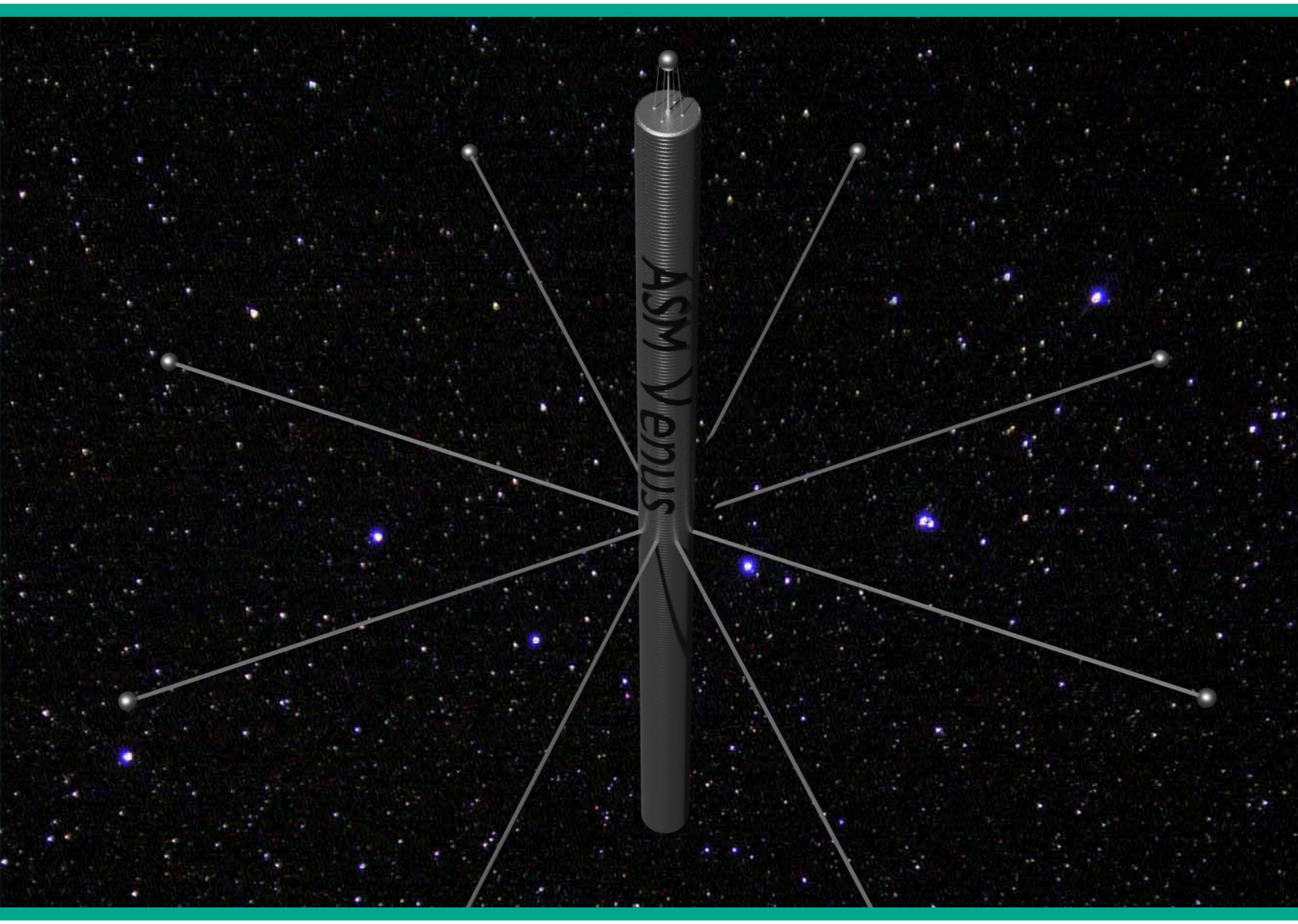


AEROSPACE MERIDIAN

ASM VENUS

AEROSPACE MERIDIAN

The AeroSpace Meridian Venus is a cylindrical space station orbiting the asteroid 16 Psyche. The space station is designed to manufacture additional spacecraft for further habitation of the solar system by utilizing this resource-rich asteroid. People from every background will be unified in one spacecraft in the hopes to improve the betterment of mankind and space technology over the course of numerous generations. This project is separated into three phases.

Phase I revolves around utilizing present-day technologies. Two space rings, the Mercury Class space stations, are constructed in low earth orbit. We designed a novel shielding panel to protect the stations from high-velocity particles. Communications will be sustained via an Earth-based ground station. We constructed a proof of concept ground station to authenticate how such a station would behave.

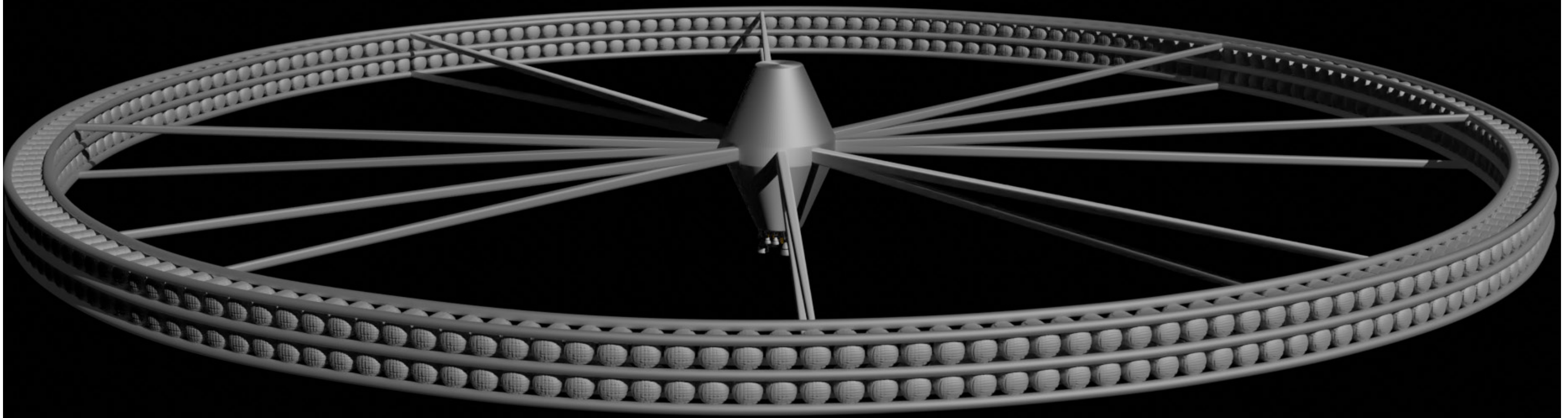
Phase II details the ASM Mercury-I and the ASM Mercury-II Hohmann transfer to 16 Psyche. The space rings ensure constant artificial gravity, which serves as a preventative to an array of short-term and chronic illnesses ranging from heart conditions to bone loss. Due to the extreme cost of shipping mass quantities of food on a long-term space expedition, the ASM Mercury stations will use aeroponics to maximize food production and minimize excess cargo weight. Phase II considers in depth how we shall overcome language barriers and cultural differences between nationalities.

Phase III describes how raw materials from 16 Psyche are acquired and how power for the immense station will be sustained. The ASM Venus will feature hexagonal housing for structural integrity. Gas detectors will ensure the safety of the inhabitants living in the enclosed space station. Ultimately, the ASM Venus will serve as long-term housing for thousands of crew members who will assemble future space stations for human expansion into the solar system.

CONTENTS

PHASE I

ASM MERCURY

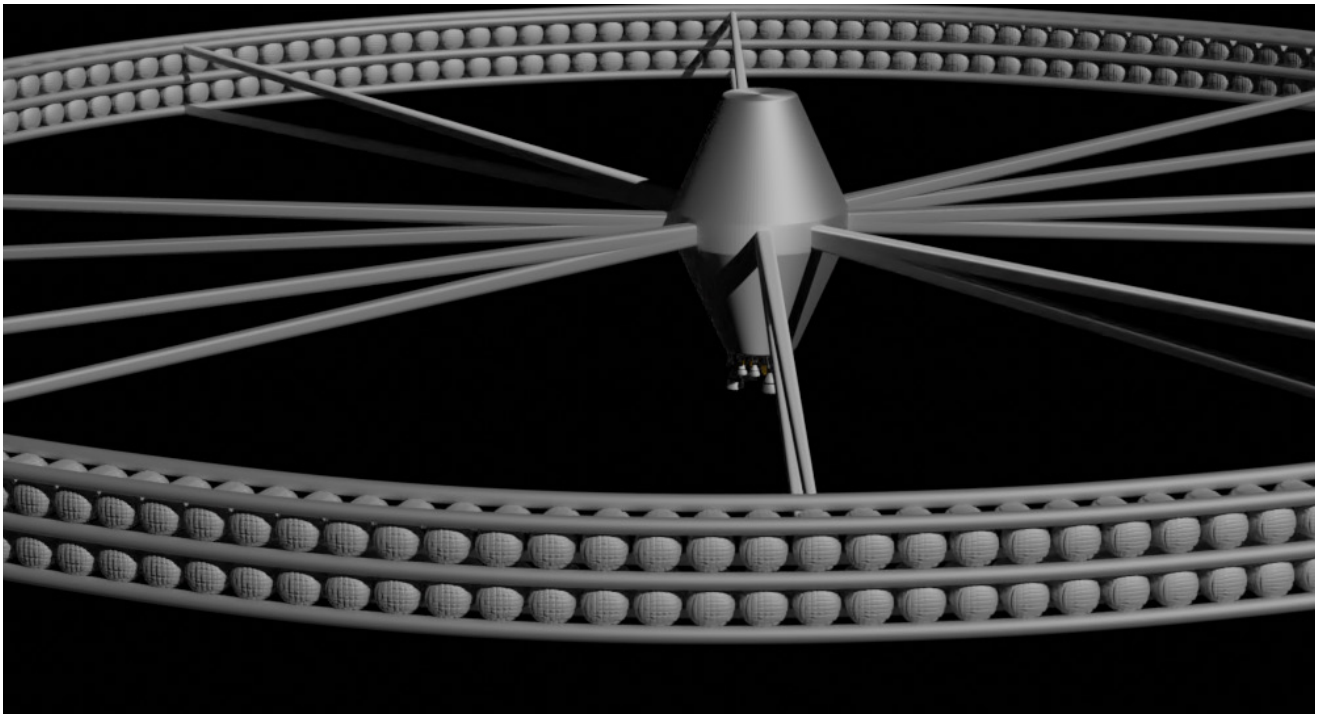


CONSTRUCTION OF
THE MERCURY CLASS
SPACE STATIONS

MERCURY CLASS SPACE STATION

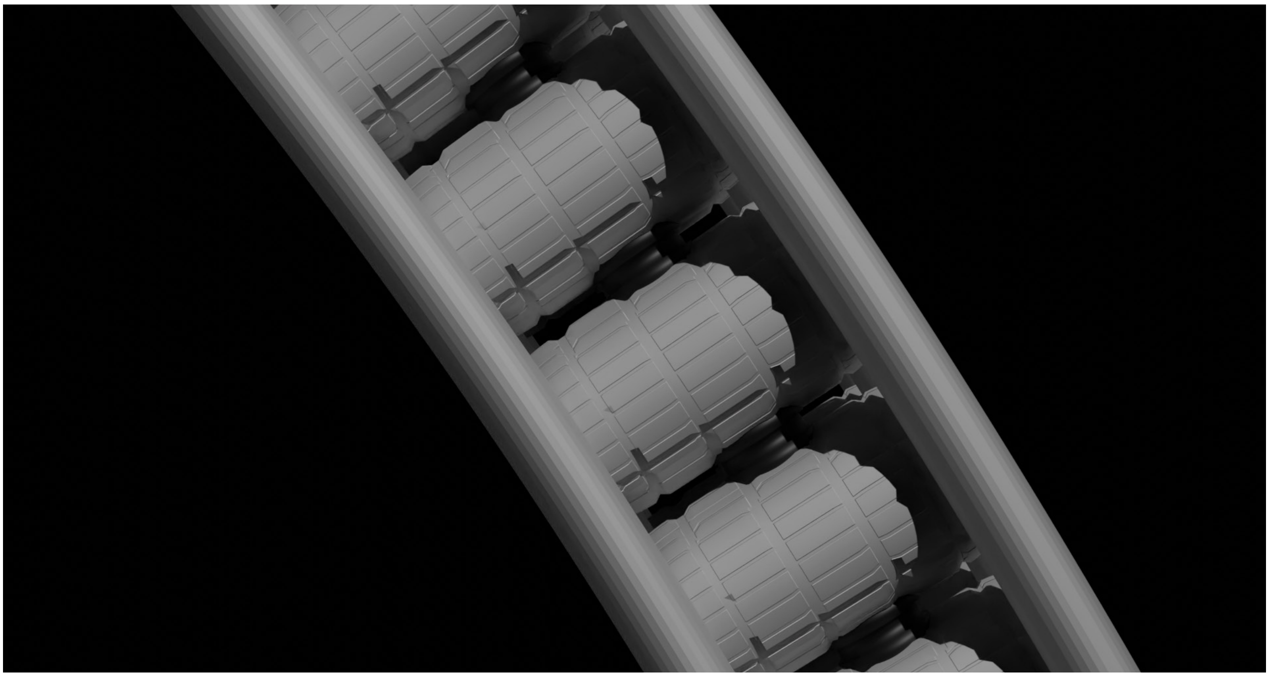
We propose the construction of two space rings composed of Bigelow Expandable Activity Modules ("Bigelow Spheres"). These spacecraft are Mercury Class space stations and will be designated as the ASM Mercury-I and the ASM Mercury-II. Each will consist of 393 Bigelow Spheres within two stacked space rings, and each will contain 100 housing Bigelow Spheres and 293 aeroponic and storage Bigelow Spheres.

The original Bigelow Sphere is 13.2 feet by 10.6 feet (4.02 by 3.23 meters) (BEAM 2021), a size is not even as large as a one-bedroom apartment. We decided to increase the scale of the Bigelow Sphere to the size of the TransHab's variant of a Bigelow Sphere, the dimensions of which are 37 by 27 feet (11 by 8.2 meters) (TransHab 2021). This variant was chosen because of its increased internal volume and reduced volume per shielding, and hence, costs. We plan on integrating three separate floors within each Bigelow Sphere for the sake of optimizing utility and privacy. There will be variants within the arrangements of every Bigelow sphere to reduce uniformity. The typical Bigelow Sphere will have living quarters fit for four people on the top floor, a living area and airlock connecting to the adjacent Bigelow Spheres on the second floor, and a lavatory on the bottom floor. The storage and agriculture model Bigelow Sphere will remain uniform. External dimensions will remain the same to prevent an offset in the rotation of the Mercury.



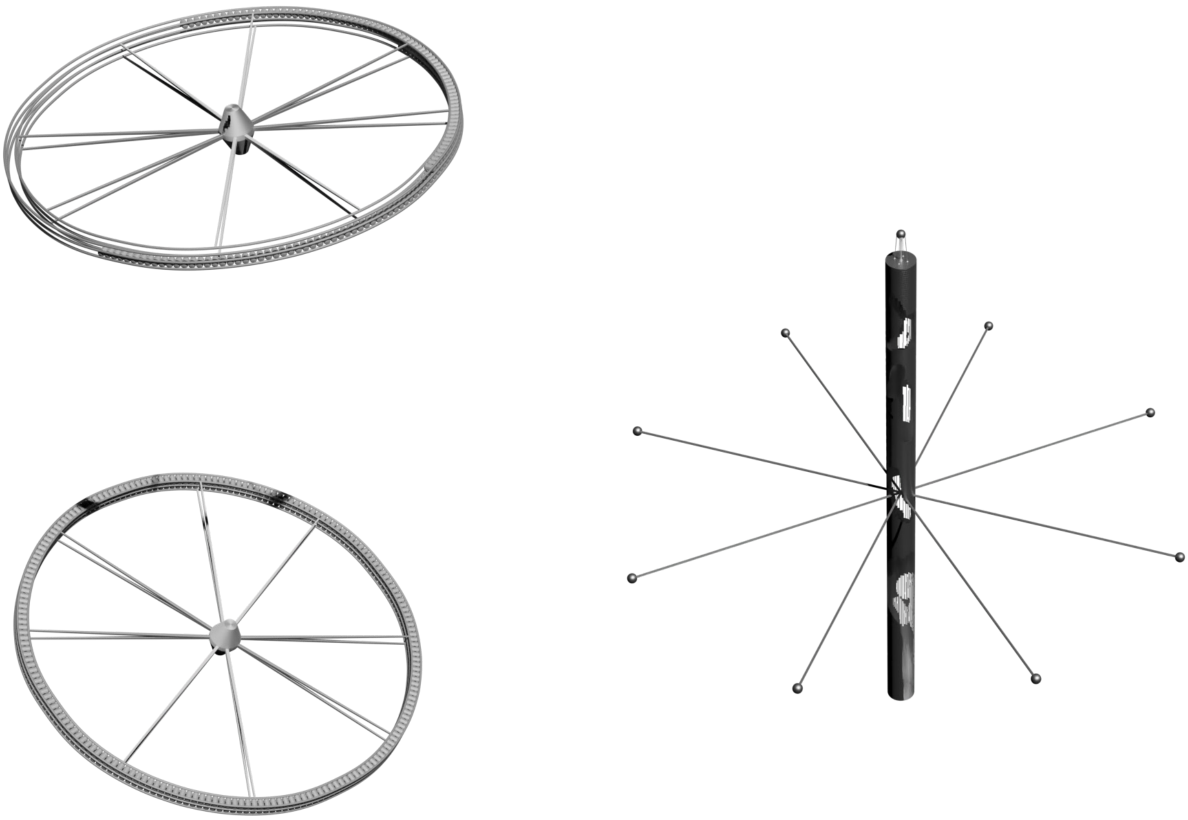
The Mercury Class space stations will house a total population of 800 people. This is a needed base population for starting a colony free of the risk of inbreeding. A population of 500 is needed to "reduce genetic drift" (Robinson 2015). Because we expect there to be an initial dip in the population (typically, 86% of women have children, according to the 2016 census (Pew 2018)), we added a cushion of 300 people. This will compensate for those who decide not to have children. At the average birth rate, a family will have 2.3 children. With this taken into consideration, it will take 12 generations to fully populate the ASM Venus. This allows for the agriculture system to fully cultivate with the rate of family growth.

The journey to 16 Psyche will require radiation shielding because the spacecraft will not be protected by Earth's atmosphere during the Hohmann transfer. Andrew Olafrud's shielding, consisting of 6.5 cm of solid and fluid material (described below), is considered sufficient to maintain adequate protection against radiation. Upon arrival at 16 Psyche, the Mercury station will be at least 2.5 astronomical units away from the sun, greatly reducing the threat of radiation.



Top-down view of a ring of a Mercury Class space station.

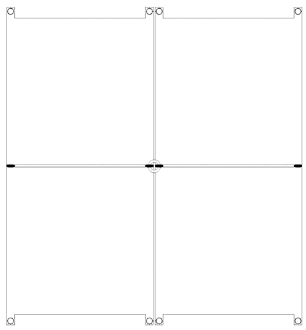
Because of the fact that the ASM Venus will require a significant amount of resources not available on 16 Psyche, the ASM Mercury-I and ASM Mercury-II will need those materials available to compensate. Our response to this problem is to overstock the Mercury Class space stations with needed resources for the Venus. The first instance of resource reuse will be in the power production system of the Mercury. Just like the Venus, the Mercury stations will be sustained by nuclear energy and the spacecraft will carry excess uranium to provide energy for the Venus when it is constructed. Another example of how resources from the Mercury will be recycled is in the frame of the spacecraft itself. The amount of titanium in each Mercury is 21,112 metric tons and every kilogram of that mass is intended to be reused on the Venus. Although the ASM Venus will not be solely constructed of titanium (such an alloy is not available on 16 Psyche), the titanium will serve as a key contributor to the initial construction of the ASM Venus.



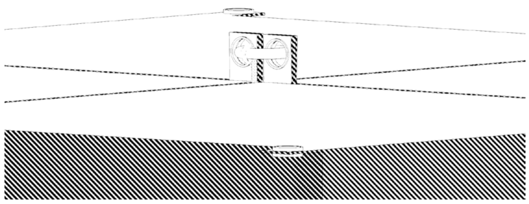
Two Mercury Class stations, one partially disassembled during the construction of the ASM Venus.

HVP SHIELDING

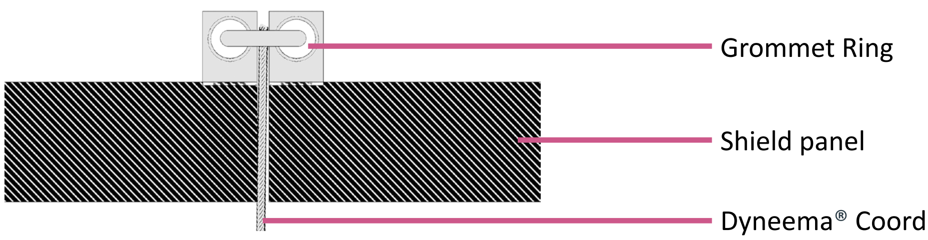
SHIELD PANEL, OBLIQUE



SHIELD PANELS, GROUPED



SHIELD PANELS, GROMMET RING



SHIELD PANELS, ATTACHMENT

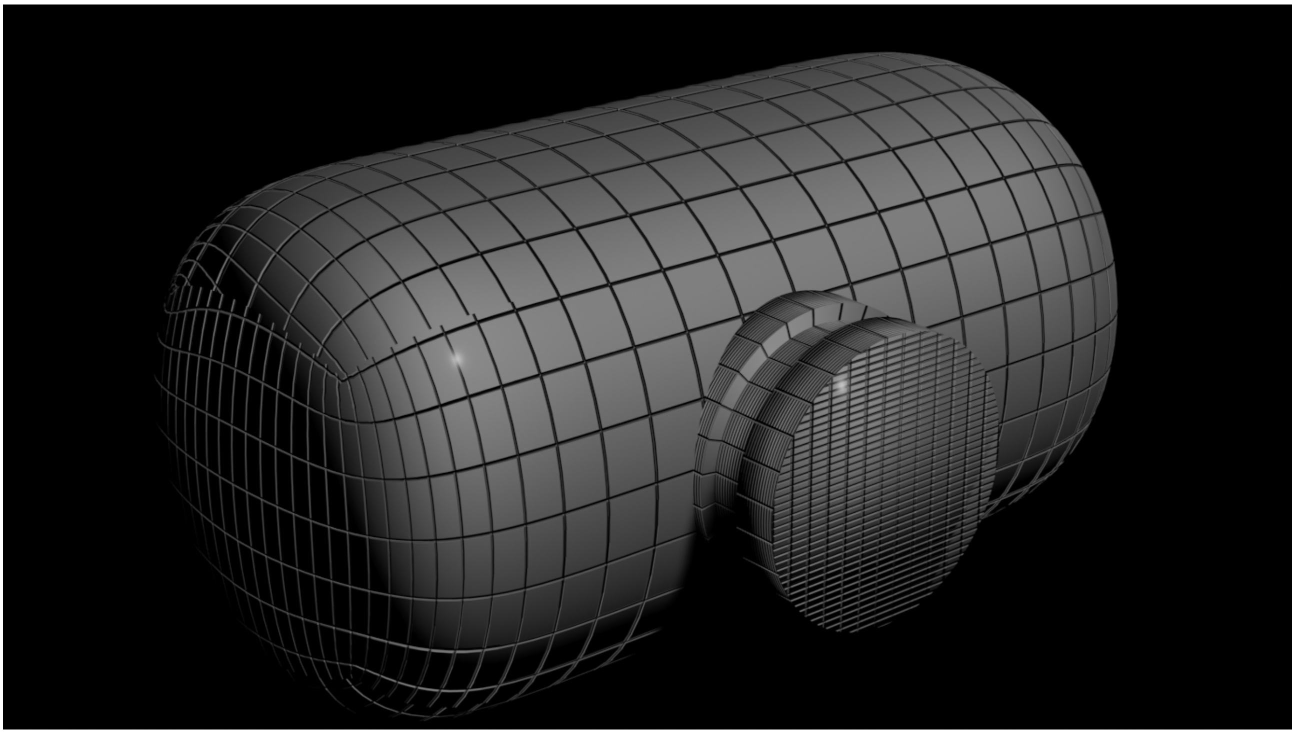
The ASM Mercury in low earth orbit will need of a layer of exterior shielding to protect against high velocity particles. We will use the shielding invented by AeroSpace Meridian team members Andrew Olafsrud, lead inventor, and Austin Pham, secondary inventor. This shielding is USPTO patented in January 2021 under the name SELF-HEALING SHIELD CONFIGURED TO PROTECT AN ENVIRONMENT FROM HIGH VELOCITY PARTICLES and previously protected by a provisional patent filed by our invention team (Appendix A).

High velocity particles (HVPs) are any particles that travel at a higher speed than two kilometers per second; however, the normal speed for a high velocity particle is considered twenty kilometers per second (Zhao, 2010; Aceti, 1994). Despite their small size, the velocity of the particles cause them to have a high kinetic energy, rendering them capable of causing substantial amounts of damage. HVPs are also very common with tens of millions of them estimated to be in earth's orbit (Zhao 2010); therefore, an impact with an HVP is an eventuality. The damage an impact by an HVP can cause necessitates shielding to protect against breaching the interior or damaging any components.

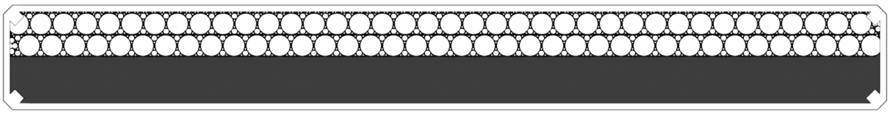
The ASM Mercury shielding will combine three primary components to create a highly durable protection for the station. The components are: Dyneema®, spheroids of four different diameters, and polyethylene glycol with suspended silica particles. These will all be assembled into individual shield panels measuring 55 X 55 X 6.5 cm in dimensions.

Dyneema® is a strong synthetic aramid fiber, similar to Kevlar®, with a few differences in operational temperature, reaction to water, and strength. Dyneema® is approximately fifteen times stronger than iron, compared to Kevlar® which is five times stronger. Additionally, Dyneema® is hydrophobic, which means that it repels water without absorbing it; this is in contrast to Kevlar®, which absorbs water (EPG 2020). Because of the presence of liquid polyethylene glycol, the Kevlar® will be unfit for use in the shielding design as it will start to absorb and leak the fluid. Due to Dyneema®'s nature as a type of fabric, it is far more flexible and lighter than iron, making it the best choice for the shielding design. The Dyneema® will be used as the walls of the shielding panels. To provide the first line of defense against the impacts of the high velocity particles and keep the weight low, the shield walls are 4 mm in thickness.

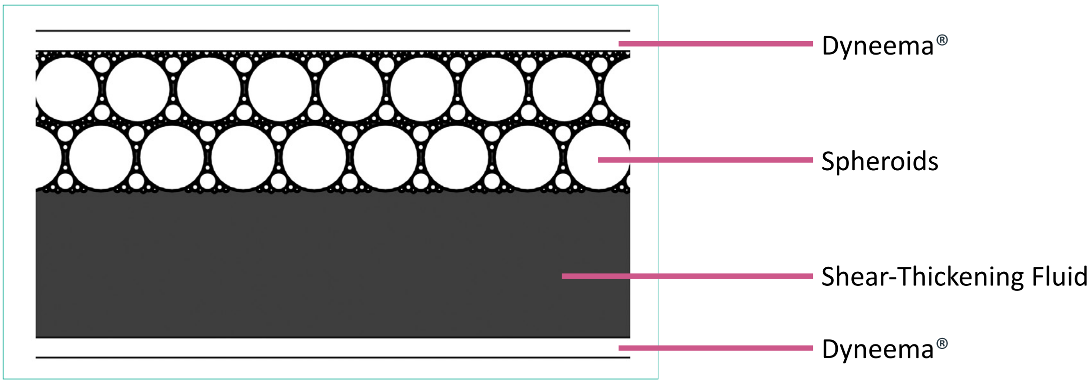
Each shield panel will be filled with approximately 50% in volume with spheroids. These will be produced in four different sizes: 0.17 mm (67%), 0.7 mm (22%), 3 mm (7.6%), and 1.26 cm (3.4%). These relative sizes and quantities were selected to correspond to the HVP flux, HVP potential puncture diameter, and shear-thickening fluid flow for self-healing (Rodman 2019; Aceti 1994). The remaining volume of the shield panel will be filled with the dilatant fluid polyethylene glycol (PEG). PEG has been chosen because when it contains suspended silica particles, it becomes a shear-thickening fluid. Such a fluid, when exposed to pressure, increases its viscosity until it is almost solid. Shield panels are placed on the exterior of the space station. For those shield panels placed perpendicularly to the axis of rotation of the space station, the spheroids will remain against the outer shield panel wall due to the artificial gravity of the rotation. For all other shield panels, the spheroids will be held against the outer wall of the shield panel by an internal viscoelastic mesh which passes through the center of the shield panel.



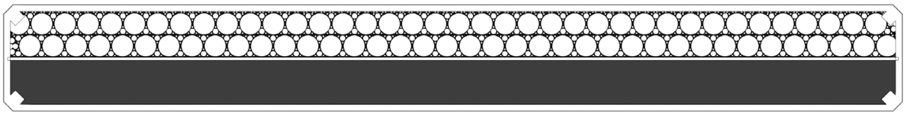
Bigelow Sphere with shielding panels. Shield panels patent pending, Andrew Olafsrud, et al.



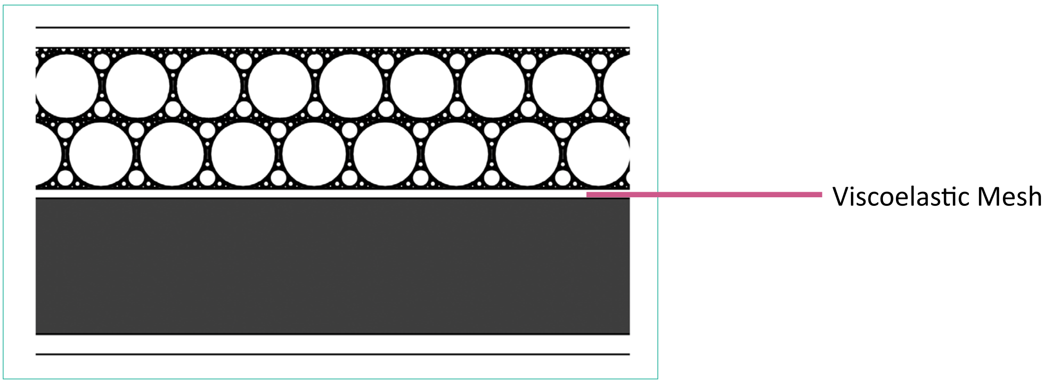
SHIELD PANEL,
REST STATE



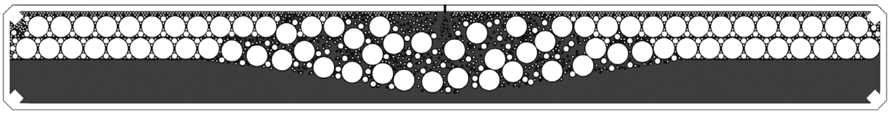
SHIELD PANEL, CLOSE UP
REST STATE



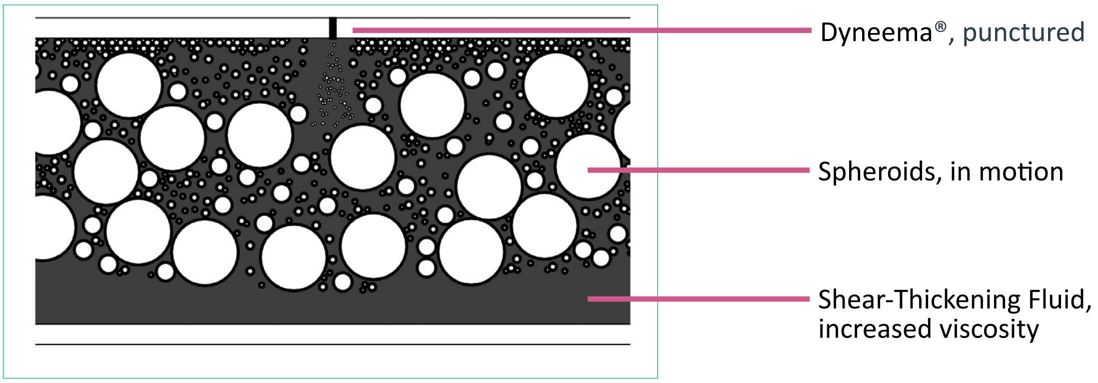
SHIELD PANEL, VISCOELASTIC MESH
REST STATE



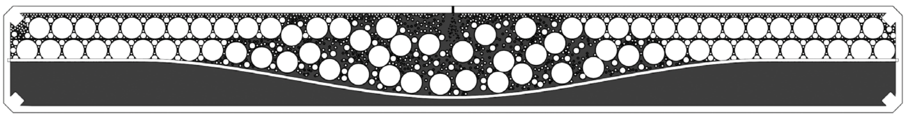
SHIELD PANEL, CLOSE UP
REST STATE



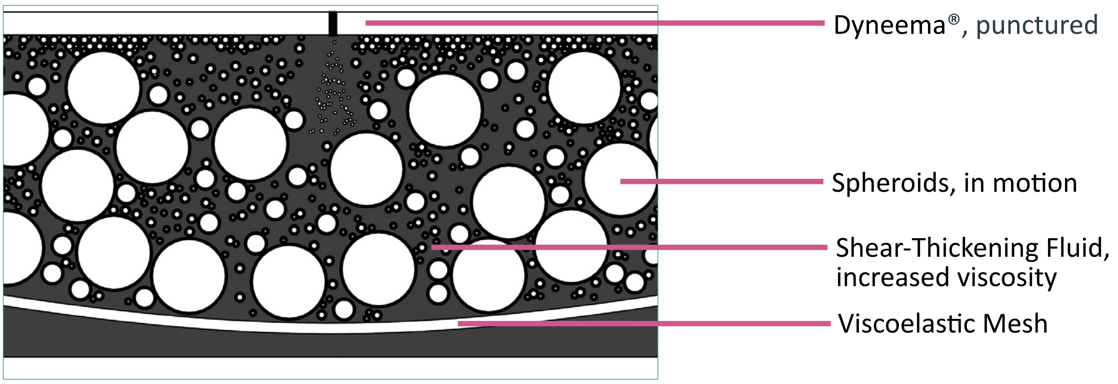
SHIELD PANEL
IMPACT



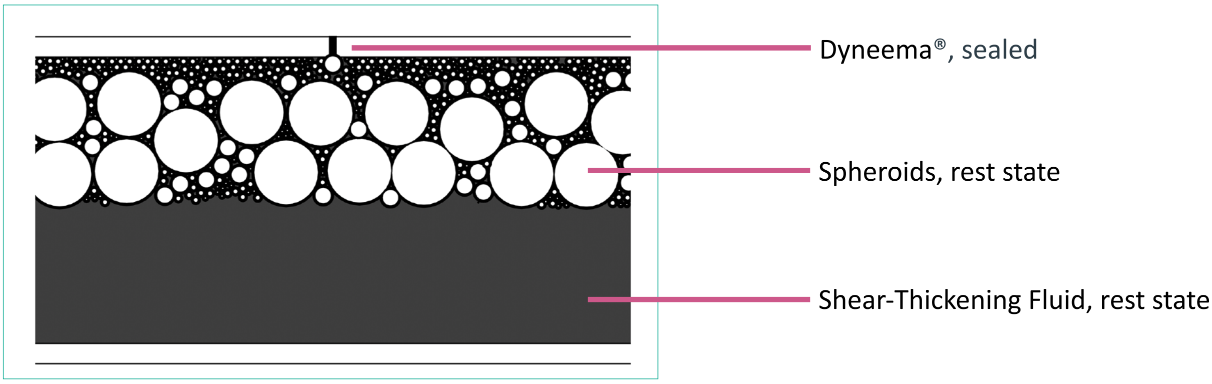
SHIELD PANEL, CLOSE UP
IMPACT



SHIELD PANEL, VISCOELASTIC MESH
IMPACT



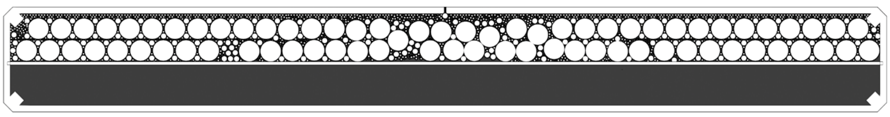
SHIELD PANEL, CLOSE UP
IMPACT



SHIELD PANEL, CLOSE UP
HEALED

An HVP impacting a shield panel will disintegrate. Upon impact, these spheroids will absorb the kinetic energy, impacting against each other, deflecting the kinetic energy radially and laterally. In turn, their motion will be dampened by the dilatant fluid. The kinetic energy will cause the polyethylene glycol to harden, absorbing the energy. This absorption will work in tandem with the spheroids to provide optimal protection.

The impact puncture in the Dyneema® will start to degrade the strength of the shield panel; the spheroids have been designed to counteract this reaction. The spheroids will move towards the puncture due to both the rotational artificial gravity and the vacuum in space. The spheroid diameters ensure that large spheroids cannot block access of smaller spheroids towards a puncture. Once a spheroid has reached the puncture, it will lodge into the puncture, clogging it, while also providing structural support to the weakened area.



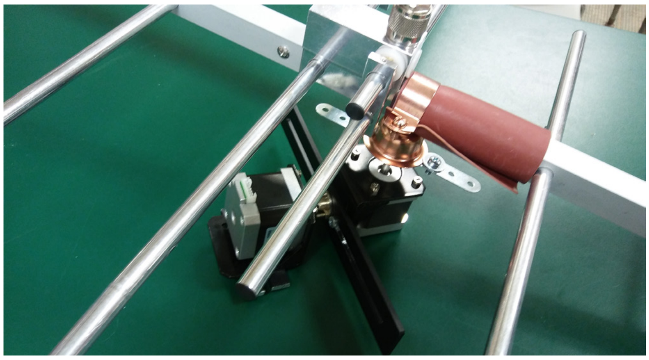
SHIELD PANEL, VISCOELASTIC MESH
HEALED

GROUND STATION

For a space colony, home to thousands of people, smooth communication is paramount. Crew members must have a way to send and receive information to a home base. Herein lies a question: How does one communicate in the vacuum of space? Communication with a space station or any other space-faring vessel involves two main sites, the ground station on the earth and the spacecraft's transceiver. Messages or information must be sent to and fro by means of radio waves or lasers.

The most basic of ground stations consist of a transmitter, receiver, satellite tracker, and antenna. The ground station must be able to transmit and receive at the same frequency as the space station so that the ground crew can understand the messages. A tracker must be able to locate the space station as it passes over the horizon and rotate the antenna in the optimal orientation as the space station travels across the sky. This way it receives the clearest signal with optimal gain.

A perfect example of a ground station is the amateur setup the AeroSpace Meridian team has built. Our ground station is outfitted with a basic Yagi antenna capable of receiving frequencies of 136MHz to 174MHz and 400MHz to 470MHz, a transceiver (capable of transmitting and receiving simultaneously using the same module), and a six-monitor computer setup that allows us to run multiple satellite tracking softwares like Gpredict and Orbitron. This rig is simple, yet highly functional. Our ground station has the ability to uplink any messages or commands to a satellite by means of FM radio waves and receive downlinks from spacecraft, including data and telemetry (status of the spacecraft's health).



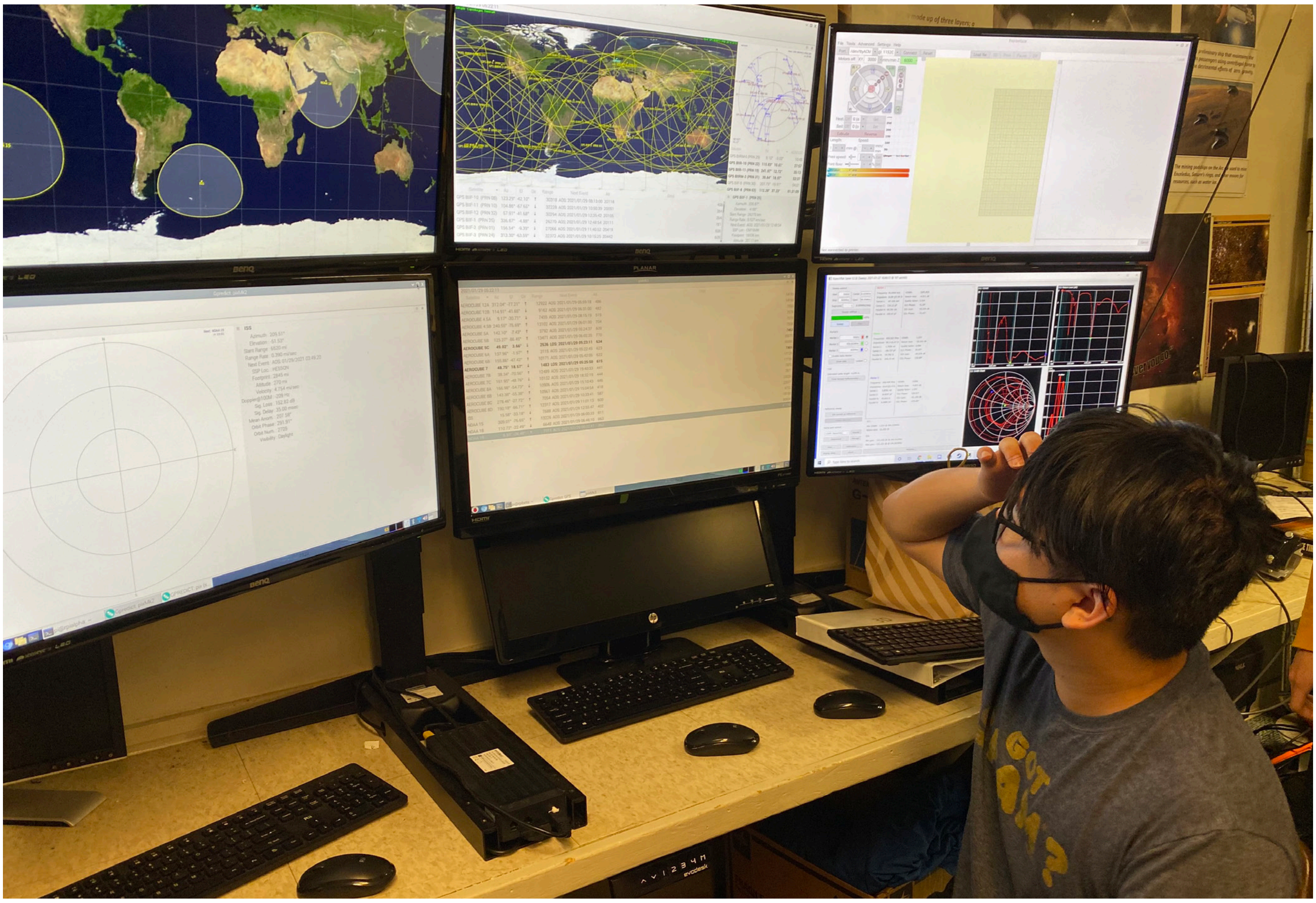
Originally our plan was to buy all of our components, but we needed to build a few of the parts ourselves, so we decided to give it a go. The first order of business was building the tracker. We researched the appropriate components for the hardware and settled on stepper motors, an Arduino, a tripod permanently borrowed from our school's film class, PVC pipe, two camera flash brackets, a hose bracket, and a few bits and pieces purchased from Lowe's. After MacGyvering the pieces together with great difficulty, our amalgamation of professional and consumer parts was mostly complete. However, we needed software to get the tracker working.

The software for our tracker directs our motors to follow satellites. The way our specific code below operates is actually pretty simple. First, the code sets standard variables for the motors. These variables act as increments that tell the motors how many degrees they should rotate. Next, the code listens to any instructions from serial ports (we use Gpredict) that will be given to an emulator (we use Rotation Control D) that mimics the software of a standard consumer-level satellite tracking rotator, converting the information from Gpredict into acceptable directions for the Arduino. The Arduino takes the instructions and uses the pre-set standard variables in order to generate the azimuth and elevation for our tracker motors to orient our antenna towards.

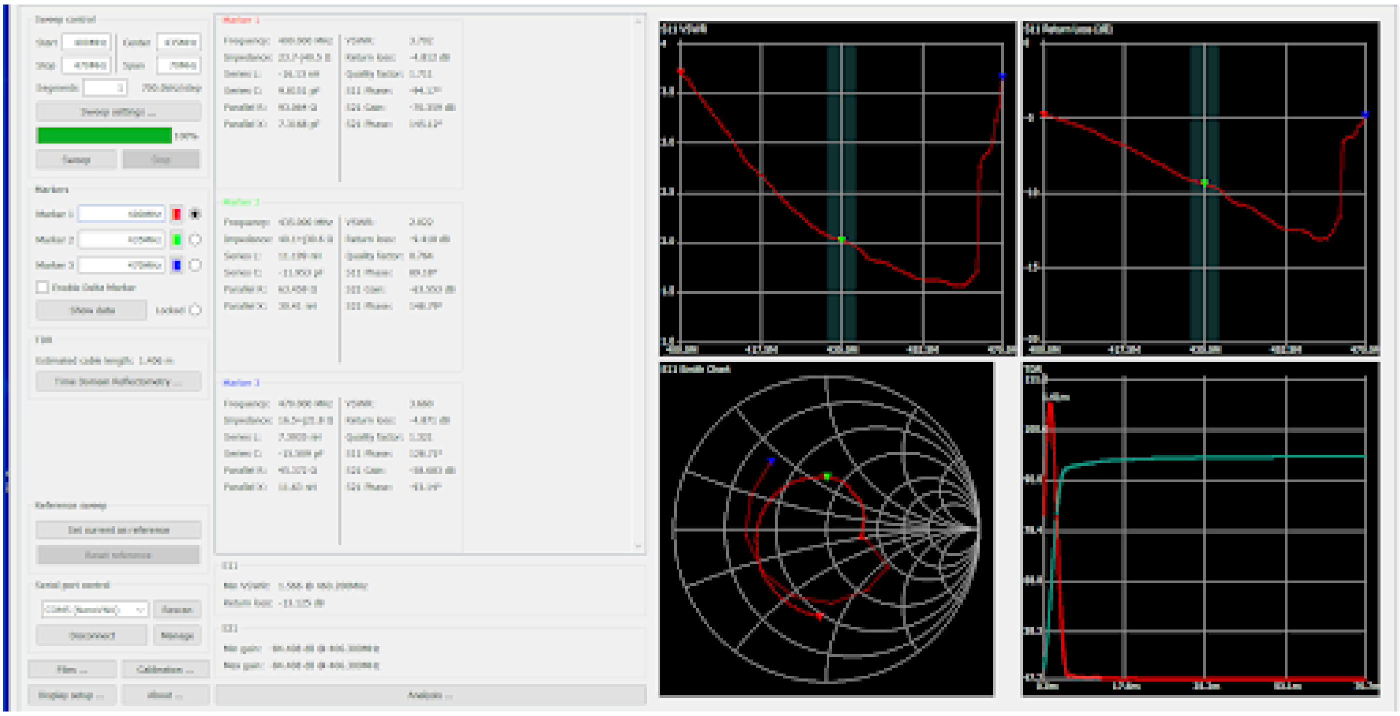
With the tracker out of the way, assembly of the station was completed with streamline efficiency. We attached the antenna to the tracker with a small sheet of rubber and a hose bracket, and we wired everything to the Arduino. As a final touch, we hooked up the antenna to a NanoVNA, which shows the signal acquisition strength. Keeping an eye on this ensures that the antenna is picking up the maximum information possible.

During trial runs using our ground station, we were able to receive signals from satellites such as NOAA-15, NOAA-18, and NOAA-19. We were able to accomplish this by predicting overhead satellite passes that have angles of elevation conducive to strong signal reception by our ground station. When a satellite passes above a ground station, the closer the angle of elevation is to 90 degrees, the better the acquisition of signal. We set our tracker to point our antenna optimally towards the desired satellite and listened for the signal.

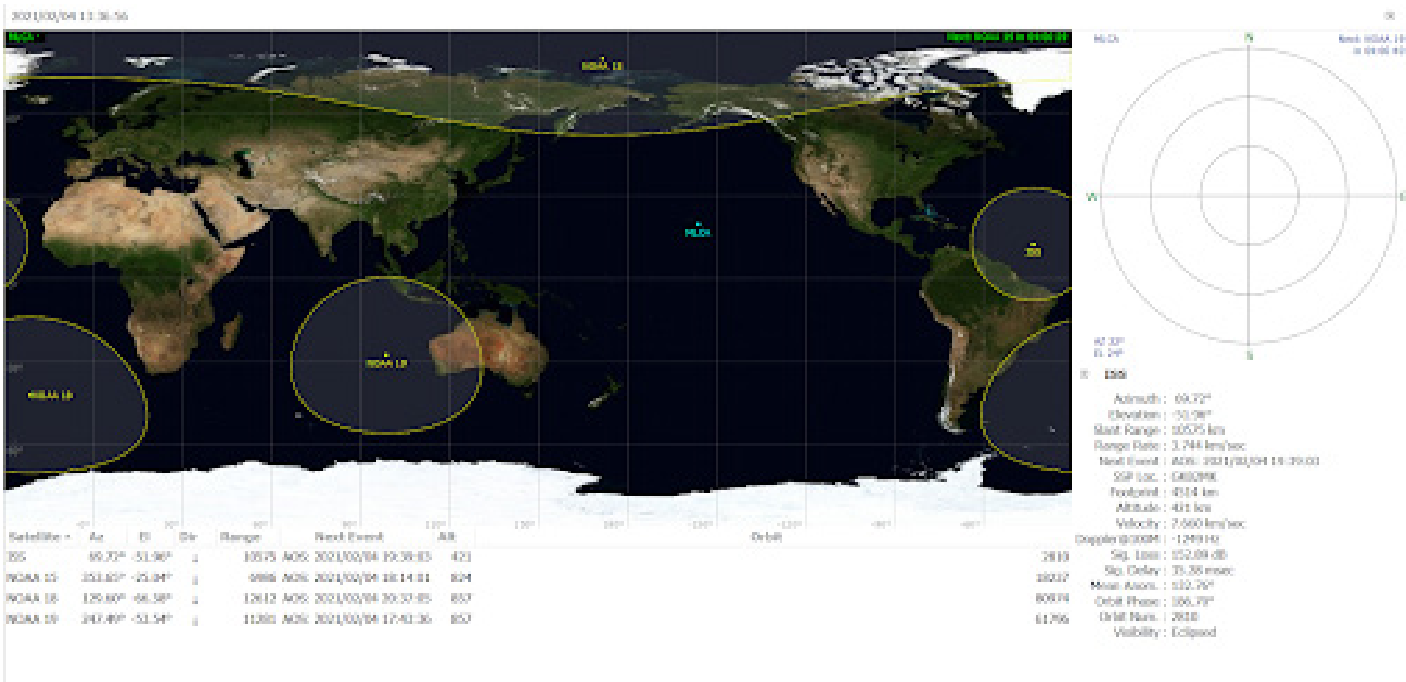
The success of our ground station with low earth orbit satellites indicates the possibility of success when contacting space stations like the ASM Mercury. This hypothesis is backed up by the fact that communication is already capable with the ISS, another low earth orbit station. As long as Mercury is transmitting within the frequency ranges of our antenna, receiving downlinks should not be an issue.



Christian Taniyama-Mento viewing satellite orbital paths to determine acquisition of signal.



Heads-up display of the antenna health.
NanoVNASaver. GNU General Public License v.3.



World Map, Radar, Next Pass and Statistics from Gpredict.
Gpredict. GNU General Public License.

Simple Steps for Contacting Satellites

1. Run Gpredict and open a new module and add the satellite(s) you wish to receive signal from. (See image below.)
2. Connect your antenna tracker to the rotator control window. (See image below.)
3. Use the future overhead passes feature to secure a time and date to receive signal.
4. On your preferred date(s), prepare your radio control window to activate when Acquisition of Signal is reached (the time when your antenna can actually receive signal from the spacecraft).
5. Engage the rotator control. Voila! Your tracker should continuously direct your antenna to the optimal overhead angle to receive the best signal.
6. Once your satellite pass has run its course and you experience Loss of Signal (when your station can no longer receive the radio waves from the spacecraft), make sure you store your recorded signal in a data storage device like a hard drive.

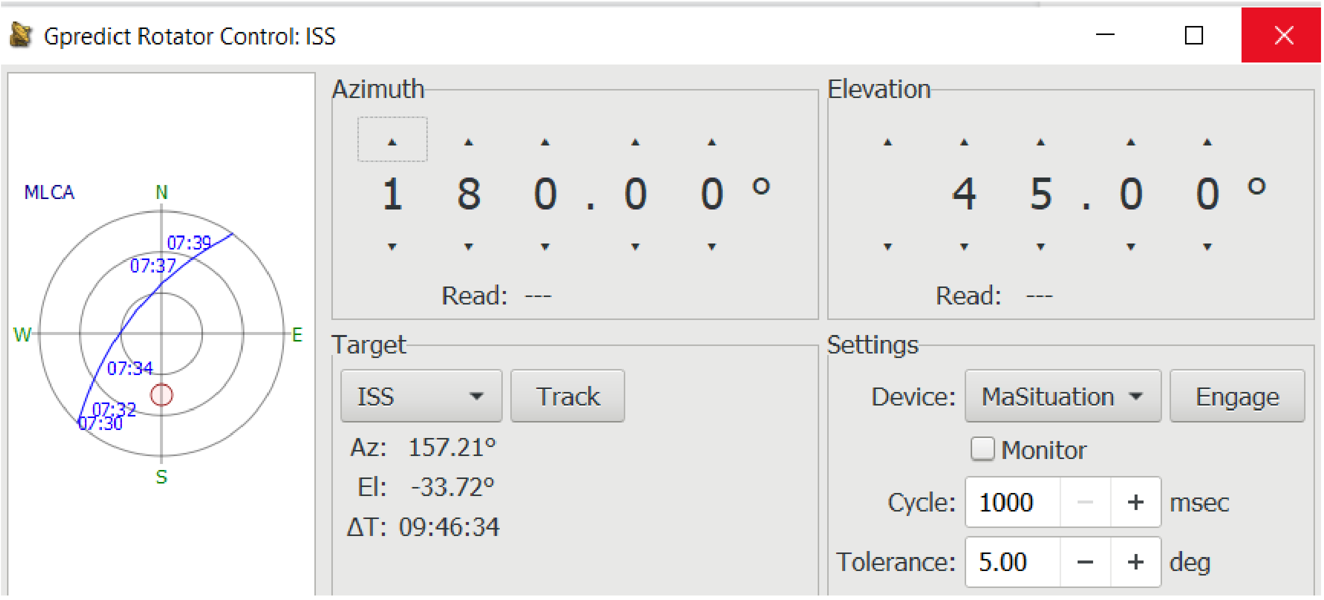
These directions will help you receive data from a satellite. Note that you will need a RTL-SDR dongle to connect an antenna to a PC.

Upcoming passes for ISS

AOS	LOS	Duration	Max El	AOS Az	LOS Az
2021/02/13 07:30:32	2021/02/13 07:41:21	00:10:49	64.93°	223.38°	35.43°
2021/02/14 16:34:11	2021/02/14 16:45:04	00:10:52	79.92°	322.36°	139.89°
2021/02/17 05:57:11	2021/02/17 06:08:00	00:10:48	64.75°	223.42°	35.40°
2021/02/18 15:00:47	2021/02/18 15:11:39	00:10:52	79.94°	322.36°	139.89°
2021/02/21 04:23:40	2021/02/21 04:34:29	00:10:48	64.97°	223.37°	35.44°
2021/02/22 13:27:12	2021/02/22 13:38:04	00:10:52	79.49°	322.42°	139.80°
2021/02/25 02:49:59	2021/02/25 03:00:48	00:10:48	65.60°	223.22°	35.54°
2021/02/26 11:53:28	2021/02/26 12:04:19	00:10:51	78.58°	322.54°	139.61°
2021/03/01 01:16:08	2021/03/01 01:26:57	00:10:49	66.66°	222.97°	35.70°

Print Save Close

The Upcoming Passes window lists all of the future passes for the next week that have an azimuth angle of above 60 degrees. Gpredict. GNU General Public License.



The Rotator Control Window, which will direct the antenna throughout the contact pass.
Gpredict. GNU General Public License.

```
CODE FOR ANGLE AND ELEVATION OF STEPPER MOTORS

#include <AccelStepper.h>
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>

AccelStepper AzStepper(2, 9, 8); //type, direction pin, step pin
AccelStepper ElStepper(2, 7, 6); //type, direction pin, step pin
LiquidCrystal lcd(A0, A1, A2, A3, A4, A5); //rs, en, d4, d5, d6, d7
SoftwareSerial hc06(3, 2); //RX, TX

const int microSteps = 16; //1, 2, 4, 8, or 16 step divisions
const int stepsPerRevolution = 800 * microSteps;
String serialIn; //stores response of the serial port
String rxd; //stores response of the HC-06 BT device
int AzInit = 0; //initial set AZ & EL positions
int ElInit = 0;
int AzCurr = 0; //initial actual AZ & EL positions
int ElCurr = 0;
int AzMaxSpeed = 50 * microSteps; //proportionate to resistance and input voltage (max 28 @ 9V)
int ElMaxSpeed = 50 * microSteps;
int AzAcceleration = 2 * microSteps; //inversely proportionate to object mass (max 150 @ 0lbs)
int ElAcceleration = 2 * microSteps;
```

```
byte alpha[8] = {
  0b00000,
  0b00000,
  0b00000,
  0b01101,
  0b10010,
  0b10010,
  0b01101,
  0b00000
  };
byte gamma[8] = {
  0b00000,
  0b00000,
  0b10001,
  0b01010,
  0b01010,
  0b00100,
  0b00100,
  0b01000
};

void setup() {
  //AzStepper.set //startup position set to home
  AzStepper.setMaxSpeed(AzMaxSpeed * 10);
  AzStepper.setAcceleration(AzAcceleration * 10);
  ElStepper.setMaxSpeed(ElMaxSpeed * 10);
  ElStepper.setAcceleration(ElAcceleration * 10);

  Serial.begin(9600); //baud rate
  Serial.setTimeout(50); //serial input timeout
  hc06.begin(9600); //the HC-06 defaults to 9600 baud according to its datasheet

  pinMode(LED_BUILTIN, OUTPUT);

  lcd.createChar(0, alpha);
  lcd.createChar(1, gamma);
```

```
  lcd.begin(16, 2); lcd.clear();
  lcd.write(byte(0)); lcd.print(ElInit);
  lcd.setCursor(5, 0); lcd.print(ElMaxSpeed / microSteps);
  lcd.setCursor(8, 0); lcd.print(ElAcceleration / microSteps);
  lcd.setCursor(0, 1); lcd.write(byte(1)); lcd.print(AzInit);
  lcd.setCursor(5, 1); lcd.print(AzMaxSpeed / microSteps);
  lcd.setCursor(8, 1); lcd.print(AzAcceleration / microSteps);

}

void loop() {

  if (Serial.available() > 0 || hc06.available() > 0) {
    if (Serial.available() > 0)
      serialIn = Serial.readString(); //read from serial
    if (hc06.available() > 0) {
      serialIn = "";
      while(hc06.available()) { //while there is more to be read, keep reading
        serialIn += (char)hc06.read();
        delayMicroseconds(100);
      }
      Serial.println(serialIn);
    }
    if (serialIn.substring(0, 2) == "C2") {
      Serial.print("AZ="); Serial.print(AzInit);
      Serial.print(" EL="); Serial.println(ElInit);
    }
    else if (serialIn.substring(0, 1) == "W") { // 0,1
      lcd.setCursor(15, 1); lcd.print("~");
      AzInit = (serialIn.substring(1, 5)).toInt();
      ElInit = (serialIn.substring(5, 9)).toInt();
      Serial.print("AZ="); Serial.print(AzInit);
      Serial.print(" EL="); Serial.println(ElInit);
    }
    else if (serialIn.substring(0, 1) == "S") { // 0,1
      Serial.print("Stopping");
```

```
}
else if (serialIn.substring(0, 2) == "AS") {
  AzMaxSpeed = (serialIn.substring(2, 5)).toInt();
  AzStepper.setMaxSpeed(AzMaxSpeed * 10 * microSteps);
  Serial.print("AzMaxSpeed=");
  Serial.println(AzMaxSpeed);
}
else if (serialIn.substring(0, 2) == "AA") {
  AzAcceleration = (serialIn.substring(2, 5)).toInt();
  AzStepper.setAcceleration(AzAcceleration * 10 * microSteps);
  Serial.print("AzAcceleration=");
  Serial.println(AzAcceleration);
}
else if (serialIn.substring(0, 2) == "ES") {
  ElMaxSpeed = (serialIn.substring(2, 5)).toInt();
  ElStepper.setMaxSpeed(ElMaxSpeed * 10 * microSteps);
  Serial.print("ElMaxSpeed=");
  Serial.println(ElMaxSpeed);
}
else if (serialIn.substring(0, 2) == "EA") {
  ElAcceleration = (serialIn.substring(2, 5)).toInt();
  ElStepper.setAcceleration(ElAcceleration * 10 * microSteps);
  Serial.print("ELAcceleration=");
  Serial.println(ElAcceleration);
}
else if (1) { //case of coords w/o specifier
  lcd.setCursor(15, 1); lcd.print("~");
  if (serialIn.substring(0, 3) != "   ")
   AzInit = (serialIn.substring(0, 4)).toInt();
  if (serialIn.substring(3, 4) == " ")
   ElInit = (serialIn.substring(4, 8)).toInt();
  Serial.print("AZ="); Serial.print(AzInit);
  Serial.print(" EL="); Serial.println(ElInit);
}
```

```
  if (Serial.available() < 1 && AzInit != AzCurr) {
   digitalWrite(LED_BUILTIN, HIGH);
   AzStepper.moveTo(map(AzInit, 0, 360, 0, stepsPerRevolution));
   while (AzStepper.distanceToGo() != 0) {
    AzStepper.run();
    AzCurr = map(AzStepper.currentPosition(), 0, 360, 0, stepsPerRevolution);
   }
   digitalWrite(LED_BUILTIN, LOW);
   for (int i = 4; i <= 7; i++) { //set motor pins back to LOW after adjustment
    digitalWrite(i, LOW);
   }
  }
  if (Serial.available() < 1 && ElInit != ElCurr) {
   digitalWrite(LED_BUILTIN, HIGH);
   ElStepper.moveTo(map(ElInit, 0, 360, 0, stepsPerRevolution));
   while (ElStepper.distanceToGo() != 0) {
    ElStepper.run();
    ElCurr = map(ElStepper.currentPosition(), 0, 360, 0, stepsPerRevolution);
   }
   digitalWrite(LED_BUILTIN, LOW);
   for (int i = 8; i <= 11; i++) { //set motor pins back to LOW after adjustment
    digitalWrite(i, LOW);
   }
  }
  lcd.clear();
  lcd.write(byte(0)); lcd.print(ElInit);
  lcd.setCursor(5, 0); lcd.print(ElMaxSpeed / microSteps);
  lcd.setCursor(8, 0); lcd.print(ElAcceleration / microSteps);
  lcd.setCursor(0, 1);lcd.write(byte(1)); lcd.print(AzInit);
  lcd.setCursor(5, 1); lcd.print(AzMaxSpeed / microSteps);
  lcd.setCursor(8, 1); lcd.print(AzAcceleration / microSteps);
 }
}
```

Original code courtesy Christian Williams, Makua Lani Christian Academy.
Christian Williams grants universal use of this code.

PHASE II

TRANSFER

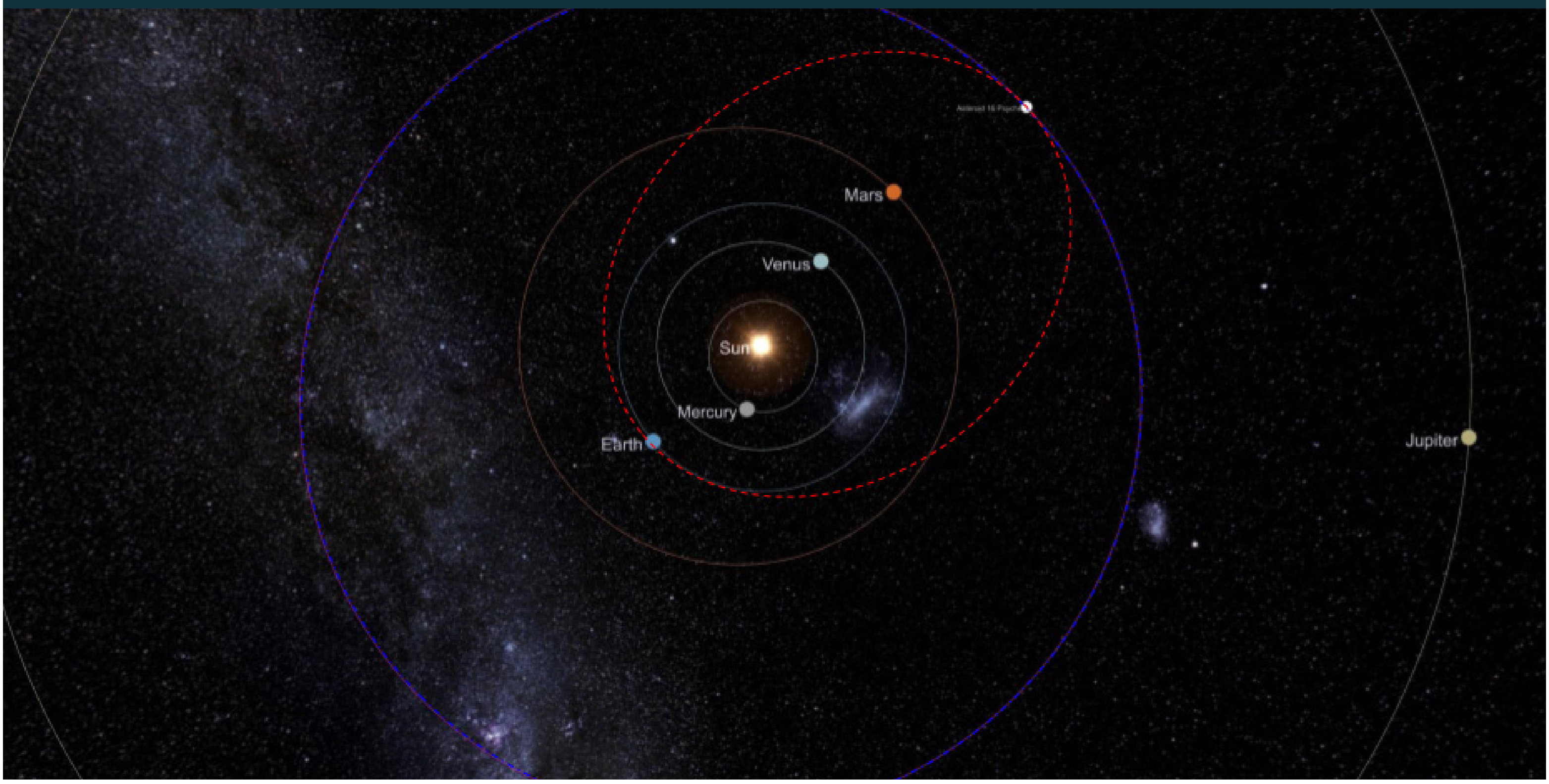


Image: theskylive.com/3dsolarsystem by permission.

HOHMANN TRANSFER TO 16 PSYCHE

LANGUAGE LEARNING

Image: Thirdman [Pexels licence permission]

The ASM Mercury space stations depart Earth with crew members from over 10 different countries and speaking 10 different languages. How will they coexist in the isolation of space? Communication is a crucial factor for unifying crew members. Crew members will inevitably encounter language barriers and require foreign language learning. AeroSpace Meridian plans to solve language barrier issues along with uniting the ASM Mercury crew members by establishing a program for foreign language learning. This program will recognize emotional and affective responses to achieve foreign language fluency while minimizing obstacles.

Language is a source of identity in society. As intercultural exchange expands and the world begins to embrace diversity in a community, language becomes a source to unify a community. Warshchauer and Florio-Hansen (2003) presented examples of this by saying "... in the United States of America, the English language is still considered as a unifying bond between individuals coming from different ethnic backgrounds" (p. 1). Therefore, language has been proven as an important aspect of societal unity, especially in diverse areas.

So what does this have to do with certain facets of emotional and affective response? Due to the expansion of studies in multilingual and foreign language learners, it has been discovered that multilingualism does not only affect identity but additionally creates a psychological response. As language becomes an essential source of identity in society, studies have confirmed foreign language learning is connected to Foreign Language Anxiety (FLA) and Communicative Anxiety (CA), gender, trait emotional intelligence response, personality response, and "feeling different" when speaking a foreign language.

Foreign Language Anxiety and Communication Anxiety

When learning or speaking a foreign language, people tend to have different responses to the language spoken. This response can expand from a genuine interest in the language or a general reluctance against speaking or learning the language. Additionally, there are many factors associated with certain responses towards a foreign language; most notably, Foreign Language Anxiety (FLA) and Communication Anxiety (CA) responses.

The ASM Mercury needs a common language between inhabitants to create a sense of unified identity under the English language. However, certain obstacles like Foreign Language Anxiety or Communication Anxiety may restrict foreign language fluency leading to division in the colony. Recognizing the effects of Foreign Language Anxiety and Communication Anxiety will help learners adjust their learning experience to avoid it.

MacIntyre and Gardner (1991) demonstrated the FLA is a facet of CA, as CA applies to communication in general, whereas FLA applies to language learning classes and second language learning (L2). MacIntyre and Gardner (1991) also defined FLA and CA as a trait that fluctuates in environments where the individual is speaking a foreign language. Last, MacIntyre and Gardner (1991) suggested that FLA and CA tend to remain in experienced learners. In contrast, Dewaele, Petrides, and Furnharm (2008) demonstrated the varied conclusions between studies on FLA and CA suggests that FLA/CA does not diminish due to advancements in the language and FLA/CA responses dissipate when foreign language learners have an immersion experience and increase in self-confidence.

FLA and CA have many possible factors that have been studied. Dewalae, Petrides, and Furnham (2008) concluded that the context of acquisition, trait emotional intelligence, number of languages, and age of acquisition significantly influenced FLA and CA responses. They state "purely classroom-based learning language instruction was found to be linked to higher levels of FLA compared to instruction that also involved extracurricular use of the language" (Dewaele, Petrides, & Furnham, 2008, p. 911). According to Dewaele, Petrides, and Furnham (2008), high trait emotional intelligence, knowing and frequently using a greater number of languages, and acquisition of the language at a younger age decrease FLA/CA.

Understanding FLA and CA is important for foreign language learners because it can help adjust the learning environment to suit the individual's situations to decrease FLA/CA: Dewaele, Petrides, and Furnham (2008) defined FLA/CA as "one of the major obstacles to acquisition and fluent production of foreign languages." (p. 9-11) Thus, by studying the factors of FLA/CA, ASM Mercury's foreign language learners can better understand ways to adjust learning styles based on sociobiography or psychological response for foreign language learners and ultimately eliminate obstacles from foreign language acquisition.

Emotional Intelligence Response

Due to the subjectivity of emotional intelligence (EI), it is difficult to define and assess it. Two constructs are often defined in EI that differ in low and insignificant correlations to each other: trait EI and ability EI (Dewaele, Pertides, and Furnham, 2008; Petrides, Furnham, and Fredeickson, 2004; O'Connor & Little, 2003; Warwick & Nettelbeck, 2004). Trait EI is tested in studies based on foreign language acquisition because it can be measured through a self-report survey (Petrides & Furnham 2001).

Ozanska-Ponikiwa (2011) demonstrated their use of the TEIQue survey when studying trait EI and foreign language acquisition. The survey consists of 15 facets of personality and the global trait EI (p. 227). These facets, along with other subfacets are measured as "lower order personality constructs" to the Big Five personalities—which is measured as a factor of FLA/CA and "feeling different" when speaking a foreign language (Petrides and Furnham, 2001).

Different facets and subfacets of trait EI are tested in different social and affective responses of foreign language learning. Dewaele, Petrides, and Furnham (2008) measured the facets of emotion regulation, assertiveness, and stress management when studying the connection between CA/FLA when speaking a foreign language. However, Ozanska-Ponikiwa (2011) measured open-mindedness, cultural empathy, and emotional stability when studying the connection between emotional intelligence and "feeling different" when speaking a foreign language. Finally, Dewaele (2019) measured well-being, emotionality, self-control, and sociability when studying English Foreign Language/English Second Language teachers' attitudes towards teaching English.

The multiple facets of trait EI being measured to different degrees based on different social and affective responses to foreign language learning is significant because it can adjust a foreign language environment more specifically. A foreign language teacher can adjust learning styles based on specific facets of trait EI instead of using a generalized score. Thus, ASM Mercury foreign language learners can adjust their learning styles based on their personality in order to minimize obstacles.

Personality Response

While trait EI is measured through self-report tests based on a wide range of facets, the studies examined measure personality response in foreign language acquisition is mainly measured by the Big Five personality test. Ozanska-Ponikiwa (2011) utilized the Big Five personality traits within cultures and suggested that Extraversion, Openness, and Agreeableness affect how individuals felt when speaking a foreign language. The research additionally indicated that the connections between trait EI and personality "show the complexity of the relationship between language, culture, and emotions" (Ozanska, 201, p. 217), which suggests that trait EI and the Big Five should be studied collectively in research about multilingualism.

The Big-Five personality test is additionally used to identify personality traits in conversation. Mariesse and Walker (2006) analyzed conversation and connected it to Big Five personality traits to recognize patterns through linguistic cues. For example, individuals who are high in extraversion "talk more, louder, and faster, with fewer pauses, and hesitations, and more informal language" (Mariesse & Walker, 2006, p. 85). Wang and Chen (2020) analyzed linguistic cues in social media to evaluate various personality traits in CEOs and to demonstrate the impact of the Big Five personality traits on the overall performance of an organization. Although these studies did not directly link to foreign languages, they suggest that personality and language have strong connections that can explain the shift in personality when speaking a foreign language. Crew members of the ASM Mercury should recognize that the shift in personality when speaking foreign languages is a common event and should be widely accepted in the colony.

Gender

Gender may play a role in foreign language acquisition and response because gender has various connections to personality, FLA, and trait emotional intelligence response. Research conducted by Gargalianou, Muelfeld, Urbig, and Witteloostuijin (2015) suggested it is possible that gender has an effect on personality and foreign language acquisition. This may be due to the influence of the Big Five personality traits on gender. These researchers hypothesized that extraversion, emotionality, and conscientiousness are linked to the effect of gender on FLA, and that this effect is stronger in females than males (p. 6). Hence, there may be a connection between gender and foreign language acquisition that is unique from person to person.

Other studies found varied results. Lai (2008) examined the general attitude between male and female foreign language learners of English, Cantonese, and Putonghua. The study concluded that "female respondents were found to be consistently more positive than their male counterparts in their attitudes towards the non-native languages while male students were more positively inclined to the vernacular" (Lai, 2008, p. 83). However, when testing the motivation in foreign language acquisition, Labagaster (2014) produced no significant data on gender's influence regarding motivation for foreign language acquisition. When studying the expression of emotions in a foreign language between males and females in the second language, Ozanska-Ponikiwia (2017) concluded that there is an indirect relationship between gender and expression of emotion in the second language due to the differences in Big Five personality traits between males and females and emotional intelligence. Given these points, the connection between gender and foreign language acquisition tends to be ambiguous.

The ambiguous connection between gender and foreign language acquisition described is important information as it can conclude that gender does not play as significant a role in foreign language acquisition as does personality, motivation, EI response, and FLA. Although gender affects these factors, it does not solely determine the efficacy of foreign language acquisition. Thus, the ASM language learners should adjust their learning styles based on personality, motivation, EI response, and FLA rather than gender.

"Feeling different" When Speaking a Foreign Language

Ozanska-Ponikiwa (2011) demonstrated that multilingual individuals tend to feel different when speaking a different language and are likely to exhibit a noticeable change in their body language and facial expressions.

What causes this change? Is it the culture that the language is a part of? Do multilingual people change their behavior due to different cultural norms? Do self-scoring personality tests in different languages hold different connotations in their words?

Chen, Benet-Martinez, and Ng (2013) concluded that culture is an aspect in the duality of multilingual people, suggesting the fluidity of personality when changing languages. Additionally, Collins (2011) established the duality of Cantonese-English speakers by documenting an experiment at Hong Kong Polytechnic University which concluded that when speaking to an interviewer in English, they "appeared more assertive, extraverted, and open to new experiences—personality traits often associated with Westerners" (p. 1). This, once again, suggests the fluidity of personality with multilingual people. Hutson (2006) also documented the change in personality between Spanish-English bilinguals. This study concluded the malleability of personality, which is triggered by a change in language. Dewaele and Botes (2019) confirmed that multilingualism is an environmental factor of personality and that levels of multilingualism positively correlated with Social Flexibility, Social Initiative, and Open-Mindedness. Chen and Bond (2010) separated the factors of a personality switch when speaking into cultural norms, language priming, and the ethnicity of the individual to whom the multilingual individual is speaking.

These studies concluded that multilingualism is a factor in personality shaping, and culture is a factor in the fluidity of personality in multilinguals. This discovery is significant because it allows a better understanding of the personalities of multilinguals. This allows foreign language learners to be aware of the fluidity of personality due to cultural awareness and sensitivity. Thus, the ASM Mercury foreign language learners should be aware of the possible encounter of personality changes when learning a new language.

ASM Venus and Language

It is desirable and inevitable that the ASM Venus will hold people of various cultural backgrounds and languages. Therefore, in order to constitute unity, the ASM Mercury will create language classes where the inhabitants must learn one language that is spoken by the majority of the crew. Presumably, this language will be the English language. If an inhabitant has already achieved English proficiency, they will learn another major language on the ASM Mercury. However, achieving language fluency will not be in a typical classroom environment. This study of the research demonstrates the various social and affective responses caused by multilingualism and foreign language learning. These connections include Foreign Language Anxiety (FLA) and Communicative Anxiety (CA), gender, trait emotional intelligence response, personality response, "feeling different" when speaking a foreign language, and personality characteristic fluidity. Therefore, the inhabitants of the ASM Venus will be tested on the multiple facets involved in foreign language learning. Language learning classes will be adjusted and grouped based on these facets and will be taught in conversational settings, either working with an inhabitant who has achieved proficiency in a specific language or having a tutor in the language. Conversational settings promote lingual unity in the ASM Venus and allow inhabitants to become comfortable in a foreign language. Thus, the language learning classes are based on the preferences and social and affective responses of the learners. By the time the ASM Mercury reaches 16 Psyche and work on the ASM Venus begins, inhabitants will be able to seamlessly achieve foreign language fluency which will assist in unity between a diverse range of cultures, backgrounds, and languages.

AEROPONICS

There are multiple methods for growing plants on a space station: soil agriculture, hydroponics, aquaponics, and aeroponics. Each method comes with benefits and setbacks. Some achieve higher yields, but lack crop variety; others, vice-versa. However, in a space station traveling millions of kilometers away from the Earth, it is vital that the food production recycles as many nutrients as possible.

Image: faverzani [Pixabay license permission]

Similar to hydroponics and aquaponics, aeroponics supply nutrients directly to the roots without soil. Aeroponics does this by dispersing the nutrient solution into a fine mist, which can be readily absorbed through the roots. This reduces the overall consumption of water and nutrient solution inside the system. Aeroponic gardens only consume 2% of the water that traditional, soil-based methods need. Additionally, aeroponics systems offer an average of 30% increased crop yields. However, research from the International Potato Center (CIP 2013) found that aeroponics can be 600% as productive as its soil counterparts when producing potatoes. Because the roots are suspended in the air, this reduces the chances of diseases spreading from one plant to another, making the aeroponics system safer than hydroponics and aquaponics. Since the plants are suspended in the air with clips, it is easy to manage the ecosystem: easy to remove and add plants, control when the plants are watered, and control the various chemical concentrations in the nutrient mix.

Matthew 4:4 states, “Man shall not live on bread alone.” Similarly, the inhabitants of the ASM Mercury cannot live solely on potatoes. Thus, a variety of fruits and vegetables must be grown to help meet the nutritional and psychological needs of every individual. The inhabitants of the ASM Mercury should maintain a balanced diet, full of different dishes. This is for two main reasons. The first is to keep the diets of the inhabitants interesting. Consuming a single dish every day can be extremely taxing on the individual’s mental health. A variety of dishes has a positive effect on individuals: hospital patients light up at the sight of better cuisines, while a large portion of prison riots originate from inadequate meals (Selling 1943). A person should be consuming at least 20 to 30 different foods per day (Geddes 2018). This is essential for both psychological and physiological purposes, ensuring crew members are happy and healthy. The USDA suggests that a balanced diet should include five different food types: vegetables, fruits, grains, protein, and dairy products. Luckily, the aeroponics system can accommodate many of these food types, including sweet potatoes, quinoa, strawberries, peas, and soybeans for soy milk. These fulfill all the necessary food types.

About 45 calories per hour is burnt just by breathing. This number increases exponentially as the individual undertakes more rigorous tasks. From performing repairs in and out of gravity to constructing space stations, the individuals on the ASM Mercury are expected to fulfill a wide variety of tasks that will burn a tremendous number of calories. The voyage from Earth to 16 Psyche is a 1.6-year-long journey. Assuming that each person of an 800-person crew consumes 3,300 calories—a generous estimate—the total caloric requirement would be about 2,640,000 kilocalories for the entire trip, which is equivalent to 4,139,911 Twinkies®. The total weight of all these Twinkies® is 159,386 kg. An aeroponics farm in space would be 61,468 kg lighter than Twinkies®. This further emphasizes the importance of having an aeroponics farm on the ASM Mercury. Considering that the total internal surface area of the Bigelow spheres is approximately 495.18 square meters, 586 Bigelow Spheres will be dedicated to agriculture, split across the two Mercury Class space stations.

HOHMANN TRANSFER

Both the ASM Mercury-I and the ASM Mercury-II will be constructed in LEO at a height of about 500 km. After the spacecraft are completed, they will travel to the asteroid 16 Psyche to begin the construction of the ASM Venus. They will begin this journey by initiating a Hohmann transfer with a prograde burn.

The following equation details the needed Δ V for the periapsis burns of both spacecraft in this transfer.

Orbital radius of the Earth (R): 149,600,000 km

Orbital velocity of the Earth: 29.78 km/s = $(GMR^{-1})^{0.5}$

Orbital radius of 16 Psyche (r): 374,000,000 - 493,700,000 km

Orbital velocity of 16 Psyche: 17.41 km/s = $(GMr^{-1})^{0.5}$

To find the needed Δ V, we use the equation:

$$\Delta V = (GM/R)^{0.5} [(2r/R + r)^{0.5} - 1]$$

$$\Delta V_1 = 29.78 * [(2 * 374{,}000{,}000/149{,}600{,}000 + 374{,}000{,}000)^{0.5} - 1]$$

$$\Delta V_1 = 29.78 * [(1.43)^{0.5} - 1]$$

$$\Delta V_1 = 29.78 * 0.952$$

$$\Delta V_1 = 5.81 \text{ km/s}$$

After a 1.16-year journey, the ASM Mercury-I and ASM Mercury-II will approach the aphelion of the transfer orbit. Here they will make an inclination change to match the orbital inclination of 16 Psyche. This will occur as close to the aphelion as possible, where the velocity of the spacecraft will be lowest. This lower velocity will minimize the amount of fuel needed for the change.

The Orbital velocity of the ASM Mercury-I and the ASM Mercury-II at the aphelion of the transfer orbit will be 14.31 km/s. We find that as so:

$$V = [GM(2/r - 1/a)]^{0.5} = 14.31 \text{ km/s}$$

Desired change in inclination: 3.095 degrees

We estimate using:

$V_i = V\sin(\Delta_i)$ (Hoffman 2020)

$$\Delta V_i = 14.31 * \sin(3.095)$$

$$\Delta V_i = 14.31 * 0.0466$$

$$\Delta V_i = 0.6664 \text{ km/s}$$

Shortly after these 0.6664 km/s burns, the two Mercury Class spacecraft will initiate their retrograde apoapsis burns, causing them to fall into orbt around 16 Psyche.

The following equation describes the needed Δ V for the apoapsis burns.

Velocity of the ASM Mercury spacecraft at the apoapsis of the transfer orbit:

$[GM(2/R - 1/a)]^{0.5} = 14.30514663$ km/s

Desired orbital velocity around 16 Psyche:

$(GM/r)^{0.5} = 0.1072555798$ km/s

This velocity will give the spacecraft an orbital radius of 133 kilometers, putting them at 20 kilometers above the surface of the asteroid.

We use the equation:

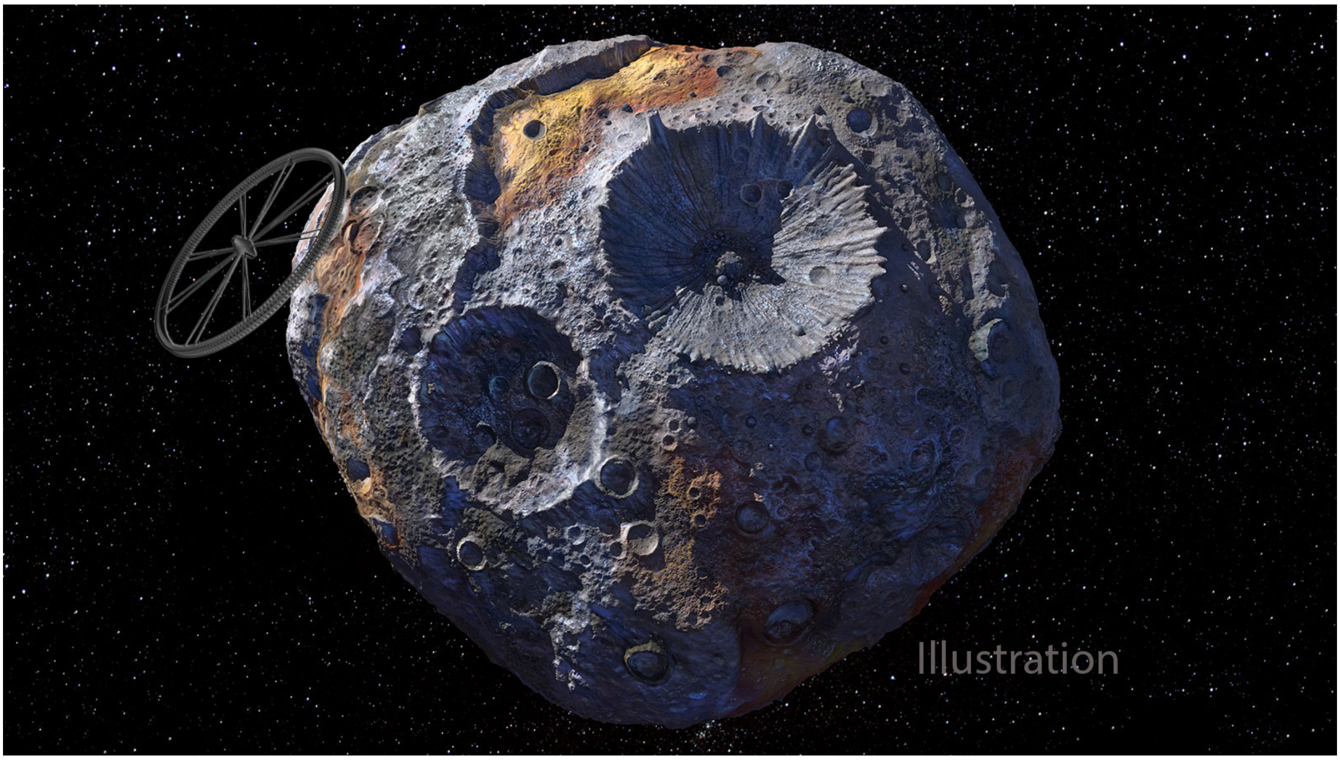
$V_a + \Delta V_2 = V_2$

$14.3051 + \Delta V_2 = 0.1073$

$\Delta V_2 = 0.1073 - 14.3051$

$\Delta V_2 = -14.1978$ km/s

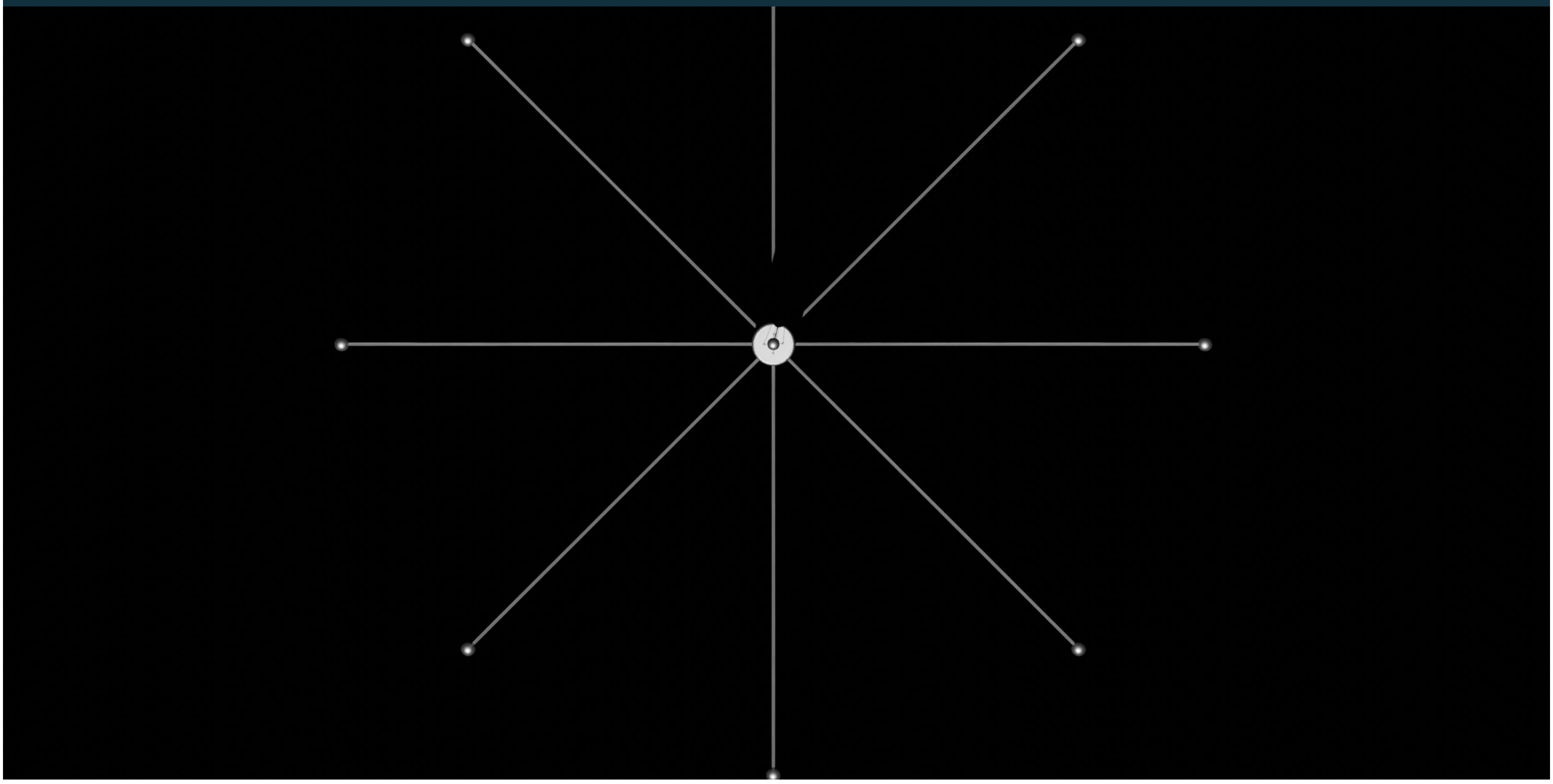
The spacecraft wil decrease their velocity by 14.1978 km/s at the apoapsis of the transfer to begin orbiting 16 Psyche.



ASM Mercury-I orbiting 16 Psyche.
16 Psyche illustration courtesy NASA/JPL-Caltech/ASU by permission.

PHASE III

ASM VENUS



CONSTRUCTION OF
ASM VENUS

RESOURCE ACQUISITION

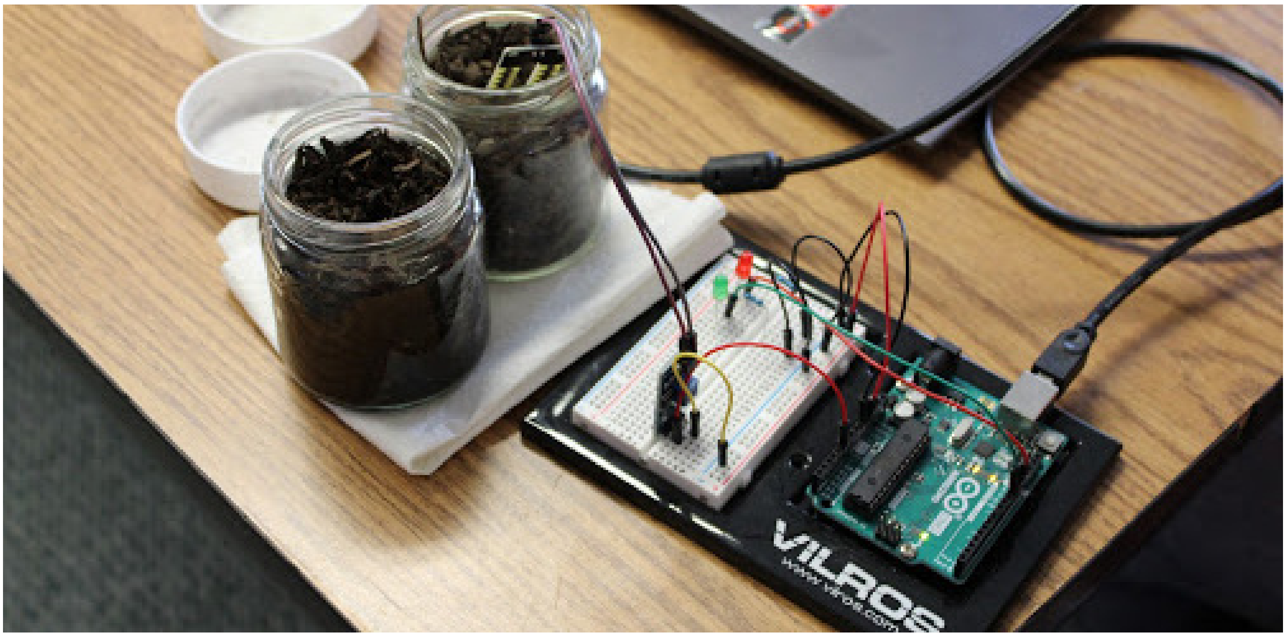
Upon arrival at 16 psyche, Mercury Class space stations will need to acquire a monumental amount of resources to be able to construct the ASM Venus space station. 16 Psyche is very large in size with a 113 kilometer radius, and is a metallic asteroid with most of the materials needed to sustain a colony. This makes it an optimal location for the construction of the ASM Venus space station. The station will require massive amounts of metal for structural construction, varied types of metals to produce electronics, and a significant amount of uranium to power the station.

The nuclear reactor aboard ASM Venus will require uranium to keep producing power. We estimate 34.99 kg of uranium will be needed per year to fuel the reactor at 40% efficiency. This is a relatively small amount of mass, meaning that transporting the uranium directly from Earth to the station is a viable possibility. The other possibility that we considered is mining and extracting the uranium directly from 16 Psyche. This method will require a large amount of work to get any substantial amount of uranium. Due to there being no uranium ores on the asteroid, it must be found in tiny pieces spread out through the asteroid. The density of uranium on 16 Psyche is, with even the most generous estimates, 0.12 grams of uranium per metric ton of asteroid mined. With such a low concentration and without any guarantee that there actually is uranium on 16 Psyche, using asteroid mining as a method of gathering uranium is not viable. Due to these circumstances and the low amount of uranium needing to be shipped, our decision is to transport uranium directly from Earth. A shipment of one metric ton of uranium will be made aboard the ASM Mercury-I and ASM Mercury-II: This is enough uranium to keep ASM Venus powered almost thirty years. If a situation of high-power consumption arises and the estimate is decreased significantly, it allows enough time for a secondary shipment to arrive.

The construction of the ASM Venus will require vast amounts of metals to allow for the construction of the station. The asteroid 16 Psyche has more than enough material to build the ASM Venus. The asteroid will be mined by remotely operated mining drones (ROMD) piloted from aboard the ASM Mercury-I and ASM Mercury-II. By not using personnel on the asteroid, the dilemma of safely transporting humans up and down from the asteroid is eliminated. 16 Psyche is in fact large enough to generate its own gravity, measuring in at 0.06 m/s^2. This is not much, but it is enough to be able to drop ROMDs onto the asteroid from orbit. From an orbit of 20 km, the ROMDs will impact at a velocity of 229 kilometers per hour. This is too fast and will damage them, as well as causing them to bounce up and veer off course post impact. Therefore, small rocket boosters will be used to slow the drones down. After ROMDs have been deployed, a refinery will descend to the surface via a rocket. At this point, mining will commence and materials will be refined. Metals will be catapulted to orbit via a mass driver. The construction of the ASM Venus will begin.

AUTOMATIC MOISTURE SYSTEM

The population of the ASM Venus will grow, and more food will be needed. The substrate of 16 Psyche will be used to increase agricultural output. Soil-based agricultural systems onboard the ASM Venus will be regulated by the Automatic Moisture System designed through Arduino and C++. The moisture system will read the moisture in the soil in order to ensure an adequate amount of water in the soil.



Code is tested on an Arduino UNO and breadboard circuit. The moisture sensor operates as follows: Two soil samples are tested: wet soil and dry soil. When the moisture sensor is tested on wet soil, the Arduino reads that there is an adequate amount of moisture in the soil and lights the green LED. The moisture sensor reads the moisture in the soil every second as the delay time is coded at 1000 milliseconds. When the moisture sensor is tested on dry soil, the Arduino reads that there is not an adequate amount of moisture in the soil and lights the red LED. This system will be used in the ASM Venus to indicate soil moisture for agricultural purposes. The moisture sensor code can be expanded to automatically water plants.

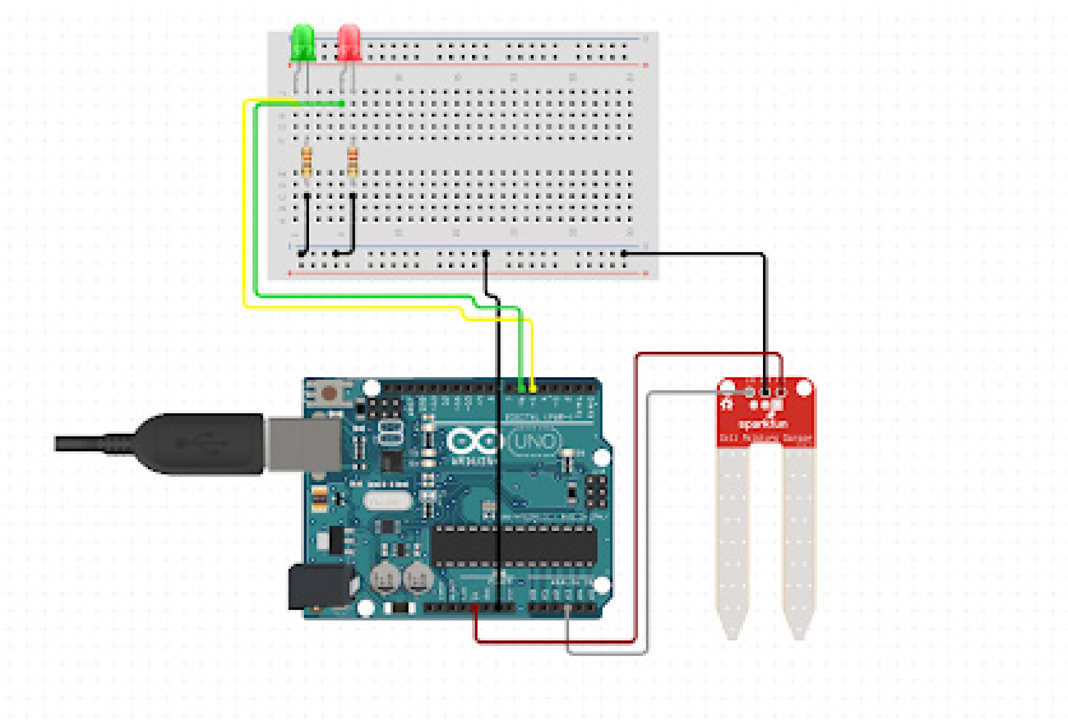


Image: Hana Husek using www.circuito.io/

MOISTURE SENSOR CODE

```
int VAL_PROBE = 0; //Analog Pin 0
int MOISTURE_LEVEL = 250; //the value after the LED goes on
int RedLED = 12;
int GreenLED = 11;

void setup () {
 Serial.begin(9600);
}

void loop() {
 int moisture = analogRead(VAL_PROBE);

 Serial.println(moisture);

 if(moisture > MOISTURE_LEVEL) {
   digitalWrite(RedLED, LOW);
   digitalWrite(GreenLED, HIGH);  //indicates high moisture level in the soil
 }
else {
   digitalWrite(RedLED, HIGH); //indicates low moisture level in the soil
   digitalWrite(GreenLED, LOW);
 }
 delay(1000);
}
```

Original code supplied by P. Marian and adapted by Hana Husek.

POWER

Space stations rely on electrical energy to power many essential functions. The ISS, for example, needs energy to power the ECLSS, onboard experiments, and most importantly their toilets. Joking aside, the power needs of the ASM Venus are no different except in scale.

The ASM Venus has a vast scale compared to current satellites around the Earth. The ASM Venus boasts an internal volume 400 times bigger than the ISS. Because of its massive scale, the ASM Venus would need an unprecedented amount of power. The population of the space station would require an estimated 112,500 kWh every day. Another 131,077 kWh is added to the total energy requirements just from the demands of the aeroponics farm (TF n.d.). ECLSS also remains a very expensive system. The Biosphere 2 project is a good analog to the power costs that will be needed for operating an ECLSS system; it used a total of 2,192 kW (Soilleux 2018). Scaling the ECLSS system to accommodate the internal volume of the ASM Venus projects the space station will consume an additional 15,0722 kW. With just these systems in mind, the total minimum power consumption would be 4,056,578 kWh per day. This would be equivalent to burning 906,492,447 kg of coal to power the ASM Venus for a year.

Although it has proven its reliability on the ISS, the ASM team has found solar panels as an impractical solution for fulfilling the power needs of the space station. Solar panels slowly degrade over time and lose efficiency, making them less useful in the long term. Furthermore, the distance from the Sun reduces the overall energy collected by the panels. On Earth's surface, the energy received from the Sun adds up to 1,360 watts per square meter; however, at the apoapsis of 16 Pysche's orbit, the total solar energy at the solar panels only equates to 48 watts per square meter. With a generous 28% solar panel efficiency, at least 63,890,771 square meters of solar panels would need to be installed to supply the ASM Venus.

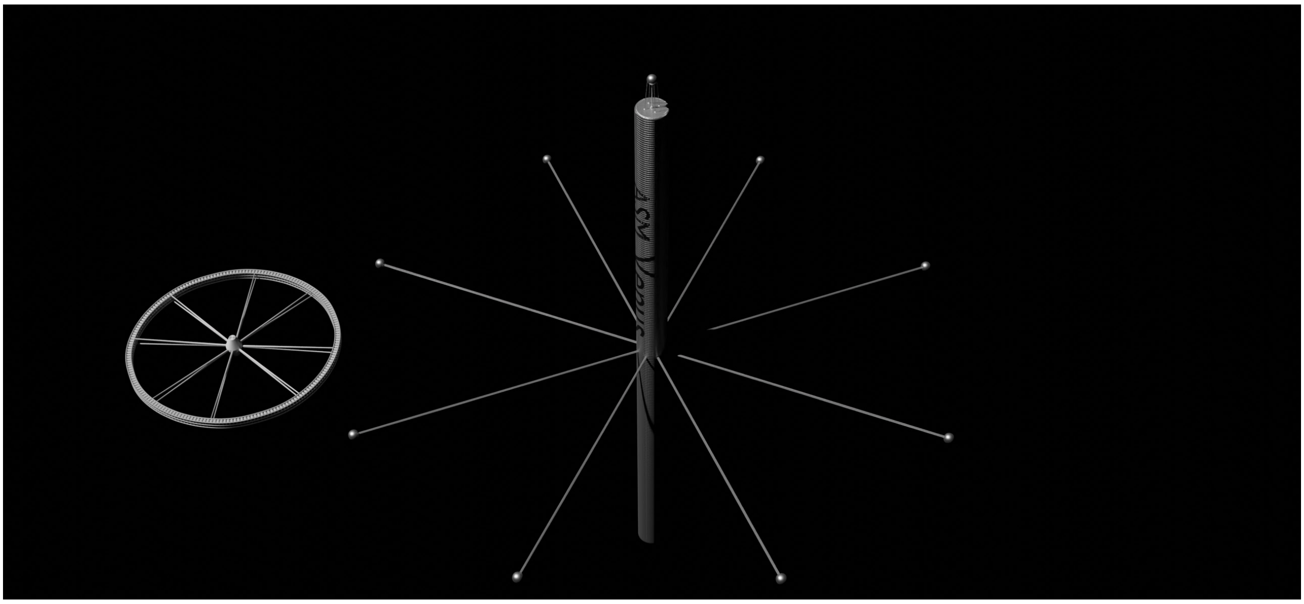
Therefore, the ASM team has recognized nuclear fission power as the best option to power the ASM Venus. A kilogram of the enriched uranium can produce up to a total of 24 million kW (OVO Energy 2018), a tremendous amount of power for a small amount of mass. Shipments of uranium from Earth are necessary because extraction of uranium from 16 Psyche would be terribly inefficient. The ASM Venus will consume an estimated 29.03 kg of enriched uranium each year of operation. The ASM Mercury stations will transport enough uranium to support the ASM Venus for 27 years.

The nuclear reactor will be situated in the low-gravity, radial center of the ASM Venus. This is done mainly to reduce the instability of moving dense and massive uranium fuel rods around the station and subsequently minimize the threat of wobble in the spinning space station.

Nuclear fission will produce waste heat; this heat will be recaptured to reduce the overall ECLSS power consumption. Since nuclear fission reactors most commonly use heat energy to produce steam and drive turbines, a method to dissipate the thermal energy is necessary on the ASM Venus. The ASM Venus is located so far away from the sun, and very little of the thermal energy from the sun reaches the station. Thus, the ASM Venus must have the means to heat the entire space station to sustain life. In the same way New York City employs the use of steam as a source of heat (NYC 2020), the ASM Venus will recapture the steam produced by the reactors and reuse it to warm the space station. By doing so, the ASM Venus can reduce the energy requirements of the ECLSS system, while condensing the steam to be reused in the steam turbines to produce more electricity. Steam will regulate the climate of the ASM Venus; steam will warm the water needed for the agricultural systems and ensure that all crew members can enjoy a warm shower.

ASM VENUS EXTERNAL CONSTRUCTION

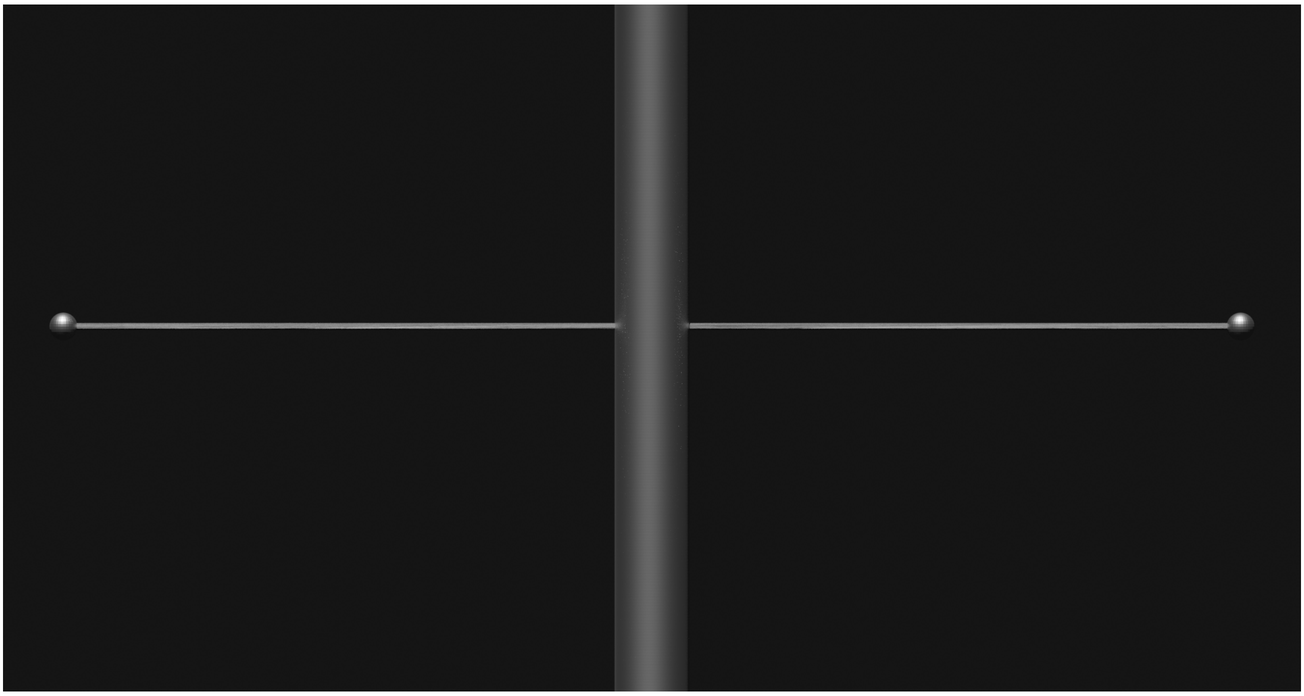
To fully utilize the two Mercury Class space stations, the ASM Mercury-I will be salvaged for the foundation of the creation of the ASM Venus and the ASM Mercury-II will be used as a temporary home for the crew members. The shielding panels from the ASM Mercury-I will be salvaged and installed onto the ASM Venus. The aeroponic bays will also be transferred once the ASM Venus is habitable.



When designing a space station, the most important value to minimize is the external surface area of the space station because heavy, expensive shielding panels must be installed on every exposed surface. We considered a number of different space station designs: cylindrical with a small center opening, cylindrical without an opening, space ring, and Stanford torus. When the ASM team calculated living area per surface area, we found that the closed, cylindrical space station was the most optimal design. For example, compared to a Stanford torus, the ASM Venus is 522% more compact. With optimized housing area in mind, the radius of the ASM Venus will be 64.16 meters and the height of 2,533 meters. This relatively narrow structure will leave a 94,194.08 square meter exterior exposed to the vacuum of space.

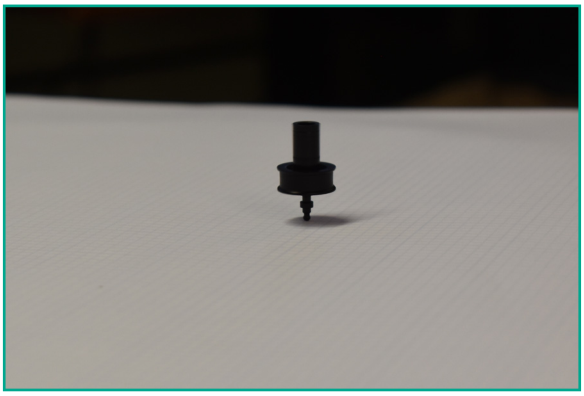
SPACE STATION SHAPES WITH FLOOR LIVING SPACE OF 162,521.99 SQUARE METERS

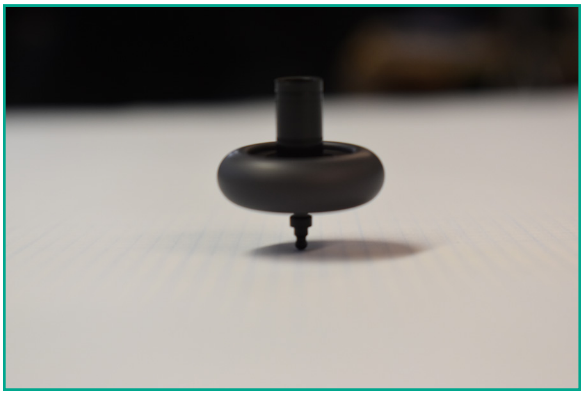
SPACE STATION TYPE	CYLINDER	CYLINDER / SMALL OPENING	HALO RING	STANFORD TORUS SHAPE
CEILING AREA	0	2,015.70	19,819.07	
WALL AREA	25,866.18	25,709.10	10,680.49	
TOTAL AREA	188,388.16	190,246.78	193,021.55	492,140.89
TOTAL MASS OF SHIELDING (KG)	7,885,297.39	7,963,093.04	8,079,235.39	



ASM Venus, multiple tethers removed for perspective.

To account for the instability caused by the narrow dimensions of the ASM Venus (Globus 2010), eight tethers with end weights will be installed around the center of mass of the space station. These tethered weights will add stability by increasing the angular momentum about the center of mass; thus, they will dampen any nutation caused by movement onboard the ASM Venus.





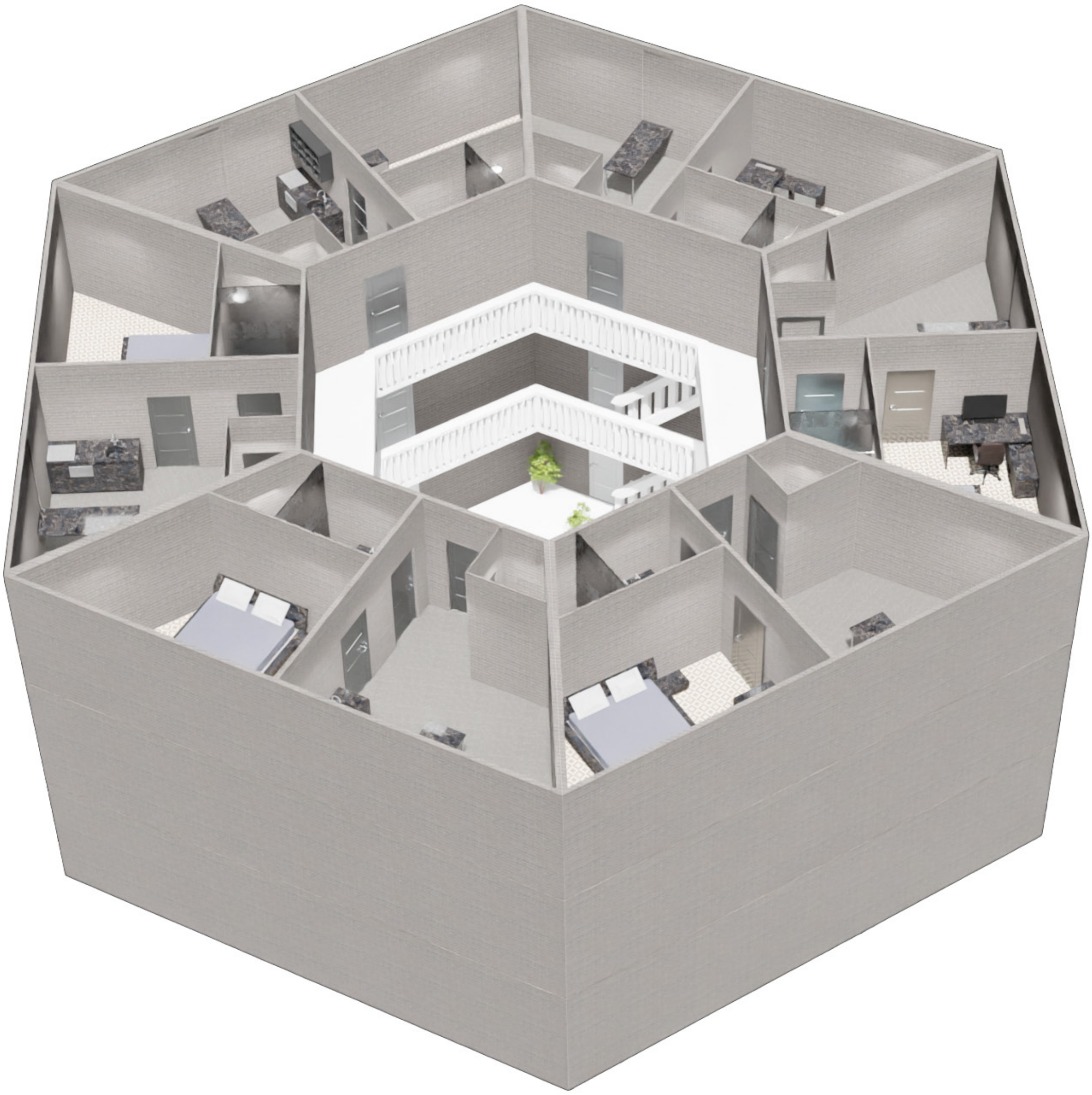
The same spinning top without and with added mass and radius. The top on the right remained stable 4.87 times longer when comparing their mean spin times.

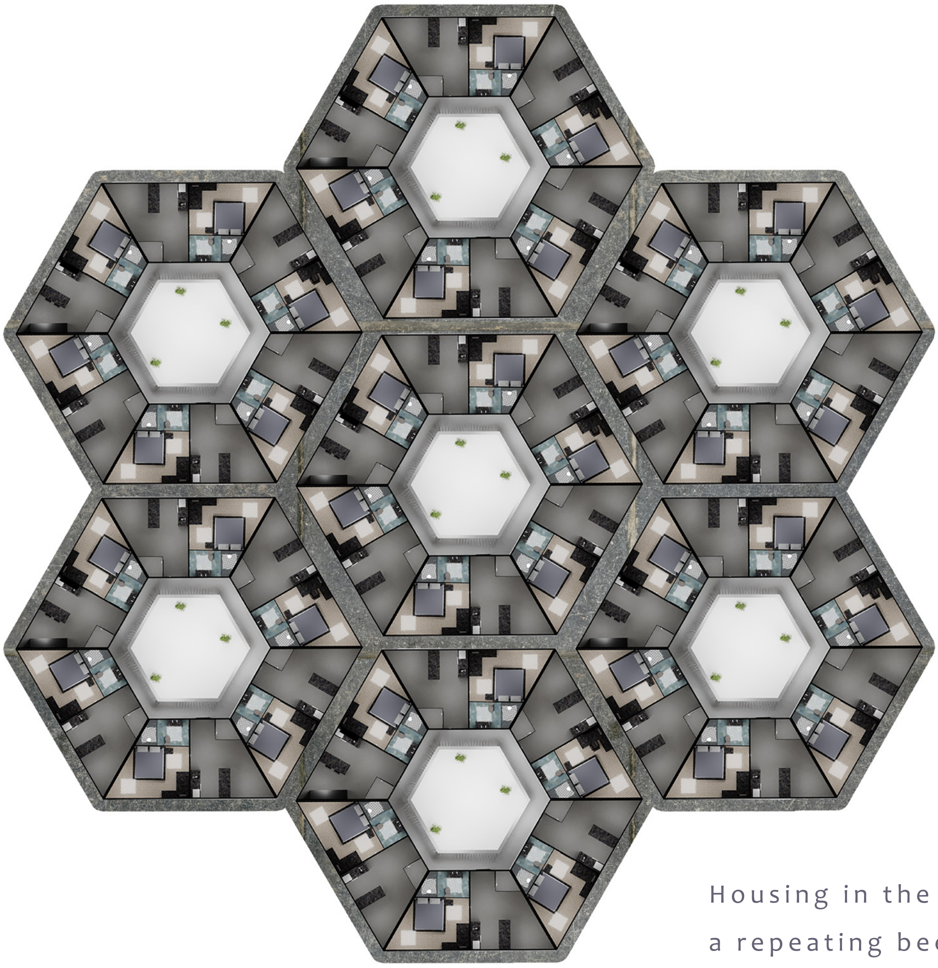
To test the efficacy of the tethers, the ASM team conducted an experiment to examine the effects of adding angular momentum to a spinning top. A top was spun with and without a weight on its outside edge. The mass of the top was 1.28 g; with the added weight, 2.33 g. The radius of the top was 8 mm; with the added weight, 12 mm. The mean duration of the top's spinning time was recorded and compared: The top with the added mass spun for an average of 41.6 seconds; the top without added mass spun for an average of 8.55 seconds. The top with the extended mass spun for an average of 4.86 times longer. This confirmed our hypothesis that the added weight extended outward from the center of mass would keep the top stable for a longer time duration, due to additional angular momentum. The tethers on the ASM Venus will act in the same manner. The weighted tethers will add angular momentum to conserve the rotational path of the space station and inhibit any destructive nutations.

ASM VENUS INTERNAL CONSTRUCTION

The narrow shape of the ASM Venus requires a strong, tension-bearing architecture that maintains the station's compact shape. This is essential, since the centrifugal forces will place a substantial amount of stress on the exterior walls. To add structural integrity, the internal housing of the ASM Venus make use of a hexagonal, beehive form. Hexagons will be used because they are the most stable geometric shape (in all directions) due to their 120-degree angles and symmetrical sides (Sullivan 2017). The hexagonal shape arranged within a cylinder combats the flexing caused by the centrifugal forces.

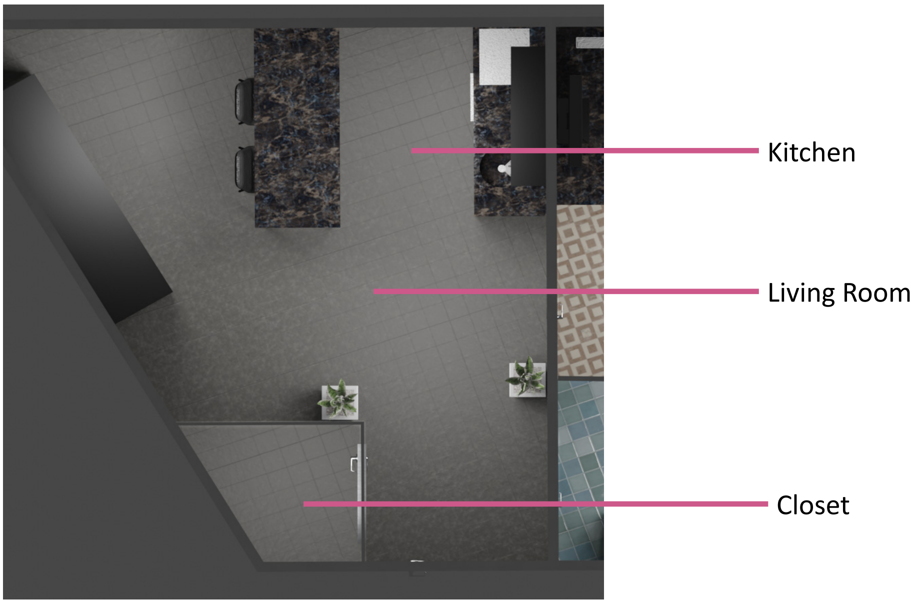
Hexagons can be placed next to each other without creating dead space, allowing for efficient use of the space, while reducing material consumption. For example, a hexagonal dome requires one-third of the struts and two-thirds of the hubs in a triangular geodesic dome (Tyler n.d.).This is in contrast to geometric shapes such as circles, which are more efficient in terms of perimeter compared to hexagons; however, they leave significantly more empty space between them than hexagons. Only 3 shapes neatly tesselate: triangles, squares, and hexagons (Ball 2016). Triangles will not be used because of their inferior structural integrity as compared to hexagons, and squares will not be used because a tesselation of squares will have at least one angle of weakness against stress. Hexagons are resilient to tension and compression, regardless of the angle of the incoming stress. Because of the strong shape, every apartment block will be built in a hexagonal shape and aligned in a grid-like, repeating pattern.





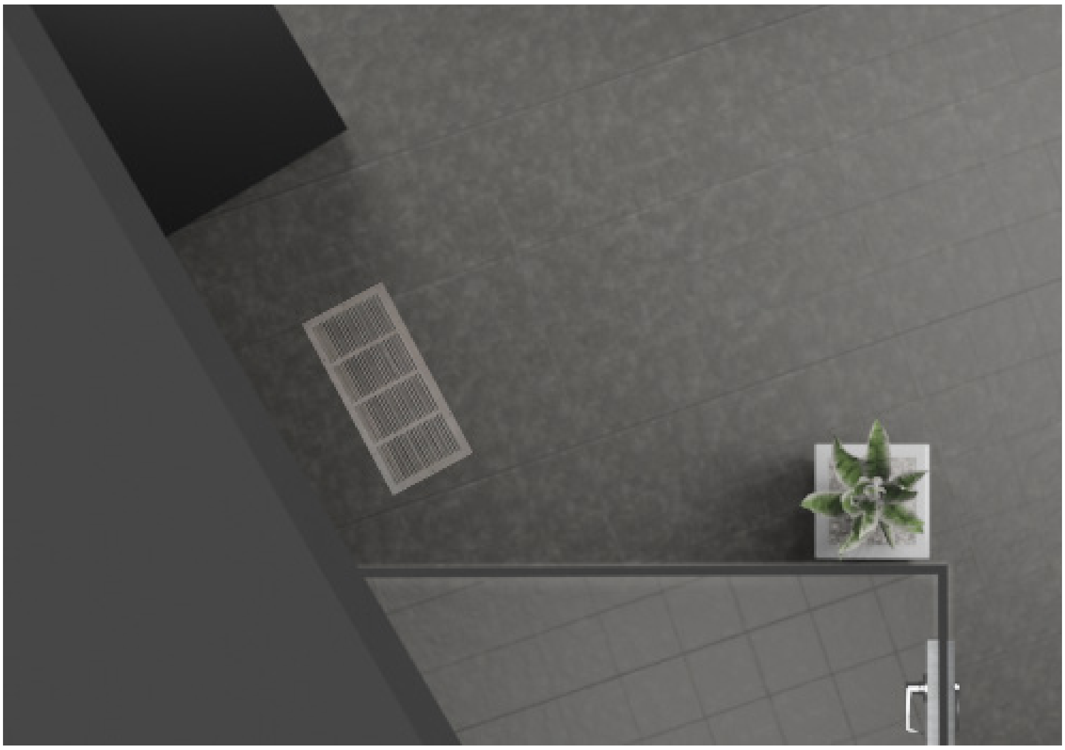
Housing in the ASM Venus features a repeating beehive pattern.

Apartment aboard the ASM Venus



The ASM Venus will be a permanent residence for thousands of people. This necessitates a comfortable living space for each person on board the space station. Unlike the ISS—where compact, tubelike compartments are reserved as sleeping compartments—the living spaces aboard the ASM Venus will be built with spacious interiors and comfort in mind. The six sides of the hexagons will be divided into six apartments—40 square meters in floor space area each. Each apartment will consist of one combined living room and kitchen, one bedroom, one bathroom, and one small closet. Some of these apartments may be linked together in the case of a family living there, so that the space will increase with the size of the family. In the very center of the apartment block, a communal area will be reserved for access to each room and as a recreational space. This layout will extend up to three floors to allow for 18 people per apartment block.

Safety is a matter for concern aboard a space station. One significant danger is being poisoned by toxic gas build-up. On Earth this is less of a threat because of home ventilation; however, aboard a space station this is a critical threat. The centrifugal forces from the spinning space station will cause heavier gases to drift towards the floor of the space station; this buildup may suffocate crew members. For example, carbon dioxide concentrations can accumulate up to hazardous levels within the enclosed spaces of the ASM Venus. Therefore, a system to test for dangerous levels of carbon dioxide will be installed in all the apartments. If toxic gas buildup is detected within the confines of the ASM Venus, floor vents will open up. The gases will be pushed into the vents by the centrifugal forces pushing the gases downwards.



Floor vents, activated by gas sensors, open to remove the buildup of carbon dioxide, a heavy gas.

[Vent image: photoshoptextures.com license permission]

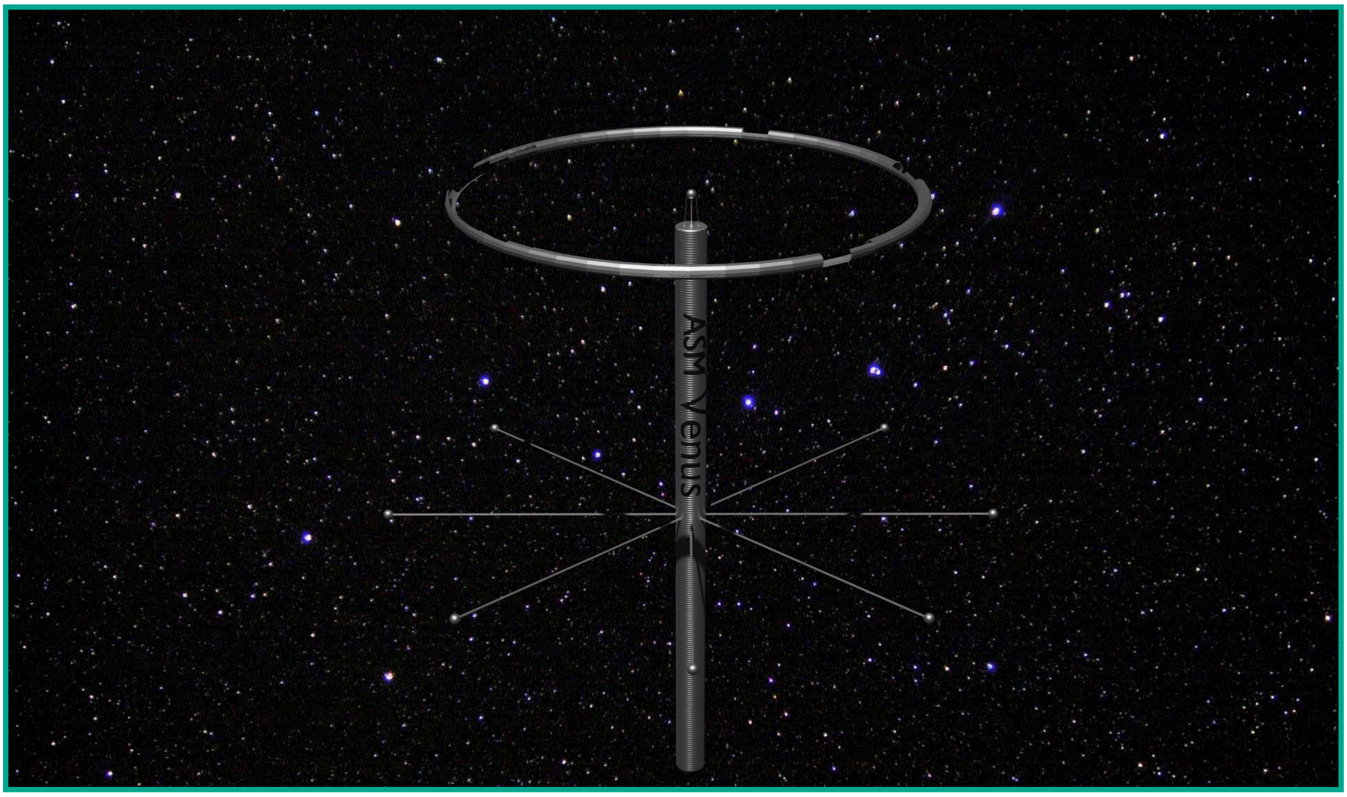
CARBON DIOXIDE DETECTOR

```
int redLed = 12;
int greenLed = 11;
int buzzer = 10;
int carbondioxideA0 = A5;
// Your threshold value
int sensorThres = 400;

void setup() {
  pinMode(redLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(carbondioxideA0, INPUT);
  Serial.begin(9600);
}

void loop() {
  int analogSensor = analogRead(carbondioxideA0);

  Serial.print("Pin A0: ");
  Serial.println(analogSensor);
  // Checks if it has reached the threshold value
  if (analogSensor > sensorThres)
  {
    digitalWrite(redLed, HIGH);
    digitalWrite(greenLed, LOW);
    tone(buzzer, 1000, 200);
  }
  else
  {
    digitalWrite(redLed, LOW);
    digitalWrite(greenLed, HIGH);
    noTone(buzzer);
  }
  delay(100);
}
```

Original code by LGPL and adapted by Hana Husek.

FUTURE SPACE STATION CONSTRUCTION

To initiate the new age of space exploration, new platforms will be required. The ASM Venus has been conceived with this in mind, to initiate a new generation of space station designs, giving humanity a permanent, and comfortable future in space. To allow for this sizable advancement in space station architecture, the ASM Venus will be placed in orbit around 16 Psyche, permitting the beneficial application of the asteroid's numerous resources such as iron, gold, nickel, and platinum.



The ASM Venus constructing a ring space station.

The abundance of resources on 16 Psyche provides the ASM Venus the metals to construct multiple space stations. These space stations will serve the purpose of colonizing the orbits of the numerous planetary objects. Each completed space station will be sent out with a small crew of five hundred as well as sufficient resources needed to reach its destination. Consequently, newly-created space stations will travel the solar system and enter the orbits of diverse planetary objects, such as moons, planets and large asteroids. These stations will function as their own communities in space as well as data collectors for potential larger-scale colonization efforts. The long term goal of the ASM Venus is to turn humankind from a planetary species to one spread out across the solar system, entering a new era of civilization.

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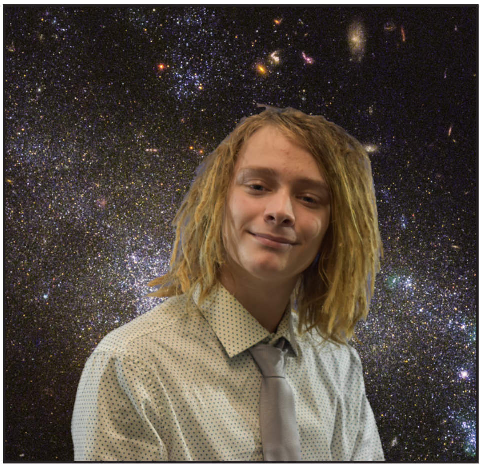
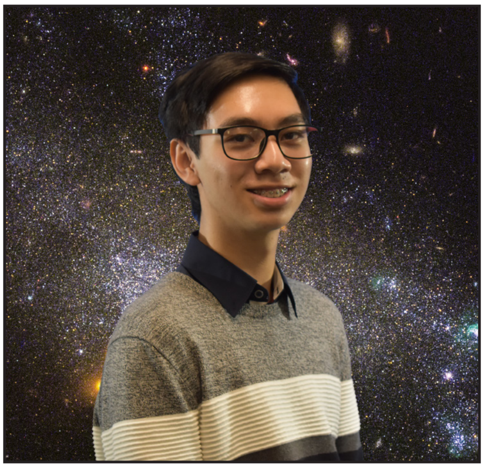


Andrew Olafsrud
Shielding
Housing
Resource Acquisition



Austin Pham
Power
3D Modeling
Agriculture
Venus Construction

Josiah Richards
Captain
Mercury Construction

Christian Taniyama-Mento
Ground Station
Space Station Construction

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AeroSpace Meridian

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APPENDIX A

Electronic Acknowledgement Receipt	
EFS ID:	41667733
Application Number:	17153815
International Application Number:	
Confirmation Number:	3431
Title of Invention:	SELF-HEALING SHIELD CONFIGURED TO PROTECT AN ENVIRONMENT FROM HIGH VELOCITY PARTICLES
First Named Inventor/Applicant Name:	Andreas Olafsrud
Customer Number:	124474
Filer:	Kerry S. Culpepper
Filer Authorized By:	
Attorney Docket Number:	09-007NP
Receipt Date:	20-JAN-2021
Filing Date:	
Time Stamp:	20:54:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$830
RAM confirmation Number	E20211JK57147490
Deposit Account	506466
Authorized User	Kerry Culpepper

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.17 (Patent application and reexamination processing fees)