comfort + Live-work + Standard Steel Components + Prefab + Climate + Flat pack + Mobility + **Modular** + Light weight+ **Connections** + Adaptability + Outdoor living + Site-Cast Conc. Slab tilt + Variations + Transportability + Human Comfort + Live-work + Standard Steel Components + Prefab + Identity through mutations + Mass customizing + Intelligent selection + **Biomimicry** (DYMAXION HOUSE + MAISON TROPICALE + CELLOPHANE HOUSE + SCHINDLER HOUSE + DYMAXION HOUSE + **EAMES HOUSE** + **EMBROYOLOGICAL HOUSE)**

Biomorphic + Conc. Plasticity + **Continuity** + Health + Shot Conc. + Stone Veneer + Transitional space + **Landscape** + **Ubiquitous platform** + Natural resources + **Immersive** + Global vision (ENDLESS HOUSE + LOVELL HOUSE + BARCELONA PAVILION + **CONTINUOUS MONUMENT)**

4.4.5. Zeta House

Theme: Topology + Nomadic
Driving Forces: Levitate + Mobile tech.

Figure 38 Texture: SOFT Blimp Bumper Bus by Mitchell Joachim, Terreform One[196]

The *Zeta house* proposes to occupy the air. This floating house will navigate the air using mobile technology. The topology of this design originates from aerodynamics, weight reduction and buoyancy.

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[196] Mitchell Joachim, “Smart DOTS + Soft MOBS: Soft Blimp Bumper Bus,” http://www.archinode.com/blimp.html (accessed May 2, 2013).

The concept of this house is prompted by the lack of appropriate land for habitation. The *Zeta house* will be a light, buoyant, prefab house that utilizes levitation technology related transportation. It will be fabricated from advanced lightweight composites. The freedom of mobility it will provide will give rise to its popularity. The *Zeta house* is proposed as a novel and inspirational nomadic architecture.

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Climate + Flat pack + Environment + **Biomorphic** + Conc. Plasticity + **Surface** + Negative site condition + **Fluidity** + Trap + Klein-Bottle (MAISON TROPICALE +**ENDLESS HOUSE** + MOSQUITO BOTTLE NECK HOUSE)

Stone Veneer + Transitional space + Material + Climate + Flat pack + **Mobility** + Pliability + **Portability** + Inter connectivity + wearable (BARCELONA PAVILION + MAISON TROPICALE + **SUITALOON)**

4.4.6. Eta House

Theme: **Technology + Live-Work**
Driving Forces: Virtual + Energy

Figure 39 Texture: A scene from motion picture Matrix [197]

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[197] Free Wallpaper, under "Matrix," posted on June 20, 2005, http://wallpapers.jurko.net/pic/6251/ (accessed May 2, 2013).

The *Eta house* will oscillate between virtual and physical worlds. Advanced interactive digital technology will be used to satisfy the proposed non-tangible experiences.

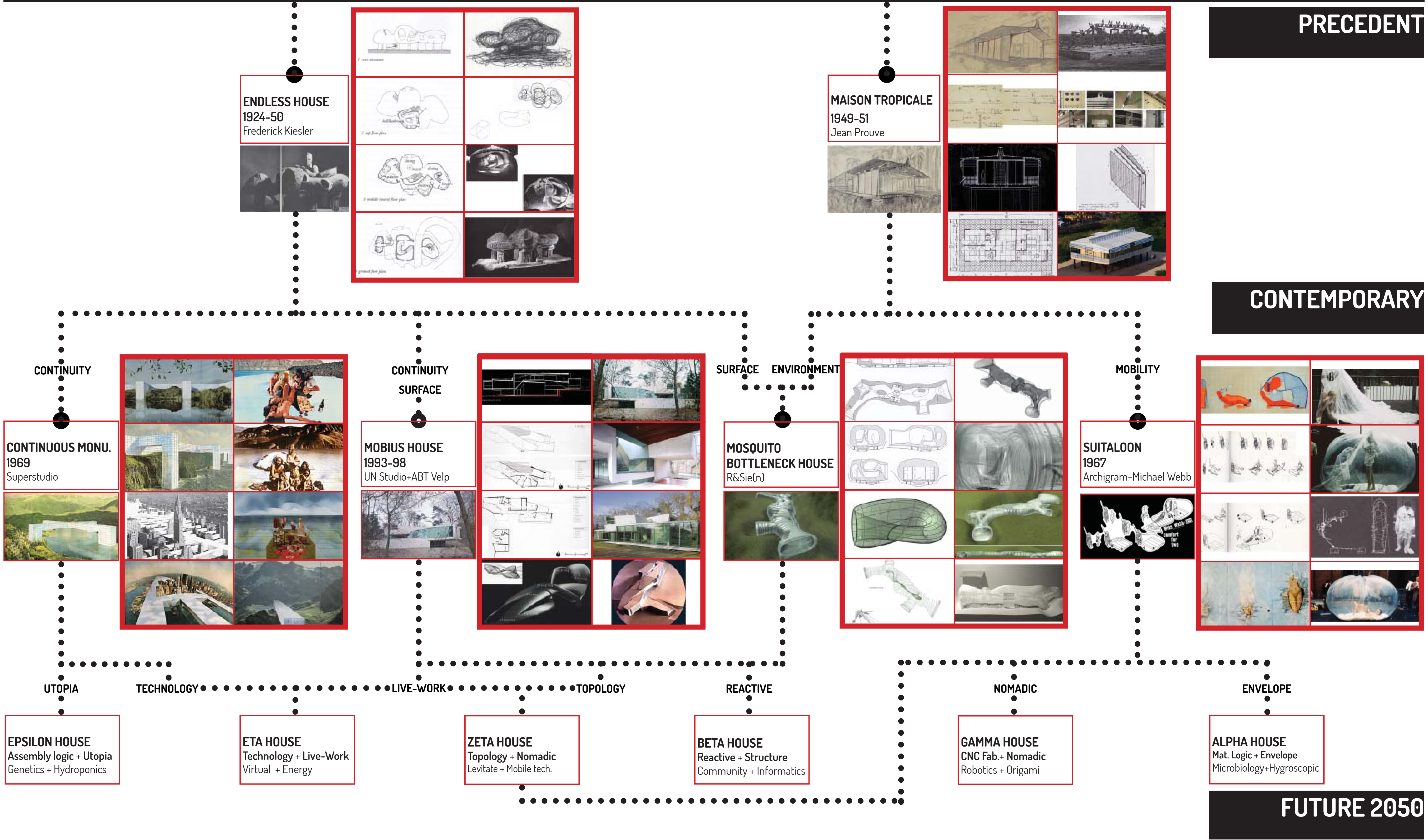
This house will be a space for object free virtual living and physical working duality. The transition back and forth fulfills humans with virtually controlled non-tangible sensations, still allowing access to tangible physical necessities of modified living. Being an in-between space, the *Eta house* will bear an analogy similar to contemporary transitional spaces that blur the boundary. Screens of projected data will bind the intangible limits in spatial transformations. The energy will be generated using solar power to operate this system. *Eta house* is proposed as a prototype experiential transitional space.

The key words that encapsulate the genealogic themes and precedents for this design are as follows:

Biomorphic + Conc. Plasticity + **Continuity** + Health + Shot Conc. + Stone Veneer + **Transitional space** + Landscape + Ubiquitous platform + Natural resources + **Immersive** + Global Vision (ENDLESS HOUSE + LOVELL HOUSE + **BARCELONA PAVILION** + **CONTINUOUS MONUMENT)**

Biomorphic + Conc. Plasticity + **Continuity** + Biomorphic + Conc. Plasticity + Surface + Single Surface + Mobius Strip + Smooth + **Blurring Boundaries** (ENDLESS HOUSE + **MOBIUS HOUSE)**

GENEALOGY OF ARCHITECTURE OF HOME



PRECEDENT

ENDLESS HOUSE
1924-50
Frederick Kiesler

MAISON TROPICALE
1949-51
Jean Prouve

CONTEMPORARY

CONTINUITY

CONTINUOUS MONU.
1969
Superstudio

CONTINUITY
SURFACE

MOBIUS HOUSE
1993-98
UN Studio+ABT Velp

SURFACE
ENVIRONMENT

MOSQUITO BOTTLENECK HOUSE
R&Sie(n)

MOBILITY

SUITALOON
1967
Archigram-Michael Webb

UTOPIA
TECHNOLOGY
LIVE-WORK
TOPOLOGY
REACTIVE
NOMADIC
ENVELOPE

EPSILON HOUSE
Assembly logic + Utopia
Genetics + Hydroponics

ETA HOUSE
Technology + Live-Work
Virtual + Energy

ZETA HOUSE
Topology + Nomadic
Levitate + Mobile tech.

BETA HOUSE
Reactive + Structure
Community + Informatics

GAMMA HOUSE
CNC Fab.+ Nomadic
Robotics + Origami

ALPHA HOUSE
Mat. Logic + Envelope
Microbiology+Hygroscopic

FUTURE 2050

Figure 40 Genealogy map of architecture of home linked by corresponding themes

4.5. Concluding Summary

This chapter examines a genealogy of past precedents, contemporary examples, and a trajectory of future prototypes. The primary themes and primary manifestations that drive them, their basic spatial, physical (structural and material) characteristics and intangible aspects are also investigated. Materials, systems and methods are investigated in comparison to their past and contemporary equivalents and influence of technology. A matrix linking the history, the social foundation on which they are built, is extrapolated into the development of a prototype *Emergent Alternative Home 2050*.

Chapter V: Design Framework

5.1. Introduction

The etymology of "preferred" *Emergent Alternative Home 2050* refers to coming about of a dwelling that is promoted for forecasted future 2050.[198] Samson in his book *The Social Archeology of Houses* describes the etymology of home as a continuity of repeated action over a period of time.[199] Receptive to the etymological description, and considering the key manifestations for future 2050, this doctorate project investigates a design that is founded on likely technological advancements.

The technological advancements that create materials, systems and methods enabling construction of *Emergent Alternative Home 2050* are discussed in chapter III.

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[198] Douglas Harper, "Prefer," Online Etymology Dictionary, http://www.etymonline.com/index.php?allowed_in_frame=0&search=prefer&searchmode=none (accessed May 2, 2013).

[199] Ross Samson *ed., The Social Archeology of Houses* (Edinburgh University Press, 1990), 23.

5.2. Design Objective

The design objective of this doctorate project is to develop and validate a visual representation accompanied by a narrative for a preferred human habitat for Scenario 2050, laid out in chapter II. The Scenarios 2030 and 2070 are included for understanding the design in the context of the relevant timeline. Chapter II elaborates the key forces that drive those scenarios, with emphasis on the physical and social context of a speculative 2050.

In this doctorate project, the design is used as a medium of proof, to test my initial hypothesis; investigating the development of a synthetic organic home, which is facilitated by the accelerated growth of technology. My research inquiry in chapter III provides a trajectory of emerging opportunities and trends for future material and methods that will facilitate the proposed design. Selected architectural case studies are presented in chapter IV. They are used as architectural precedents to illustrate a genealogy matrix that identifies primary architectural themes and key drivers to assist arriving at the proposed design solution.

5.3. Design Criteria

In essence, a design prototype for *Emergent Alternative Home 2050* is investigated for proposed urban project sites that are discussed in chapter I. As deduced in chapter II, the primary users of this design are aging, single individuals.

Designing for 2050 incorporates a longer life span for its users, with a life expectancy up to 150 years. The aging process will slow down compared to 2013. As in any society, the physical and cognitive capacities of users will vary. However, on average, an 80-year-old in 2050 will have the physique of a 40-year-old healthy adult in 2013. With advancements in medicine, their cognitive ability will be stable, similar to a healthy 60-year-old in 2013.

My research suggests that the high density of aging population, and the shifts in the economy and family, will demand dependence on a supplementary support system. Autonomous systems along with robotic services are proposed to supplement the abilities, agility, accessibility, and endurances of the aging population. Dependence on such systems in turn requires careful consideration into energy-efficient designs, primarily because of the high concentration of aging individuals.

Other user requirements include social health and social stability.[200] Today's health facilities such as hospitals, laboratories, which are mandatory for supporting an

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[200] Ross Samson *ed., The Social Archeology of Houses* (Edinburgh University Press, 1990), 275.

elder population, will become obsolete and redundant by 2050. Along with advanced technology, personalized digital care, service robots, and ubiquitous infrastructure will replace many such conventional needs. Healthcare will incorporate enhanced virtual techniques and digital technology, advanced biotechnology, advanced pharmaceuticals, and robotics.

The fertility rate dropped over time, as large extended agricultural families gradually changed to nuclear families. By 2050, the family will dissolve to a single individual, and the community assumes the role as the smallest social unit. Community becomes significant in promoting physical and emotional health of the inhabitants.

In order to achieve a design that is minimal in nature, emphasis is needed to be given to lightweight materials with material and energy efficiencies. A design that is most suited for the tropical climate, and with consideration to changes in lifestyle over time. It also needs to cater to the changing needs of each individual and their choices, as well as the needs of the changing society that demands flexibility and adaptability.

A challenge exists to ensure individuality, privacy, and safety of the users. In *The Social Archeology of Houses* Samson discusses how privacy can be attained through simple design interventions. For instance, Samson discusses the visual illusion of separating the entrances, and the path, in semi-detached houses away from each other. Rather than having a central entrance, and a common path to both houses and positioning hall-ways further from each other. Although he attributes these design arrangements to the marketability of the semi-detached houses, privacy can be attained through similar design interventions.[201]

5.3.1. Site/Context

The urban environment of these project sites are discussed in chapter I and II. The land shortage and demand for housing creates an unprecedented need to increase density in 2050. The megacities will completely encroach every available open space. For this reason, the *Emergent Alternative Home 2050* project prototype will anchor itself onto extant buildings and grow as needed to facilitate the high density population of 2050. Being largely open spaces, transportation corridors and water course edges also hold potential for new construction. Such sites may also be available particularly, as there is little or no private ownership to these edge conditions.

The images below show examples of vertical and or horizontal urban edge conditions.[202]

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[201] Ross Samson *ed., The Social Archeology of Houses* (Edinburgh University Press, 1990), 274.

[202] Metropolis, "Megacities: Mexico City," http://www.metropolis.org/commission/megacities (accessed May 2, 2013); Travel Wallpapers, under "Tokyo," http://www.wallpaperstravel.com/view/tokyo-vacation-apartments-1024x768-travel.html (accessed May 2, 2013); Wave Mega City Center, "Commercial Office Space," Real Estate India.com, http://property.realestateindia.com/projects/wave-mega-city-centre-noida/ (accessed May 2, 2013); Wikimedia, "File: Hockley Heath-Water Edge, Dickens Heath.jpg," posted on September 7, 2008, http://commons.wikimedia.org/wiki/File:Hockley_Heath_-_Water's_Edge,_Dickens_Heath.jpg (accessed May 2, 2013).

Figure 41 Urban edge conditions by transport corridors and water courses

5.3.2. Environmental/Climatic Requirements:

The natural environment reaching near exhaustion is described in chapter II. In response to that the environmental improvements will be essential in 2050. They will be met through advanced materials, technology and interactive surfaces. Human comfort is proposed to be achieved through passive climatic control. For instance, via access to daylight and natural ventilation, noise reduction and provision of suitable acoustics.

5.4. Design Concept

The *Emergent Alternative Home 2050* proposes a generative, autonomous, synthetic organic habitat that is able to regulate its size and environment according to user needs. Simultaneously, it regenerates organic biodiversity. There are two distinct parts to it; a parent scaffold structure and a plurality of parasite-like cocoon or pod that attaches to it.

This design is a response to the challenge of land shortage, and the anticipated population peak in 2050. Previously undeveloped, open sites will be completely encroached by 2050. However, the corporate mega-towers of 2030 will be abandoned, due to the shift in the economy, environmental issues, and energy inefficiencies. This gives rise to an opportunity to utilize their façades, and structure as an available surface to inhabit. This phenomenon will create a new typology in architecture that occupies vertical surfaces.

This design is propagated by a coordinated team of nano-bots infesting an existing building. Collectively, they demolish the nonstructural interior of the building and deposit the demolished materials on the ground along the external surface of the façade. Following that, an abiotic process rapidly synthesizes organic molecules from the deposited inorganic materials. This is carried out through a complex biochemical coding process and using a catalyst deposited by the nano-bots. This can be thought of as a process that is analogous to earthworm converting organic matter into humus and regenerating the fertility of soil.

Assisted by the nano-bots, the organic components that are coded to autonomously generate, begin to self-assemble or grow a structural composite. An adaptable, resilient web of tubular, organic, clear, extrusions sprouts and takes over the existing façades, in matter of days. This structural scaffold develops in two directions creating a web, as it wraps around the façades of abandoned buildings. In elevation view, the tubes spiral perpendicular to each other to create this web of scaffold. As the extrusion gets taller, lower levels gets thicker and stronger, at times penetrating through the soil and creating an underground network. While functioning as a structural foundation system, these underground spaces later serve as spaces to process and store nutrient systems essential for humans, and store the surplus of accumulated materials.

The multifunctioning structural scaffold is conceptualized as a hybrid between a tree stem and a root, capturing the cross sectional microscopic cell structure properties. Therefore, the structural scaffold will function like a biological system, similar to stems and root of a tree, to exchange and distribute services. In addition to providing infrastructure, medical and other routine services needed by the pods, the structural scaffold also transfers energy harvested by the biomimetic cells. The transfer of nutrients required for the growth of synthetic organic plant environment that originates from it, and the nutrients required by the humans living in the attached pods, are also embedded in the structural scaffold of the *Emergent Alternative Home 2050.* In essence, it replaces many conventional services required by humans in 2013.

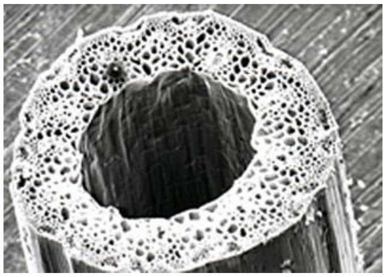
[203]

Figure 42 A cross-section of a plant stem (Photo by Prof. Lorna Gibson)

The structural scaffold-with an anatomy of a biomimetic cellular structure-uses genetic codes to initiate a controlled growth of the synthetic organic plants that originate from the external surface of the structural scaffold. The synthetic photosynthesis mechanism that is embedded in the biomimetic cells in these plant components captures and harvest solar energy. This energy is then transferred to the underground storage facility in each community, through the structural scaffold. This is a primary component that facilitates the autonomy of this design.

Once the structural scaffold establishes a safe path of its own to distribute the load, including a system of lateral bracing, the nano-bots activate the demolishing of the structural components from the existing building. Demolishing starts from the top, and

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[203] Lorna Gibson," Freshman Seminar: The Nature of Engineering," MIT, under "Plant Stem," http://ocw.mit.edu/courses/materials-science-and-engineering/3-a26-freshman-seminar-the-nature-of-engineering-fall-2005/index.htm (accessed May 2, 2013).

then gradually moves to lower levels. These materials are transferred to a below ground processing level for up-cycling into organic elements and components.

Within a matter of hours from the first propagation of the structural scaffold, it begins to facilitate the pods to attach to it. Essentially, these pods are climatic envelopes that attach to the structural scaffold similar to a parasite. Wearing their pod as a suit, the humans are able to freely navigate across the structural scaffold and anchor on to any available place. The embedded advanced digital technology in the suit or the pod coordinates their navigation. A number of retractable devices that act as a rag bolt or a pin with a hook on its shaft, further anchor the pod to the structural scaffold. This device uses the biomimicry mechanism that mimics mosquitoes' serrated mandibles, to tap into the infrastructure services available in the structural scaffold. The pod is able to then draw services and nutrients from the structural scaffold using multiple of these devices.

The connection to the infrastructure allows the suit to inflate, drawing the necessary compressed air from it. Basic architectural standards such as ergonomic and anthropometric data are used to design the pod or the *Emergent Alternative Home 2050*. The minimal needs of a low mobility user are illustrated in the following architectural drawings as an extreme case. However, the presented drawings should not be considered as a static, permanent architectural solution. Instead, the flexibility of the pod, structural scaffold and the macro level concept, is presented taking into account possible variations due to social, health and economic preferences.

The pod itself incorporates biomimetic and biotechnology techniques and materials, and hangs on the structural scaffold. The pod uses a pneumatic space in the floor to maintain its upright position.

The exterior of the pod is a tensile mesh that acts as an exoskeleton made from advanced durable, elastic, tough, biopolymer. The passive climatic envelope is an egg-shaped inflatable pouch. Selected panels of this pouch structure use advanced bio-thermal material that curl when heated, and close when contacted with water. The surface uses an advanced technology that mimics a lotus leaf, to provide self-cleaning and self-repair.

The envelope is a malleable surface that can be molded, by pulling, pushing and twisting motion of a digital finger glove technology, from within or using assistance from advanced digital communication between the surfaces and the user, via its communication system. The internal layout offers a stretchable, continuous surface of a single open unified interior. The embedded technology allows specially customized parts of the envelope to function as an interactive system. For instance, the interior ceiling is a surface that provides interaction and information inputs and outputs. For less mobile users-who are mostly lying on their back-this is a primary surface of interaction. It includes forms of surveillance, communications and entertainment.

These pods are self-repairing, autonomous, highly flexible or adaptive version of a minimal version of 2013's studio type living. The malleability and elasticity of the pod allows it to be reconfigured for variations due to status of health or sociable preference of the user. They have the option to expand and interlink, giving opportunity for smaller units to cluster with other pods as required. People requiring isolation can remain in the private envelope with little or no contact with others. Comfort is achieved though shading and ventilation that lower humidity.

The pods withstand wind uplift, and will have minimum impact from seismic factors. This is due to the materials properties of advanced biomaterial construction of the pod and structural scaffold. The lightweight, strength, elasticity, and toughness aid in withstanding these natural impacts. During high magnitude natural disaster, the mobility of the pod ensures its safe evacuation from dangerous areas.

Orientation for sleeping area is easily configured in individual pods establishing the cooler side of room, for instance, in the north which accumulates least sun exposure. Alternatively, the pods may move to the north façade for sleeping.

After the existing mega-structures are demolished, large, internal open spaces are created within the structural scaffolds. This new internal environment is used for communal spaces and recreational facilities. Bridge-like, lateral link structures provide lateral stability to the structural scaffold. These link structures serve a dual purpose. Then serve as circulation systems to connect community facilities. This minimizes the commuting distance, and promotes easy communal interaction, especially for people with low mobility. These circulation routes make commuting to ground plane less needed. Accordingly, a defined connection to a common ground plane or a point of entry to the habitat, and an organized circulation system is deliberately left ambiguous. Individuals are therefore free to circulate in a variety of vertical and horizontal routes.

The internal hollow space in the structural scaffolds allows light to penetrate. This enhances energy harvesting by the synthetic organic plants, and provides natural light to the pods.

My design project promotes and adheres to user comfort, well-being, and reestablishing the biosphere for user survival to be of highest value.

5.5. Preliminary Design Program

The minimum interior space for a pod is defined by the ergonomics of person's reach and space clearance for a single person: Approximate minimum of 86"x 70"x 86" (Approximately 7'-0"x 5'-6"x 7'-0") taken from anthropometric data for a male in the 95th percentile. However, since the envelope is stretchable, the interior dimensions can be pushed and pulled as to the user's desire. Considering an expandability of a magnitude of five in two directions, the maximum extensions of a single pod would vary from about 150 square feet to 3300 square feet. The smallest spaces will primarily cater for the least mobile users, supported with digital communication and nano-bot assistance. They would typically be in horizontal laying position. Depending on the physical condition and preferences of the users, they may have varying space requirements; larger space for maneuverability for the user, or owing to the selection of large interior spaces, which is a personal preference. Other users may decide to take advantage of tactile functions of the pod and keep to the minimum dimensions. Opening sizes for access ways and circulation vary according to the user requirements; maximum entry way to a pod would be 7'-0"x 3'-0."

A database that is incorporated into the specialized surfaces in the pod digitally monitor the user's personal health. The underground storage and the nutrient processing systems are closely linked to provide complete services, especially in the case of any health emergency.

The interior program includes spaces for sleeping, sanitation station, semi-public or transition spaces, and social spaces. However, due to the malleability of the envelope these shapes can be configured by the user.

Identified community spaces include the hollow interior of previous buildings, ledges of the existing structure waiting to be demolished. Typically these spaces would include the community's remote wellness centers; clinics, dialysis, surgery, physiotherapy, spas, gyms, pharmacies, convenience centers, social and entertainment spaces, swimming pools, digital libraries, and tele-portals to virtual worlds (similar to the movie *Avatar*)[204] are new additions.

Flexibility in use is of prime importance. As discussed earlier, depending on the need for extension to contraction, or space transformations to suite individual changing need is accommodated.

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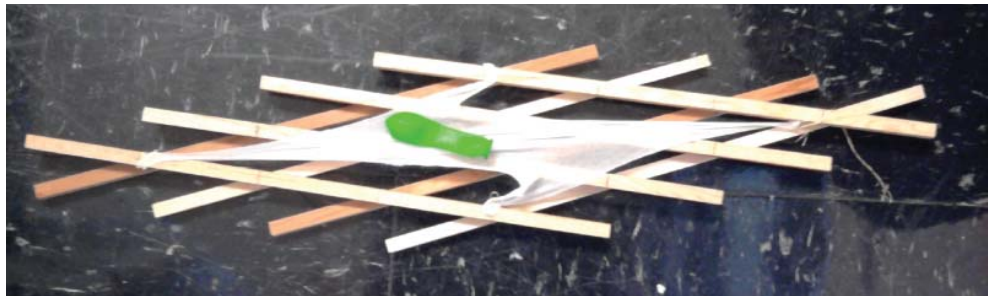
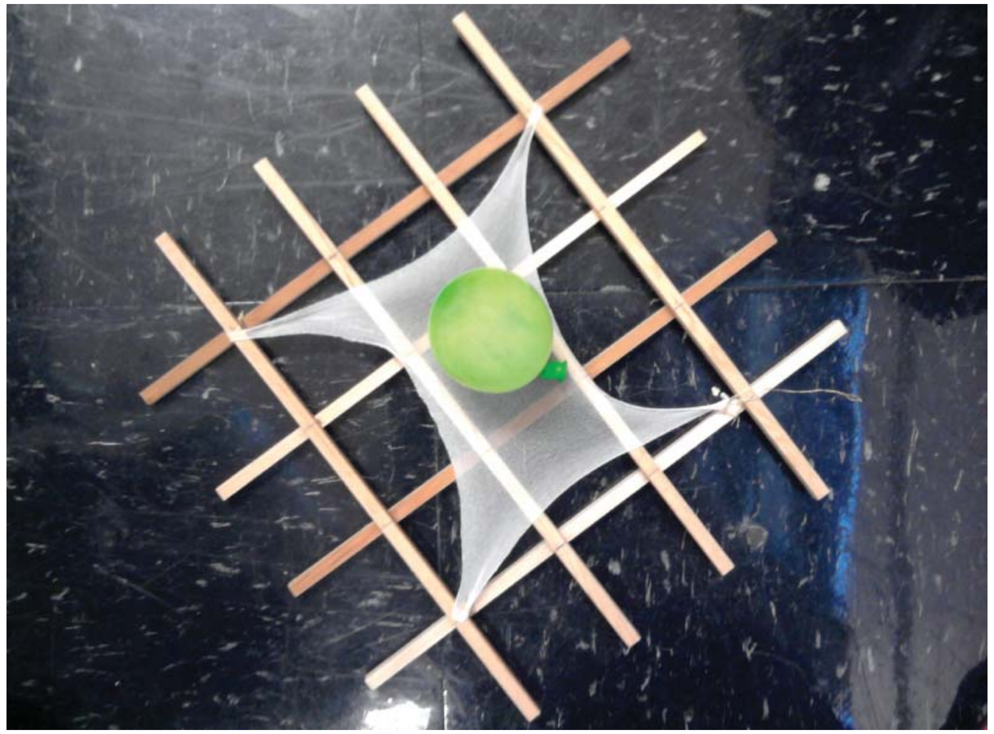
[204] James Cameron et al., *Avatar*, Beverly Hills, CA: 20th Century Fox Home Entertainment, 2010.

EXPERIMENTAL CONCEPT MODELS - EXPANDABLE, LIGHT WEIGHT

EXPANDABLE SCAFFOLD + POD

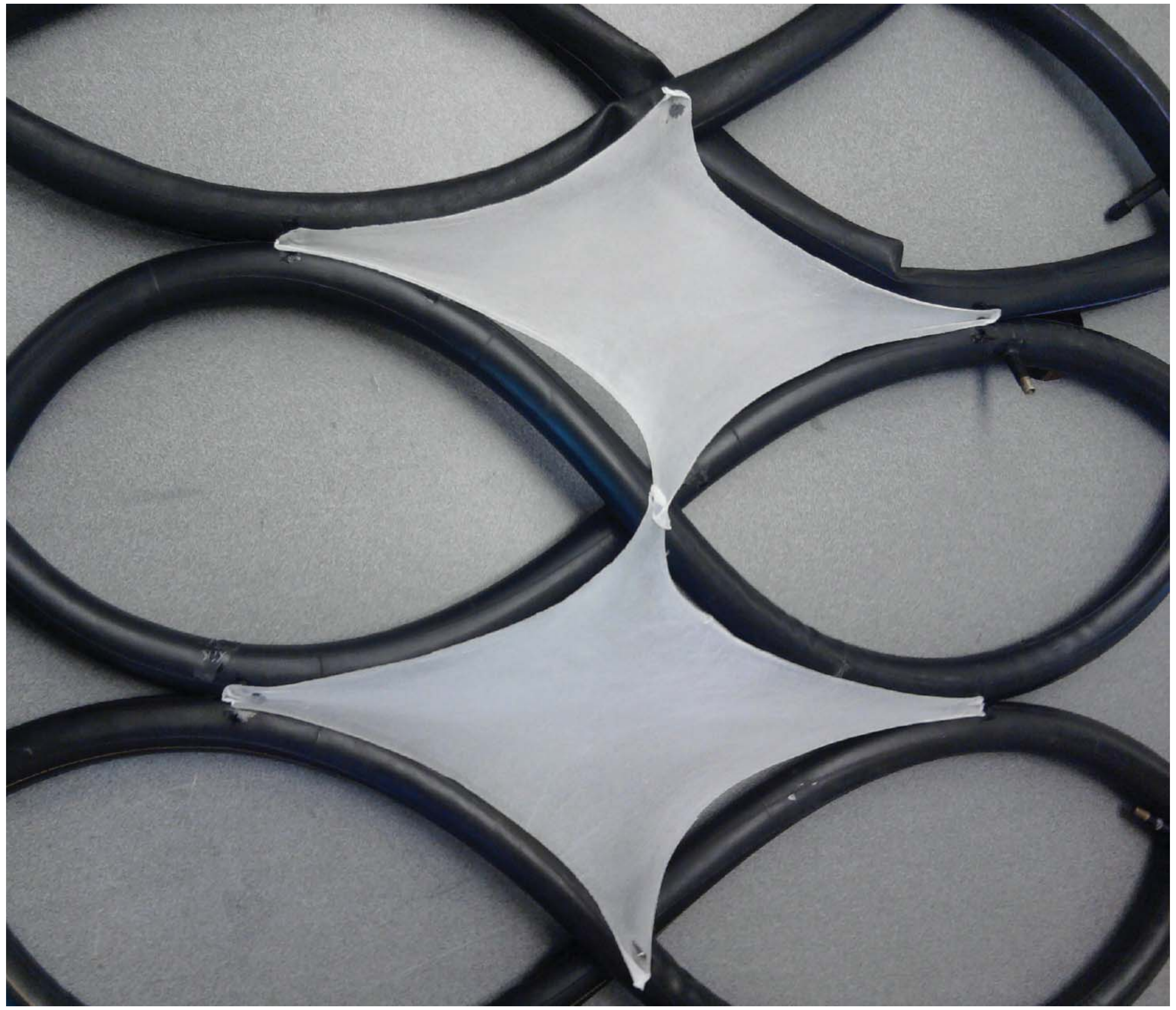


CONTRACTED SCAFFOLD AND DEFLATED POD



EXPANDED SCAFFOLD AND INFLATED POD

PNEUMTIC SCAFFOLD + EXPANDABLE POD

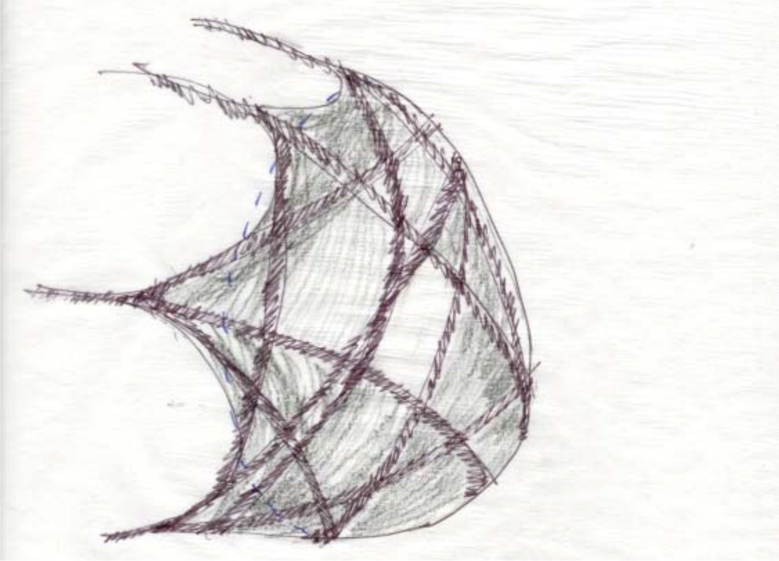


INFLATED SCAFFOLD AND EXPANDED POD

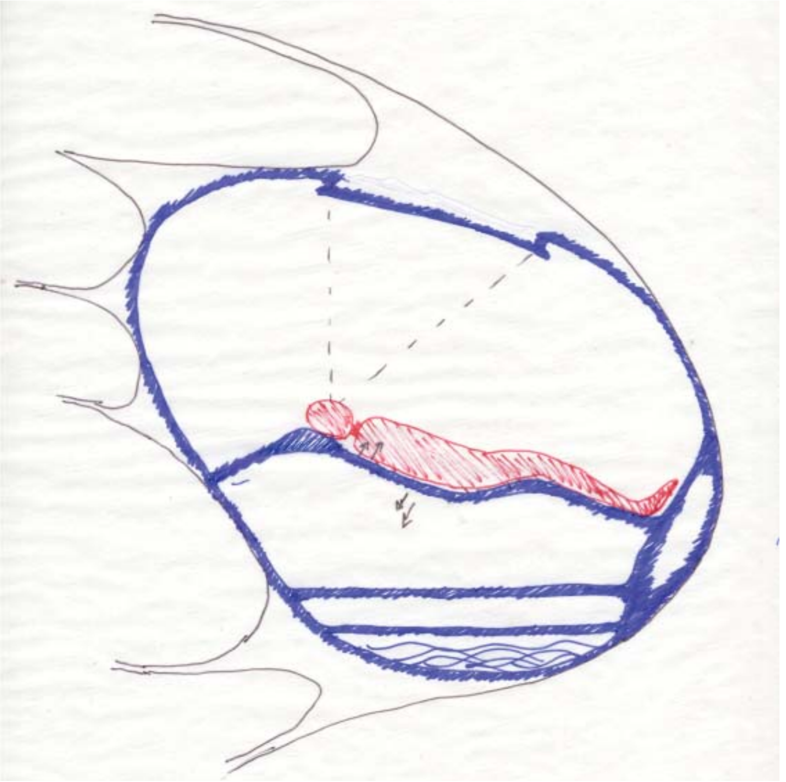
Figure 43 Experimental conceptual models - prototype pod and scaffold

CONCEPTUAL SKETCHES

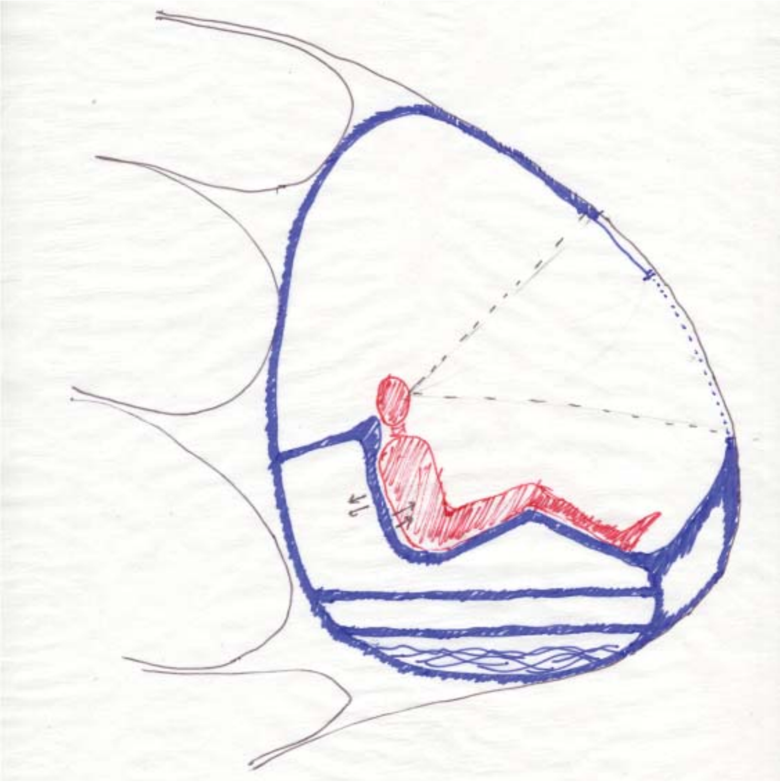
POD



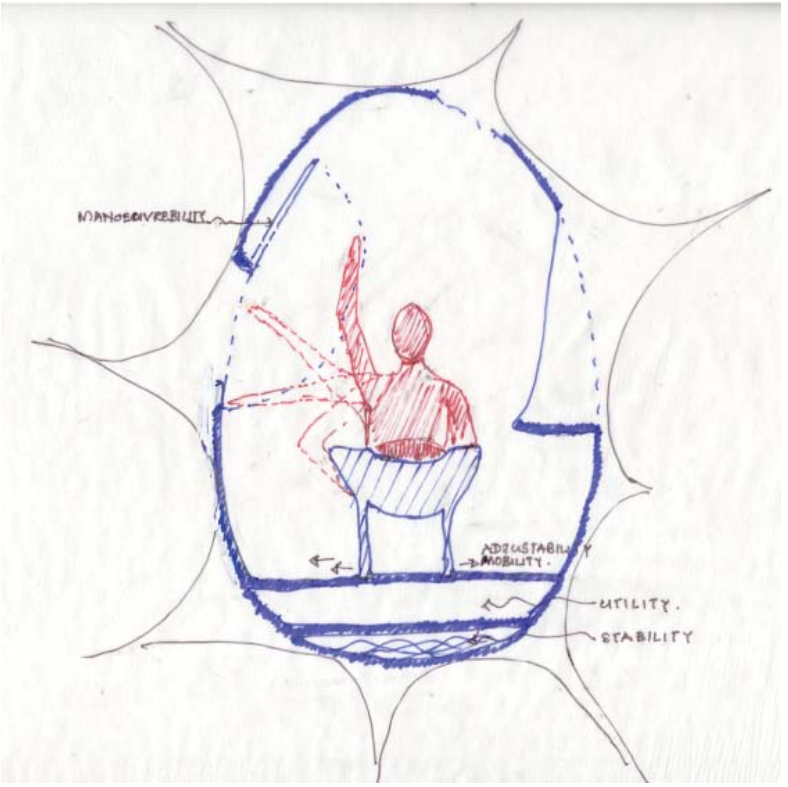
POD ELEVATION - A



POD SECTION - A OPTION 1



POD SECTION - A OPTION 2

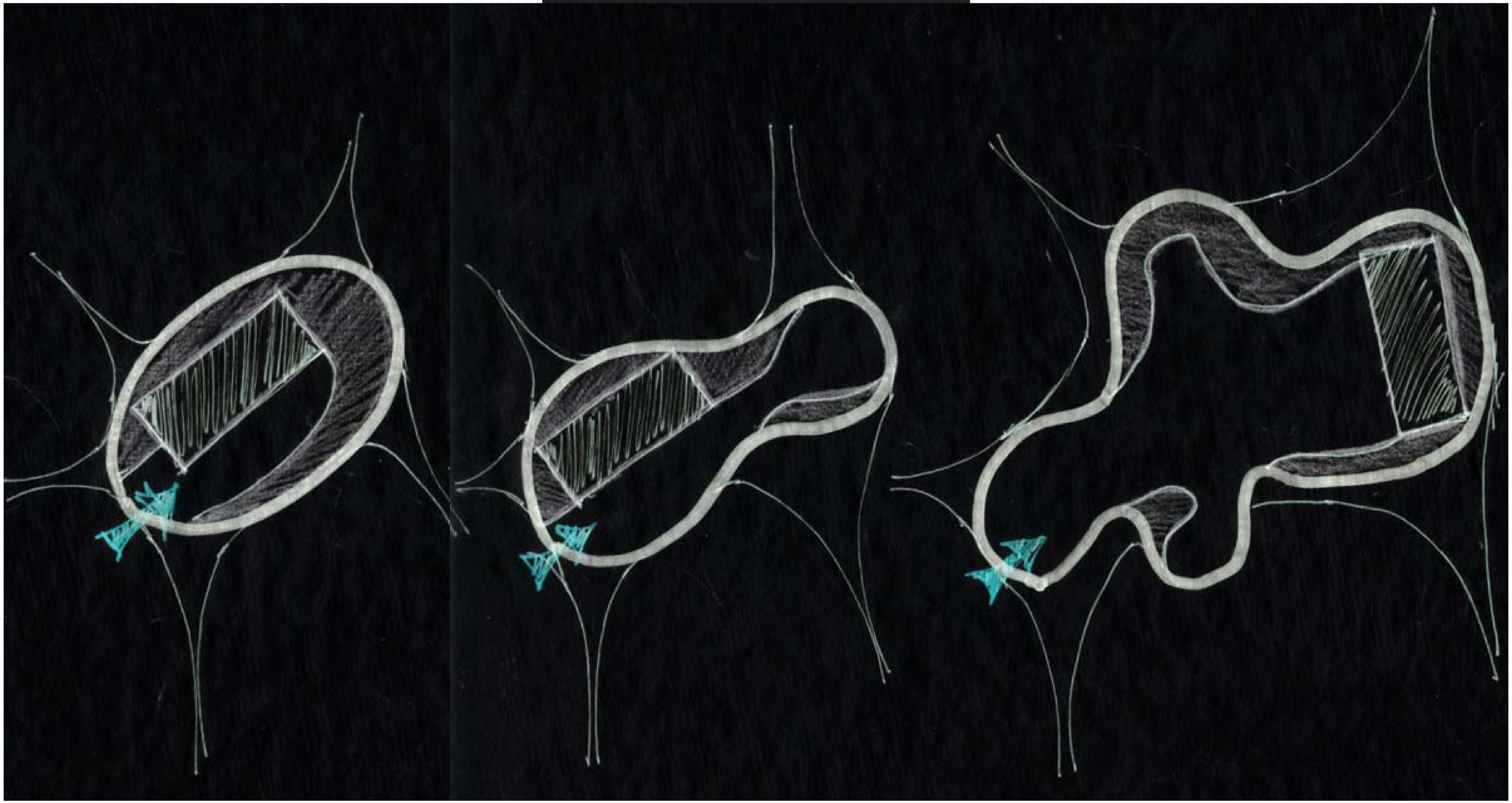


POD SECTION - B OPTION 2

Figure 44 Prototype pod - conceptual sketches

FLEXIBILITY - EXPANDABILITY/ MALLEABILITY

POD MORPHOLOGY OPTIONS



POD OPTION-X

POD OPTION-Y

POD OPTION-Z

Figure 45 Prototype pod flexibility - expandability/ malleability

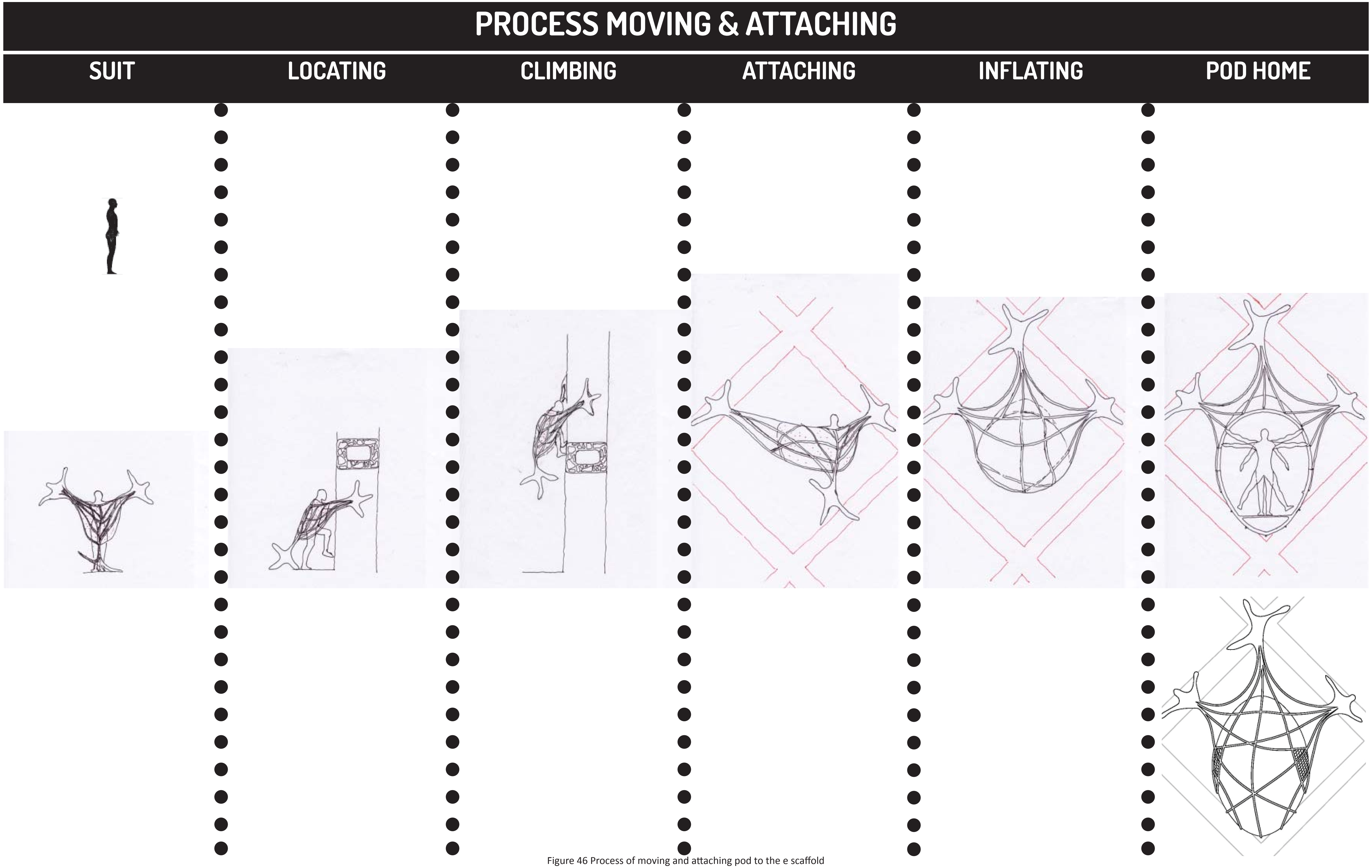
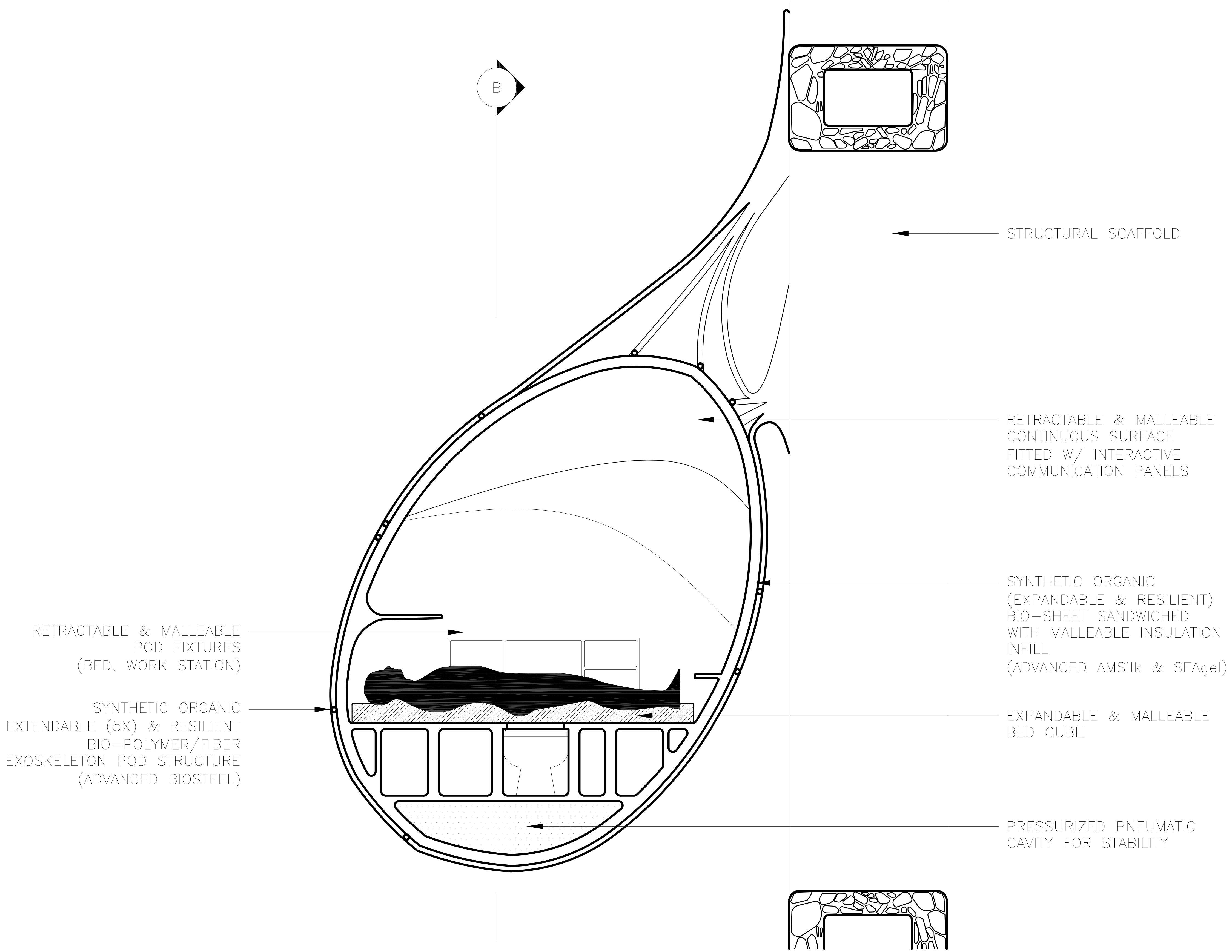
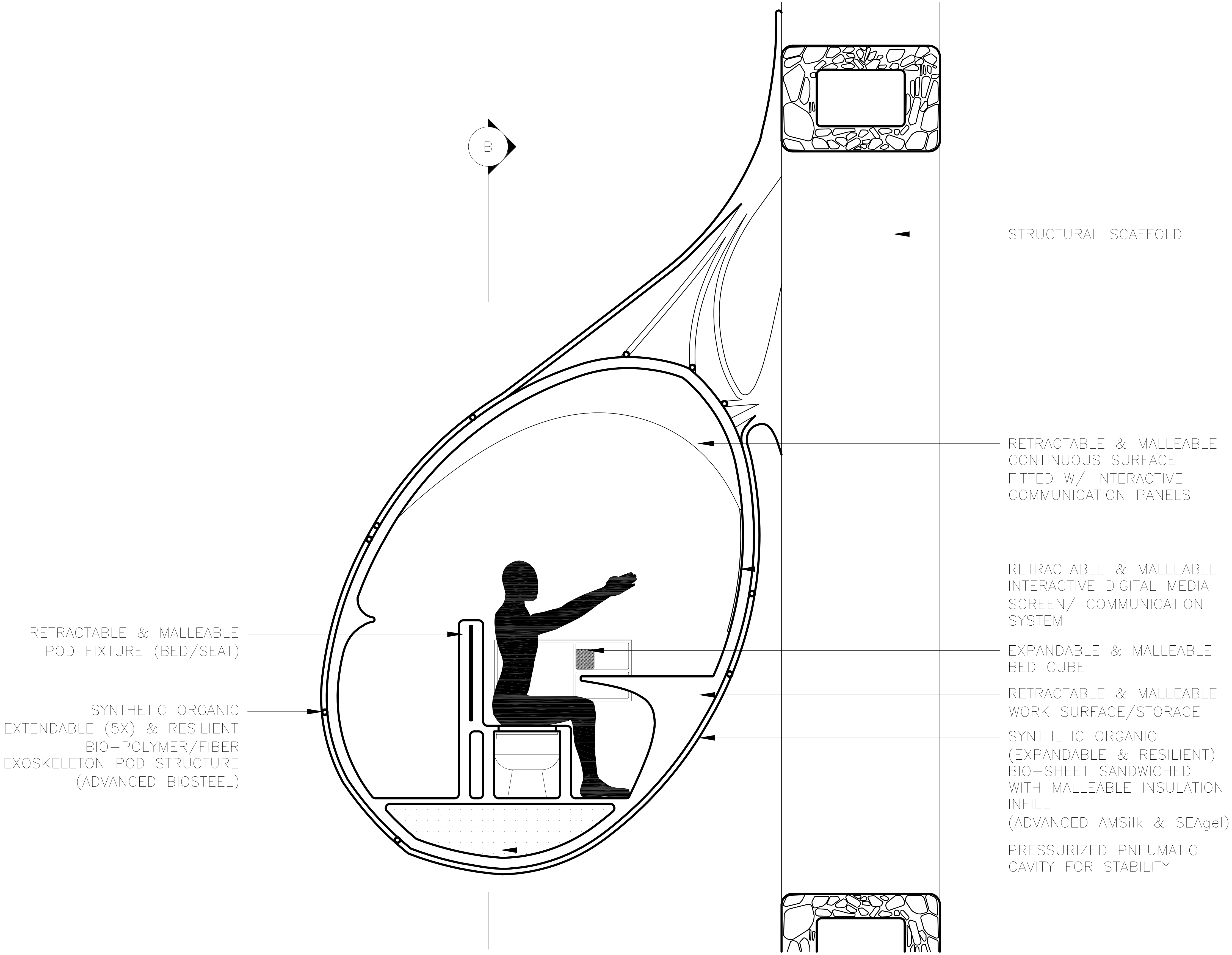


Figure 46 Process of moving and attaching pod to the e scaffold



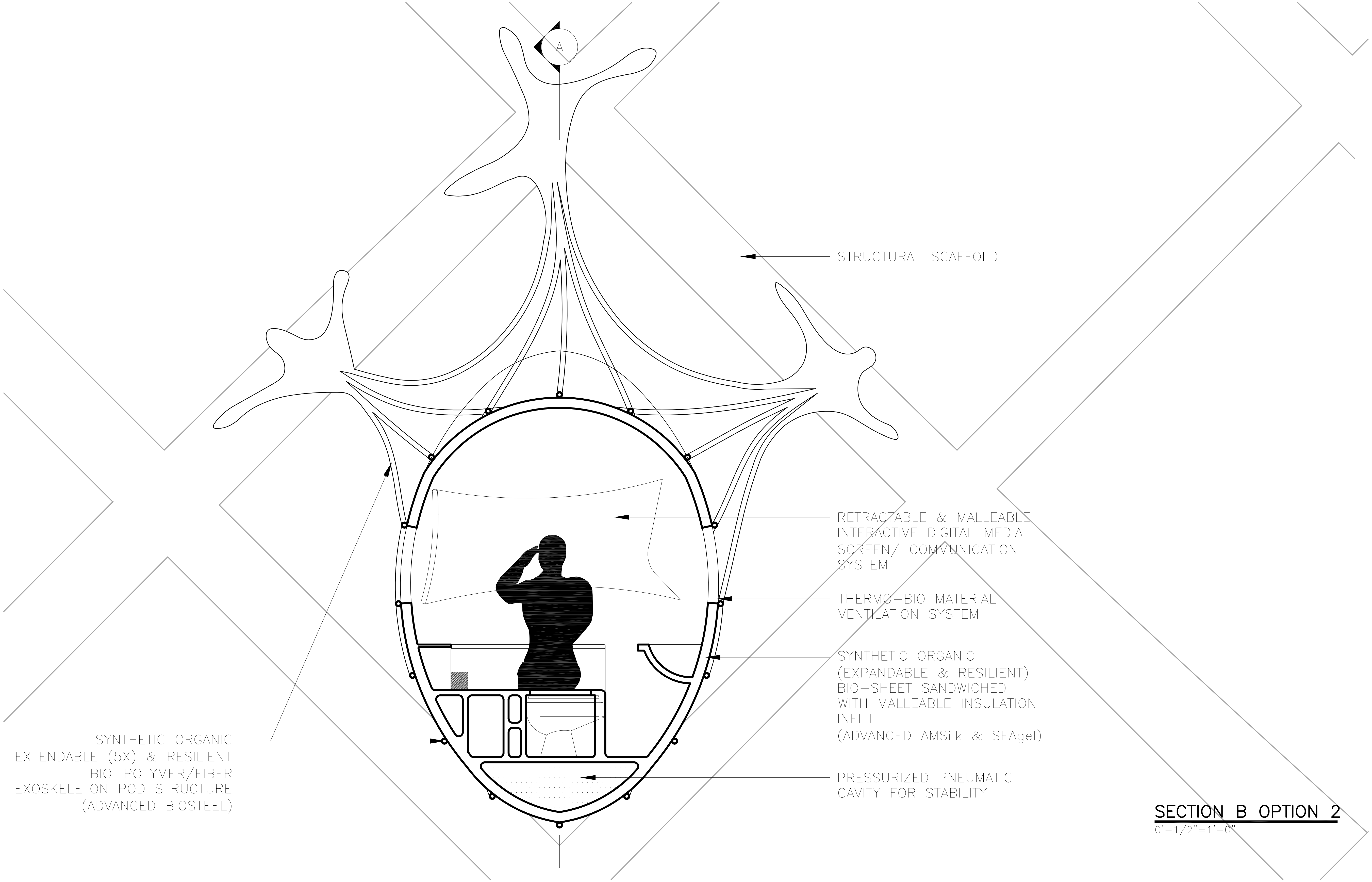
SECTION A OPTION 1

0'-1/2"=1'-0"



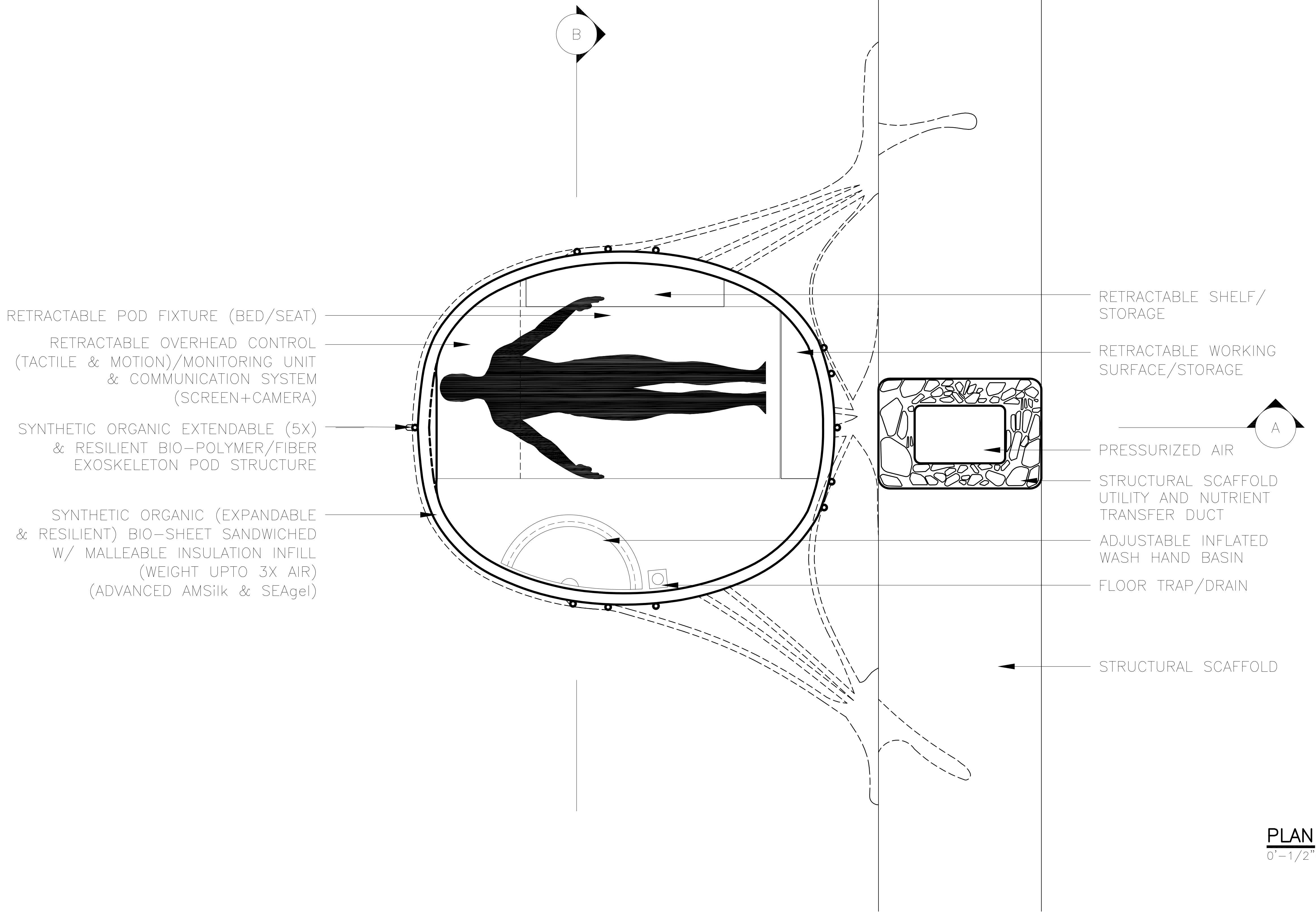
SECTION A OPTION 2

0'-1/2"=1'-0"



SECTION B OPTION 2

0'-1/2"=1'-0"



RETRACTABLE POD FIXTURE (BED/SEAT)

RETRACTABLE OVERHEAD CONTROL (TACTILE & MOTION)/MONITORING UNIT & COMMUNICATION SYSTEM (SCREEN+CAMERA)

SYNTHETIC ORGANIC EXTENDABLE (5X) & RESILIENT BIO-POLYMER/FIBER EXOSKELETON POD STRUCTURE

SYNTHETIC ORGANIC (EXPANDABLE & RESILIENT) BIO-SHEET SANDWICHED W/ MALLEABLE INSULATION INFILL (WEIGHT UPTO 3X AIR) (ADVANCED AMSilk & SEAgel)

RETRACTABLE SHELF/ STORAGE

RETRACTABLE WORKING SURFACE/STORAGE

PRESSURIZED AIR

STRUCTURAL SCAFFOLD UTILITY AND NUTRIENT TRANSFER DUCT

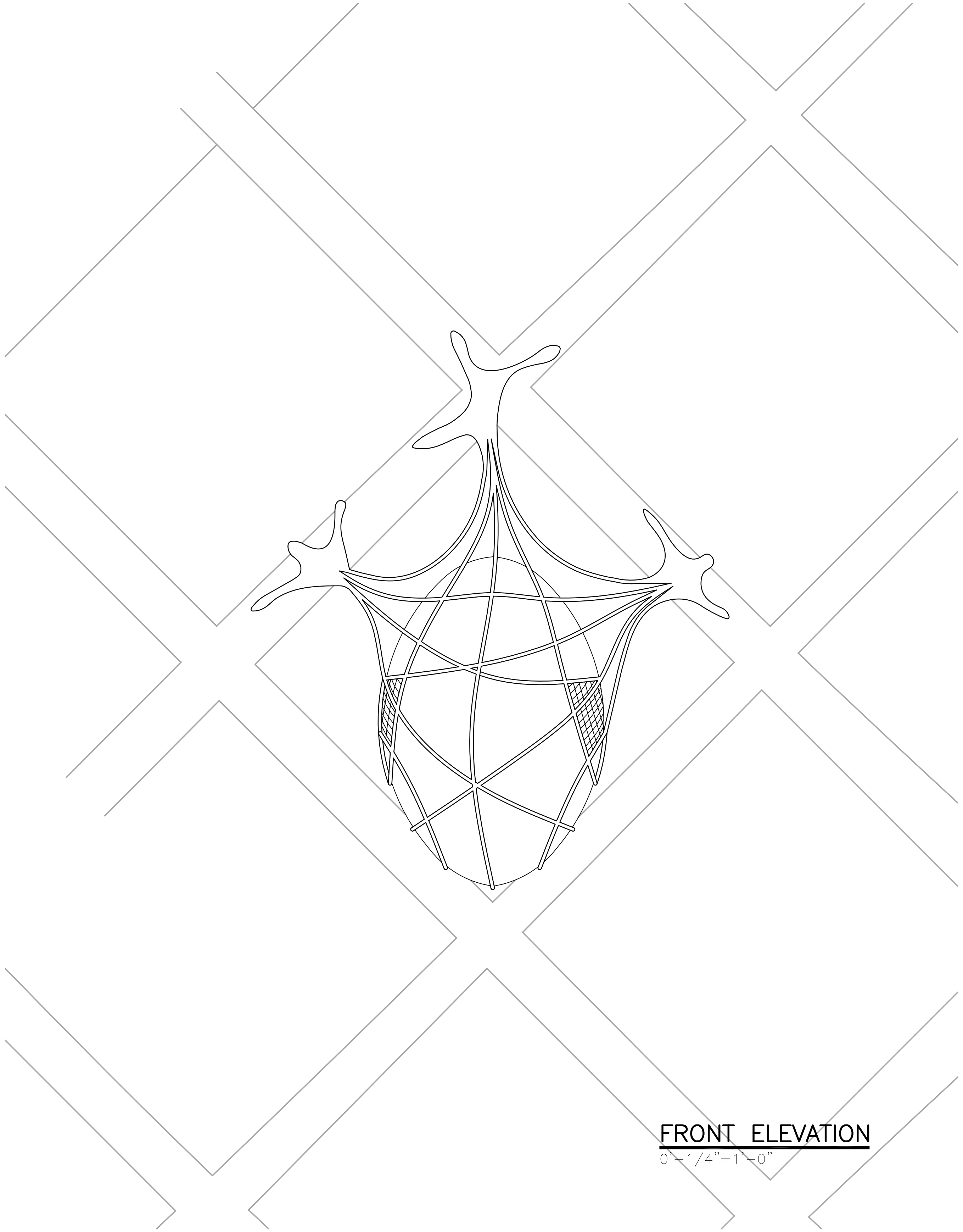
ADJUSTABLE INFLATED WASH HAND BASIN

FLOOR TRAP/DRAIN

STRUCTURAL SCAFFOLD

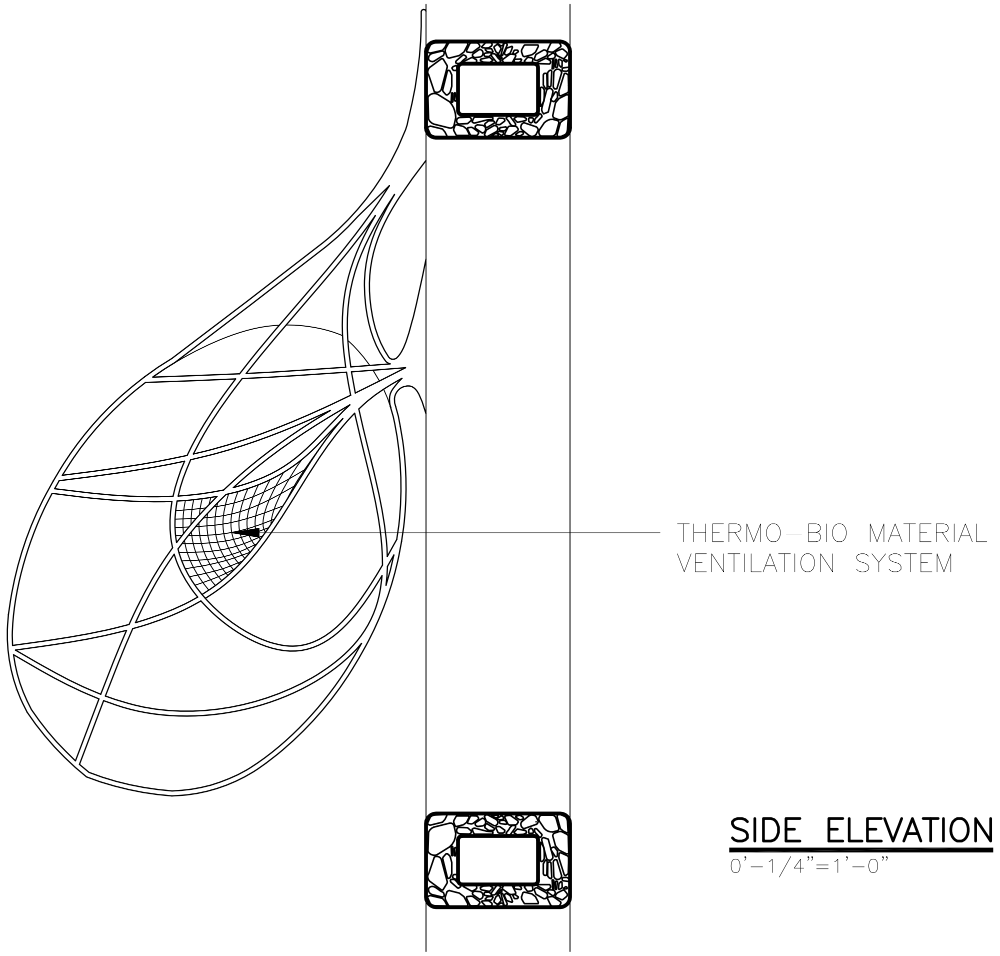
PLAN

0'-1/2"=1'-0"



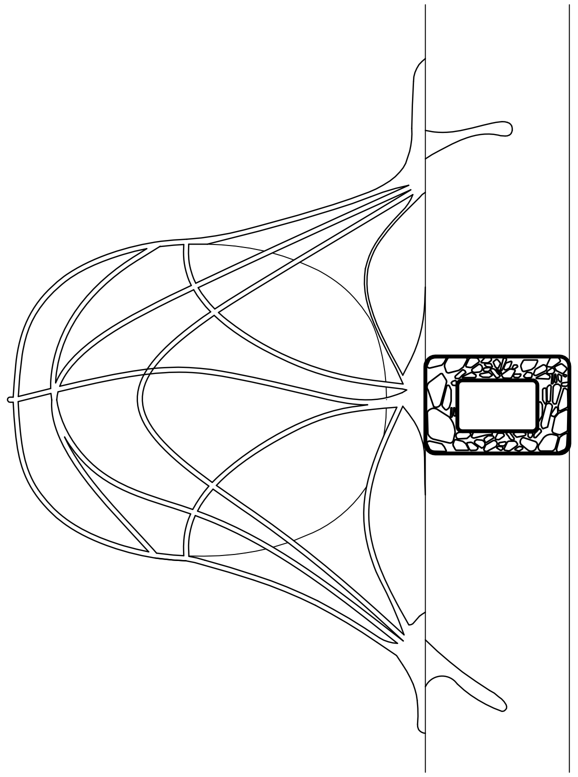
FRONT ELEVATION

0'–1/4"=1'–0"



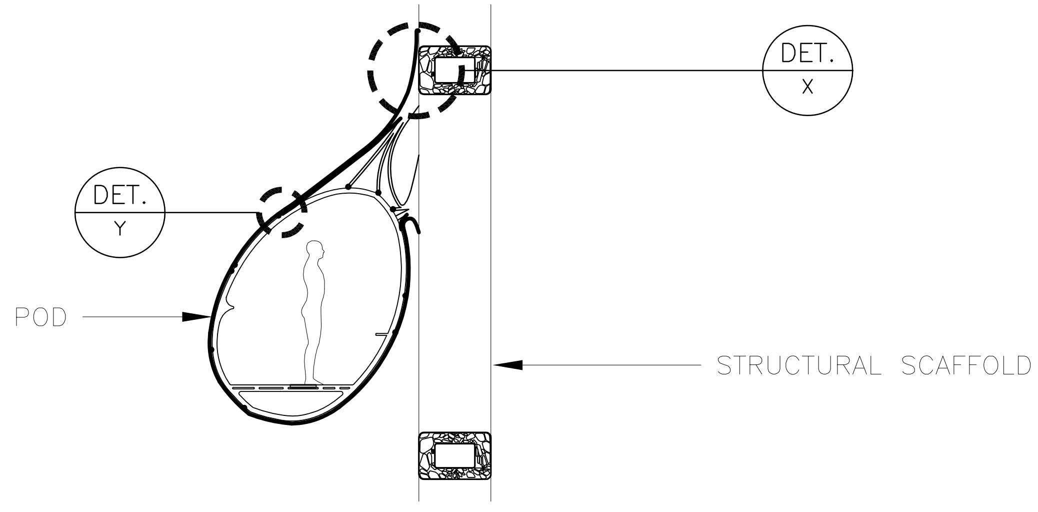
SIDE ELEVATION

0'–1/4"=1'–0"



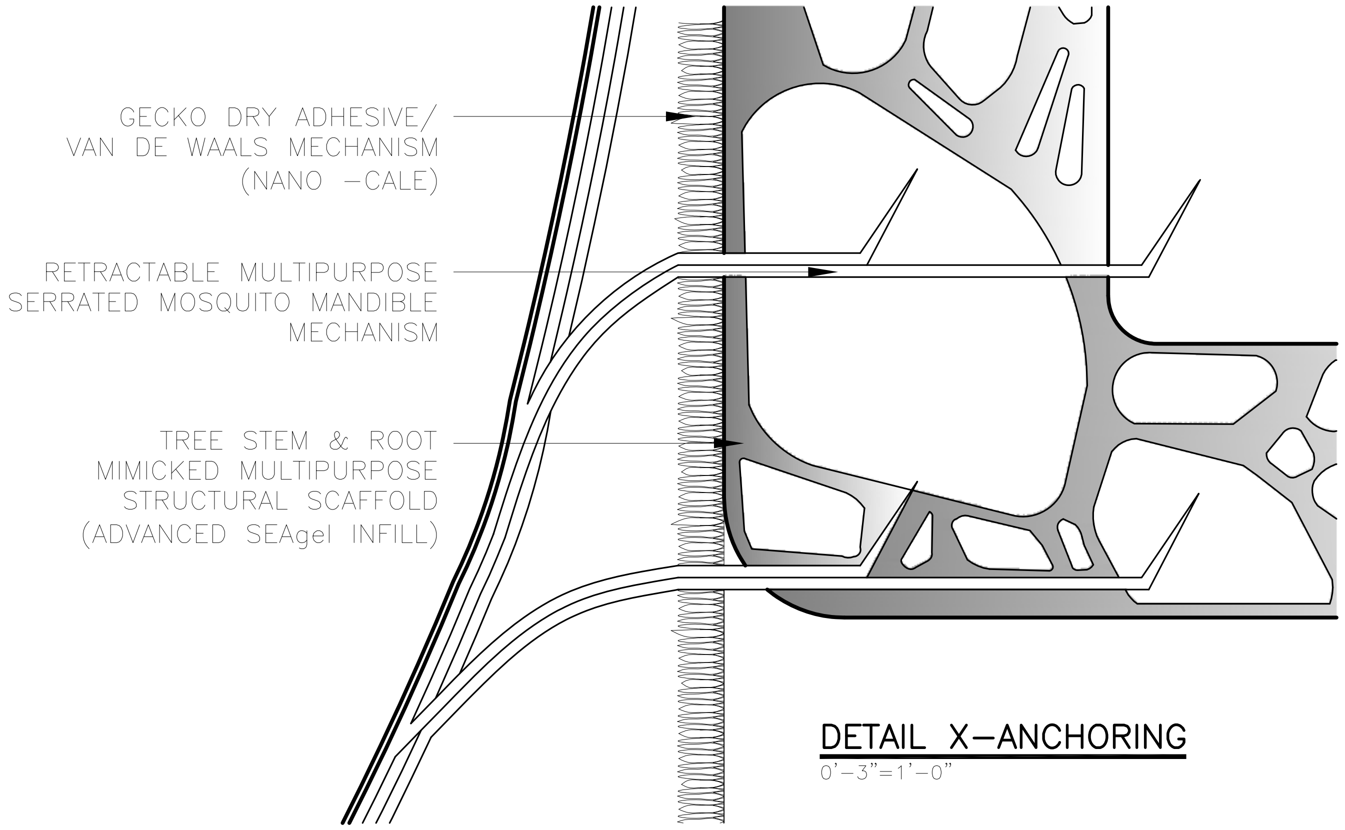
ROOF PLAN

0'–1/4"=1'–0"



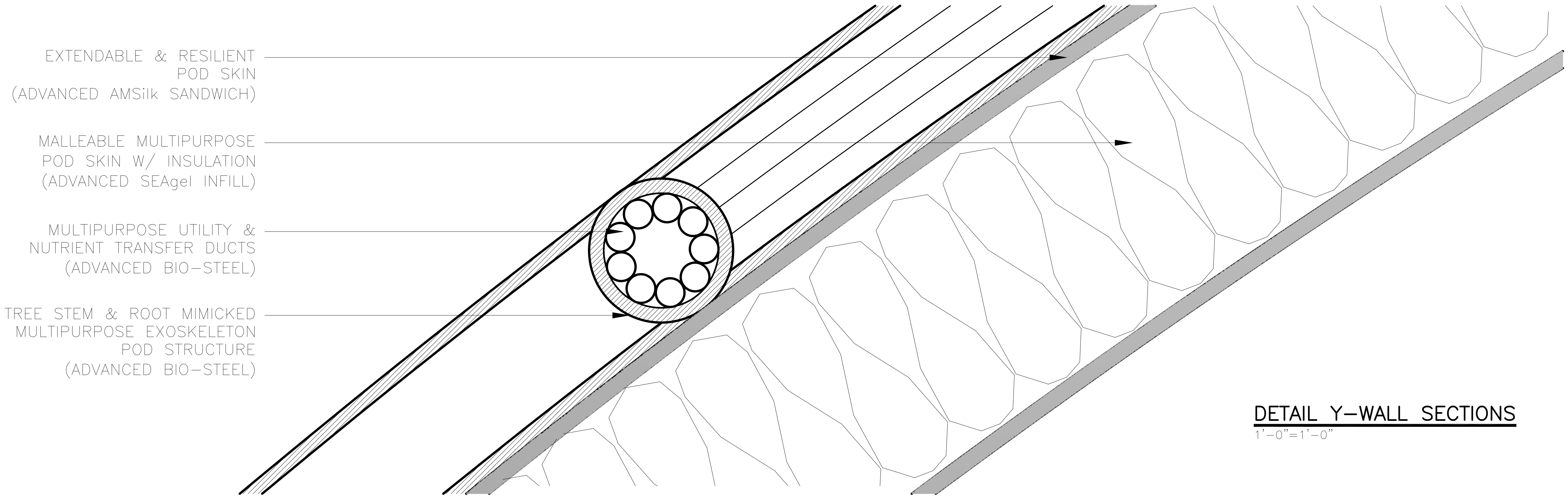
KEY

0'–1/8"=1'–0"



DETAIL X—ANCHORING

0'–3"=1'–0"

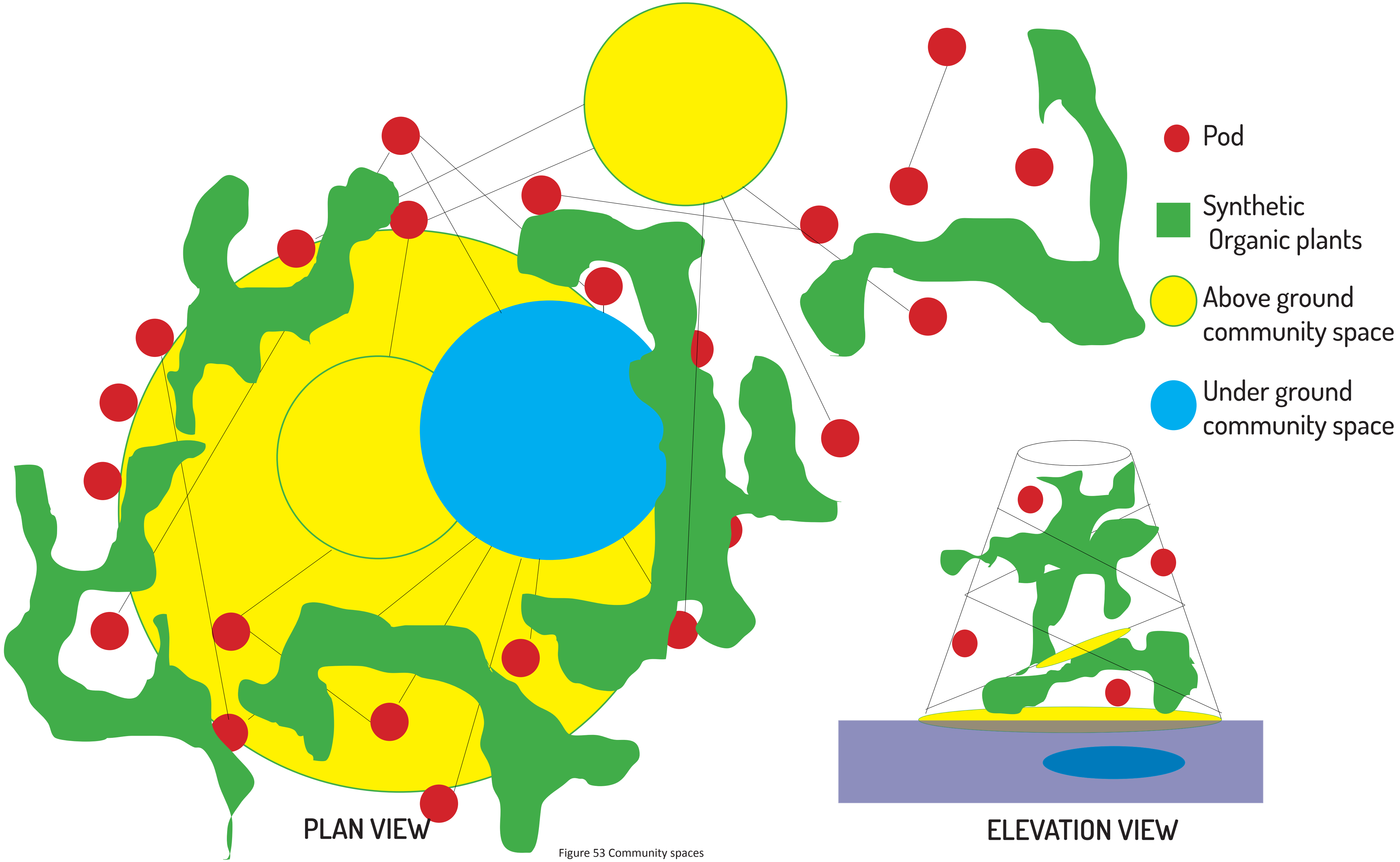


DETAIL Y—WALL SECTIONS

1'–0"=1'–0"

CONCEPTUAL ABSTRACT REPRESENTATION OF LAYERED COMMUNITY SPACES

PROPOSED COMMUNITY SPACES WITHIN AN INDIVIDUAL HABITAT



PLAN VIEW

ELEVATION VIEW

Figure 53 Community spaces

CLUSTER FLEXIBILITY - ENLARGE/ EXPAND

COMMUNITY FORMATION

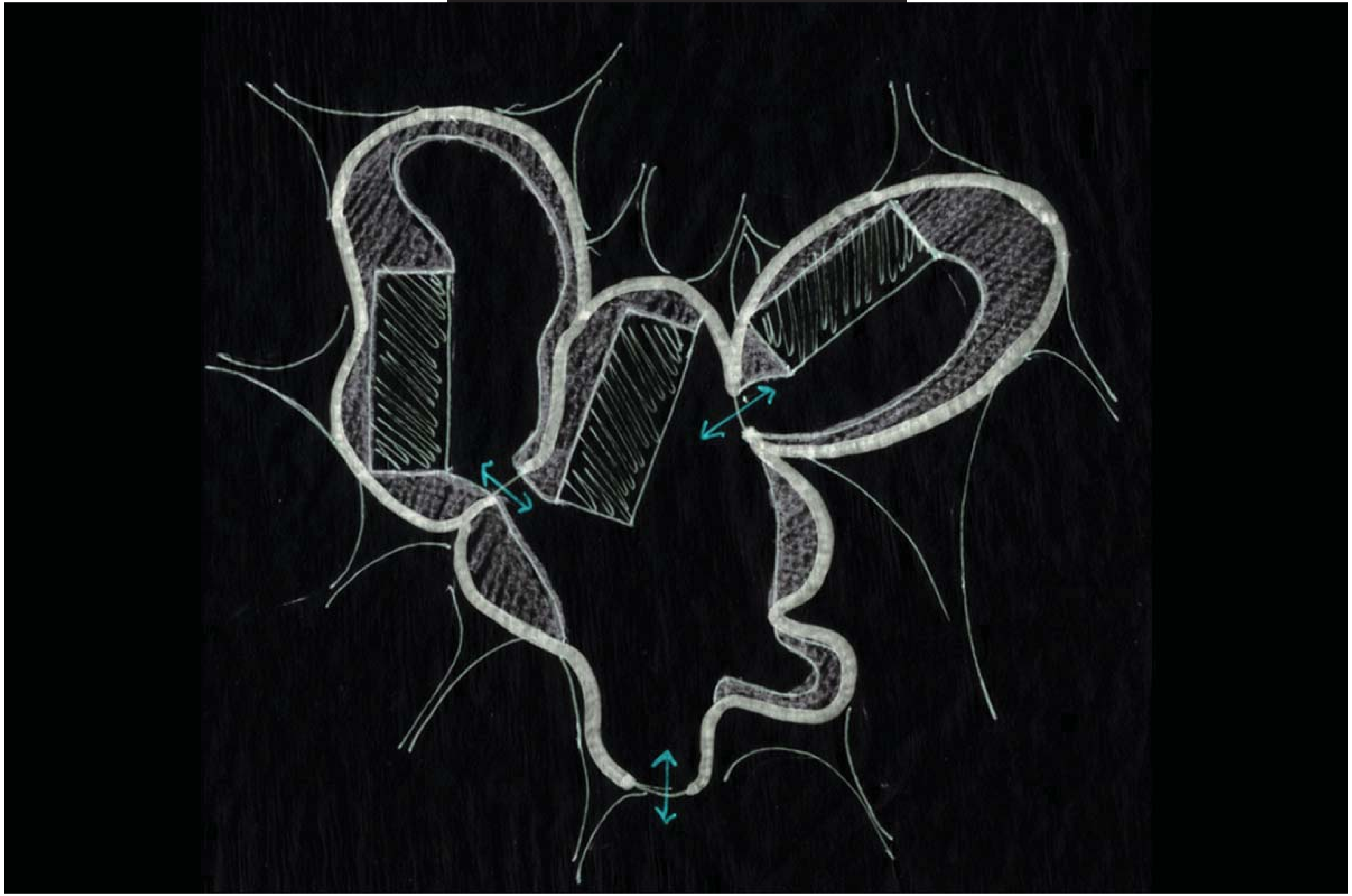
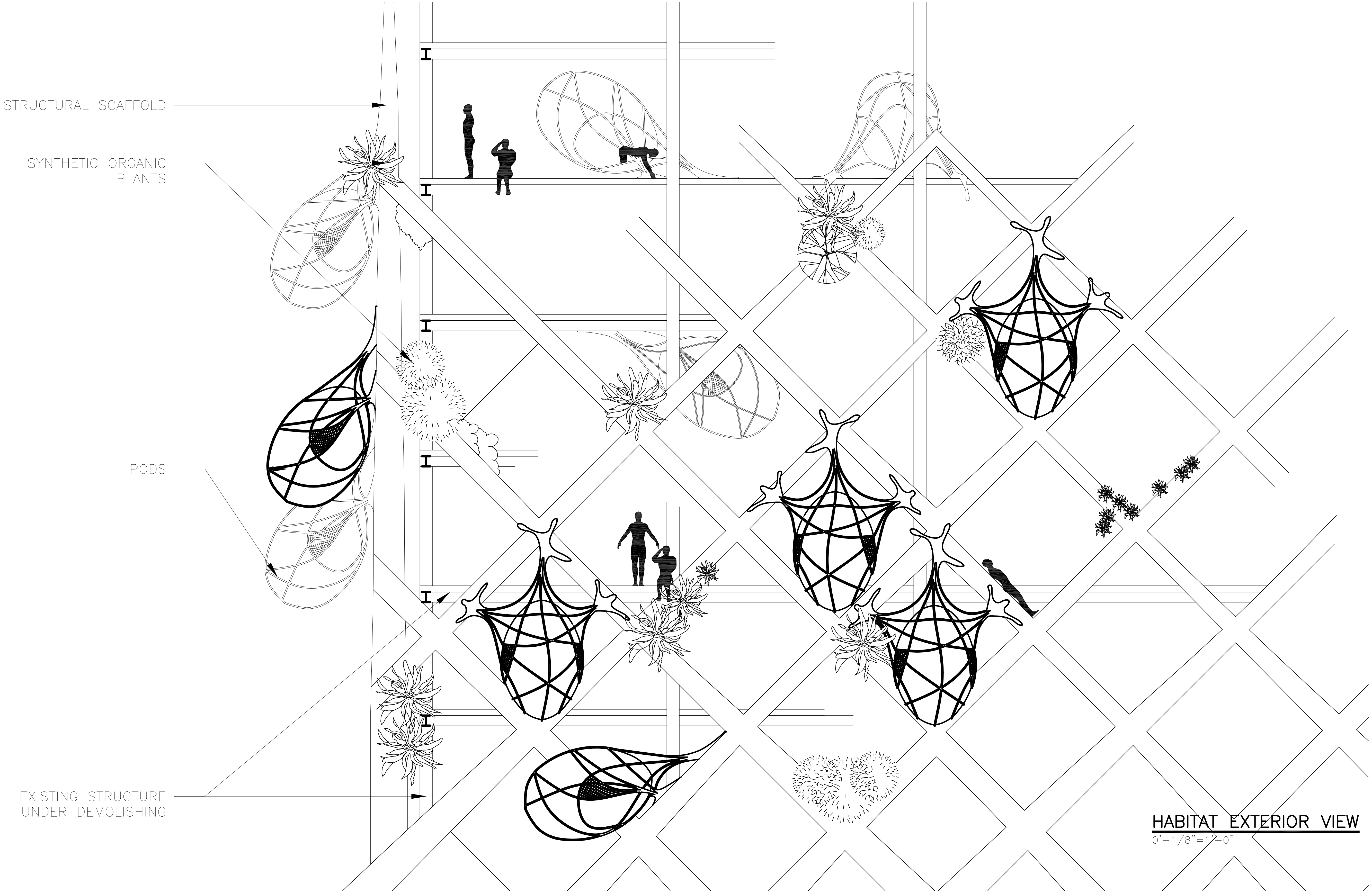
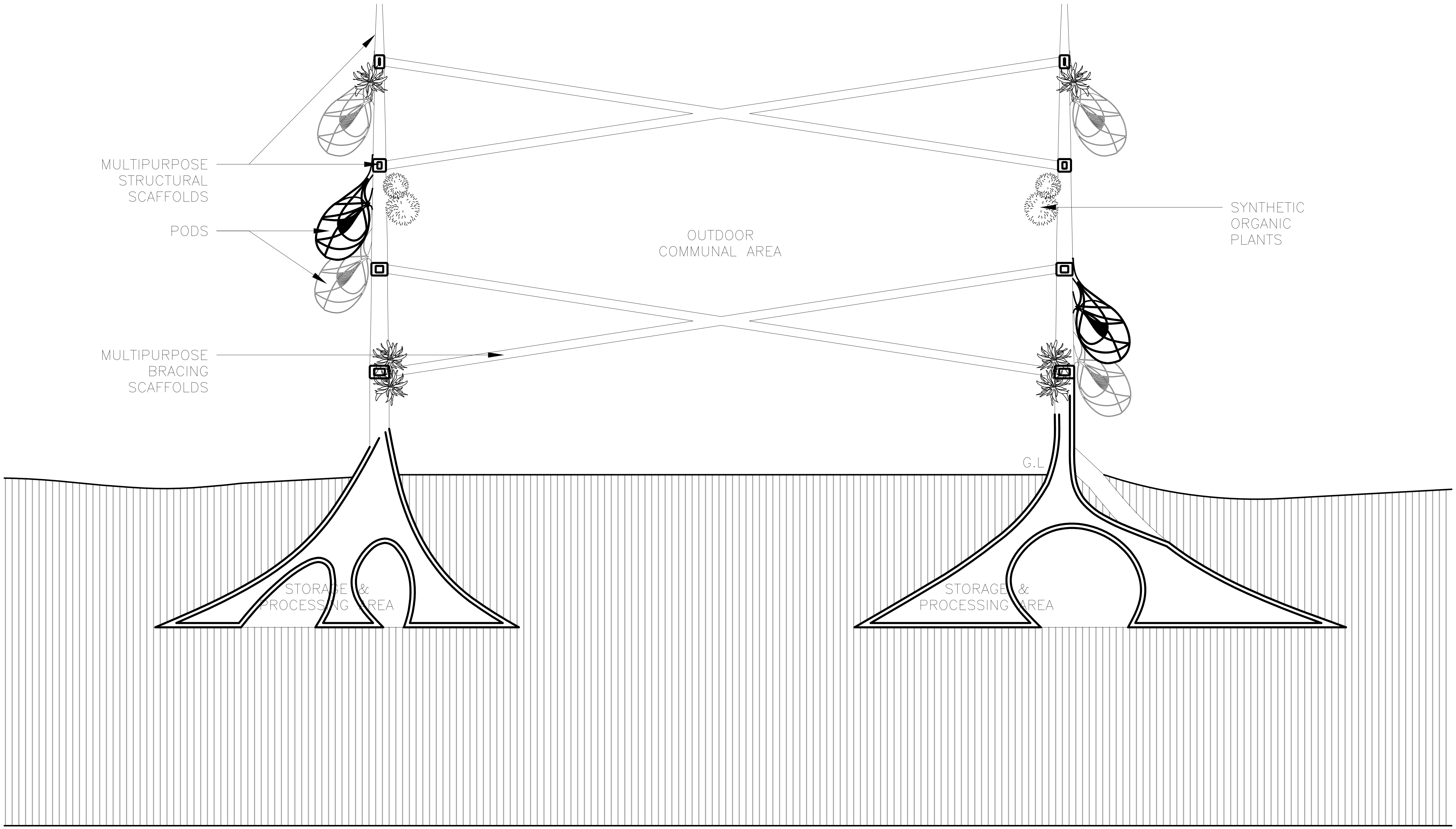


Figure 54 Cluster flexibility - enlarge/ expand



HABITAT EXTERIOR VIEW

0'-1/8"=1'-0"



STORAGE AREA SECTION

0'-1/16"=1'-0"

ENVIRONMENT TRANSFORMATION

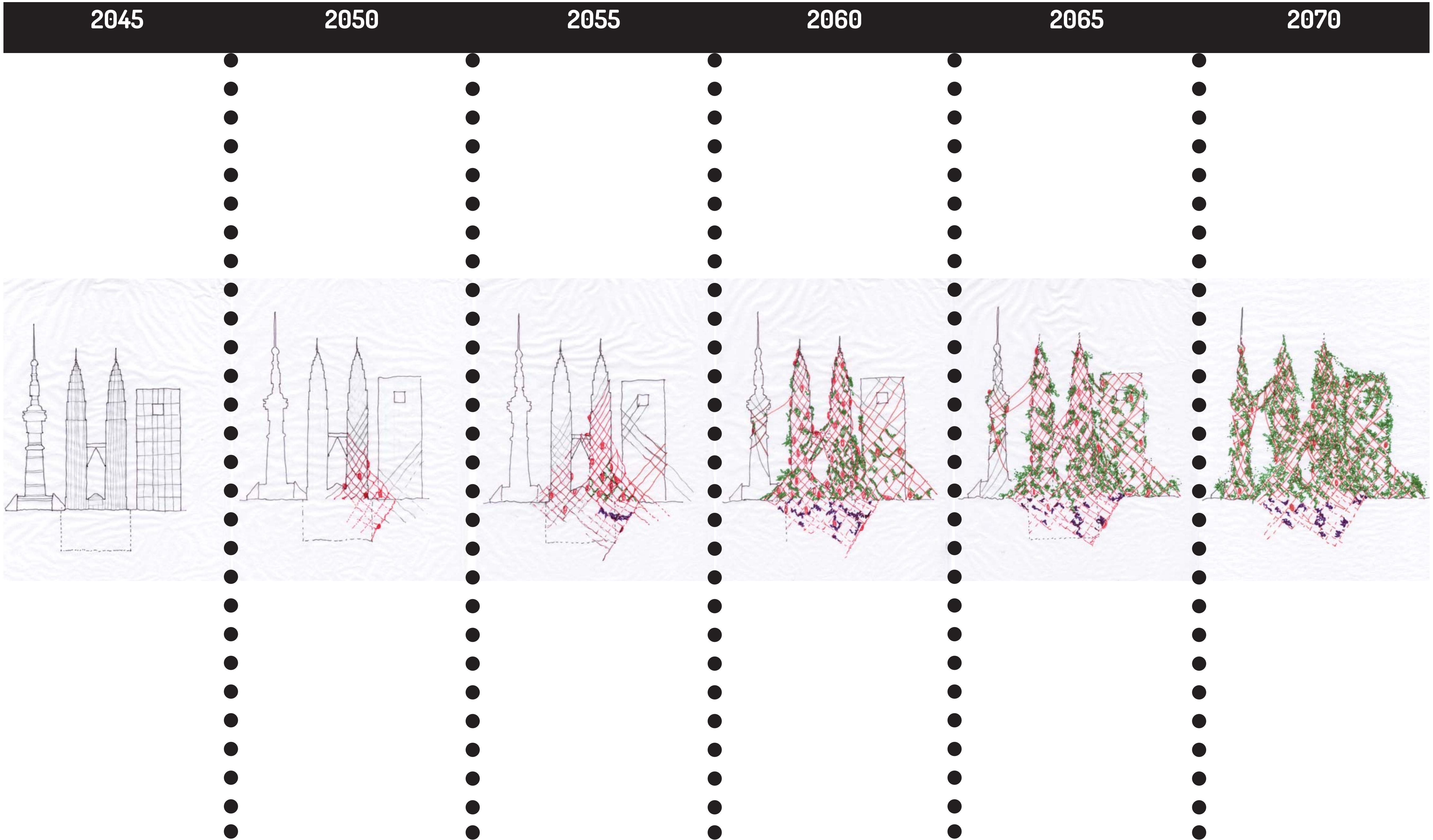


Figure 57 Urban environment transformation

5.6. Constraints of This Design

The proposed design is heavily dependent on the forecasted drivers, emerging opportunities, and potential trends. They may take alternate routes of development, cease, or never become a reality. In case they do become a reality, the forecasted time frame may be shifted, which will fail to create the desired projected outcome.

In the most optimistic situation, many issues will rise from new concepts or techniques, such as the projected rapid advancement of technologies that have not stood the test of time. However, over time there is potential for improvements for these concepts and techniques.

This architectural composition is initially founded upon existing structures in the urban environment. To have the desired significant impact on the environment at macro level, a number of adjacent abandon buildings needs to comply with the proposed design. In the case there are private ownership to the adjacent properties the overall effect of the concept will be substantially reduced.

Contextual issues such as orientation require customized solutions. In an overcrowded condition, the privacy of the users, negotiating circulation on the surface could become challenged.

5.7. Possibilities of This Design

The opportunity to identify, narrow down, explore and experiment with architectural approaches, morphologies and holistic systems integrations, are discussed in the paper. For example, this paper proposes biotech and nanotechnology innovations, and explorations of systems such as active integrated surfaces with advanced properties. Additionally, the paper compares design and construction options allowing varied explorations such as a generative design approach.

The question of suitability of new architecture over renovation, restoration or retrofit can be justified because of the opportunity to propagate a synthetic organic environment over the previously dilapidated natural environment.

This architectural design proposes to up-cycle uninhabited, non-biodegradable building, extant structures, and materials to create a synthetic organic home that cohabits in a synthetic biodiversity. The use of up-cycled material, energy autonomy, and use of biomimetic techniques, ensure that the costs incurred in the construction is negligible. Further, the extendability and malleability of the design materials, and mobility of the design of pod that has the freedom to anchor onto any available space on a structural scaffold, suggest its potential ubiquitous use, allowing mass fabrication including customizing possibilities.

Not requiring procurement or ownership of land is another positive characteristic of this prototype design. In a densely populated urban condition living in an economically divided society, energy autonomy this design projects is also attractive.

The sale of pods, structural scaffolds, and renting of space on privately or publically owned surfaces, could become a new opportunity for a permanent market of aging people.

5.8. Client(s)

Governing authorities, technology companies, pharmaceutical companies, medical boards and institutions constitute the potential clientele to promote this design approach in establishing a synthetic organic habitat in the tropics.

5.9. Historical Tradition and Culture

Chapter IV illustrates a genealogy matrix that draws a lineage to this design proposal. Residual past morphologies are used to curtail the nostalgias about the past. Technological interactions through virtual visits and 3d printing are also considered. How this happens in the proposed design is that the initial parasitic, synthetic organic plant structural scaffold drapes over the existing urban morphology. This is somewhat similar to wrapping a fabric over existing architecture. Hence, the new form holds closer to its original shape and forms of the underlying original architecture, even after the original structure has been completely demolished.

Moreover, the new architecture is completely constructed with the materials that are up-cycled from the older urban structures. The existing morphology of the city is maintained as reminiscence and it leaves a venue to relate to the past urbanity.

5.10. Concluding Summary

The *Emergent Alternative Home 2050* design considers user comfort, social needs, and advanced technology materials, methods and systems efficiencies, leading to a minimalist conceptual design. The *Emergent Alternative Home 2050* prototype urban home is an architectural vision for 2050 that novel and space efficient.

The design is for a context that is highly transformed due to emerging trends and drivers. Intelligent design communications that facilitate efficient imitation of natural processes are applied to achieve desired outcomes. The elements of the design can be mass customized and fabricated at low cost. *Emergent Alternative Home 2050* acts as a generator of positive environmental footprint and regenerates the biodiversity.

Moreover, this proposal pushes the boundaries emphasizing characteristics, including self-assembly, flexibility, fluidity and mobility. Expandability, mobility, malleability, and functionality of this design cater to changing needs of *Emergent Alternative Home 2050*.

Chapter VI: Conclusion

This doctorate project examines my hypothesis of a preferred synthetic organic biomimetic home, as an emerging vision for 2050. Typically, the understanding and application of biomimetics is seen as abiotic imitation of natural life, its components or processes. *Emergent Alternative Home 2050* uses emergent opportunities, and trends, to present a potential trajectory for the creation of biotic or synthetic organic architecture, by 2050. Using Manoa Future Studies methodologies, I investigate the manifestations of biotechnology that facilitates such advancements.

My investigation borrows from Gary Golden, among others, who argue for potential bio-based industrial processes that utilize nano-scale engineered materials, becoming a primary driver for future social and economic shifts.[205] This argument supports my theory of technology driven architecture in 2050. Within this time line, biotechnology, nano-scale, and biomimetics are expected to become the norm. In respect to key materials and methods, selected examples that show high potency to supplement my design are presented below.

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[205] Gary Golden, "Carbon Capitalists of the World Unite! The Future of Carbon's Bio-and Nano-based Wealth Creation; Bio Industrialism," posted on December 22, 2009, http://www.garrygolden.net/2009/12/22/carbon-capitalists-of-the-world-unite-the-future-of-carbon-based-wealth-creation/ (accessed May 2, 2013).

One such method that has aided my own analysis is Suzan Lee's practice that grows clothes out of "green tea, sugar, a few microbes and a little time."[206] It is a proof of an emerging-bio-generative process. By 2050, advanced bio-chemistry and genetics[207] combined with advancements in Shape Deposition manufacturing,[208] have the potential to create autonomous organic structures. Desired morphologies will be programed and embedded in to the material properties.[209] Similar self-generating processes are anticipated to validate my synthetic organic design, which comprise of structural scaffold, pods, underground processing, storage areas, and synthetic organic plants.

Functioning similar to collagen in an organism, Biosteel from Nexia is used as a broadly divergent application in this proposal. It shows high probability to develop advanced characteristics, such as expandable and resilient biopolymers, for the structural scaffold and the structural/tensile web portion of the pod. The expandability is especially useful as bridges that interlink different structural scaffolds, tensile pod structure that hangs from the structural scaffold, and for the person wearing the pod to navigate across the vertical surface of the structural scaffold. The pod uses the expandable attaching arms that protrude from the suit or the pod. These arms stretch

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[206] TED, "Suzanne Lee: Grow your own clothes," filmed Mar 2011, posted May 2011, TED 2011 video file, www.ted.com/talks/suzanne_lee_grow_your_own_clothes.html (accessed May 2, 2013).

[207] BBC, "The goats with spider genes and silk in their milk," BBC, posted on January 16, 2012, http://www.bbc.co.uk/news/science-environment-16554357 (accessed May 2, 2013).

[208] TED, "Robert Full: Engineering and evolution," filmed Feb 2002, posted June 2008, TED video file, http://www.ted.com/talks/robert_full_on_engineering_and_evolution.html (accessed May 2, 2013).

[209] TED, http://www.ted.com/talks/robert_full_on_engineering_and_evolution.html (accessed May 2, 2013).

as much as five times its length. Working alternatively they spring out[210] with minimal effort, and attach to the structural scaffold. Mimicking gecko feet, these arms peel off the surface,[211] facilitating the movement along it. Using a mechanism that mimics mosquitoes' serrated mandibles, the pod anchors itself to the structural scaffold. This mechanism is retractable, and is embedded in the palm-like end of the expandable arms of the pod.

AMSilk[212] is another advanced synthetic-bio-material, from recombinant spider silk. Its material characteristic has the potential to develop into resilient and elastic building skin. My design proposes an AMSilk sandwich-panel skin or an envelope, with SEAgel[213] (Safe Emulsion Agar gel) infill. The malleable property of SEAgel allows the envelope to change its shape as needed. The envelope adapts its interior through push, pull, and a twist of a smart finger glove, creating many different variations, according to user needs and preferences. SEAgel also has excellent insulating properties. AMSilk has an exceptional ability to absorb high impact. These characteristics are valuable considering tropical heat, and other climatic conditions, including high wind and heavy rain.

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[210] TED, "Robert Full: Engineering and evolution," filmed Feb 2002, posted June 2008, TED video file, http://www.ted.com/talks/robert_full_on_engineering_and_evolution.html (accessed May 2, 2013).

[211] TED, http://www.ted.com/talks/robert_full_on_engineering_and_evolution.html (accessed May 2, 2013).

[212] AMSilk GmbH www.amsilk.com englische Version, "Spidersilk2011," YouTube video file, posted on May 19, 2011, http://www.youtube.com/watch?v=FRyQa3wzCY4 (accessed May 2, 2013).

[213] Grommo, "SEAgel Aerogel lighter than air solid. Not a UFO," YouTube video file, posted on Jun 20, 2008, http://www.youtube.com/watch?v=HoCAxS4vqwQ (accessed May 2, 2013).

Exploring building materials that are adaptable to disparate climatic conditions, and are autonomous, architect Doris Kim Sung presents a method that allows the materials to "breathe" according to their material logics. She argues that "human skin is the organ that naturally regulates the temperature of the body," and she proposes that "building skins should be more similar to human skin."[214] At the moment this is demonstrated using a lamination of two different metal veneers. Due to the difference in coefficient of expansion, when exposed to heat, cause one side to expand more than the other, producing a curling effect. This method requires no energy or control. [215] Application of this principle to thermo-bio-materials is proposed as means of passive ventilation, in the pod of the *Emergent Alternative Home 2050*.

Additionally, Robert Full Biologist at UC Berkeley presents an abiotic device that has the ability to withstand the human weight hung from a vertical surface as well as it aid in climbing a wall.[216] It has an advanced dry adhesive mechanism that mimics the gecko feet. This device uses intermolecular or Van de Waal forces, to walk a vertical surface. Similar constructs in biomaterials are embedded in the suit or the pod. Application of this method enables enhanced mobility that is required to climb the vertical surface of the structural scaffold of the proposed design.

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[214] TED, "Doris Kim Sung: Metal that breathes," filmed May 2012, posted Oct 2012, TEDx USC video file, http://www.ted.com/talks/doris_kim_sung_metal_that_breathes.html (accessed May 2, 2013).

[215] TED, http://www.ted.com/talks/doris_kim_sung_metal_that_breathes.html (accessed May 2, 2013).

[216] TED "Robert Full: Learning from the gecko's tail," filmed Feb 2009, posted Jun 2009, TED2009 video file, "http://www.ted.com/talks/robert_full_learning_from_the_gecko_s_tail.html (accessed May 2, 2013).

My design is also validated through an architectural genealogy that connects it back to key seminal precedents. As discussed in chapter IV they are: *The Endless house, Il Continuo Monumento, Mobius House, Mosquito Bottleneck House*, *La Maison Tropicale* and *Suitaloon & Cuschicle*. Their themes and drivers are identified and carried over to future trajectories, linking them through a genealogy map. The preferred *Emergent Alternative Home 2050* is developed using a hybrid of prevalent themes and drivers arising from Future Trajectories in chapter IV. These themes and drivers pertain to 2050 scenario discussed in chapter II.

Moreover, the proposed design considers projected contextual issues in 2050, and generates a positive impact design solution. The flow of inspiration and influences for *Emergent Alternative Home 2050* from the precedents are summarized below.

Change in population demography to an aging society and technology peak in 2050 has shifted habits, norms that shape this composition, the function and the morphology of home. My design solution entails many aspects of *The Endless House*, including anthropometry, as a notable factor that links the *Emergent Alternative Home 2050* to *The Endless house*. Additionally, it considers ergonomics of a single human user, living in a high technology era. Furthermore, boundaries of *The Endless House* and the pod or envelope of the *Emergent Alternative Home 2050* are shaped by the inhabitant's living space. Other key influences that are derived from *The Endless house* include: plasticity in the spatial concept, design initiating as a volume and considering plan only as a footprint of it, and its quasi natural morphology. The *Emergent Alternative Home 2050* joins with *The Endless House,* having common characteristics such as endless space, a space that responds to human sensibilities, and the egg-like morphology that is analogous to amniotic sac, where a fetus develops; not only as the first place of human habitation, but as the most agreeable place for humans to experience life.[217]

The design of structural scaffold is linked to *Il Continuo Monumento, Mosquito Bottleneck House* and *Suitaloon & Cuschicle*. Essentially, the structural scaffold functions as a continuous surface, and a system to plug into.

The proposed pod converts from a wearable suit, to a private climatic envelope, similar to *Suitaloon & Cuschicle* that functions as an extension to the human body. It shelters humans from weather elements, and is plugged on to the structural scaffold. It is proposed as a synthetic organic solution that arises with the technology peak in 2050. Mobility and creation of community spaces in *Emergent Alternative Home 2050* also share ideologies with *Suitaloon and Cuschicle* principles.

The proposed pod is an endless single surface, and a derivative of *The Endless house,* the *Mobius House* and the *Mosquito Bottleneck House.* It hangs from the vertical surface of the structural scaffold, and occupies the air, and is independent of the ground plane, similar to *The Endless house.* It takes an unusual topology similar to the *Mobius*

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[217] Jae Eun Yoon, “A Study on the Co-relationship between the Endless Space of Frederick J. Kiesler and Non-territorial Space Expression in De-constructivism Architecture,” http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/cd_donotopen/adc/final_paper/189.pdf (accessed May 2, 2013).

House. Additionally, *Emergent Alternative Home 2050* identifies itself with *Mosquito Bottleneck House,* due to the use of unusual materiality and it is concept as a response to a negative environment.

Similar to the *Mosquito Bottleneck House,* the *Emergent Alternative Home 2050,* demonstrates how environment and technology works hand in hand. This is in contrast to *Il Continuo Monumento,* which presents technology as a malicious form that destroys the nature.

The *Emergent Alternative Home 2050* draws on *La Maison Tropicale* as a light weight, mobile structure that adapts to environmental needs. Another aspect it shares with *La Maison Tropicale* is the external load bearing system. This is similar to an exoskeleton, and it liberates the interior.

According to my analysis, overtime, construction of homes has evolved to assembling newer, lighter, thinner, modular, and factory produced, standard components. The intensity of labor shares a process of automation, which originated during the industrial revolution. Its efficiency seems twofold: cater to mass production and become cost effective. Having considered other variables and tangential explorations, while acknowledging other feasible solutions, I have come to conclude that the preferred future architecture will be driven by “bio-based industrial processes and nano-scale materials engineering."[218] The accelerating pace of advancing technology, especially in biotechnology and nanotechnology, hold a high promise of delivery for 2050.

Bond *et al.* illustrate that biological structural materials have advanced properties such as toughness, and are able to synthesize at low temperature. They attribute these advantageous, superior, mechanical properties to hierarchical, composite, structural arrangements in the materials. Furthermore, Bond *et al.* point out that material scientists and engineers approach biological designs and processes, with the aim to achieve high performance in synthetic materials and conventional fabrication processes through biomimetics.[219] My design is founded according to this concept investigating nanotechnology facilitated observations, analysis and applications and extrapolating their potentials to emerging future 2050. In addition, bio-chemical and genetic interventions are introduced as facilitators, to generate advanced synthetic organic materials. Armstrong *et al.* also discuss how biological systems excel over traditional manmade systems. They reason that nature generates complex structures that are ideally suited for their functions. Moreover, nature provides aspiration for direct imitation, and exemplary enhancements to distant uses, achieves functional

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[218] Gary Golden, "Carbon Capitalists of the World Unite! The Future of Carbon's Bio-and Nano-based Wealth Creation; Bio Industrialism," posted on December 22, 2009, http://www.garrygolden.net/2009/12/22/carbon-capitalists-of-the-world-unite-the-future-of-carbon-based-wealth-creation/ (accessed May 2, 2013).

[219] G.M. Bond, R.H. Richmon, W.P. McNaughton, "Mimicry of natural material design and processes," *Journal of Materials Engineering and Performance* 4, no 3 (June 1995), 334-345.

requirements in synthetic systems and preferred outcome of processes.[220] In reference to the pace of technology advancements, I am confident that by 2050 bio-synthetic architecture will offer such preferred solutions through biomimetics.

Armstrong *et al.* also point out, that the natural syntheses processes are environmentally benign, and that their products are biodegradable.[221] This is another aspect that makes Synthetic Organic *Emergent Alternative home 2050* a preferred solution.

I agree with Frei Otto, who points out that the use of natural construction does not equal to “natural” building, and that it can as well be used for destruction of nature.[222] Gruber agrees with him stating that the use of nature does not guarantee that constructions, materials, and/or processes will be environmentally friendly.[223] However, contrary to that, *Emergent Alternative Home 2050* outlines how such constructions will be managed to become environmentally positive. *Emergent Alternative Home 2050*’s potentials are primarily credited to the speculated technology peak in 2050, which integrates biotechnological interventions at nano-scale to achieve advanced process that regenerate the environment, through synthetic biodiversity. Advanced genetic codes and advanced bio-chemical manipulation will enable up-cycling inefficient

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[220] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 140.

[221] Armstrong, 140.

[222] F. Otto. et al., Narurliche Konstruktionen, (1985), 104.

[223] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 262.

materials, creating desired properties including organic, biodegradable, generative materials by 2050.

In this doctorate project biomimetics is the point of departure, for a future home, for an aging population in the tropics in 2050. As the point of takeoff, biomimetics is considered to be a technique that gives architecture the potential to advance. Using biomimetics as a technique, my design utilizes generative biotic or synthetic organic materials. The biomimetic borrows its methods and aspirations from t nature, and it has the potential to attain high tech, high quality, and time sensitive, autonomous, architecture by 2050. Emerging technologies were elaborated as proof of potentials to attain this autonomy that validates my design proposal. Hence, *Emergent Alternative Home 2050* complies with Gruber, who points out that preferred architectural designs must exist autonomously.[224]

For the Scenario 2050 described in chapter II, completely autonomous architectural solution is preferred for the aging users in an efficacy driven bio-economy. A process that has the potential to convert solar energy in a biotic cell is emerging. The bio-architectural solutions advances applications that propose to harvest energy required for autonomous designs, in relation to tropical weather.

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[224] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 262.

I am confident that Gruber correctly projects that innovative architectural solution will emanate when technological societies become confronted with limitations.[225] She argues that the visionary architecture that utilizes minimal materials, and advanced technology, will validate this claim. Biotechnology at nano-scale has the potential to achieve a positive environmental footprint using biomimetic concepts and process. In fact, Sahara Project is an early example of that. Hence, I positively conclude that my design has a strong forecast leading to an advanced architectural creation for *Emergent Alternative Home 2050*.

The urban context of the *Emergent Alternative Home 2050* is conceptualized as a reductivist urban landscape; that gradually demolishes the inefficient structures and generates diverse synthetic organic biodiversity over time.

"The living world can now be viewed as a vast organic Lego kit inviting combination, hybridization, and continual rebuilding."[226]

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[225] Petra Gruber, *Biomimetics in Architecture: Architecture of life and buildings* (Wien, NY: Springer, 2011), 263.

[226] E.Yoxen, *The Gene Business: Who should control Biotechnology?* (London: Pan Books, 1983).

Glossary

For clarity following terminology has been adopted:

“**Biotechnology** is the use of biological science to create chemicals, materials, and organisms through the control of biological processes. There is no presupposition that the target product be naturally occurring biological or biochemical entities.

Bio-Inspired is the current terminology used to describe the class of materials based either directly or indirectly on material structures and functions observed in the biosphere. Clearly, there is overlap where a biotechnological manufacture approach is adopted in the production of chemicals, materials, and organisms to be used for nonbiological applications and where a product is a hybrid of products of strict biotechnology and abiotic analogs of biological forms or functions.

Biotics refers to direct use of materials of biological origin.

Biomimetic refers to the use of abiotic methods to mimic the structure and/or properties of biological materials.”[227] And the “attempt to imitate features of living systems – biomimesis.”[228]

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[227] Robert E. Armstrong et al. eds., *Bio-inspired innovations and national security* (Washington D.C: National defense University Press, 2010), 140.

[228] George Bugliarello, “Biomimesis: The Road Less Traveled,” *The Bridge: Engineering Evolving* 27, no. 3 (Fall 1997), http://www.nae.edu/Publications/Bridge/EngineeringEvolving/BiomimesisTheRoadLessTraveled.aspx (accessed May 2, 2013).

Biomimetic or **biomimicry** can be of various forms. Direct replication of an organism, or its part, or its process, or a conceptual idea can be pointed out as some of these forms. These are considered biology to design solutions. Alternatively in the design to biology solution people identify human design issues and draws biological functional inspirations to solve design challenges.[229]

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[229] Biomimicry Institute, "What do you mean by Term Biomimicry?" http://www.biomimicryinstitute.org/about-us/what-do-you-mean-by-the-term-biomimicry.html (accessed May 2, 2013).

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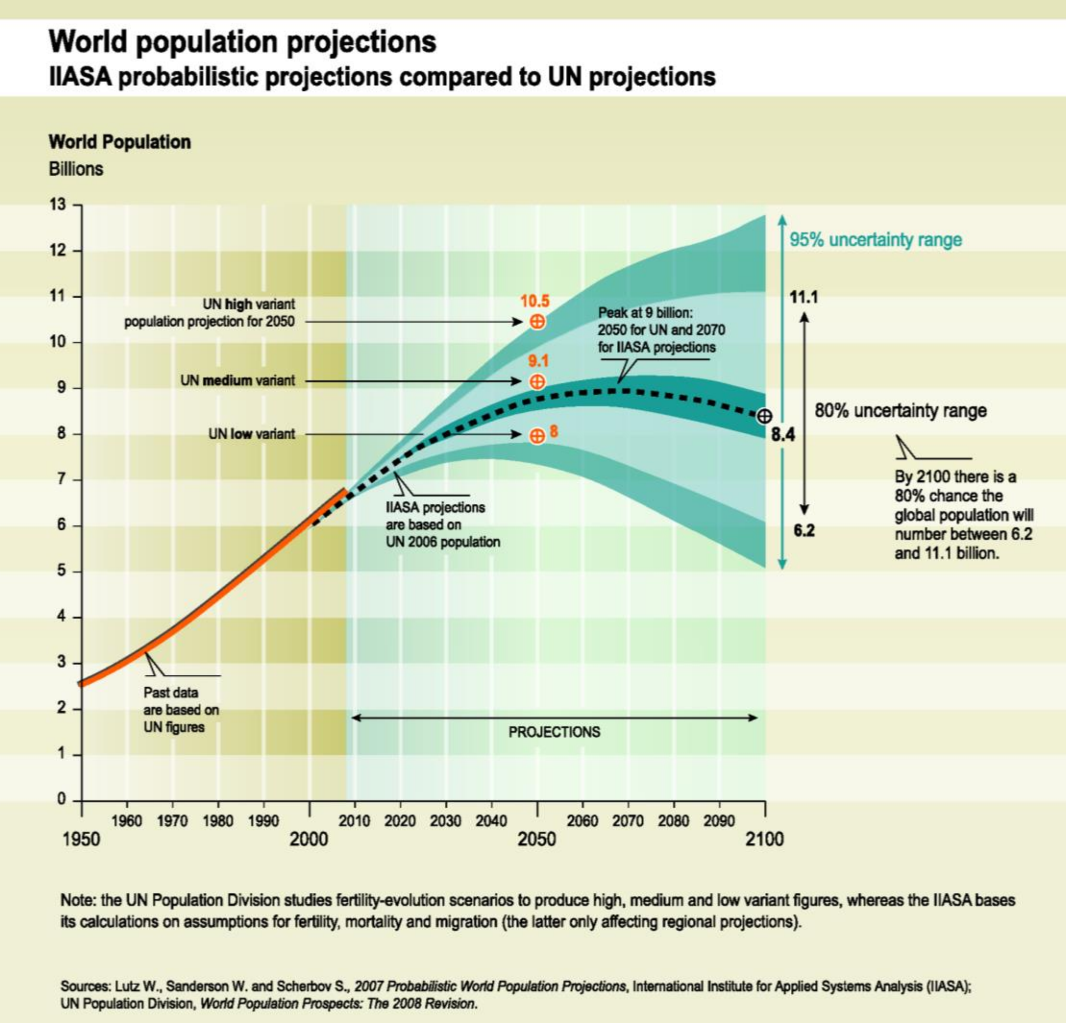
Appendix A

Global population projections


World population projections
IIASA probabilistic projections compared to UN projections

Note: the UN Population Division studies fertility-evolution scenarios to produce high, medium and low variant figures, whereas the IIASA bases its calculations on assumptions for fertility, mortality and migration (the latter only affecting regional projections).

Sources: Lutz W., Sanderson W. and Scherbov S., *2007 Probabilistic World Population Projections*, International Institute for Applied Systems Analysis (IIASA); UN Population Division, *World Population Prospects: The 2008 Revision*. [230]

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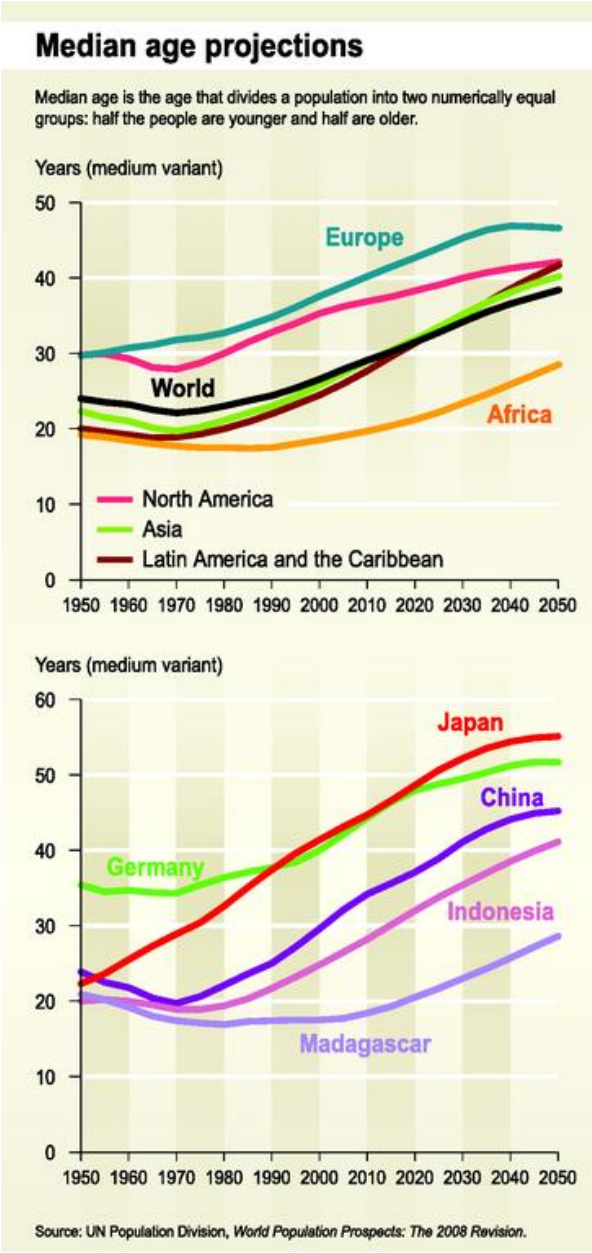
[230] European Environment Agency, "World population projections - IIASA probabilistic projections compared to UN projections," created on Dec 10, 2010, posted on Dec 10, 2010, http://www.eea.europa.eu/data-and-maps/figures/world-population-projections-iiasa-probabilistic (accessed April 6, 2012).

Appendix B

Aged 60 year and over population dynamics



Source: UN Population Division, *World Population Prospects: The 2008 Revision.* [231]

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[231] European Environment Agency, "Median Age Projections," created on Dec 10, 2010, posted on Dec 13, 2010, http://www.eea.europa.eu/data-and-maps/figures/median-age-projections (accessed April 6, 2012).

Figure 8. Average annual growth rate of total population and population aged 60 or over: world, 1950-2050

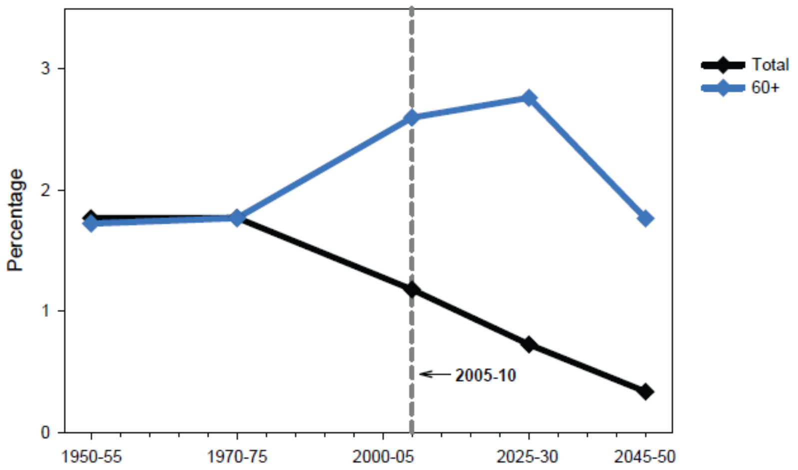
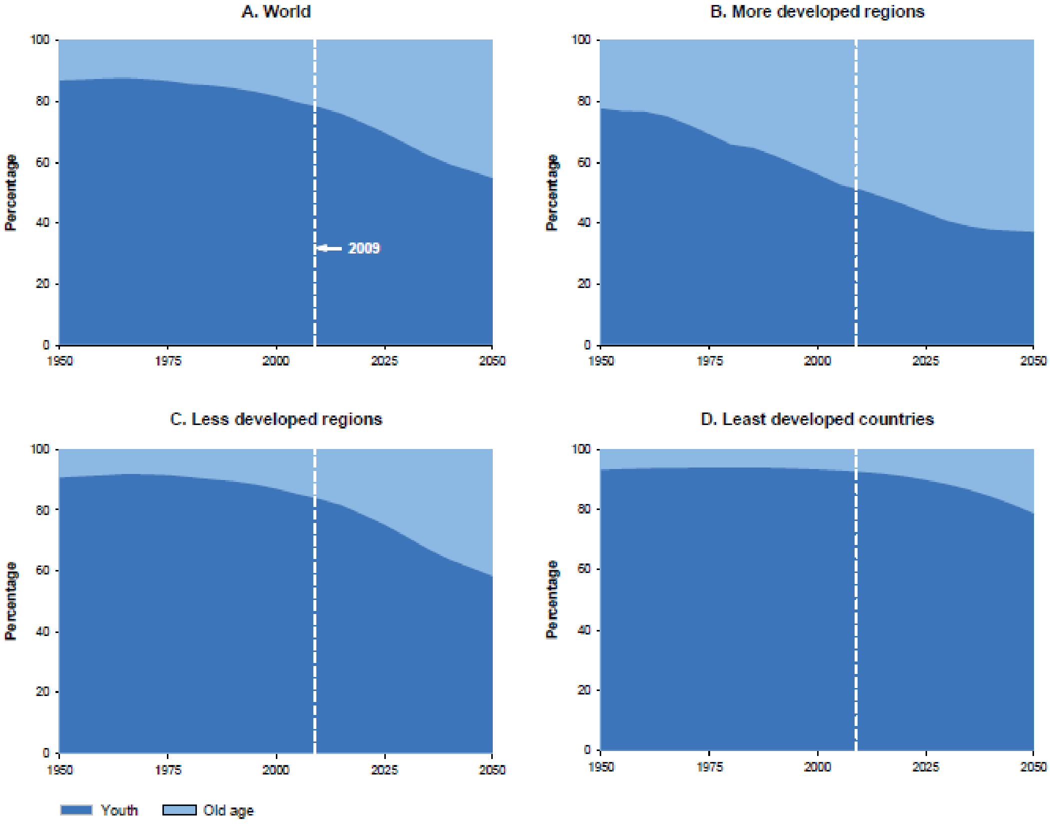


Figure 15. Composition of the total dependency ratio: world and development regions, 1950-2050



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[232] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Figure 18. Number of persons aged 15-64 per persons aged 65 or over: major areas, 2009 and 2050

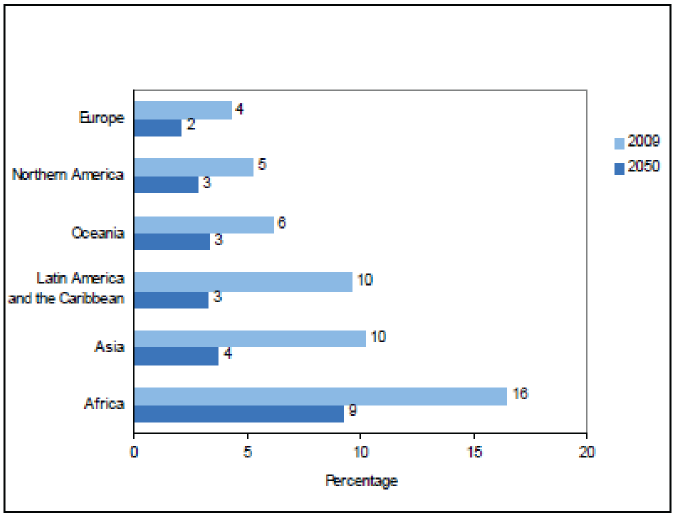
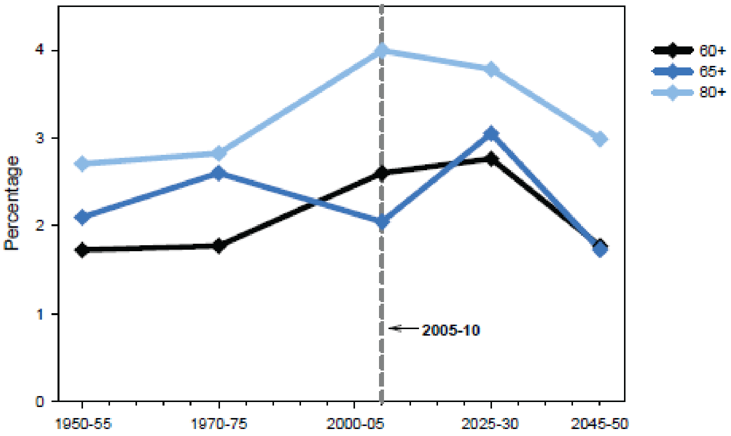


Figure 19. Average annual population growth rate at ages 60 or over, 65 or over and 80 or over: world, 1950-2050



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[233] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Figure 21. Population aged 80 or over: world, 1950-2050
(Millions)

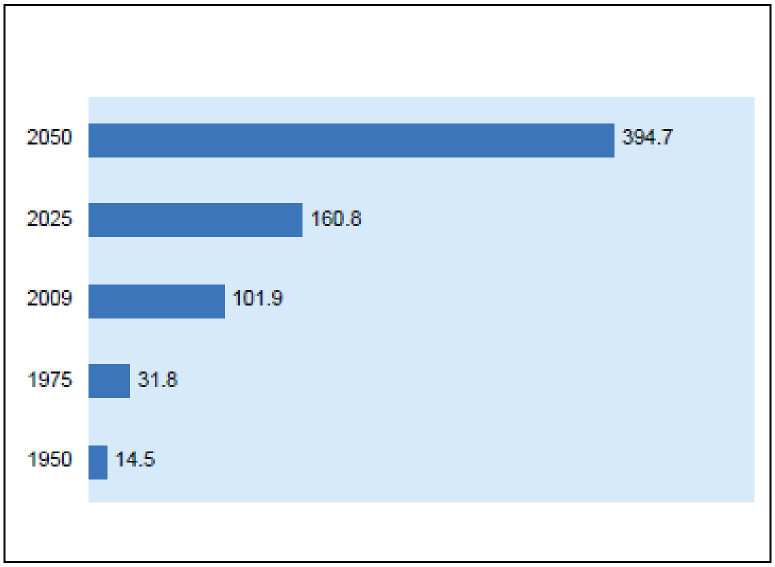
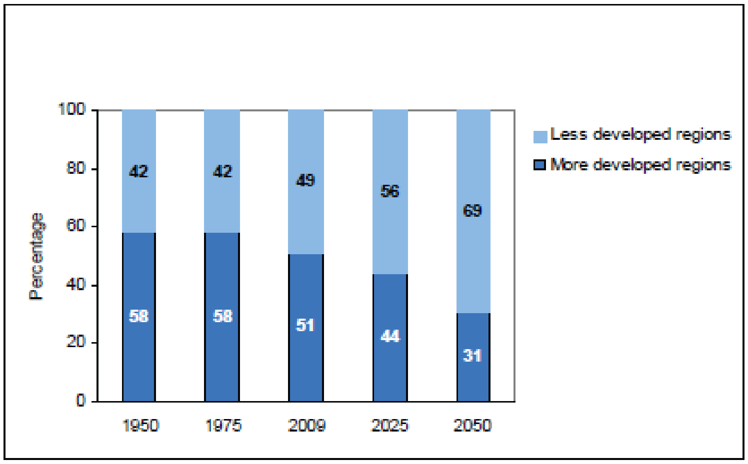


Figure 22. Distribution of world population aged 80 or over by development regions, 1950-2050



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[234] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Figure 23. Distribution of world centenarians by development regions, 2009-2050

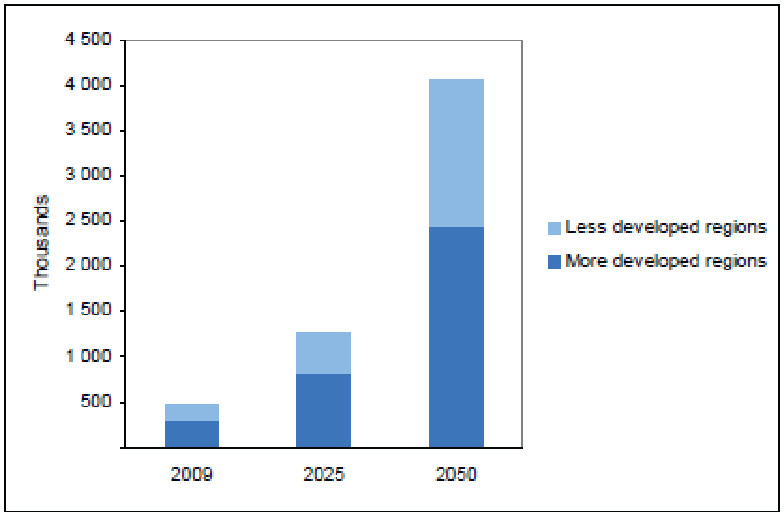
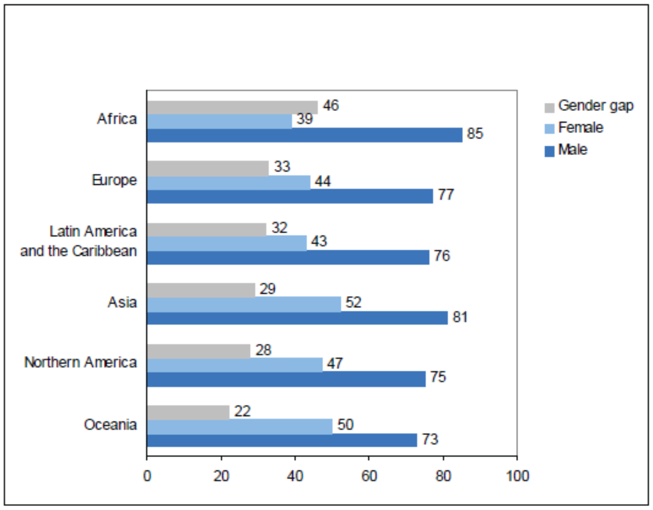


Figure 28. Percentage currently married among men and women aged 60 or over and gender gap: major areas, around 2005



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[235] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Figure 30. Percentage of population aged 60 or over living alone, by sex: major areas, around 2005

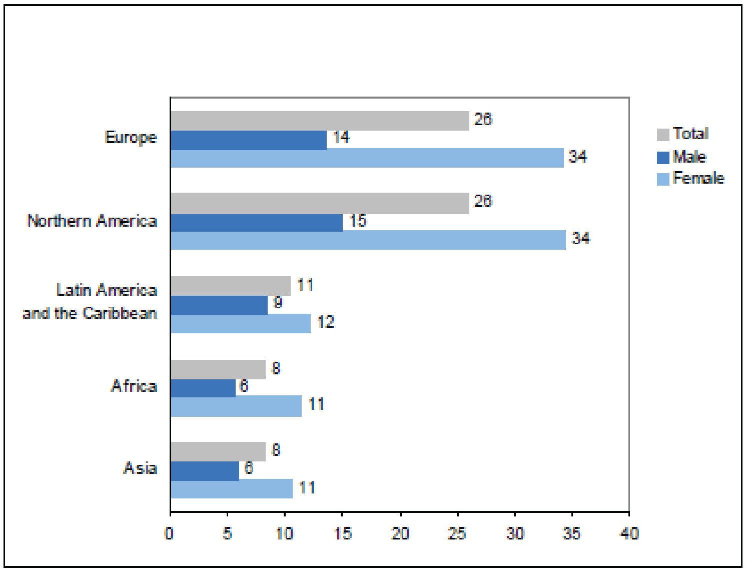
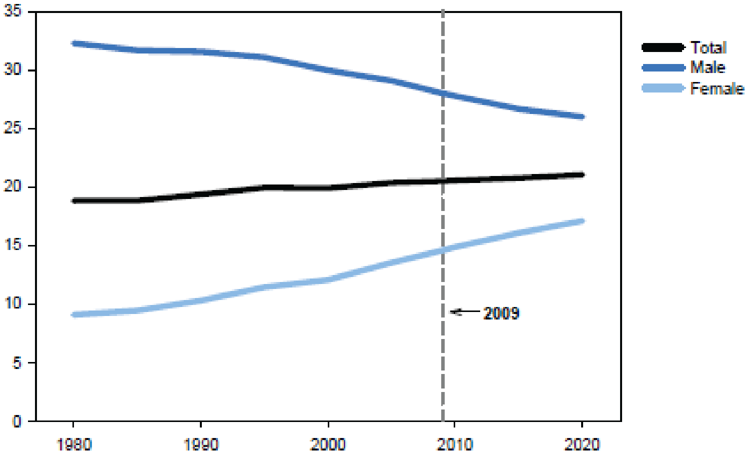


Figure 36. Total, male and female labour force participation at age 65 or over: world, 1980-2020



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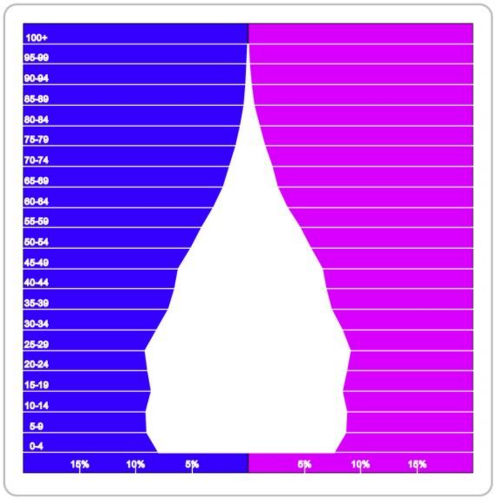
[236] United Nations, "World Population aging 2009," (NY: United Nations, 2010), http://www.un.org/esa/population/publications/WPA2009/WPA2009-report.pdf (accessed May 2, 2013).

Appendix C

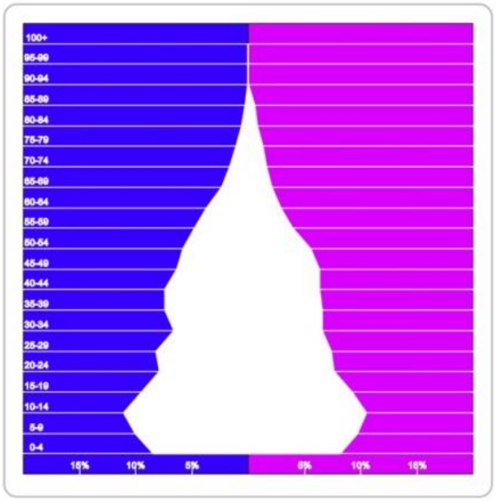
Demographics of proposed project sites

Shown in blue are percentage of male population and pink/purple corresponds to female population.

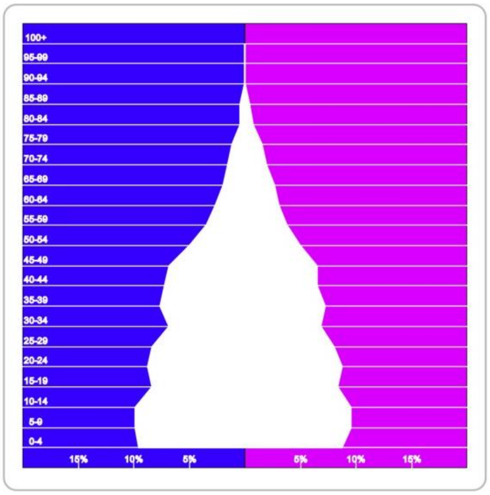
Brazil
2010 **195.424.000**



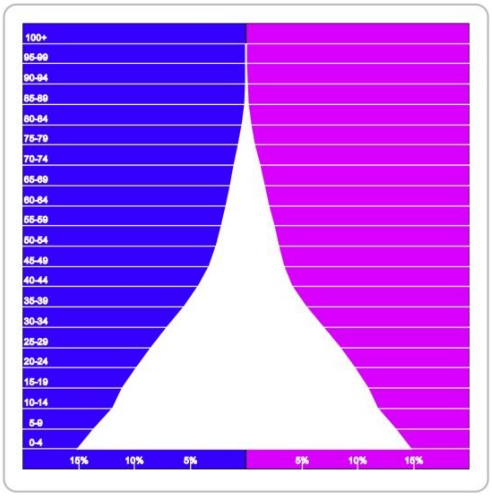
Guyana
2010 **763.000**



Suriname
2010 **527.000**



Congo
2010 **3.759.000**



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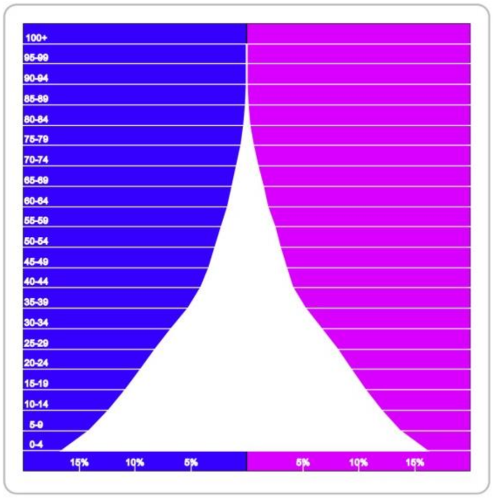
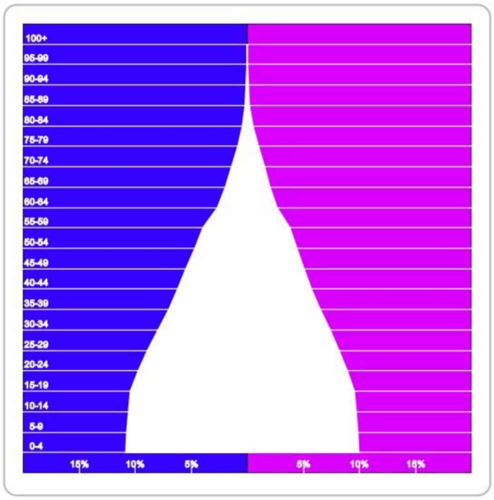
[237] Population pyramids, "Population pyramids of the world from 1950 to 2100: World 2010," http://populationpyramid.net/ (accessed April 7, 2012).

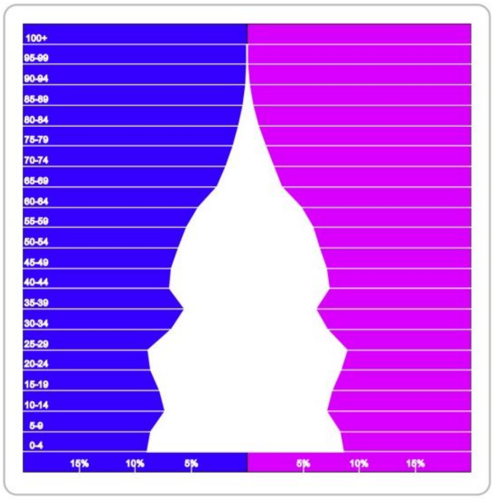
Nigeria
2010 **158.259.000**



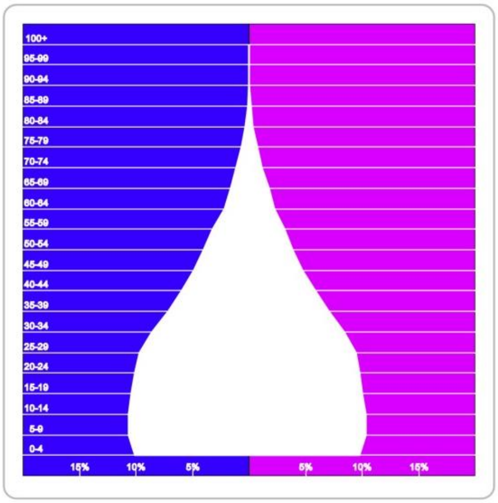
India
2010 **1.214.465.000**



Sri Lanka
2010 **20.411.000**



Bangladesh
2010 **164.423.000**



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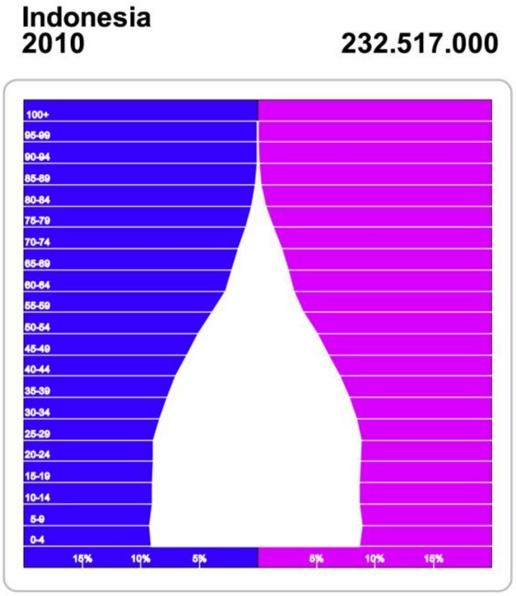
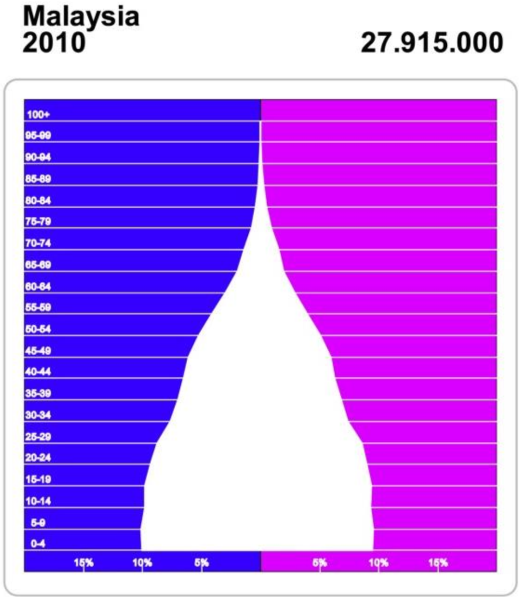
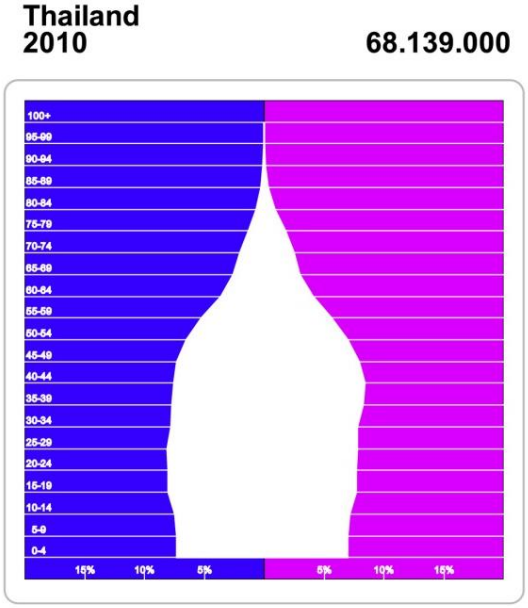
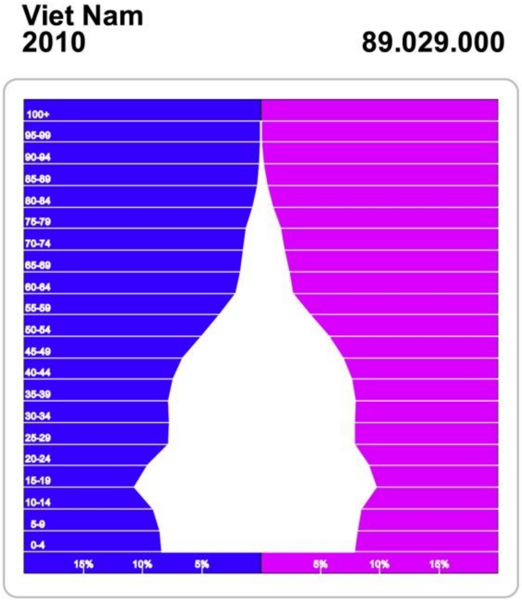
[238] Population pyramids, "Population pyramids of the world from 1950 to 2100: World 2010," http://populationpyramid.net/ (accessed April 7, 2012)..









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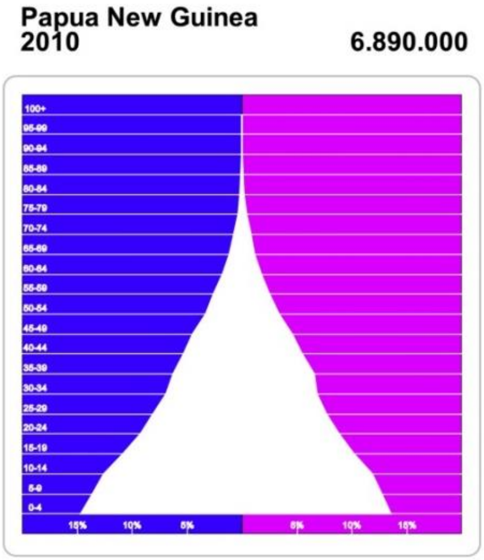
[239] Population pyramids, “Population pyramids of the world from 1950 to 2100: World 2010,” http://populationpyramid.net/ (accessed April 7, 2012).



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[240] Population pyramids, “Population pyramids of the world from 1950 to 2100: World 2010,” http://populationpyramid.net/ (accessed April 7, 2012).