GENTERRA MONS

Museum of Outdoor Arts Design and Build Competition
2021 Design Challenge “Out of This World:” A Monument for Mars

Architectural Designer

Malequi S. Picazo (primary contact)
2021 Bachelor of Architecture Graduate
Ball State University
Estopinal College of Architecture and Planning

Landscape Designer

Tanner J. Prewitt
2021 Bachelor of Landscape Architecture Graduate
Ball State University
Estopinal College of Architecture and Planning

Malequi S. Picazo

Architectural Designer

Malequi graduated *summa cum laude* in May 2021 from Ball State University. He graduated from the R. Wayne Estopinal College of Architecture and Planning with a Bachelor of Architecture degree, and from the university's Honors College. Over the course of five years, he was a member of the National Society of Collegiate Scholars, American Institute of Architecture Students, and the scholastic honor society known as Tau Sigma Delta. Malequi has authored two published works in the field of sustainability: first, as a contributing author to the book titled, *Facing Sustainability: A Facing Project Exploring Sustainability in East Central Indiana*; second, as the author of a peer-reviewed article titled, "Community is Sustainable" published in the *Journal of Community Engagement and Scholarship*. During his final year at Ball State, he was a Production Editor of *Stance*, an international undergraduate philosophy journal.

In his thesis year, Malequi was one of five students in his class to win a Thesis Design Book Award for his project, "A Martian's Home: A Housing Solution for Astronauts on Mars." In previous years, Malequi was also a finalist in two other architecture design competitions in his second and third years of school. The focal points of his thesis project were the logistics, construction, longevity, and future growth of an individual home on Mars. In his design, six temporary astronaut residents would arrive on Mars to inhabit and improve a home created for them by autonomous robots and 3D-printing machines. After two years of research and aiding additional construction, the individuals would return to Earth. The next phase of colonization would then begin with several manned missions that would send volunteer colonists to live their lives furthering their new Martian civilization.

Malequi Picazo is now working as an Architectural Graduate at RQAW Corporation, a multi-disciplinary architecture firm located in Fishers, Indiana. His primary focus is multifamily and public safety projects, but he is also one of the office's primary render production members. He plans to gain further experience in the fields of architecture and design before sitting for the Architect Registration Examinations in 2022.

EDUCATION

BALL STATE UNIVERSITY
Bachelor of Architecture
R. Wayne Estopinal College of Architecture and Planning
August 2016 - May 2021

Thesis
A Martian's Home: A Housing Solution for Astronauts on Mars
Instructor: Michel Mounayar
Advisor: Joshua Coggeshall

AWARDS + HONORS

2018 Indiana Hardwood Lumbermen's Association Spring Competition Finalist
2019 MKM Steel Spring Design Competition Finalist

EXPERIENCE

ARCHITECTURAL GRADUATE
RQAW Corporation | Fishers, IN | 2021 - Present

AMERICAN INSTITUTE OF ARCHITECTURE MEMBER
RQAW Corporation | 2021

STANCE PRODUCTION EDITOR
Ball State University | 2021
Responsible for final production of the journal

TAU SIGMA DELTA MEMBER
Ball State University | 2019 - 2021
Top 20% of architecture cohort academically

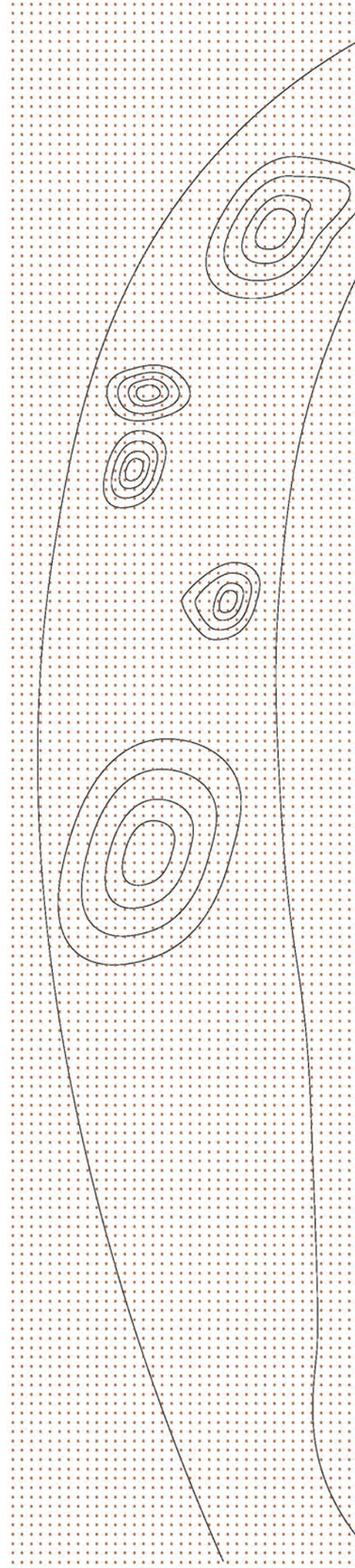
AMERICAN INSTITUTE OF ARCHITECTURE STUDENTS MEMBER
Ball State University | 2018 - 2021

ASSISTANT PRODUCTION DESIGNER
Tabberson Architects | Muncie, IN | 2019 - 2020
Schematic design, design development, construction documentation, design detailing

FACING SUSTAINABILITY CO-AUTHOR
Ball State University | 2020
Scholarly work with an Honors College colloquium concerning sustainability

NATIONAL SOCIETY OF COLLEGIATE SCHOLARS
Ball State University | 2017

ASSISTANT FIELD SPECIALIST
Springfield Restoration & Remodeling | Fort Wayne, IN | 2017 - 2018
Roofing of homes and small-scale buildings, interior restoration, construction



Tanner J. Prewitt

Landscape Designer

Prewitt graduated *magna cum laude* in 2021 from Ball State University R. Wayne Estopinal College of Architecture and Planning with a Bachelor of Landscape Architecture. During his five years in the landscape architecture program, he served as president of the Student Chapter of the ASLA and as a board member of *The Glue Publication*, a collegiate design journal. He was also an award-winning landscape architecture student. His thesis project — The National Mall Expansion Plan for Washington, D.C. — examined the Mall's history and failures in concerns to memorial landscape architecture. His thesis was recently submitted to the American Society of Landscape Architects' 2021 Student Awards program. Preceding that thesis, in 2019, Prewitt won an Indiana ASLA Student Design Award for his proposal for a new memorial landscape in Indianapolis, Indiana. Located downtown on the American Legion Mall, his memorial was to the tragic sinking of the U.S.S. *Indianapolis*. It not only remembered the sinking of the warship but the impact its mission to deliver atomic bombs to the Allies had on 20th and 21st century politics.

In addition to architecture school, Prewitt graduated from the university's Honors College. He served on the Student Honors Council for several years, ending his time there as its president. He also presented projects at two national and two regional honors conferences. In 2019, he won first prize for his presentation on Renaissance landscape gardening in regards to dynastic and ecclesiastical power during the 16th century. He combined his experiences in the university's history department with his own research into the Renaissance period. That same year he served as the marketing director for the Mid-east Honors Association.

Outside of academics, in 2021, Prewitt collaborated with urban designer Jeffrey Thompkins on a submission for a campus master planning design competition sponsored by University of Saint Francis in Fort Wayne, Indiana. Their submission restructured the current campus along a pedestrian greenway. It then grouped students with similar disciplines on collective parts of campus, providing them housing, student services, and a "village." Focusing on sociability, sustainability, and student growth, their submission won the competition's grand prize.

Prewitt is now a landscape designer at Luckett & Farley, a multi-disciplinary design firm in Louisville, Kentucky. He specializes in memorial landscape architecture, research, campus master planning, parkland design, planting design, and graphics production.

EDUCATION

BALL STATE UNIVERSITY
Bachelor of Landscape Architecture
R. Wayne Estopinal College of Architecture and Planning
August 2016 - May 2021

Thesis
The National Mall Expansion Plan for Washington, D.C.
Instructors: Chris Marlow + Natalie Yates
Advisor: Malcolm Cairns

AWARDS + HONORS

2021 University of Saint Francis Design Competition 1st Prize
2019 Indiana ASLA Student Design Award
2019 Mid-east Honors Association Student Presenter 1st Prize

EXPERIENCE

LANDSCAPE DESIGNER
Luckett & Farley | Louisville, KY | 2021 - Present
Corporate Commercial + Hospitality Studio

STUDENT CHAPTER PRESIDENT OF THE ASLA
Ball State University | 2019 - 2021
Responsible for professional advocacy, college representation, and student governance

THE GLUE PUBLICATION
Ball State University | 2018 - 2020
Responsible for the collection and curation of student projects in the college's portfolio

STUDENT HONORS COUNCIL PRESIDENT
Ball State University | 2020
Reponsible for the management of the student-governing body of the Honors College

LANDSCAPE ARCHITECTURE INTERN
Luckett & Farley | Louisville, KY | 2020
Mixed-use development planning, COVID-19 responsary planning, construction documentation, modeling + renderings, civil engineering, park design, client-stakeholder meetings

NATIONAL GARDEN CLUBS, INC. SCHOLARSHIP PROGRAM
New York City, NY | 2019
Competitive scholarship program in which a selection committee chooses applicants submitting and interviewing from accredited programs in landscape architecture or related disciplines.

LANDSCAPE ARCHITECTURE INTERN
Kovert Hawkins Architects | Jeffersonville, IN | 2018 - 2019
Residential design, construction documentation, modeling + renderings, institutional master planning + marketing strategies

MID-EAST HONORS ASSOCIATION MARKETING DIRECTOR
Muncie, IN | 2019
Responsible for all print promotions, apparel, branding, and social media campaigns for the 2019 Conference at Ball State University

GENTERRA MONS

SITE DESCRIPTION

Genterra Mons has a spatial relationship with its environmental context, colonial context, and interior layout. It rests at the epicenter of an imaginary crosshair on the surface of Mars. Olympus Mons, one of the planet's most identifiable landscape features, sits across from an authoritative line of three smaller, dormant volcanoes known as Tharsis Montes. Listed south to north, this chain includes Arsia Mons, Pavonis Mons, and Ascraeus Mons. These landmarks create a line from southwest to northeast, and run perpendicular to Olympus Mons which sits northwest of the region.The monument's resting place will be most significant and symbolic at the intersection point of these four natural formations, approximately 400 kilometers north of Biblis Tholus. Genterra Mons will be the first Martian landmark and monument built by humankind. If given appropriate weather conditions, Martian colonists would be hopeful to see the neighboring shield volcanoes from within the memorial.

The colony is approximately 1 kilometer away from Genterra Mons, which itself has a 63 meter total diameter, making it 3,969 square-meters, or 1 acre (see Figure 02). This distance would create a journey filled with ever changing experiences between the two human gathering places. A less obstructed view of the horizon is also a desired effect given that the settlement would eventually grow in any given direction. While this separation might also create wayfinding issues, this design theorizes that portions of the exterior structure would eventually be replicated and placed in a linear manner between the settlement and monument. Even though the spacing of these elements is unimportant, introducing the scale and grandiosity of mankind's first Martian monument could be integral to the design connection between the existing and the new.

Genterra Mons' interior would be a closed-system controlled by an airlock. Colonists visiting the monument could remove their helmets and breathe the purified air within the dome. The ground would be covered in a variety of steppable plants to emulate a lawn on Earth. Trees arrayed in a radial pattern around the dome, with vines climbing up the various columns holding up the exterior guardians, would echo a terrestrial forest. Due to the transparent nature of the ice dome, views of the shield volcanoes and surrounding Martian landscape are ever-present in this preserved piece of paradise.

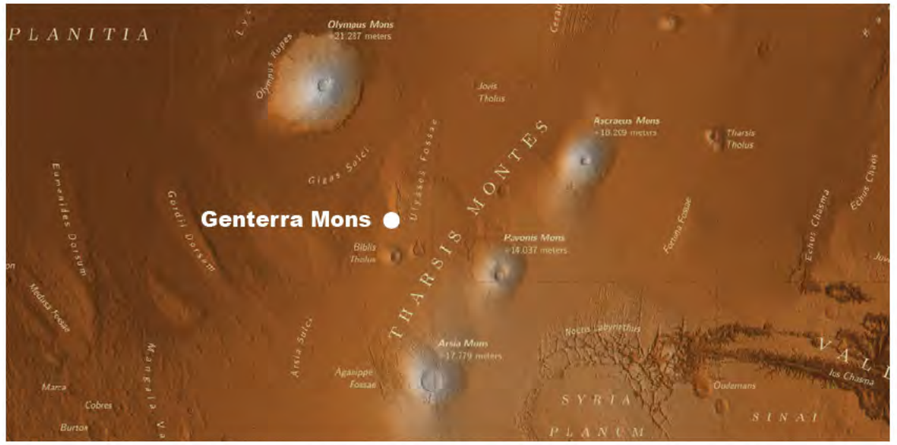
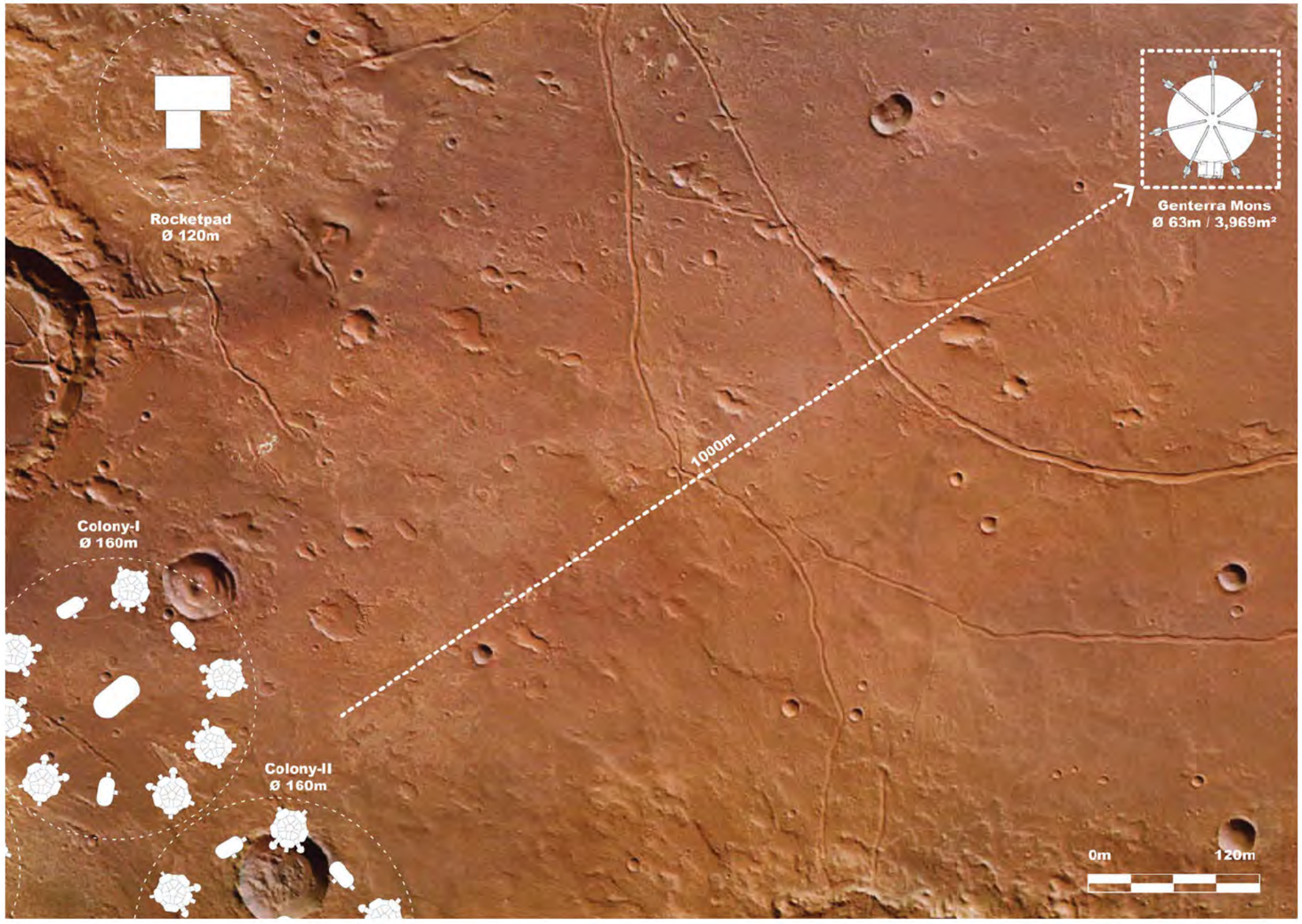
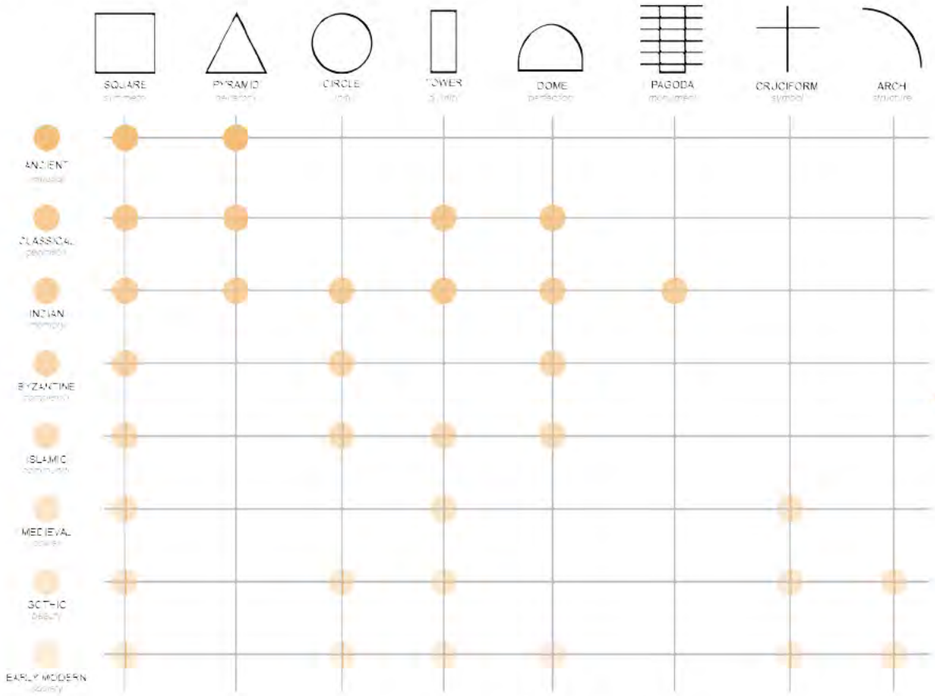


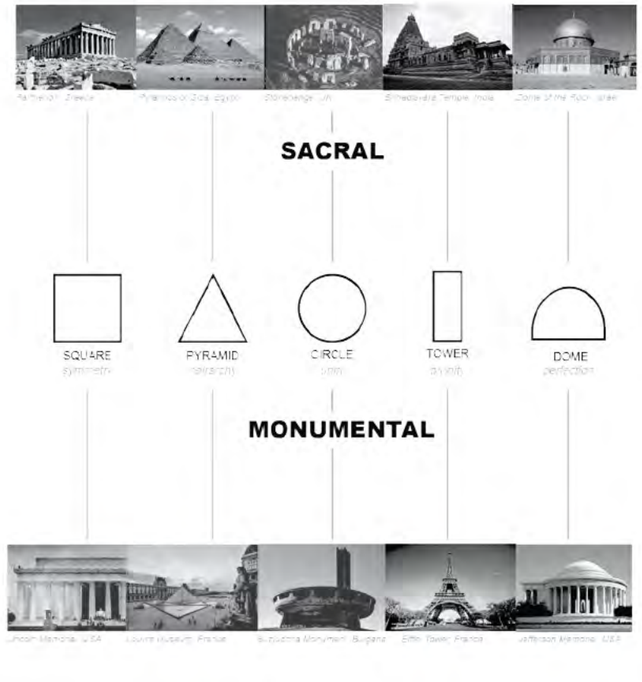
Figure 02 — The larger geographic map pinpoints Genterra Mons in the midst of the Tharsis Montes and Olympus Mons landscape. The context map below details the spatial relationships between Genterra Mons and the colony.



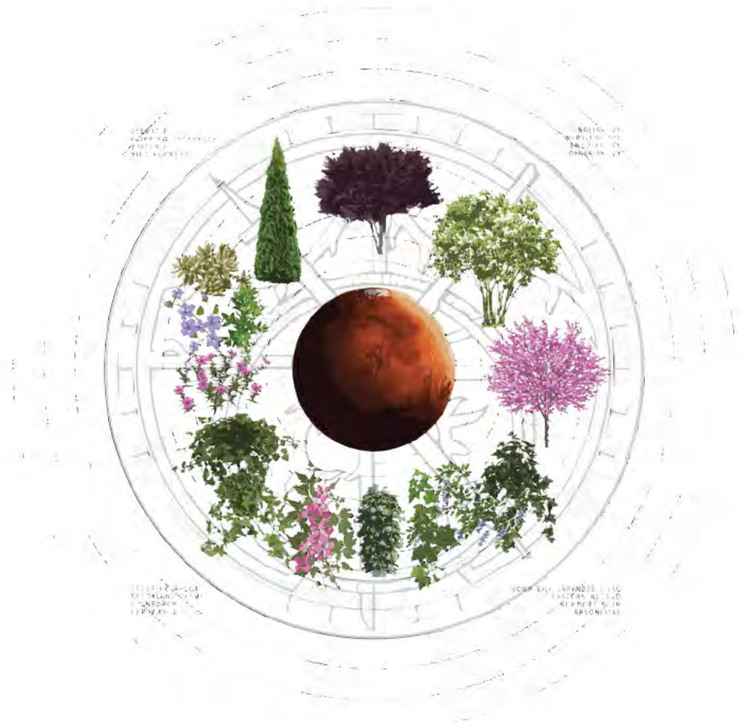
GENTERRA MONS

PROJECT DRAWINGS





SACRAL ARCHITECTURE



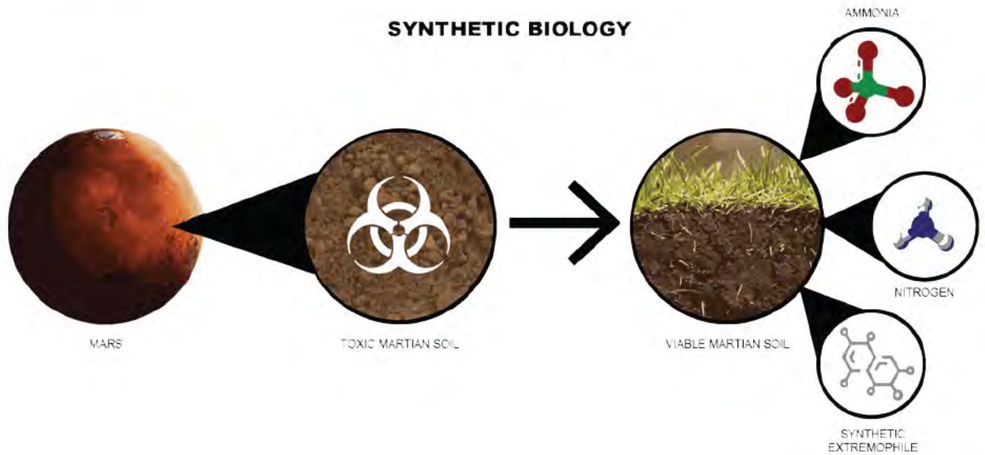


Figure 03 — These diagrams synthesize research on sacral architecture, monumentality, synthetic biology, soil remediation, and horticulture for Mars.

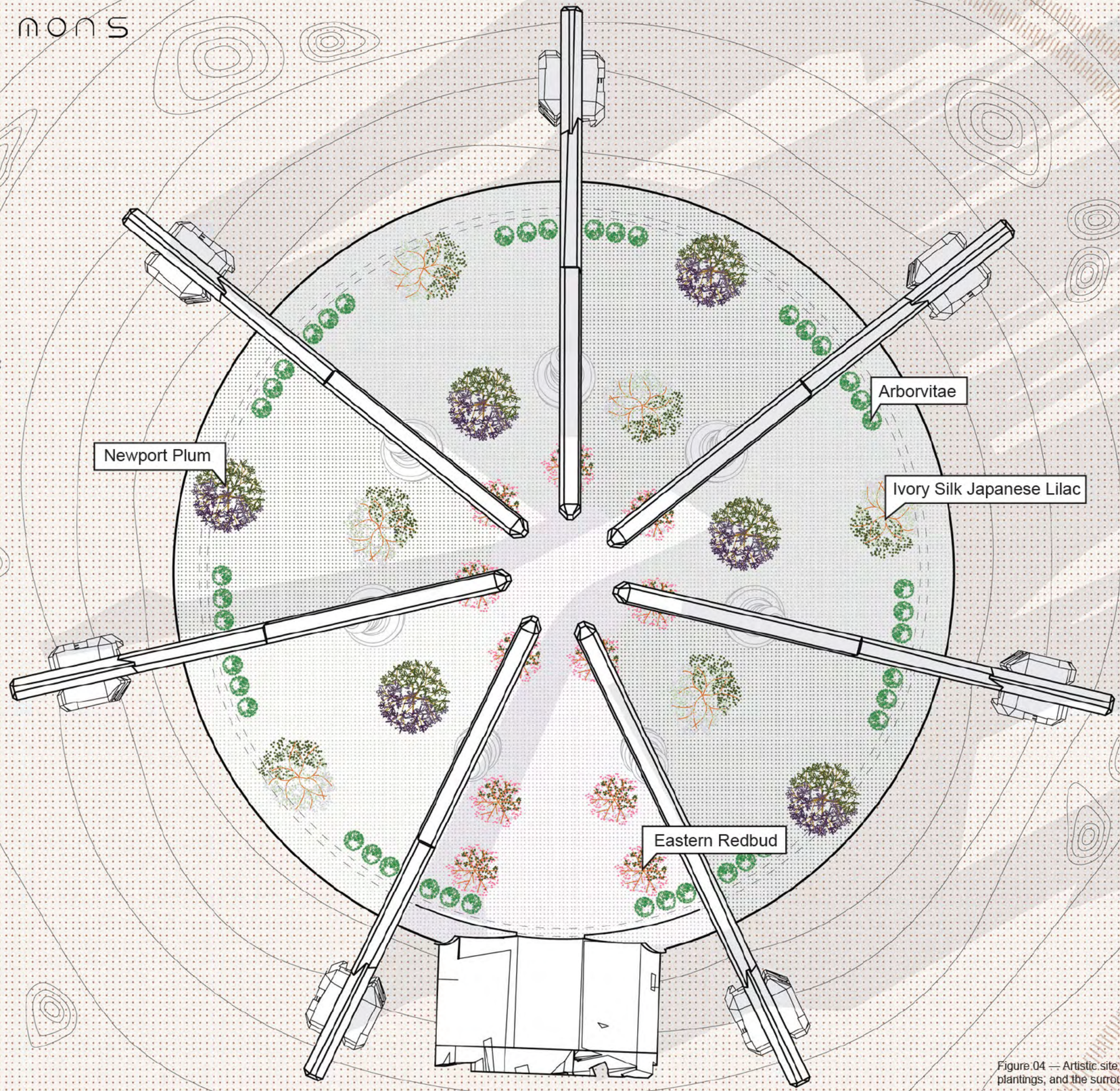
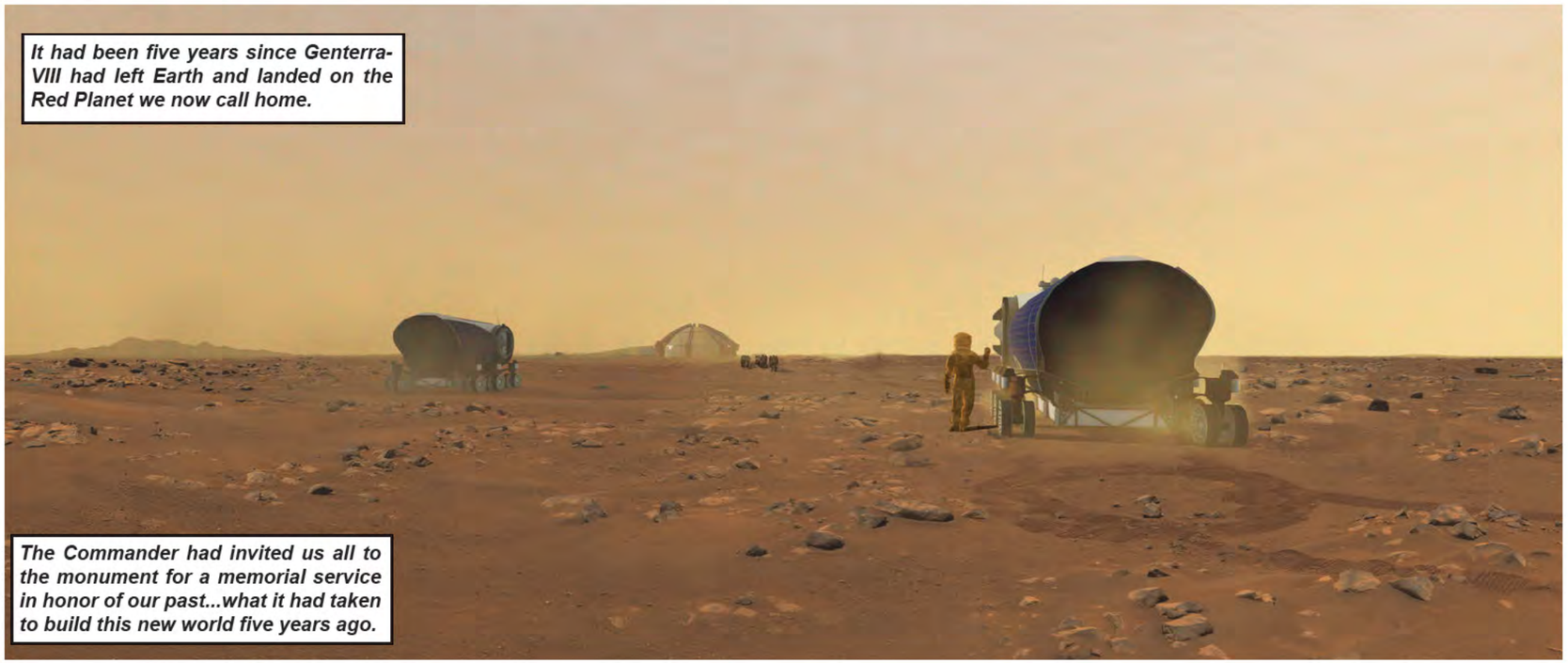
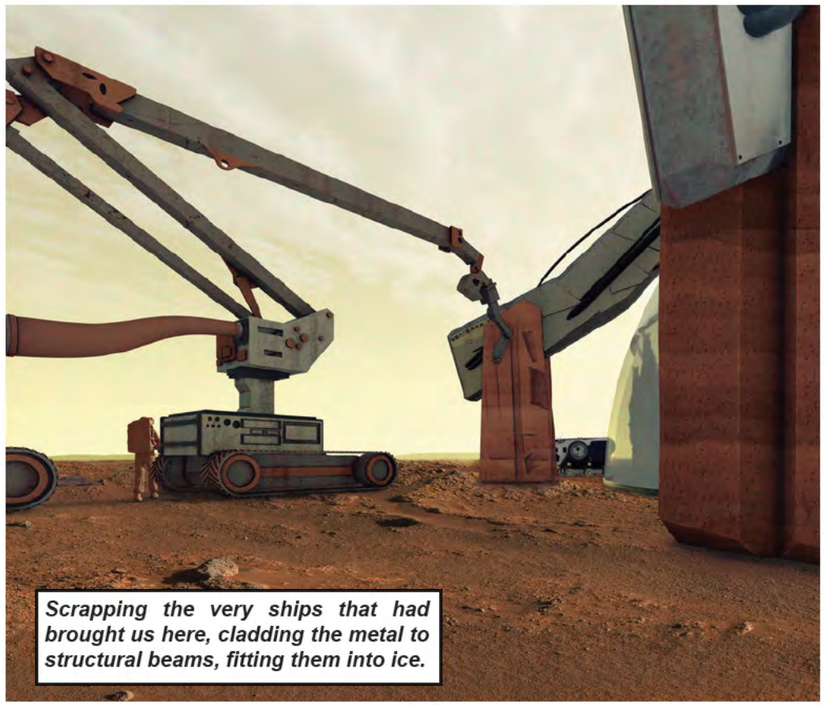
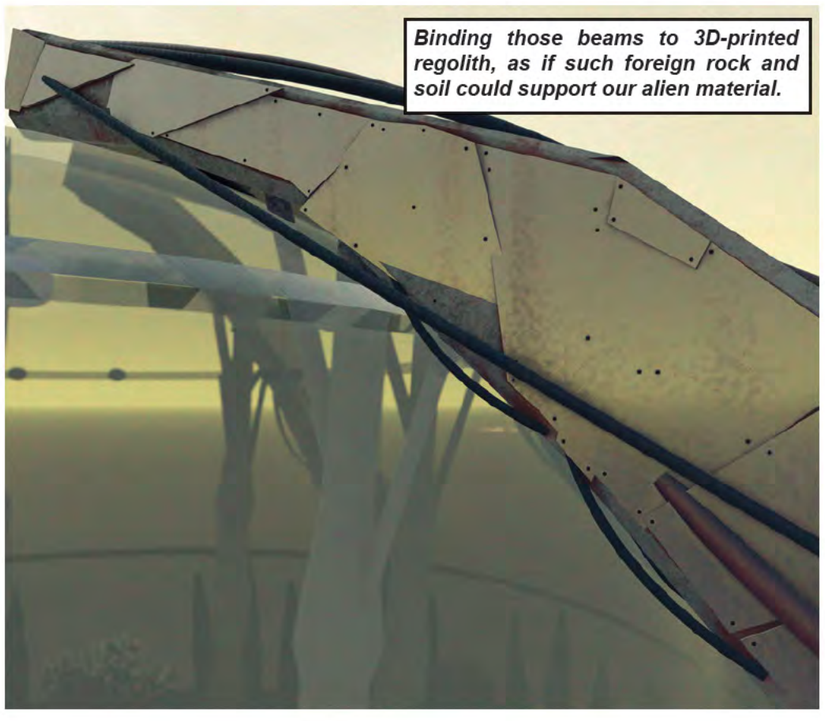


Figure 04 — Artistic site plan detailing the guardian buttresses, the interior plantings, and the surrounding landscape.







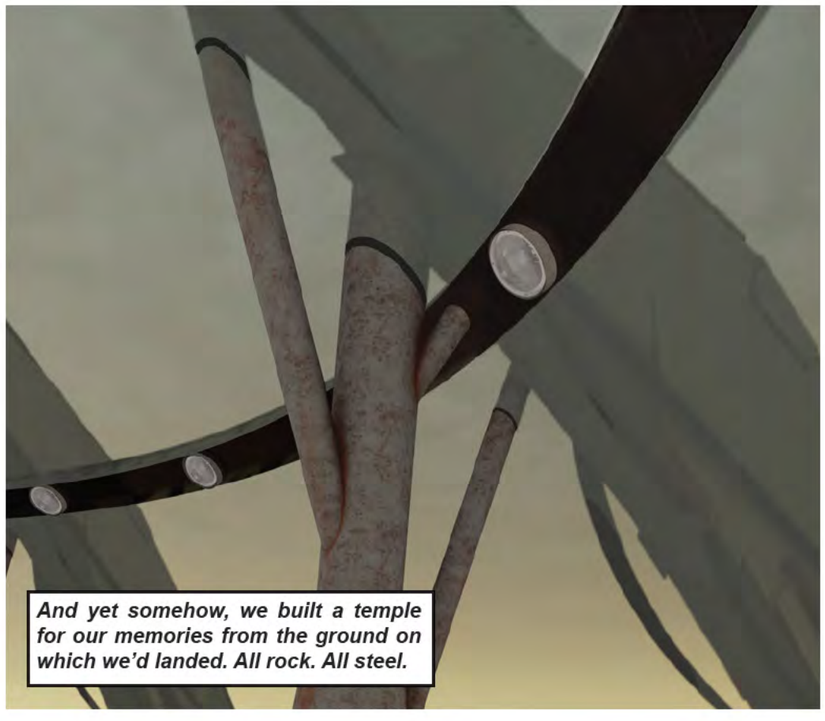


Figure 05 — Storyboard detailing the construction process behind Genterra Mons, as further explained in the Project Narrative.

Figure 06 — Above, elevation of Genterra Mons in site context. Below, orthographic view of Genterra Mons to detail the site, structure, and interior.

Figure 07 — The front entrance of Genterra Mons features an airlock that controls access into the closed-system interior.

Figure 08 — Side-by-side spread of the vegetated interior of Genterra Mons and the structural supports necessary to keep the memorial aloft.

Figure 09 — Exterior night view of Genterra Mons and the galactic sweep of the universe in a Martian sky.

What materials and methods are used to build/install your structure/ artwork/installation?

Genterra Mons is to be a long-lasting and sustainable gathering place for Martian colonists present and future. Primary materials will include components from the manned spacecraft sent to Mars, red soil, and subsurface water in-situ. In this project, seven hypothetical Mars missions culminated with its colonization: five manned spacecraft and two unmanned supply vessels. Upon arrival, these ships will be deconstructed and reused to create structural elements for Genterra Mons. The remaining structure will be crafted from Martian regolith since it has a desirable property in construction techniques. Finally, the ice dome will be formed using a hybrid ice mixture that will stay completely frozen indefinitely. The monument will be created through two slightly different 3D-printing methods, semi-autonomous robotic fabrication, and minimal human supervision or intervention.

What is the estimated build/setup time?

Genterra Mons will be constructed over a period of several months. Once all seven spacecraft have arrived on Mars, specific pieces of the vessel will be identified, marked, disconnected, and relocated by semi-autonomous robotic equipment. In the meantime, excavation and 3D-printing equipment will begin preparing the site for construction. After sufficient materials have been collected, construction will begin. After the columns and beams are assembled and installed, the ice dome can begin to take shape. The structural elements will be integral to ensuring the integrity and form of the ice dome for many Martian years.

Since earthen vegetation is being transported to Mars, considerations have to be made for growth in a new environment. This is a pioneering branch of astrobiology and alien horticulture in regards to a Martian landscape. Currently, Morgan Irons, CSO of Deep Space Energy, has examined the effects of spaceflight and microgravity on soil aggregates. If colonists would take earthen soil and synthetic organisms to Mars, they have to be assured their chemical makeup will remain the same. Freezing samples or designing what would essentially be a spacecraft serving as a greenhouse are two potential transportation methods for the plant life. Aggregates, one of the significant differences between soil on Earth and Mars, are part of a soil's structure and determine porosity according to size. These pores allow for water infiltration and are crucial for the long-term viability of Martian biology. Irons has studied fibrous, organic, and clay soils to understand which is best in a closed-system mimicking the Martian environment. In time, she believes a closed, ecological system — like that of the monument — will yield plant growth, but reliance on the Martian environment as a singular ecosystem would be foolish.[1]

For Genterra Mons, a spacecraft designed as a greenhouse would make the most sense. The trees will have to be brought to Mars near-maturity in the spacecraft's closed-system. The vining plants and groundcovers, obversely, could be brought as plugs to be planted within the monument and since the closed-system would replicate their natural, earthen environment precisely, these plants would begin growing in a matter of three to six months. Ungerminated saplings, seeds, and additional plugs could be brought on any of the spacecraft for future use. Ideally, with architectural construction and plantings in place, Genterra Mons could open its airlock to welcome colonists a year after the final spacecraft's arrival.

How would collaboration be utilized in realizing the design?

Problems and obstacles must be solved through collaboration in numerous instances, especially in an extraterrestrial project like a monument for Mars. In the hypothetical case of the seven Genterra missions, multinational individuals with unique backgrounds will be the first colonists on Mars. Healthcare workers, public servants, educators, tradespeople, and first responders will fulfill certain social roles. Scientists such as astrobiologists, astronomers, and physicists will ensure the continued viability of Mars as a home; but engineers, architects, planners, and designers will be crucial in the urban cosmetics of this Martian colony and others like it. Finances, human lives, and innumerous resources will be put at risk should there be an accident or miscalculation. Collaboration is non-negotiable. Genterra Mons celebrates this multinational venture by offering a new environment with new natural resources and materials. A traditional design process will likely take shape: community conversations, stakeholder meetings, cross-discipline charrettes, and construction phasing. The difference is that this is a pioneering process, one that will require thoughtful considerations and trial and error. We envision a more extensive and intensive planning and decision-making period. In one sense, people are once again working together to create something unique and new on a grand scale. In another, two planets will be unified for the first time ever if proper planning, cooperation, communication, and practical execution are involved.

1 Matt Williams, "What Martian Settlers Need to Know About Soil Can Teach Us How to Grow Better on Earth," *Universe Today*, 2020, https://www.universetoday.com/148428/what-martian-settlers-need-to-know-about-soil-can-teach-us-how-to-grow-better-on-earth-1/

How will your structure/installation be used by the public? Provide an example of how the public will interact with your space.

Mars is a barren landscape of violent dust storms, frigid nights, and red wastelands. The colony will be an isolated environment at times, sealed off from the outside world to create a habitable space for colonists. Earth is millions of kilometers away, practically imperceptible in the Martian sky. Terrestrial designers know that parkland is crucial for the viability of an urban environment and to the well-being of people. Creating this earthen paradise, a monument to the scientific feat of colonizing Mars and to the memory of these colonists' homes, is essential.

Genterra Mons will function like any other park on Earth: as a place defined by its users. A scientist who has been trapped in her lab all day ventures into the memorial landscape to contemplate a problem. A mother and her children, bored of the confines of their pod, escape here for some much needed exercise. A group of teenagers, fresh off their work schedule, board an MEV, disembark, and converse in the verdant paradise. A couple, fresh off the spacecraft, decide to mark this moment with a ceremony in the monument. They exchange vows in the glen. Inspired by this, two young lovers sneak away and etch their initials into the metal plates of the interior columns, like they would have on a tree on Earth. These are only a handful of the countless, unique, human interactions we envision occurring within the boundary of Genterra Mons.

How does the structure/artwork/installation address the climate in which it would reside?

As stated previously, the Martian landscape is harsh and unforgiving at times. Genterra Mons was designed to soldier through such a world with ease. The guardians' wide bases, the sturdy exterior beams, and the structural columns inside the dome provide resistance against frequent dust storms. The ice dome creates a resilient shield around the precious interior, protecting it from those incessant storms and deflecting harmful portions of sunlight. Artificial LED lighting will be used in congruence with sunlight to stimulate plant growth during dark spells. The monument's closed-system provides vital nutrients and biological protections. Shapes and forms will be sculpted in such a way that debris slips across without resistance or sedimentation. Its design is also indicative of this new world. Whereas such a place on Earth might be built in an urban setting, surrounded by high-rises or residences, Mars cannot yet permit such construction. On Earth, some of these species might invade native flora and overtake the ecosystem, but in the monument's closed-system, such aggression is monitored. Its aesthetic is unique — a golem of the planet's resources.

What type of technology is implemented in your design?

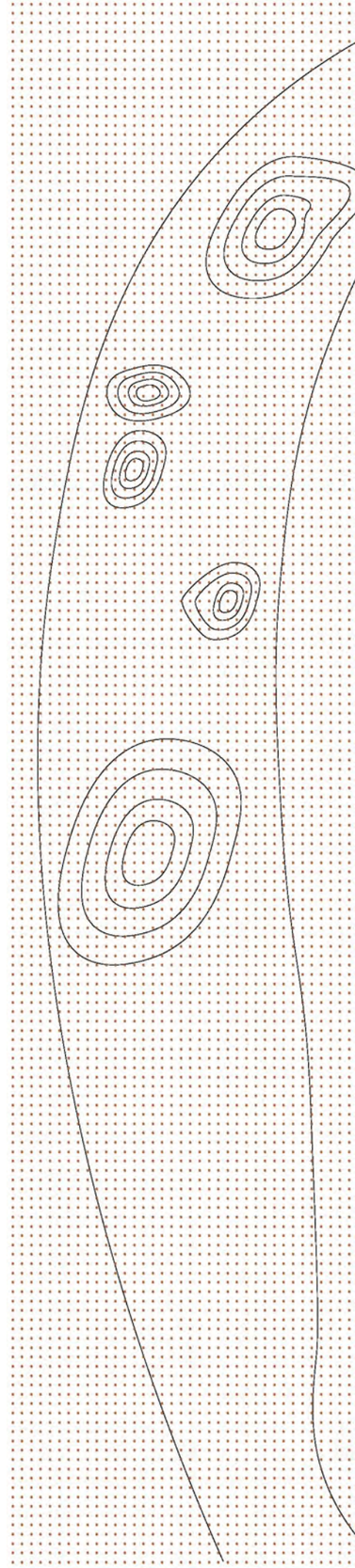
Genterra Mons will be a technological marvel. Construction is a hybridization of traditional earthen processes and 3D-printing of natural resources. It will require enormous printing machines, artificially-intelligent droids, and some manual labor. Construction crews will be a memorable sight on the Martian landscape for several months. However, there will be new technology involved to ensure the biology survives. Synthetic organisms and compounds will be necessary to remediate the barren landscape. Micro scale terraforming will be a likely outcome after the success of this project and others. Closed-system technologies for habitability are going to be necessary components for people and plants to survive in Genterra Mons. Mundane aspects of design like lighting, irrigation, waste disposal, and maintenance will be monitored short-term and will quickly be of more importance than on Earth.

What makes the design environmentally friendly/sustainable?

Since this is a two-fold disciplinary approach to Genterra Mons, both the architecture and landscape are sustainable systems for Mars. Architecturally, the construction materials are mostly locally sourced. The large dome will be created using a new method of 3D-printing that utilizes a water mixture to create strong, translucent ice. Additionally, large portions of the seven spacecraft will be reused and combined with Martian regolith to create reinforced columns and longspan beams that will support the dome and provide a terrestrial experience. 3D-printing will also be used to extrude the soil into the seven major pairs of structural components in the monument. In concept, the majority of the monument could be returned to its original state if there is intent.

Genterra Mons + Synthetic Biology

The landscape architecture is the second sustainable design solution. Unfortunately, Martian soil is an unviable material for plant growth; however, there have been theoretical studies conducted at NASA on sustainable biology for Mars.The agency's foremost search is for a synthetic biology architecture to desalinate Martian soil and enrich it with ammonia (see Figure 02). NASA postulates a two-system process of desalination and nitrogen fixation, which individually exist in earthen biology, through a synthetic organism. It would eliminate toxic wastewater and would grow in-situ with resources as opposed to other systems. NASA hopes to replicate earthen extremophiles in a synthetic Martian environment for future transportation to Mars. In time, this study could be extended to bioremediation and non-arable land enrichment which would terraform the Red Planet.[2] Additionally, Martian biology will be crucial in



purifying air recycled through the closed systems proposed by NASA.[3] More sustainable methods of waste disposal, like composting, will lead to further enrichment of soil structures.

An international selection of plants have been chosen to inundate Genterra Mons. Given the unique, globalist efforts to colonize Mars, a pannational selection felt appropriate. The plants were chosen from between Earth's 60° N and 50° N latitude lines, also called Global Hardiness Zones 5 and 6. This area is characterized by a continental climate with long winters, thus allowing plants transplanted on Mars to withstand its cold temperatures even in a closed-system. See Figure 02 in Architectural Renderings for more insight.

A green carpet is laid in Genterra Mons with steppable groundcovers that often survive in harsh earthen conditions and are therefore suitable for the monument's closed-system. The groundcovers are creeping phlox (*Phlox subulata*), Breckland thyme (*Thymus polytrichus*), English stonecrop (*Sedum anglicum*), and common periwinkle (*Vinca minor*).

Ornamental trees are the only viable tree type in this situation. Shade trees and large evergreens are unable to root properly in Martian soil for a primitive colony like the one that exists for Genterra Mons. The closed-system with artificial climate controls will allow the trees to experience continental seasonality. The ornamentals are Ivory Silk Japanese Lilac trees (*Syringa reticulata 'Ivory Silk'*), Eastern Redbuds (*Cercis canadensis*), Newport plum trees (*Prunus cerasifera 'Newport'*), and arborvitae (*Thuja occidentalis*).

In order to achieve the shade canopy supplied by deciduous trees, climbing vines have been selected. Perhaps one of the most viable plants given their ability to grow vertically in even low gravity environments, their invasive nature will allow them to cover the guardians' support columns. They will also be guided along vertical and horizontal cables.[4] The climbing vines include clematis (*Clematis spp.*), climbing hydrangea (*Hydrangea barbara*), wisteria (*Wisteria spp.*), English ivy (*Hedera helix*), Nepalese ivy (*Hedera nepalensis*), Swedish ivy (*Plectranthus australis*), and Canarian ivy (*Hedera canariensis*).

How does your project address a high quality and unique aesthetic?

Genterra Mons is both a memorial landscape and an example of sacral architecture. The avant-garde, brutalist guardians flanking the dome are golems made of Martian regolith and scrapped parts from spacecraft. They represent the seven missions to Mars which culminated in its colonization. The ice dome is a hybridization of Martian materiality and Earthen horticulture, a structural component, and a gathering place for the colonists. The conglomeration of two planets' materials, elements, and fundamentals creates the most unique anomaly humankind could witness. By integrating a form of life with a foreign environment millions of kilometers away, the aesthetic will be unforgettable and unrepeatable.

Genterra Mons + Memorial Landscape Architecture
Spaces devoted to war memorials, figure monuments, and traumascapes — these being places where traumatic events occurred and are memorialized — are called memorial landscapes. They are part of a greater conversation about democratization of space, constructed pasts, and historiography which have become dependent on nuanced memory. Nostalgia tempers memory by negating associated pains.[5] Each person has their own memories which contribute to a collective memory through nostalgia concerning an event or person. Genterra Mons will be a space for colonial society and individual experiences. Memorial landscapes are more than political devices though. They are sacred spaces, important cultural markers which are considered hallowed ground for society. Nothing should disrupt their eternal nature. Genterra Mons, nestled in an iconic landscape and devoted to remembering the missions which brought humans to Mars, will absolutely be a hallowed space for colonists.

Maya Lin's Vietnam Veterans Memorial in Washington, D.C. is an excellent example of the subtleties of memorial landscape architecture. Lin's memorial "brought to a sharp awareness [the] loss [associated with the war,] and [left it] up to the individual to resolve or come to terms with this loss. For death in the end is a personal and private matter."[6] Genterra Mons is not concerned with death and war, but the thickly vegetated dome allows for private retreat from colonial life, for a glimpse at what once was their earthly home. There will be a certain element of loss felt in this space.

Monumentality has its drawbacks though, namely through propaganda and nationalism. In this project, it was important to avoid monuments which "offer[ed] an anachronistic experience: a face-to-face encounter in a specially valued place set aside for collective gathering."[7] Genterra Mons had to hybridize memorial experiences through earthly and Martian means. It had to become an ancient wonder and a modern marvel, a hallowed ground made sacred to the colonists.

Genterra Mons + Sacral Architecture
Religious, spiritual, or celestial architecture is considered sacral, with other synonyms like hallowed and monumental associated with it (see Figure 02). In this project, ancient and early-modern sacral architecture served as a design aesthetic. With this being the first colony on Mars, a

2 Adam Arkin, "A Synthetic Biology Architecture to Detoxify and Enrich Mars Soil for Agriculture," NASA, 2017, https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Mars_Soil_Agriculture/

3 R.L. Orwell, R.L. Wood, J. Tarran, F. Torpy, and M.D. Burchett, "Removal of benzene by the indoor plant/substrate microcosm and implications for air quality," *Water, Air, and Soil Pollution*, 157 (2004), 193-207.

4 R. Wheeler, plant physiologist and a leader in the Advanced Life Support Research activities at Kennedy Space Center at NASA, in an interview on July 7, 2015.

5 Brandi Thompson Summers, *Black in Place: The Spatial Aesthetics of Race in a Post-Chocolate City* (Chapel Hill: The University of North Carolina Press, 2019), 87.

6 Kirk Savage, *Monument Wars: Washington, D.C., the National Mall, and the Transformation of the Memorial Landscape* (Los Angeles: University of California Press, 2009), 270.

7 Ibid, 4.

harkening back to historical design principles seemed appropriate. If these architectural forms were also considered monumental, embracing both would unite the hallowed nature of the space with hallowed forms. Figure 02 in Architectural Renderings features a matrix diagram connecting architectural forms with sacral, architectural movements. These inspired the geometric layout, circular plan, and forms in Genterra Mons' design.

Additionally, with Mars serving as a new world template, the Seven Wonders of the Ancient World were analyzed to understand how these served as the defining monuments of ancient civilizations. The wonders are hallowed examples of the contributions made by ancient Mediterranean and Middle Eastern cultures to modern society. The Great Pyramids of Giza are the only wonder to still exist, but the other six still remind designers of the values placed on ancient architecture. The pyramids and the Mausoleum of Halicarnassus in present-day Turkey were memorial tombs for political leaders, similar to memorials to Presidents Jefferson and Lincoln in Washington, D.C. The Hanging Gardens of Babylon, built by Nebuchadnezzar II in 600 B.C.E., inspired the vegetated interior of Genterra Mons. The Statue of Zeus in Olympia and the Colossus of Rhodes are both figure monuments to celestial entities, and similar to Genterra Mons' guardians, protectors of a culture. The Lighthouse of Alexandria was a beacon for travelers and defined the city. In a similar manner, the Temple of Artemis in present-day Turkey served as a landmark for the people. These motifs — memory, landscapes, monumentality, and placemaking — continue to guide architectural design today. These became important to the design and aesthetic of Genterra Mons.

Is there anything else you would like to tell us about your proposal?

Several safety factors have also been considered with this design. The most important is that each visitor will keep their suit on at all times. While helmet and glove removal is allowed inside Genterra Mons, a storage solution will be provided to allow each colonist to carry around these pieces of their suit if a sudden emergency should occur. Additionally, only a specified number of colonists will be allowed inside the dome at any given time. Visitors will be monitored to minimize the risk of possible injury or ensure no one goes missing during the journey between the colony and the monument. The design will also include emergency oxygen tanks and helmets for those who may have damaged their suit in an accident. We anticipate that a few authorized colonists will be in constant communication with Earth-based crews to perform routine inspections on Genterra Mons. Regular maintenance and minor repair work will essentially eliminate any possibility for failure or injury on the site of the memorial.

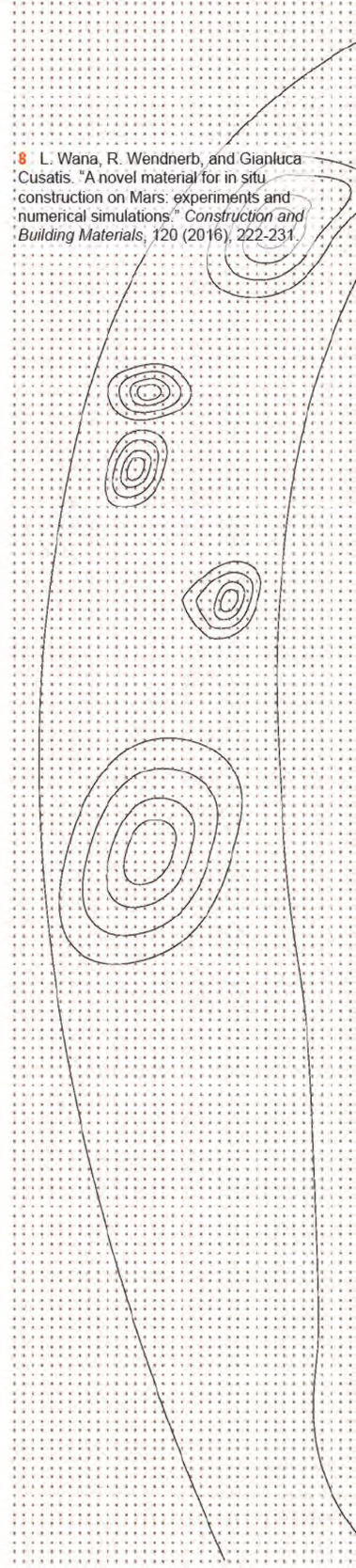
Provide an estimated budget.

While the budget for colonizing Mars will easily be in the tens, if not hundreds, of billions of U.S. dollars, the amount of additional cost that Genterra Mons would require is practically negligible. However, in order to abide by the instructed $1,000,000 USD budget, this project has taken measures to reduce the cost of the monument as much as possible. It envisions a three-phase construction plan in order to reach completion.

Phase 01
The first phase sees the five manned and two unmanned spacecraft used in the seven Genterra missions disassembled and reallocated to create the structural beams and interior columns for the monument. This process will cost nothing monetarily upfront, but rather requires notable time for planning and execution. There could be an assumption made about the cost of labor and salary for workers, but this phase of the project can be completed on site at no additional cost to anyone.

Phase 02 A
The second phase has to be split into two additional parts given the complex nature of printing naturally occurring elements found in-situ. Phase 02 A pertains to 3D printing the Martian regolith. After a refining process, the surface regolith will be divided into two parts: an aggregate made of sand and small crushed stones, and a sulfur based compound that will act as a binding element.[8] A modified soil sifting machine capable of refining regolith into necessary components stores material and discards the remaining portions. On Earth, an industrial grade soil sifting machine costs about $15,000 USD, and with the said modifications, the final machine may cost around $25,000 USD.

The next step in this process is heating the concrete for extrusion. When heated to approximately 120° Celsius (248° Fahrenheit), the sulfur will melt and can be mixed with the aggregate to create a concrete derivative. This mixture would then feed into the extrusion-based 3D printer to form the column bases. The cost of manufacturing the 3D printing machine and excavator is difficult to determine, but given the hypothetical nature of this project and in reference to several Martian colony proposals as precedents, the machine is already on hand. 3D printing is a common solution for problems associated with construction on Mars, and building Genterra Mons will only require an attachment modification to the existing rig. An assumption must be made that engineers and builders will be among the Martian colonists and familiar with this type of machinery. They will first use this machine to erect the beams and interior columns. Then, they will install the modification. The attachment will add another $25,000 USD to the project's budget for engineering, production, and testing.



8 L. Wana, R. Wendnerb, and Gianluca Cusatis. "A novel material for in situ construction on Mars: experiments and numerical simulations." *Construction and Building Materials*, 120 (2016), 222-231.

Phase 02 B
The second part of Phase 2 pertains to an ice-like compound that will stay frozen annually on Mars and is ideal for Genterra Mons' dome. Given that the monument is north of the equator, and the average surface temperature on Mars is -63° Celsius (-81° Fahrenheit), it exists in a climate that experiences temperatures significantly lower than the freezing point of regular water, let alone a modified water mixture. In order to construct the dome through a modified 3D-printing process, an additional cost of $5,000 USD is necessary for a modified extruder and tubing. Hypothetically, the colony already has an efficient and reliable water extraction system which harvests and filters groundwater. This is then transported from the colony to the monument. Minor costs for general maintenance and repairs can be calculated here as well.

Phase 03
The third and final phase includes the plant life and vegetation that is integral to the design. Since anything being transported to Mars takes around nine months to arrive, the flora for Genterra Mons will be put into an artificial dormancy period. This process would cost very little since dormancy can be forced through relatively simple means. Additionally, plugs and seeds will need very little, if any attention during this journey. Because of this, there will be no significant cost in this phase. One thing to consider in this aspect of the design is that time and research will be necessary for identifying how to safely send these plants to Mars. Once the colonists introduce the plants into their new environment, tending to them and ensuring soil and water levels are adequate will be a matter of routine maintenance.

Finally, the budget of Genterra Mons will include transporting the equipment and components necessary. For argument's sake, sending this cargo to Mars will abide by a recent cost estimate provided by SpaceX: $150 per kilogram.

In total, the cost of Genterra Mons is broken down as follows:

Cost of equipment:
$25,000 for modified soil sifting machine
$25,000 for 3D printer attachment (concrete)
$5,000 for 3D printer attachment (ice)
$1,625 for 65 tree saplings (approx. 1 m tall, at $25 each)

Total cost of equipment = $56,625 USD

Cost of transportation:
2,500 lbs for the soil sifting machine = 1,134 kg
500 lbs for 3D printer attachment (concrete) = 227 kg
100 lbs for 3D printer attachment (ice) = 45 kg
175 lbs for 1 tree sapling x 65 saplings = 9,750 lbs = 4,422 kg

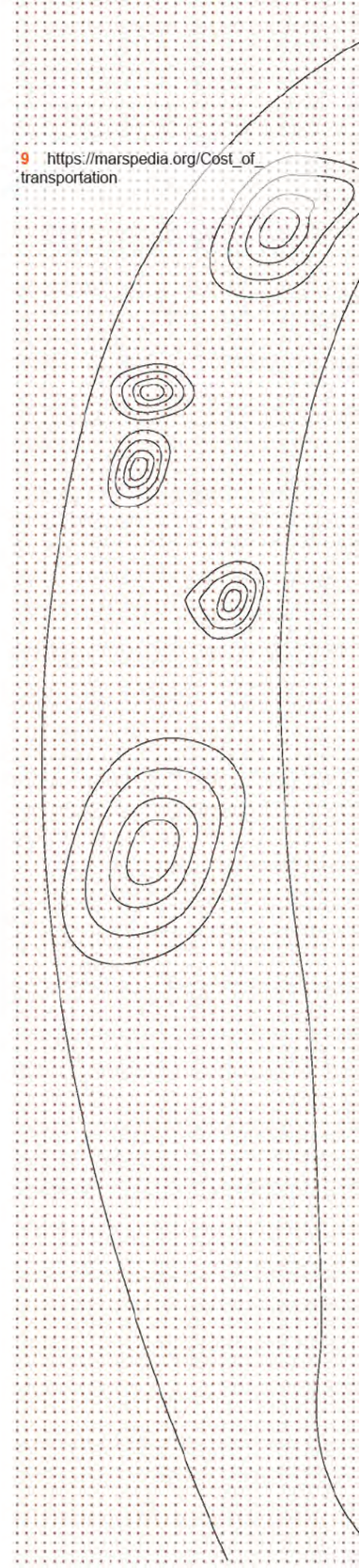
....5,828 kg of equipment, materials, and plants (x $150 / kg)

Total cost of transportation = $874,200 USD

Total cost of Genterra Mons' construction: $930,825 USD

As shown in this schematic budgetary breakdown, Genterra Mons is $70,000 under the required $1,000,000 USD budget.

9 https://marspedia.org/Cost_of_transportation



Thank You for Considering

GENTERRA MONS

Museum of Outdoor Arts Design and Build Competition
2021 Design Challenge “Out of This World:” A Monument for Mars

Figure 10 — Exterior rendering of Genterra Mons as a dust storm begins to gather on the Martian surface.

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