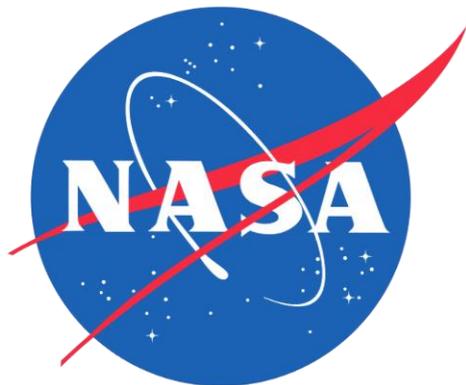


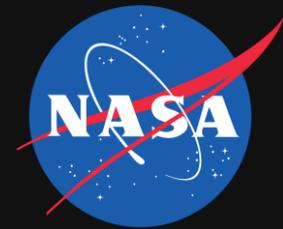
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Porter Dixon
EV3 Intern, JSC, NASA
Summer 2018



About Me

Introduction

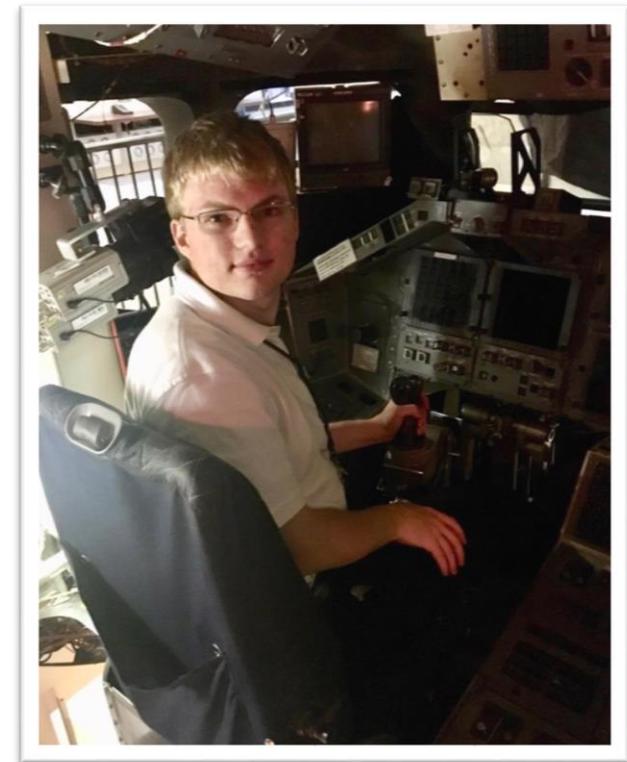


Educational Background

- Currently senior at North Dakota State University in Fargo, ND majoring in Mechanical Engineering
- Graduating in December 2019
- Senior Design Project: Designing and building a “resistojet” thermal rocket

Professional Interests

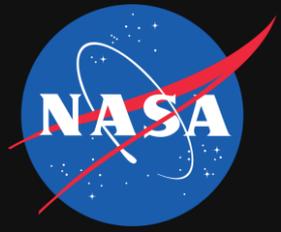
- General propulsion systems, interested in advanced propulsion techniques such as nuclear thermal propulsion.
- Thermionics power systems
- Aircraft/Spacecraft mechanical design



Me sitting in SAIL cockpit

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Projects



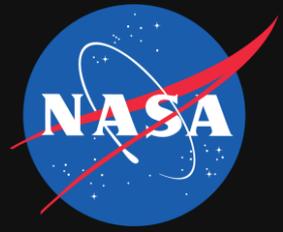
- Near beginning of internship, I settled on two main projects to work on with one project taking up the month of June, and the other taking up the month of July.
- 1st project: Develop instructions for importing CAD models into AR, refine process so that it is easy. Use Z2.5 (xEMU) suit as demo model
- 2nd project: Import CAD assembly of ISS airlock and Z2.5 demo suit into VR to determine 5 things



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Project 1: Microsoft HoloLens:

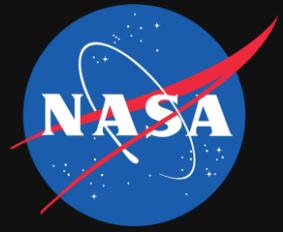
HoloLens Overview



- The Microsoft HoloLens is an augmented reality visor that projects holograms on the user's field of view and allows the user to manipulate these holograms using a few finger gestures (or an optional clicker)
- System specs:
 - See-through holographic lenses (waveguides)
 - 2x HD 16:9 light engines
 - Automatic pupillary distance calibration
 - 2.3M total light points holographic resolution, 2.5k light points per radian (**only 30x18.5 degree FOV**)
 - **Sensors: Inertial Measurement Unit, 4x environment understanding cameras, mixed reality capture, 4x microphones, ambient light sensor**
 - Processor Custom Microsoft Holographic Processing Unit HPU 1.0, Intel 32-bit architecture
 - RAM 2GB
 - Storage 64GB
 - Weight 579g (1.2lbs)
 - Camera 2MP photos, HD video
 - Audio External speakers, 3.5mm audio jack
 - Connectivity Wi-Fi 802.11ac, Bluetooth 4.1 LE, Micro-USB 2.0
 - Power 2-3 hour active use battery life, 2 weeks standby, passive cooling
 - OS Windows 10 with Windows Store
 - **Human Understanding: spatial sound, gaze tracking, gesture input, voice support**

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Project 1: Augmented Reality -
Justification



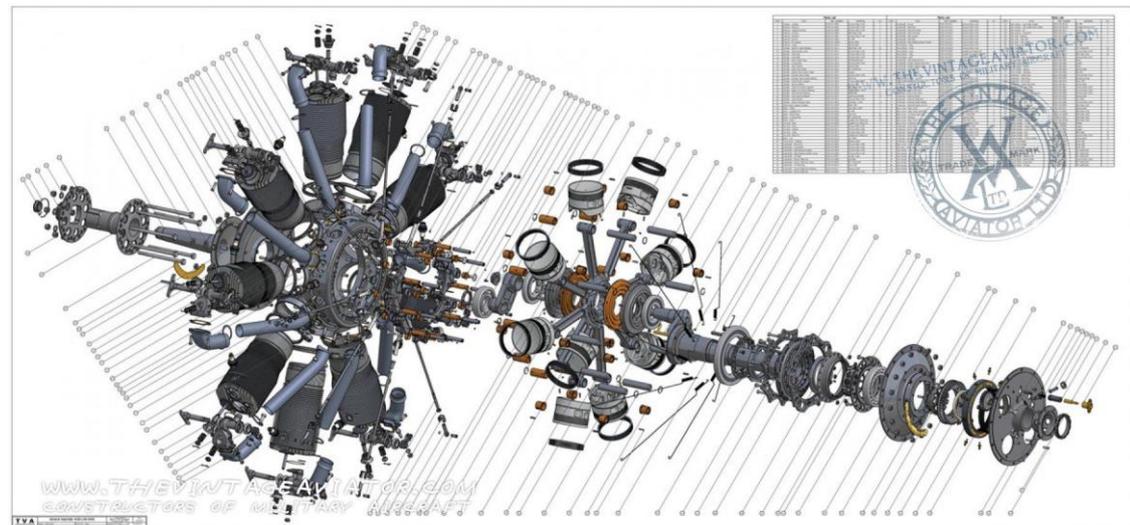
- The Human Integrated Vehicles and Environments (HIVE) lab allows for designs that feature any sort of human interface to be quickly validated and tested in a virtual reality environment. The HoloLens has been used in the past to this end, particularly to test student-designed HUDs for possible use in the xEMU suit.
- The HoloLens also might have a use as quickly presenting 1:1 scale designs as holograms for tabletop discussions. This was one of the justifications for figuring out how to take CAD designs and port them to the HoloLens.

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Project 1: Augmented Reality – Project Details

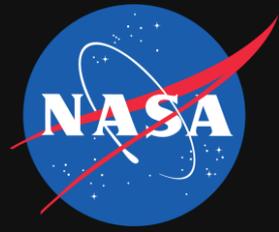


- Because engineering designs are often done in a CAD environment, going from a CAD model to a simplified mesh representing the entirety of the 3D object with preservation of detail can be difficult depending on the complexity of the assembly and can require a lot of work.
- The image on the left shows a typical 3D model that consists of a single, surface mesh. The image on the right shows a model consisting of thousands of parts.



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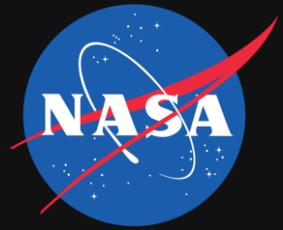
Project 1: Augmented Reality – Possible CAD
Integration Solutions



- For importing small assemblies or individual parts, exporting the assembly or part to a .obj file then importing the .obj file and the associated .mtl file into Unity works just fine.
- For large assemblies, exporting to .obj works fine, but the number of triangles in the mesh exceeds the Unity limit and attempting to import the .obj into Unity will result in all available RAM being used up and Unity crashing. Using a large chord height for the export process results in a 3D model that has very poor resolution and still doesn't perform well in Unity.
- “Shrink wrapping” the part in Creo Parametric, that is, taking the assembly and converting it to a single .prt file works pretty well, but there is a major bug in Creo that doesn't allow shrinkwrapped parts to be exported to a Wavefront file, so this method ends up being useless.
- How the graphics lab does it: export assembly to .stl file with maximum resolution, open resulting mesh in Blender, spend hours preparing mesh by repairing surfaces, decimating, rigging for animation, then texturing object.
 - For the HIVE lab, this takes too long and is not conducive to our goal of quickly creating “human-in-the-loop” testing.
 - Blender's learning curve is also super steep and it takes up to a year to become proficient.

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Project 1: Augmented Reality – PiXYZ As A Solution

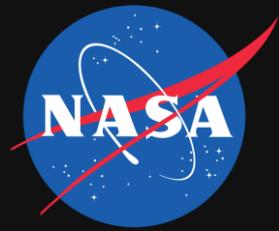


- PiXYZ Plugin is a add-on for Unity that allow for CAD data in almost any format to be quickly imported into Unity as lightweight, optimized meshes while also preserving part hierarchy.
- Out of all the methods tried, PiXYZ was the most effective solution. The only other method that worked was going through a model and suppressing all internal parts while only leaving surface geometry, then exporting to wavefront file.
 - However, this can be time consuming with huge assemblies that take time to regenerate every time a part is suppressed.
 - At the end, you are still left with a singular mesh that doesn't have part definitions intact (this will be important later when discussing second project).

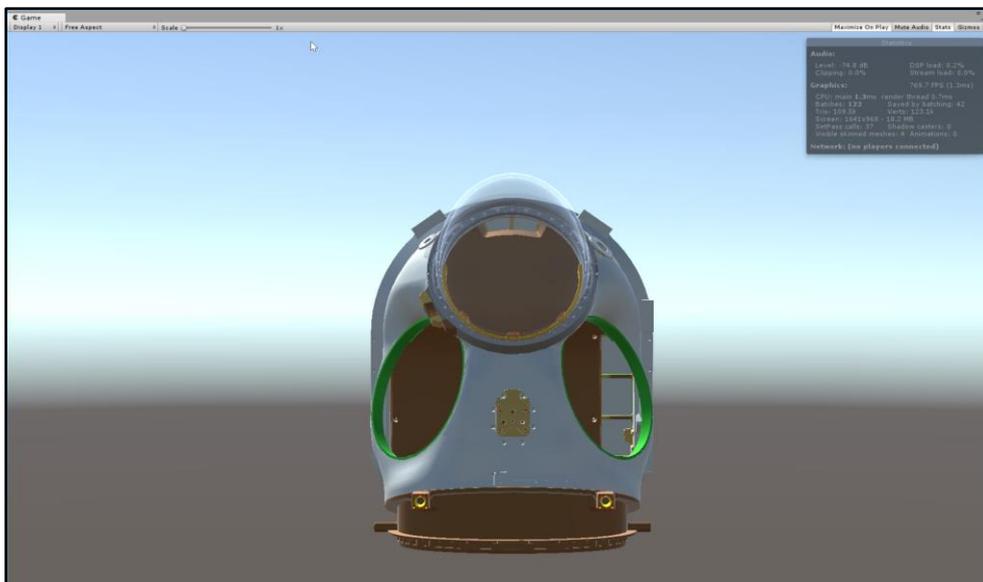


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Project 1: Augmented Reality – Process Used With PiXYZ

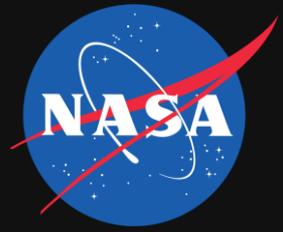


- PiXYZ was able to produce lightweight, yet quality meshes for use in Unity from the CAD data. The picture on the right is the end result of the 3D model after shrinkwrapping it in Creo for performance reasons then using PiXYZ to import it (~110 K polygons total), and on the right is the shaded model with edges as seen in Creo Parametric 4.0.
- Exporting the CAD model to a .obj file using the default export settings produced a model with a smaller polygon count (~88 K polys) but because Unity only supports 65,536 vertices PER mesh, trying to import a mesh that exceeds this 16 bit limit freezes Unity. PiXYZ gets around this by splitting up model into multiple meshes.



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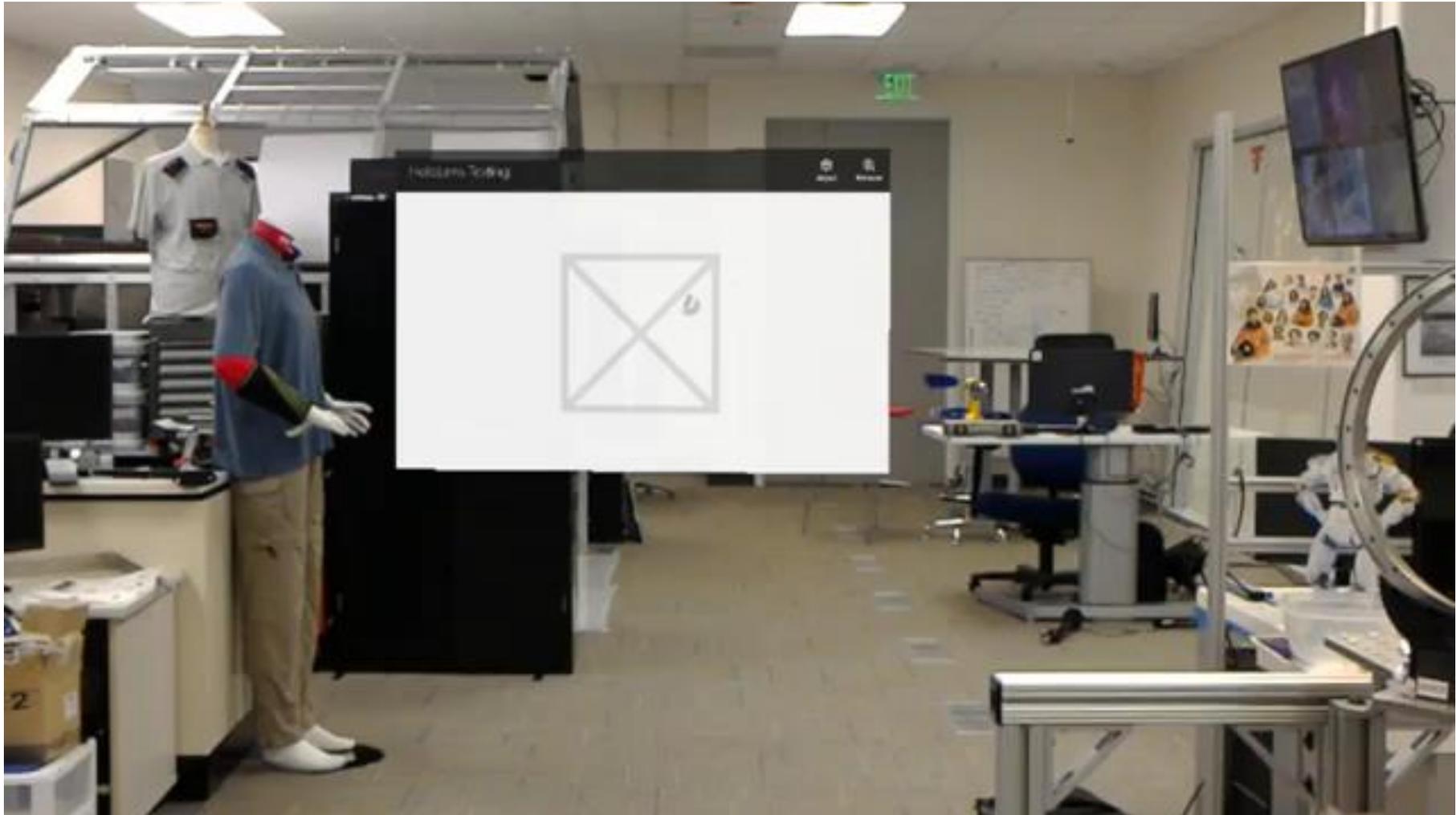
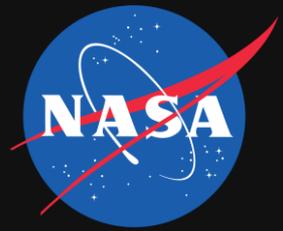
Project 1: Augmented Reality – Developing A Simple
Demo AR App in Unity



- After the model was imported into Unity, and a little optimization done by deleting unneeded meshes i.e surfaces the user will never notice or see, the Mixed Reality Toolkit (MRTK) was downloaded as a unity package from Github and imported into Unity.
- MRTK allows for rapid prototyping of AR apps and comes with an assortment of pre-made assets and C# scripts that allow the holograms to become interactive.
- The hologram was then made to be capable of being translated, scaled, and rotated in any direction.

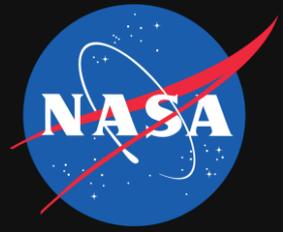
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Project 1: Augmented Reality – Developing A Simple Demo AR App in Unity



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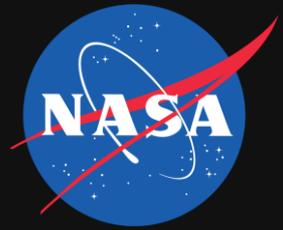
Project 1: Augmented Reality – Technical
Documentation



- Technical documentation was produced for this project to use as a reference guide for any future interns or employees who might want to work with the HoloLens, serves a “Getting Started” guide.
- Includes screenshots to supplement written instructions
- 11 pages
- Published internally in EV3 department

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Project 2: Virtual Reality – Project Overview

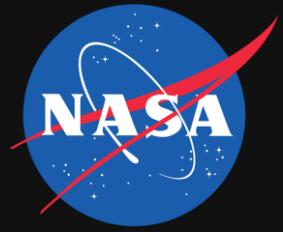


- Fun Fact: NASA established a VR lab in 1990.



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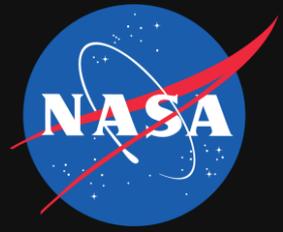
Project 2: Virtual Reality – Project Overview



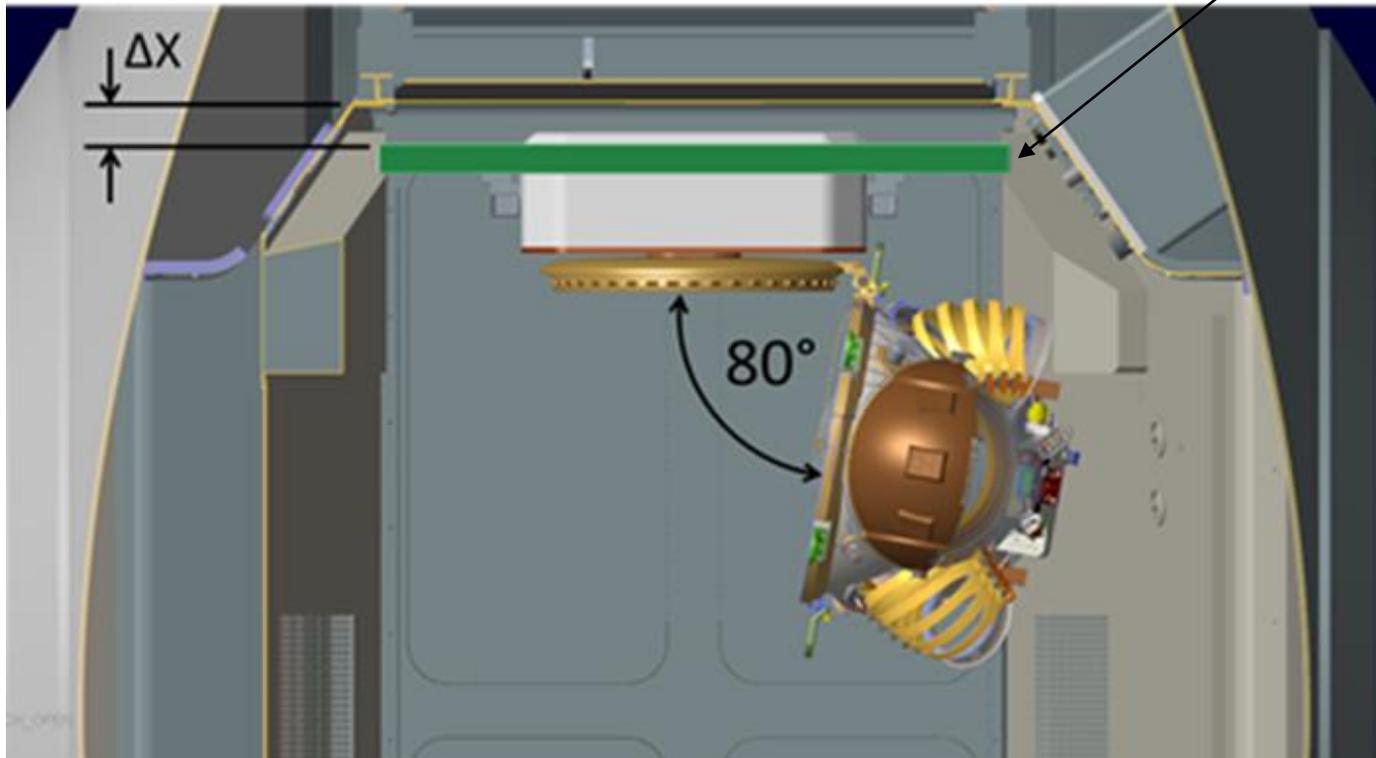
- Because of my previous experience with going from CAD to Unity gained in my previous project, Jeff Watters, who works in Advanced Space Suit Team, tasked the HIVE lab with setting up a VR simulation of the ISS airlock and xEMU suits.
- 5 goals for project:
 - 1. Simplify airlock assembly and import into VR environment (Unity in this case)
 - 2. Simplify Z-2.5 model to a lightweight version and import into VR
 - 3. Conduct VR don/doff simulations to determine how much offset delta-x is required to facilitate donning
 - 4. Determine approximate minimum angle required for donning
 - 5. Evaluate various EDDA (basically the frame the suit mounts on in the crewlock) heights and whether angling the EDDA relative to the wall improves don/doff

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Project 2: Virtual Reality – Project Overview

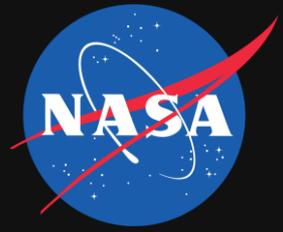


- CAD Assembly of Equipment Lock + EDDA + xEMU (crew lock omitted)

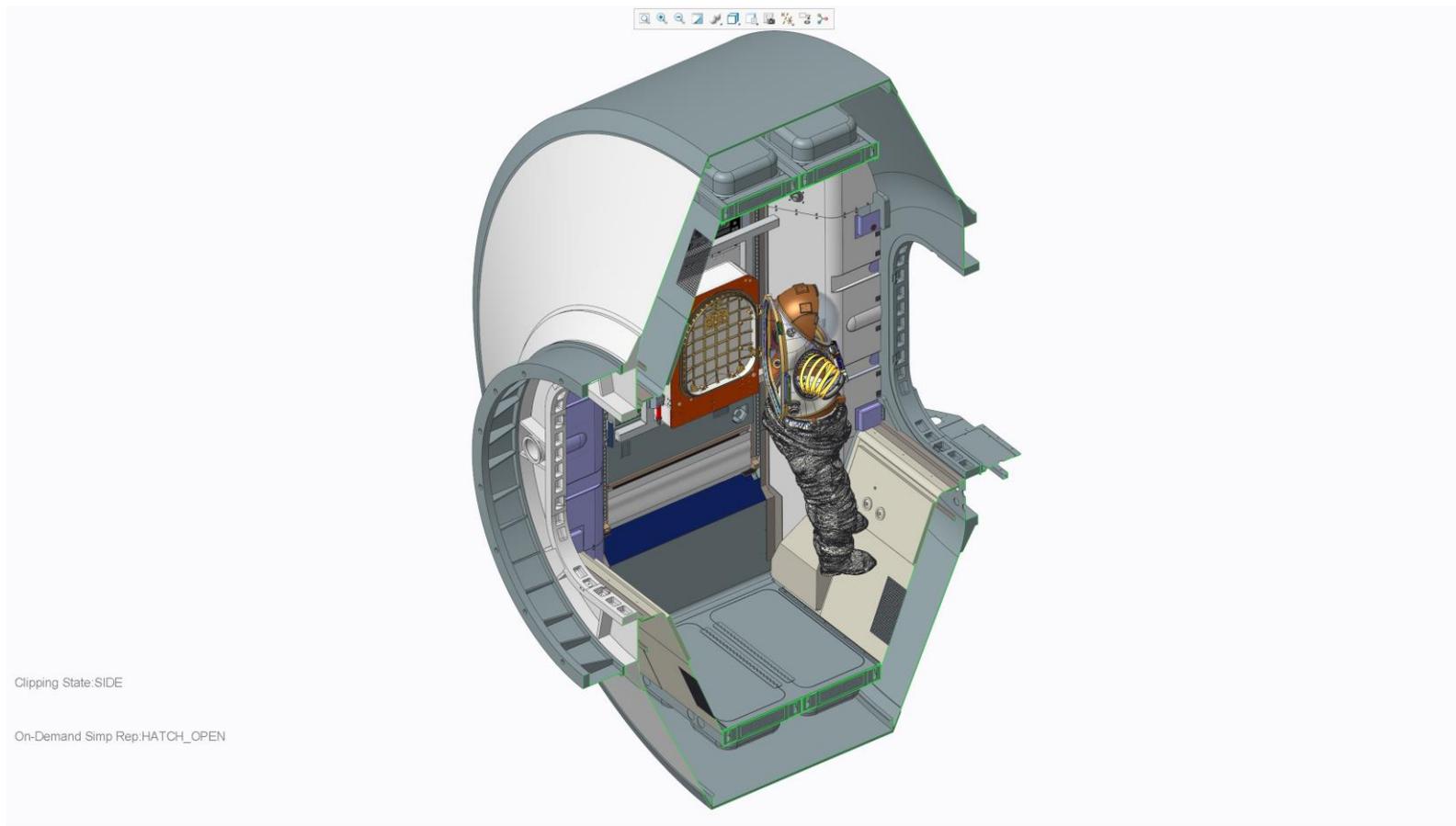


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Project 2: Virtual Reality – Project Overview

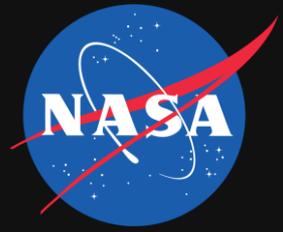


- CAD Assembly of Equipment Lock + EDDA + xEMU (crew lock omitted)



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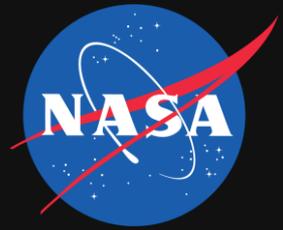
Project 2: Virtual Reality – Import Process



- Using lessons learned from experimenting with PiXYZ for my AR project, I used PiXYZ to import the entire airlock assembly into Unity.
- Imported entire assembly rather than just importing separate pieces in order to preserve dimensions and orientations as they are in the model; Unity is not very good for setting up precise relationships between pieces of geometry.
- Initially just kept everything in model and used the default import settings, which balances quality and performance.

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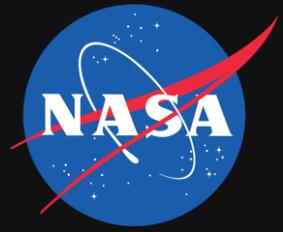
Project 2: Virtual Reality – Import Process



- Overall model ended up being 6 M triangles. While this ran ok on the VR headset, it wasn't great and sometimes struggled.
- Over the course of refining the VR model, I found a bunch of ways to improve performance and my final version as of this writing is 1.5 M triangles and I get at least 90 FPS at all times.

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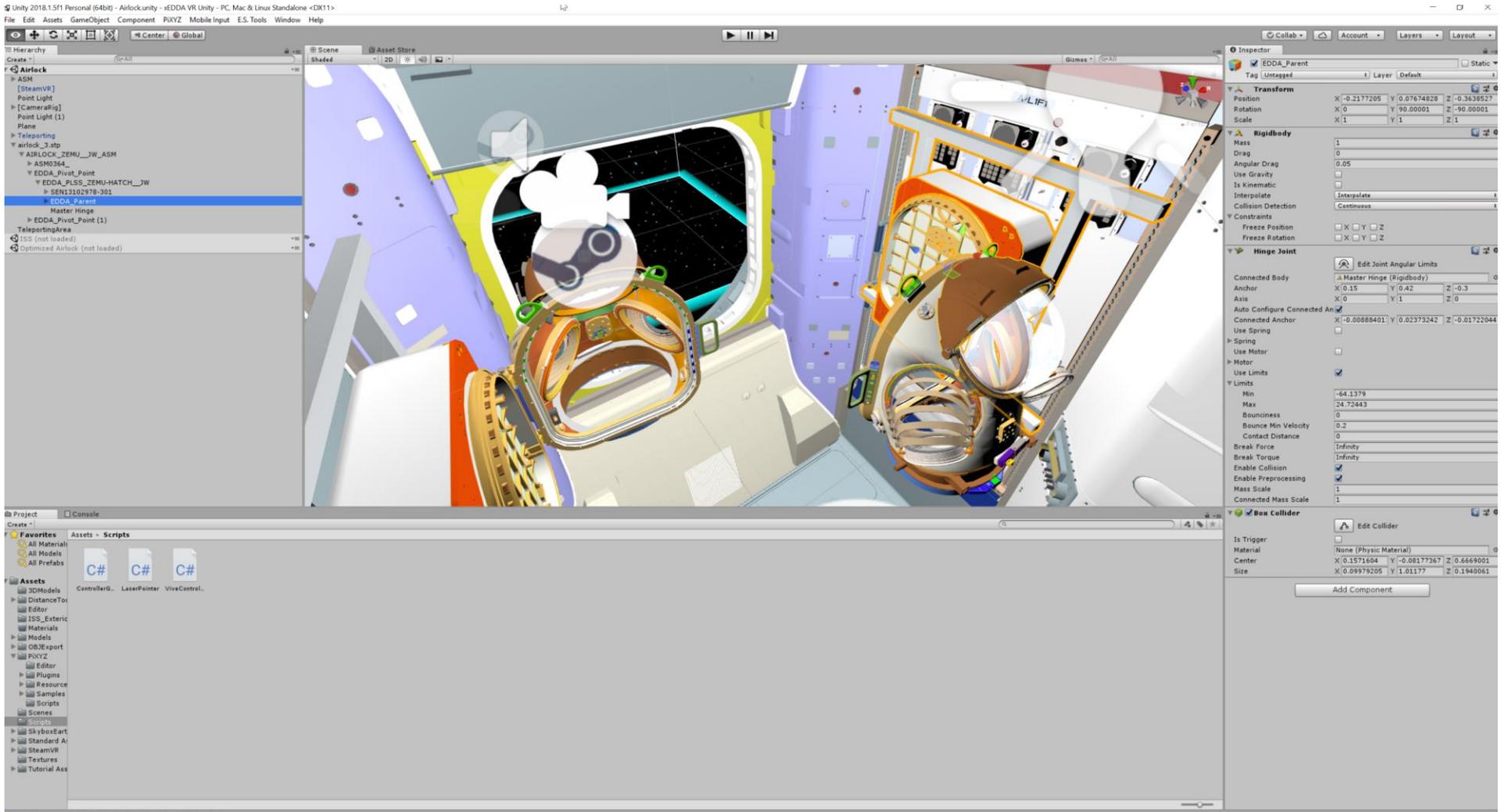
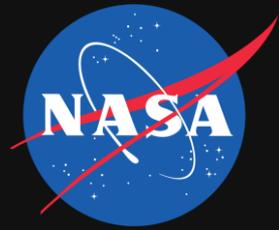
Project 2: Virtual Reality – Model Development



- Initially, scene was only static, and the user couldn't really move around in the scene unless they physically moved around the room.
- Things added to model in Unity:
 - Used SteamVR unity package to include support for VR. Used package to add controller models that user sees within the virtual world
 - Added ability to teleport around the scene (since using a joystick to move around while wearing a VR headset can be uncomfortable).
 - Turned suit and EDDA frame into physics objects that could be manipulated by the user by using hinge-joints and parent-child relationships within the part hierarchy
 - Added simple point lights to scene
 - Eventually just deleted airlock and just left the crewlock to save on performance.

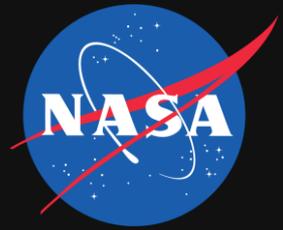
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Project 2: Virtual Reality – Screenshots and Video Demonstration



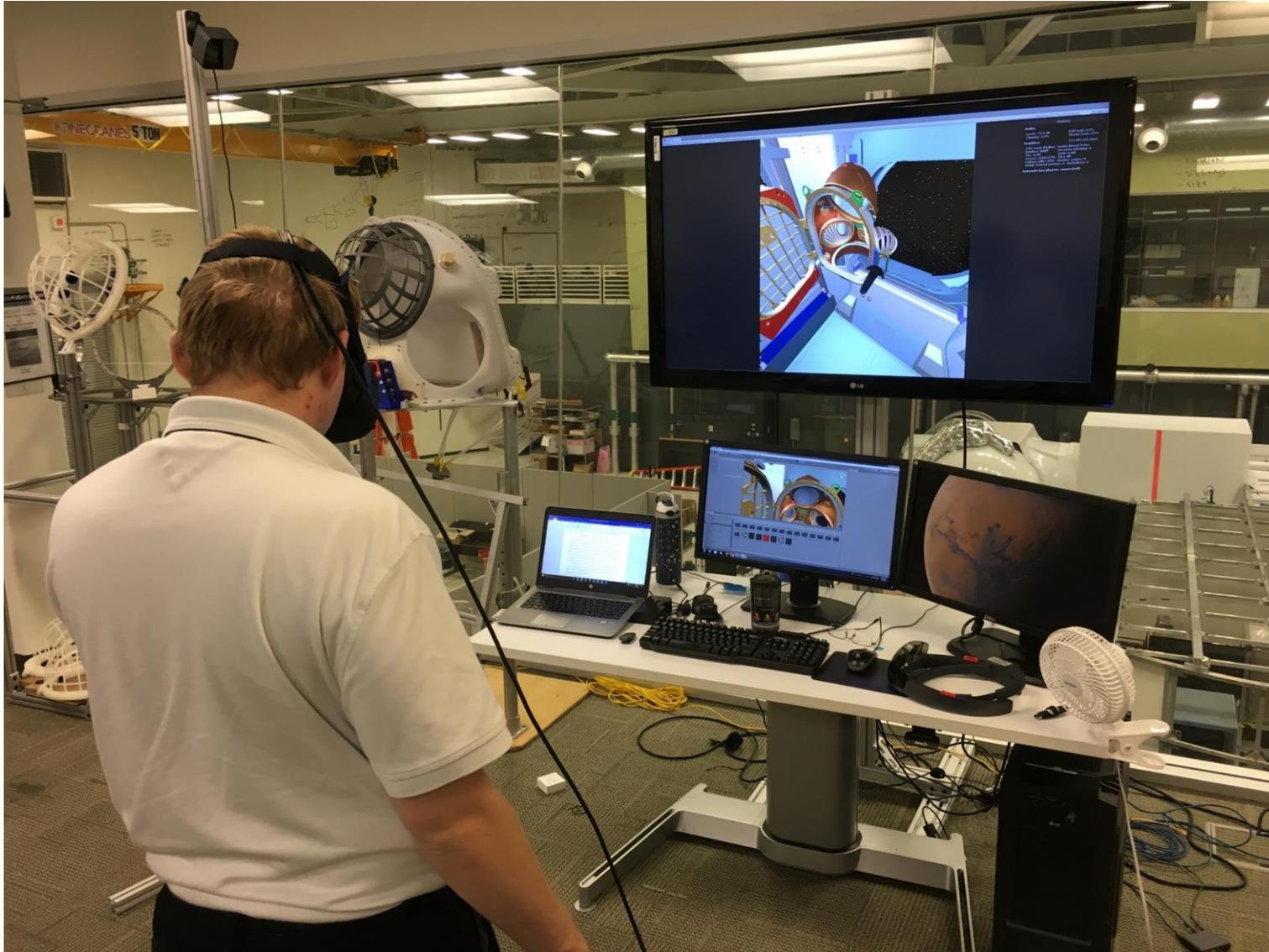
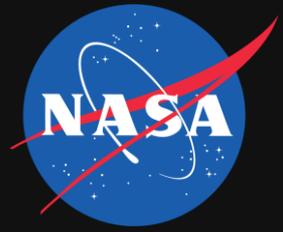
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Project 2: Virtual Reality – Screenshots and Video
Demonstration



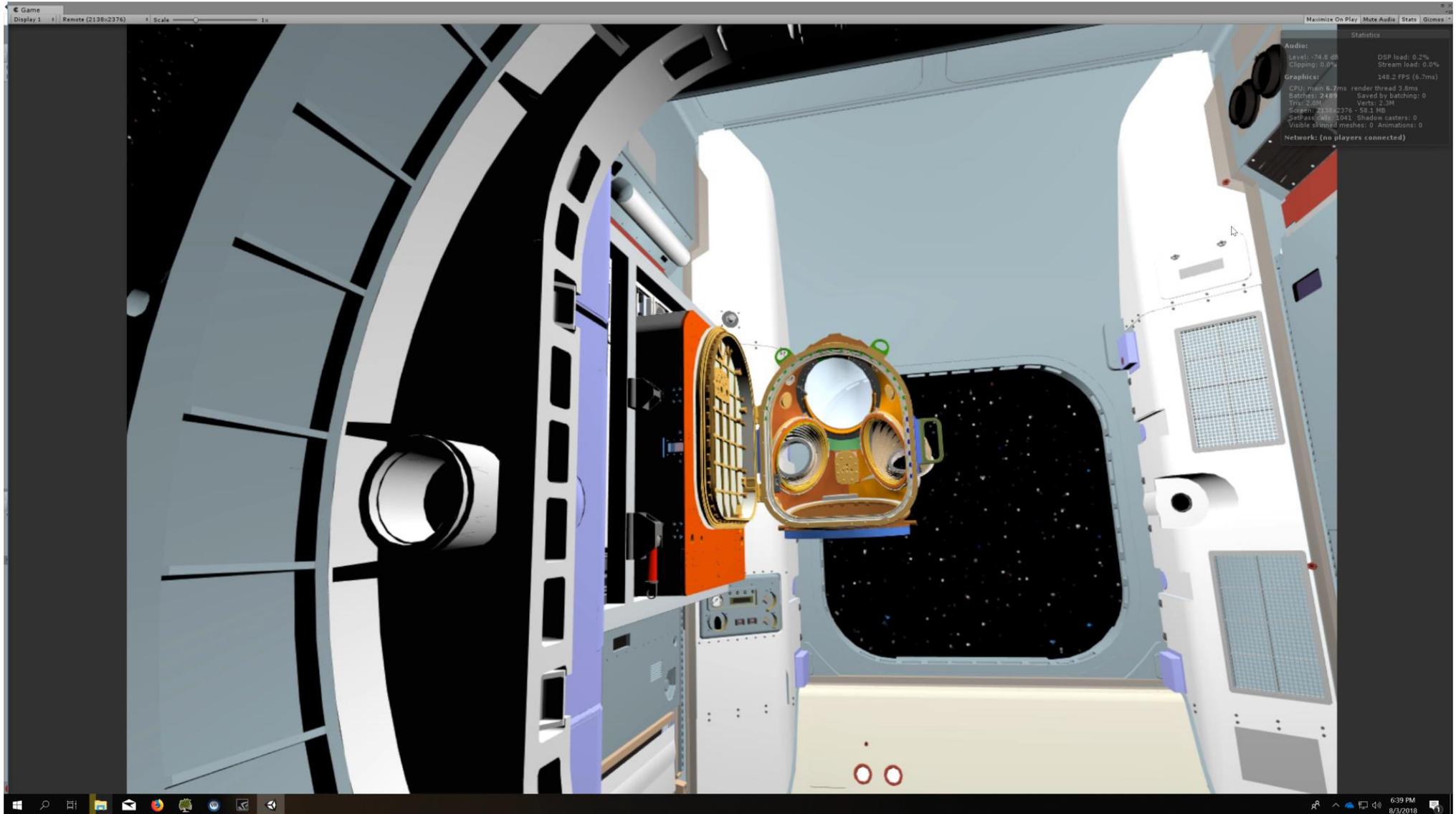
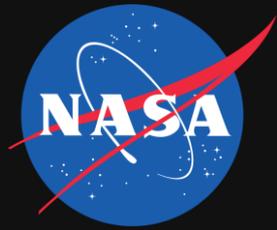
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Project 2: Virtual Reality – Screenshots and Video
Demonstration



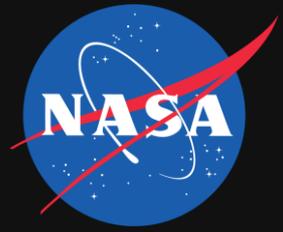
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Project 2: Virtual Reality – Screenshots and Video Demonstration



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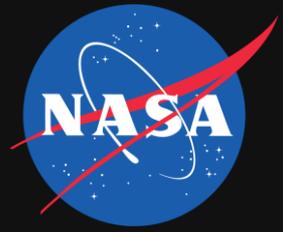
Project 2: Virtual Reality – Conclusions From Testing



- After working with Jeff Watters, we determined that a delta-x offset of 7” (measured from the front of the EDDA frame to the track at the back) and an angle offset of 5 degrees is ideal for optimal donning/doffing of the suit. We used the VR controllers as substitutes for arms/hands and made sure they didn’t “clip” through any of the airlock geometry when doing donning/doffing. This is how we determined if a configuration was ideal or not.
- Using a VR mockup taken directly from a CAD model, we were able to avoid having to spend time actually building a full-fledged mockup to just test a simple idea.
- Produced documentation on how to setup a VR scene in Unity similar to the “Getting-Started” guide I made for the HoloLens. Published internally in the EV3 department

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Miscellaneous Things – Community of Practice
AR/VR July Meeting

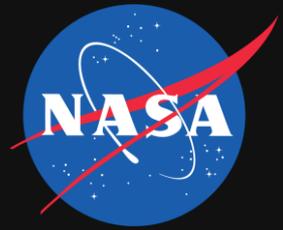


- Gave a presentation on PiXYZ and its advantages to the July VR/AR Community of Practice Meeting



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Miscellaneous Things – Intern Space Program, R&D and Propulsion

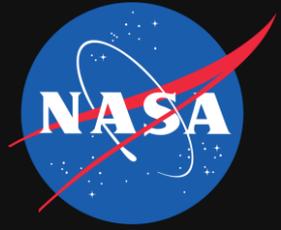


- Helped design and build a hybrid rocket motor prototype that we plan on test firing and recording this week.
- Helped pick out best rocket motor for main rocket (didn't get to fly this semester ☹️)



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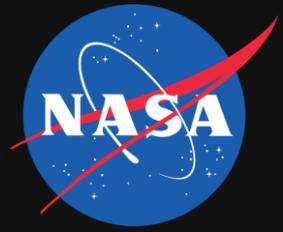
Future Plans



- Want to do another internship at Marshall Space Flight Center or Glenn Research Center, work on propulsion.
- My primary choice for a career is becoming a full-time civil servant for NASA.
- Working for a NASA contractor like Aerojet Rocketdyne would be nice too.

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Things Learned From This Internship



- When I first began this internship, I had no idea how to use Unity and I had never used a HoloLens before
- Learned how to use the Unity editor
- Learned how to develop, build, and deploy HoloLens apps
- Learned how to develop, build, and deploy VR apps.
- Gained important job experience for future internships/jobs.
- Networked with people, made contacts.
- Learned time management/organization
- During my first couple weeks here, I didn't think I'd like my internship. Right now though, I can say that I've thoroughly enjoyed my time here.