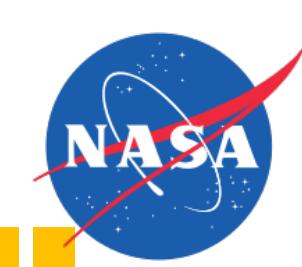




# Greater Heights VR Experience

Matt Chalabian and Sonia Lin, Spring 2024 Interns  
Simulation Engineering (AFRC-630)  
Mentor: Aamod Samuel



# Introduction

**Matt Chalabian**

**Oregon State University**

B.S. in Computer Science

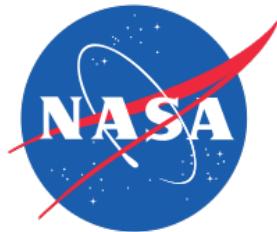
Previous Work:

- University Lecturer in Guilin, China
- NASA Intern, Fall 23'
  - Sound design + programming, motion base, physics, VR UI

Future Work:

- I will be extending this internship into this Summer!
- Interested in aerospace / VR / gamedev





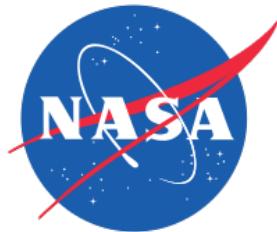
# Introduction



## Current Personal Projects:

*Top-Down 2D Rogue-lite  
Shooter With Varied  
Random Level Generation  
and my own AI Pathfinding  
System.  
Developed using Godot.*





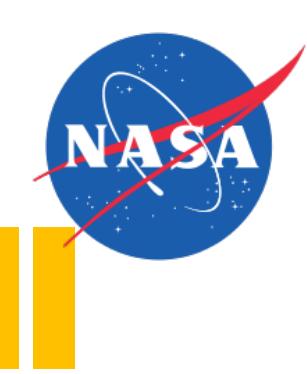
# Introduction

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## Hobbies:

- *Rock Climbing*
- *Designing Table-Top RPGs*
- *Programming Video Games*
- *Composing Music*





# Introduction

Sonia Lin

**University of Michigan**

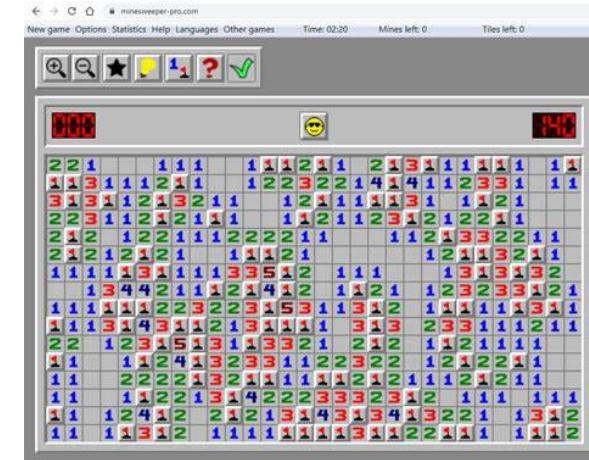
B.S. in Computer Science

Previous Work:

- Research Assistant at University of Michigan
- Contract work at local Detroit mobile app startup

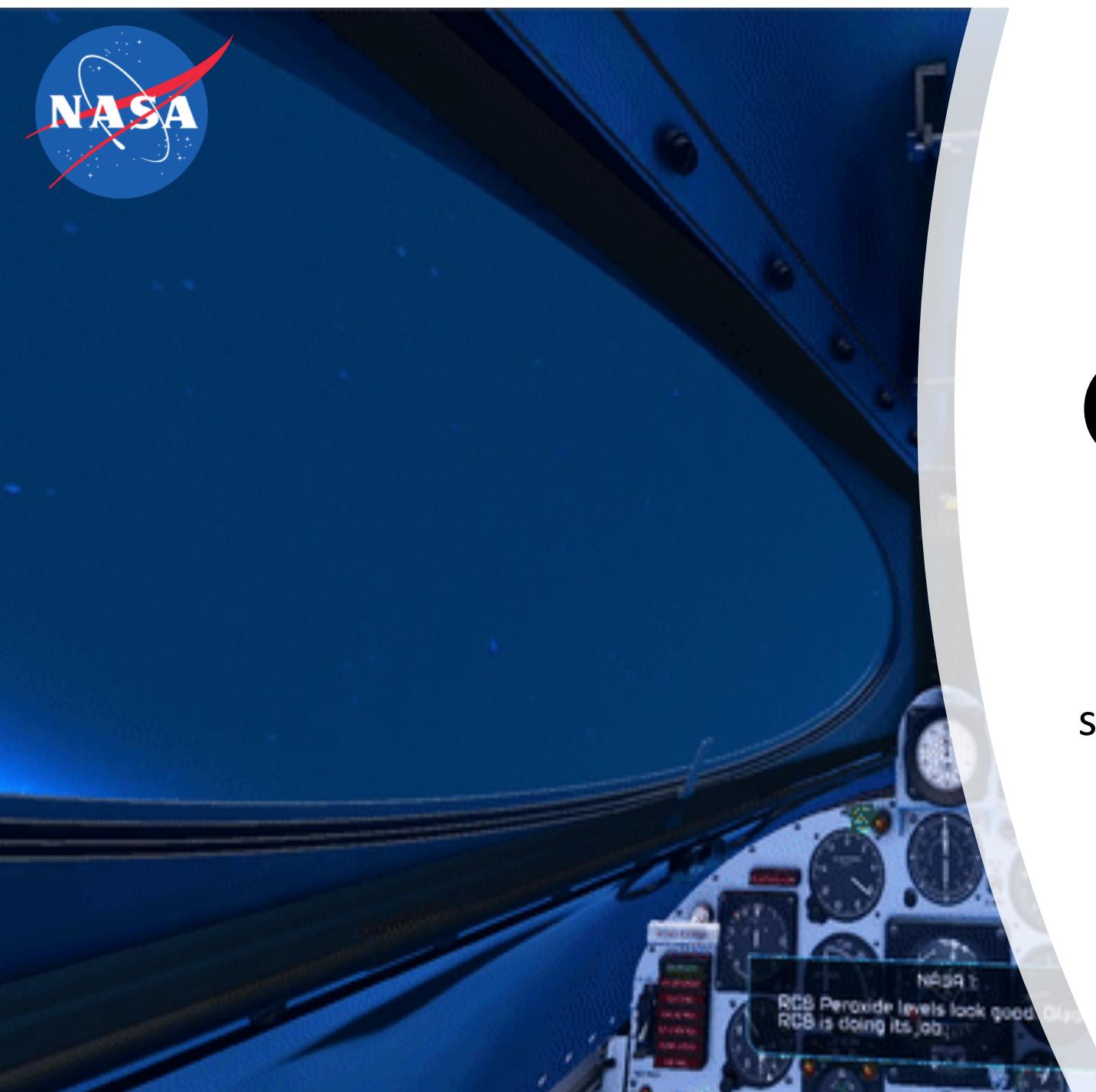
Future Work:

- Interning at Goddard over the summer in AR/VR
- Returning to school in August for my final year



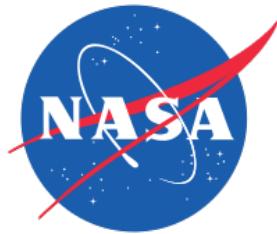
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# Overview

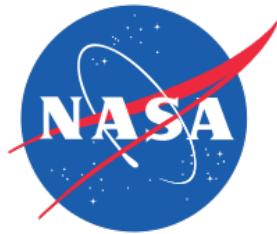
Greater Heights is an intern-led, narrative Virtual Reality experience seeking to engage the public with the work that NASA does.



# Project Goals

- Exciting and engaging outreach for people of any age who are curious about what NASA does
  - Focus placed on AFRC achievements
  - Multiple versions made to accommodate different setups
    - Museum Exhibit
    - Onsite / 630 tour component
    - Festival Exhibit (IMS / Oshkosh)





# Experience Overview

## • Office Scene

- Setting: Neil Armstrong's office before suiting up for his X-15 flight
- Provides historical background context of who you are, what you are doing, and why
- Can interact with different objects to trigger a corresponding inner monologue by Neil



## • Runway Scene

- Setting: Inside the X-15 cockpit preparing for takeoff
- Provides a tutorial for piloting in the "Flight Scene"
- Introduces the user to the 5 different controls in the cockpit and when to use them
- As the B-52 takes off, user starts to feel some of the motion that will be present in the "Flight Scene"



## • Flight Scene

- Setting: Inside the X-15 cockpit
- Is the main scene where users can pilot the X-15 into space and glide back down for landing
- Uses all the controls introduced in the "Runway Scene" to affect the plane physics and chair motion and sounds

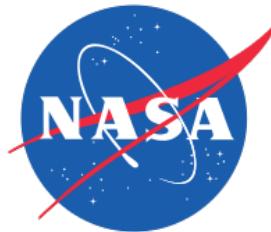




# Notable Features

- VR Headset, Controllers, Position Trackers (SteamVR compatible devices)
- Motion Base
- Sound & Visual Effects





# Overview of Spring Contributions



## Major Tasks

- Integrate Position Tracker
- Refactor Input Code
- Add Autopilot Mode & VR Controller Pilot Mode
- Complete Office Scene
- Test with tour guests, test pilots, employees, general public
- General Programming, Polish, and Bug Fixing

## Tools

Godot

Git

Logic Studio

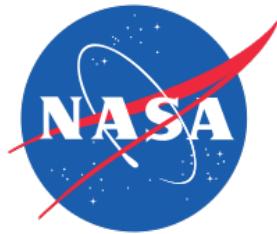
Blender

Motion Chair

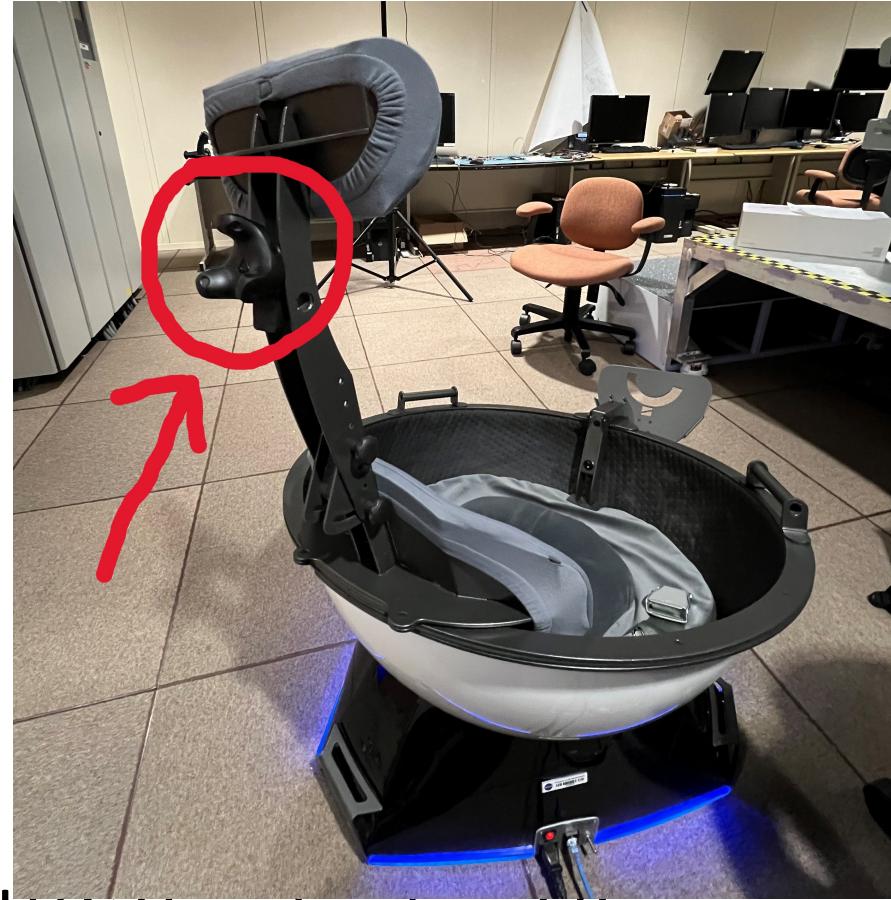
Steam VR

## Main Goal

Create a complete, fully-playable, polished user experience



# Position Tracker



The tracker we use is an HTC Vive Tracker 3.0

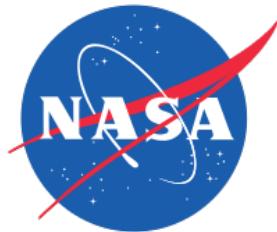


# Position Tracker



## Motion Compensation:

- Previously, we did not use a tracker to help calculate motion chair compensation for the headset.
- Used inverse chair pitch and roll values
- Chair Yaw problem
- New approach: Track changes in chair pitch, roll, and yaw, using tracker.



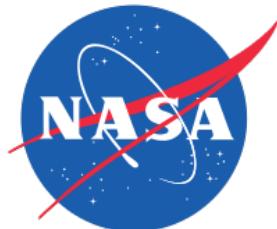
# Position Tracker



## User Height Offset:

- We use the difference between the tracker and headset positions to calculate an offset for the in-experience head position
- Allows us to accommodate users of any height



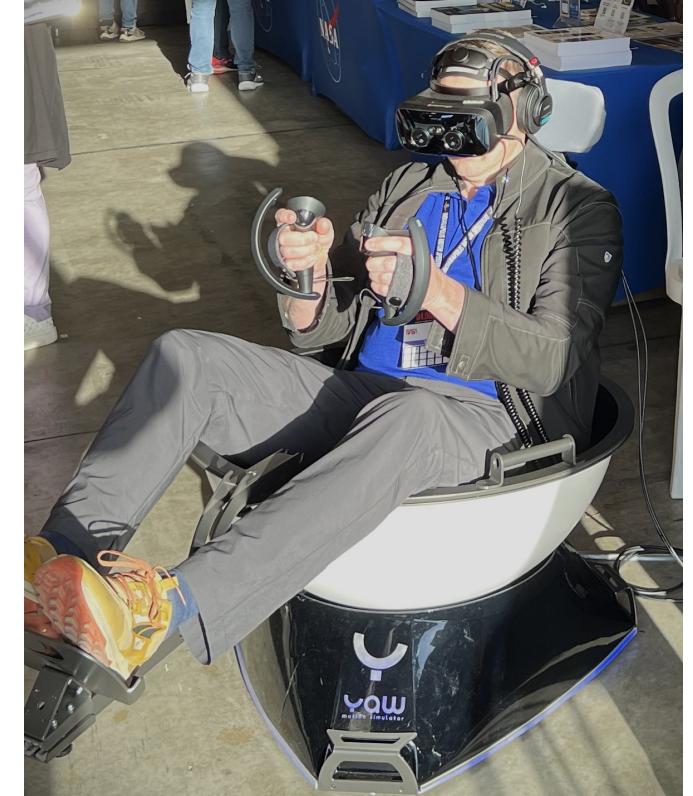


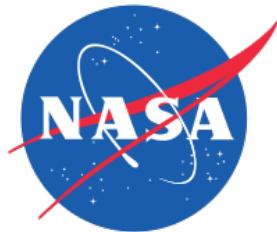
# Input Refactoring



Reasons:

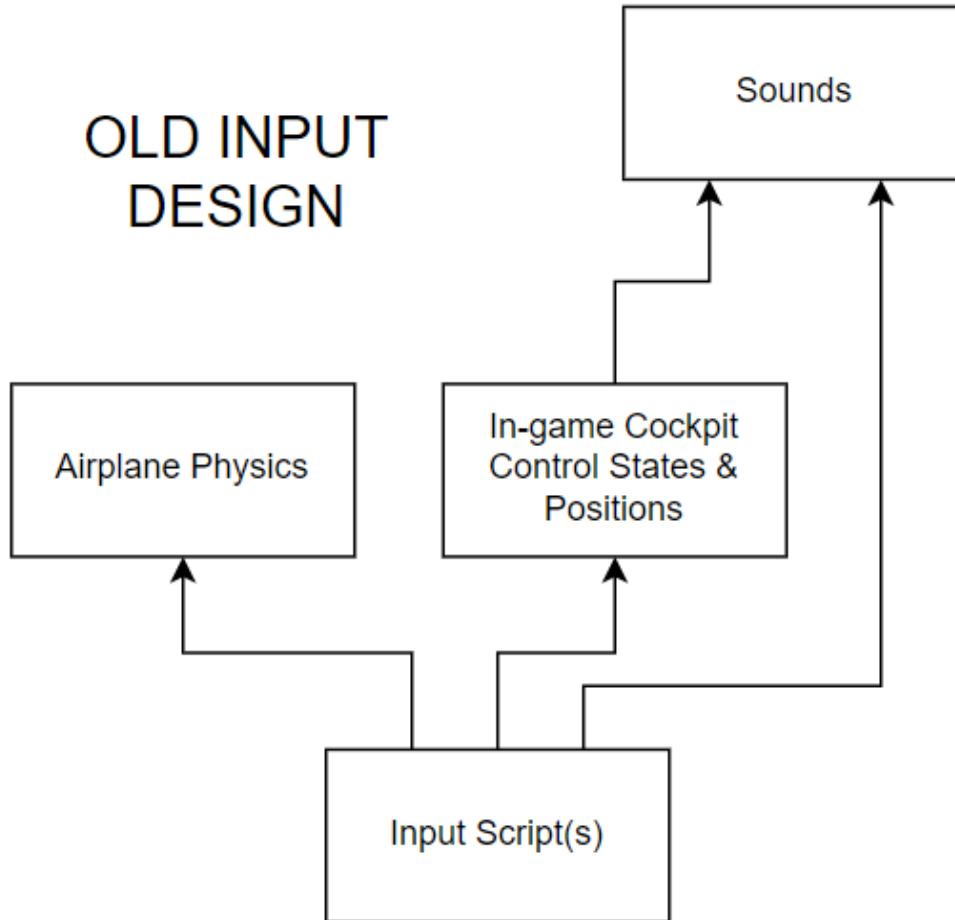
- Wanted to add new forms of control to the project (VR and Autopilot)
- Current system was not expandable



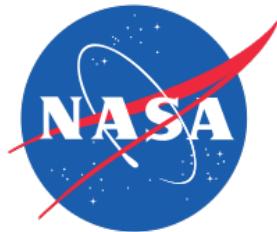


# Input Refactoring

## OLD INPUT DESIGN

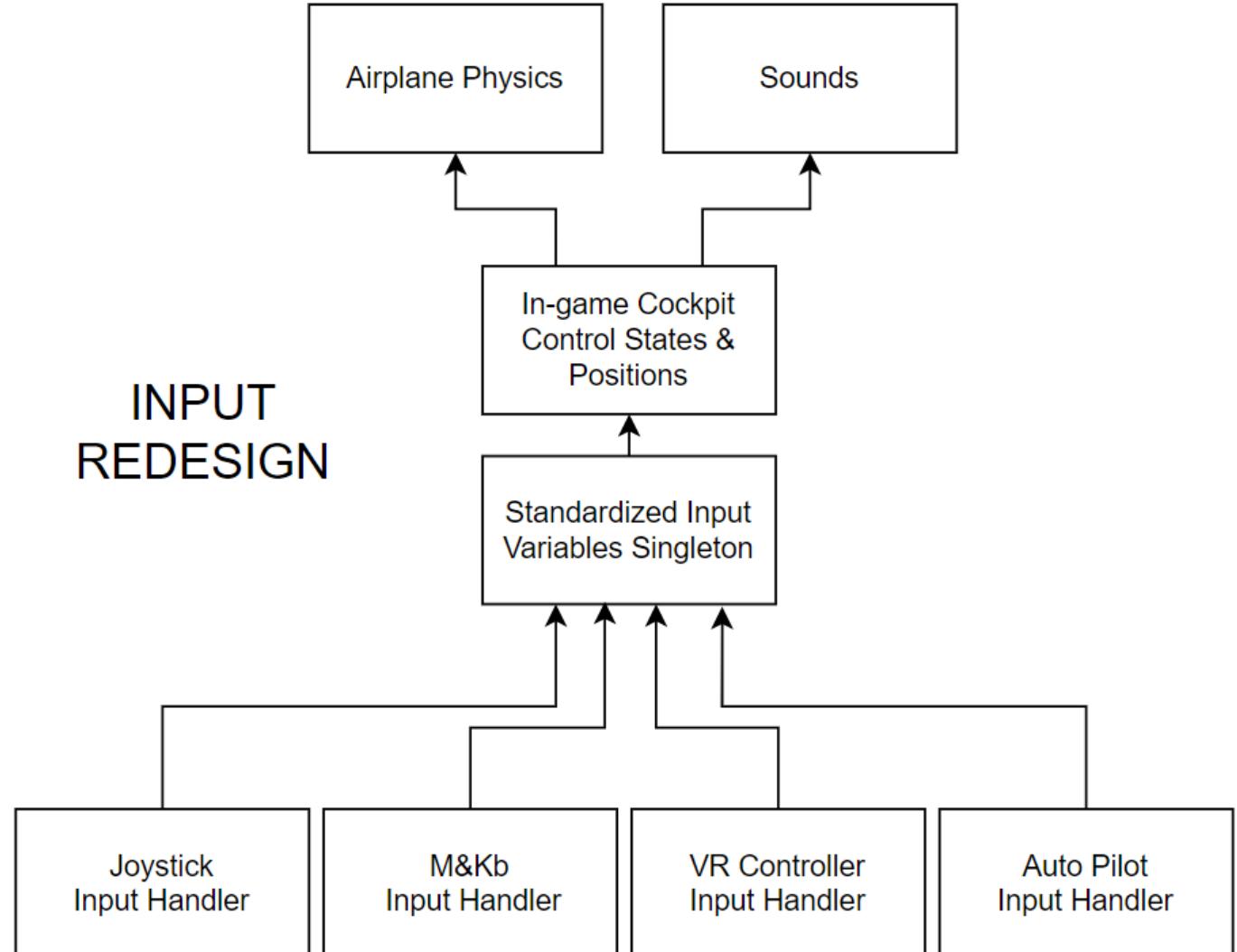


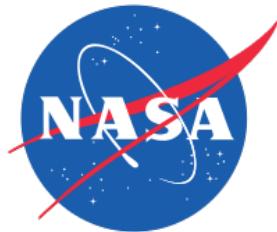
- Airplane Physics and Cockpit Control States & Positions aren't linked.
- Input is spread across multiple scripts and occasionally the same input is read more than once.
- Sounds are controlled by both Input and Control States and Positions.
- Original method could only accommodate Mouse & Keyboard inputs and analog Joystick controller inputs.



# Input Refactoring

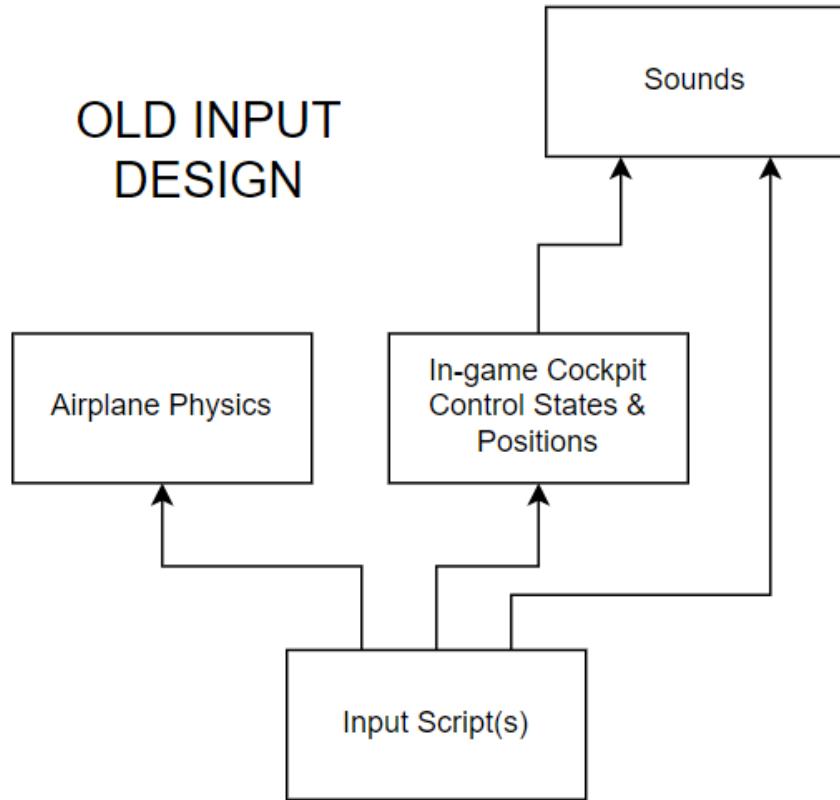
- In-game Cockpit Controls now control physics and trigger control sound effects.
- A Global Singleton contains variables that effect the positions and state of the Cockpit controls.
- Unique Input scripts handle how the input is received, converted, and then set in the Global Input Variable Singleton. One input type per script.
- This refactor facilitated a far smoother process of adding VR and Auto Pilot to the project.



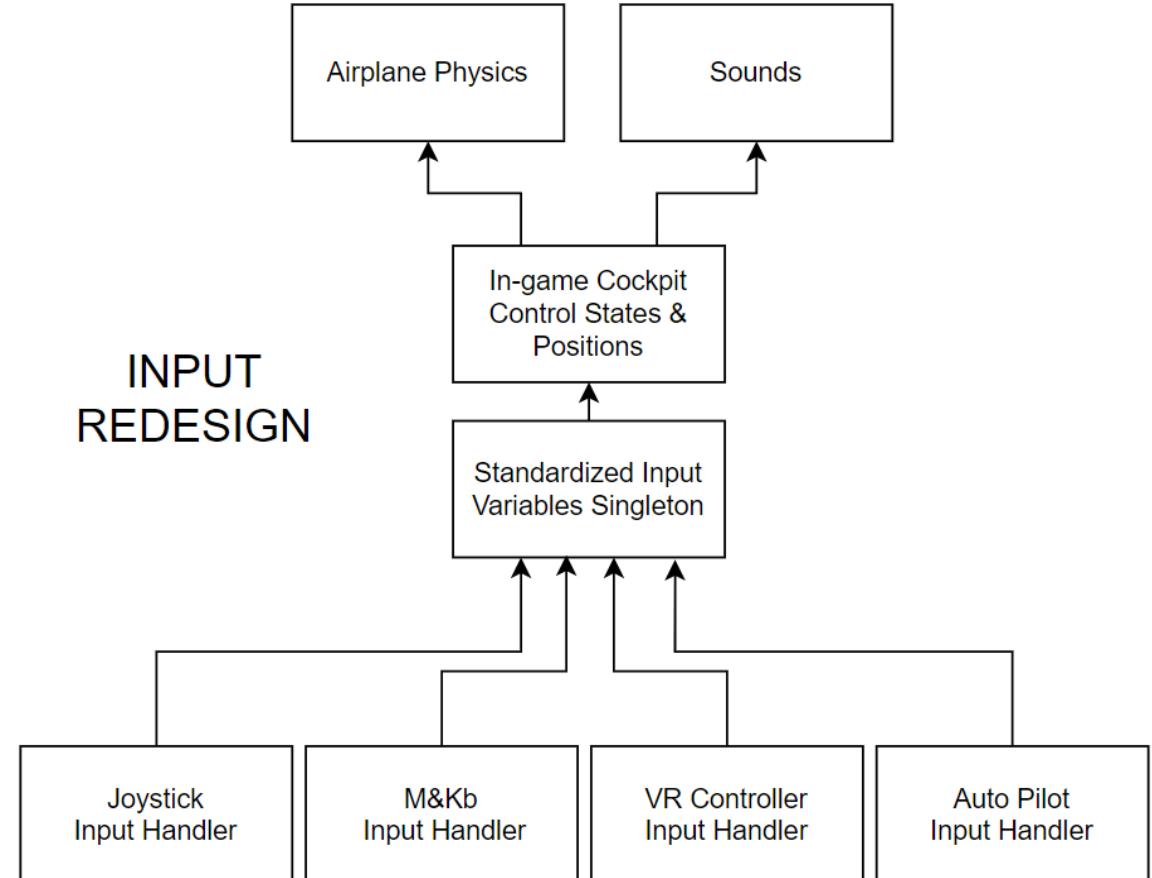


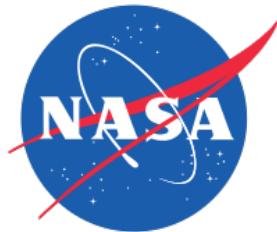
# Input Refactoring

OLD INPUT DESIGN



INPUT  
REDESIGN





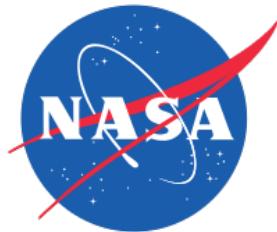
# New Input Methods



## Autopilot Mode

- No longer needs operator to use the keyboard to pilot the plane
- Allows users to just sit back and watch without fear of piloting going wrong
- Used to create a condensed / shortened version of the experience to be featured at demos with long lines of people
  - Reduced to only flight scene as it maximizes engagement in a short amount of time



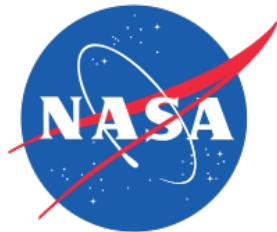


# New Input Methods



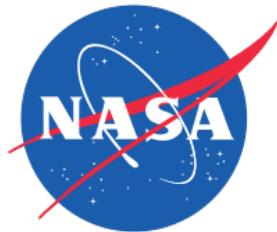
## VR Controller Input Mode

- User-piloted version of the experience where users can move and trigger the controls in the aircraft
- Used one trigger button for simplicity
- Implemented VR controller vibration haptics to provide users feedback and guidance on whether the cockpit controls are working or not
- Shrunk cockpit size for controls to be in reach and match accurate sizing



# New Input Methods



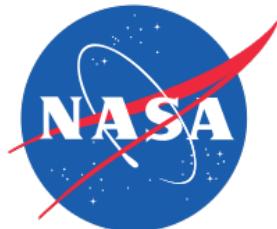


# Interactive Office Scene



- Implemented VR grabbing and throwing of five different interactable objects
  - Grabbing objects triggers a corresponding dialogue narrated by Neil
- Optimized office scene model from 7.5mil tris  
-> 700k tris which improved loading time and performance
- Improved lighting and previously broken textures
- Designed audio for ambience loop and grabbing
- Added a panorama shot of Edwards taken by one of our photographers (credits to Steve Freeman)

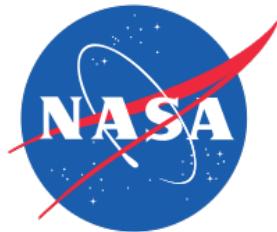




# Testing and Feedback

- Tested with and received valuable feedback from a variety of users of different backgrounds
  - Including:
    - NASA test pilots
    - Code 630 employees
    - Other interns
    - Tour guests
- Demoed our experience at IMS during the Solar Eclipse Event as the first public showing outside of NASA
  - Not only gave ideas on what to add programming-wise but also gave insight on improving setup and crowd control
  - Helped prepare for Osh Kosh demo

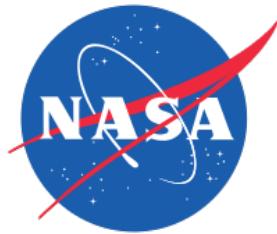




# Testing and Feedback



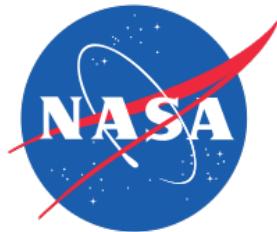
Test Pilots



# Testing and Feedback



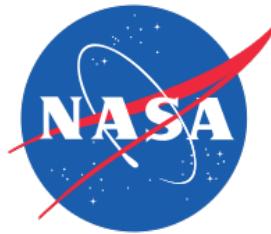
Indianapolis Motor Speedway Event



# Testing and Feedback



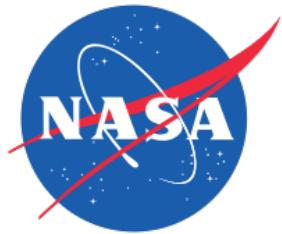
Indianapolis Motor Speedway Event



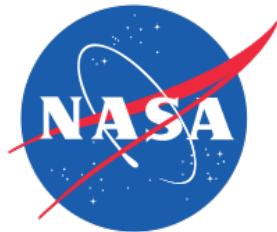
# Testing and Feedback



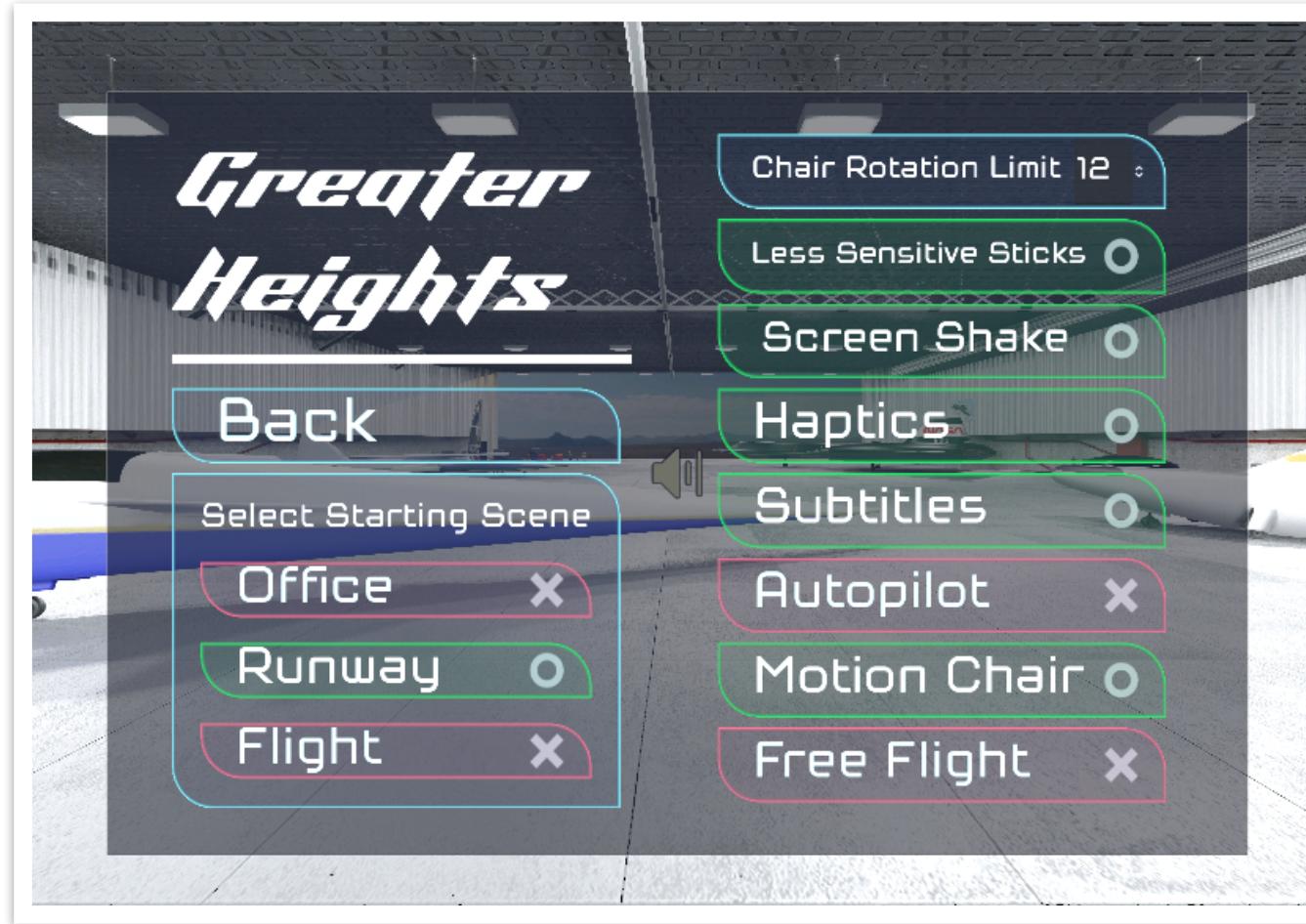
Indianapolis Motor Speedway Event

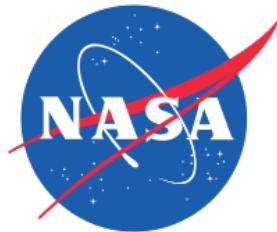


**Features added based on  
feedback and observations from  
testing**



# Comprehensive Settings Menu





# Operator QoL Improvements



## Operator Commands

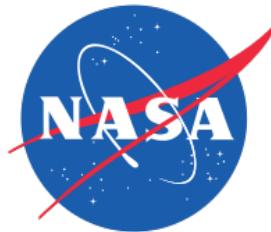
- Reorient headset
- Abort system

## Headset Calibration Warning



## Out of Bounds Vision Fade





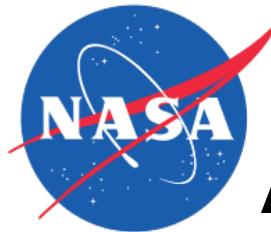
# More Instruction and User Guidance



- Reminds the user to look at attitude ball for directional hints



- Ensures user is on the right path
- Lack of confirmation may cause user to think they are doing something wrong



# Accurately Functioning Aircraft Instruments

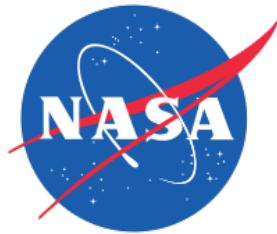
Angle of Attack

Attitude

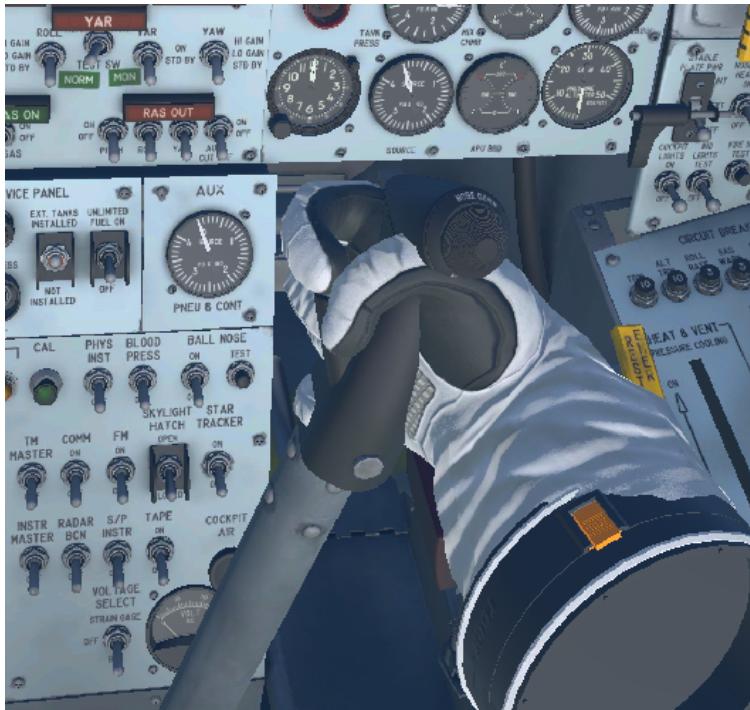
Altimeter

Roll Rate





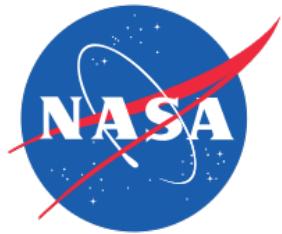
# VR Grab Offset



Hand and Joystick Position On  
Grab Before



Hand and Joystick Position On  
Grab After



# Other additions and improvements

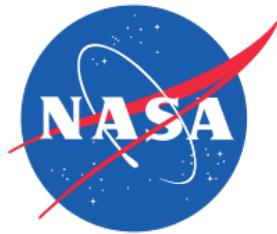


- Improved start menu scene environment
- Created a 360 panorama from Blender instead of rebuilding materials and lighting



# Visual Polish

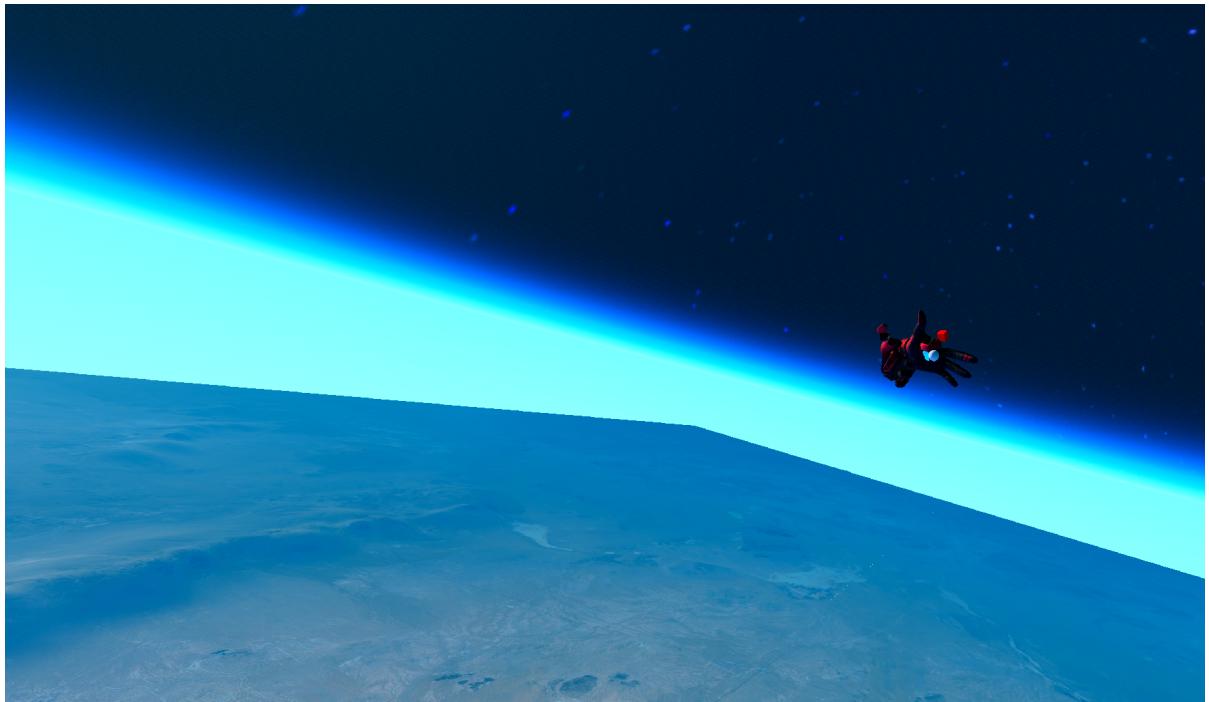




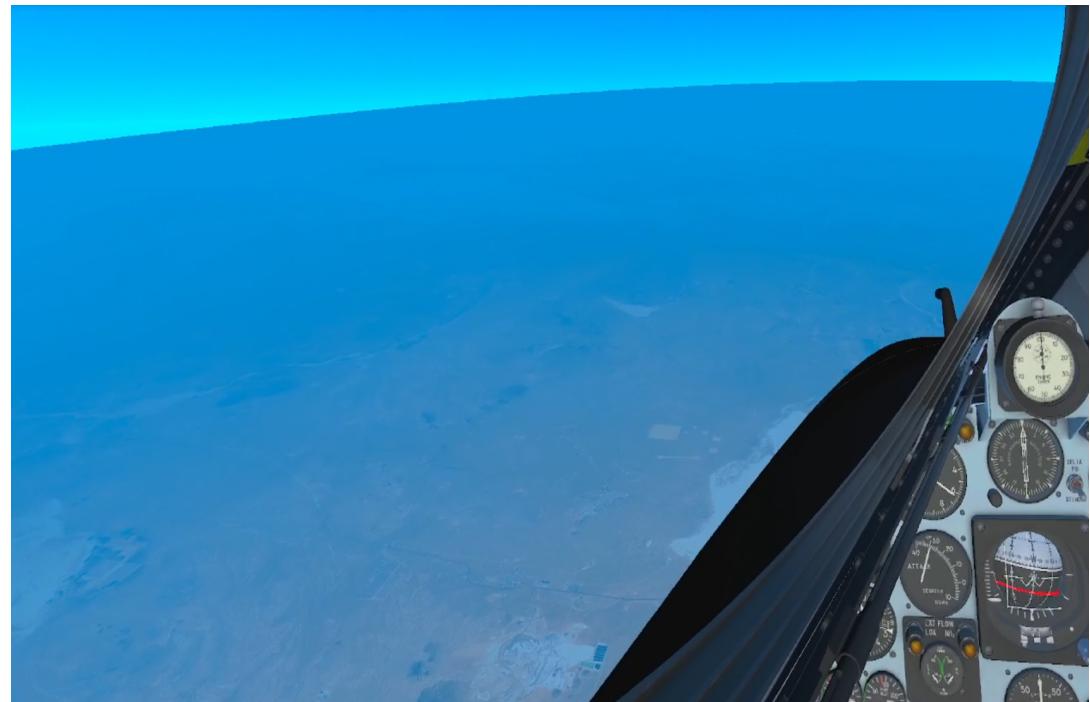
# Visual Polish



Flat Earth



Round Earth





# General Polish



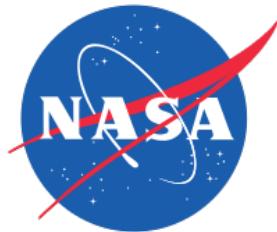
- **Double Compiled Godot**

- Avoid floating point errors
- Prevent strange cockpit jitter



- **Angle of Attack (AoA) Effect Value**

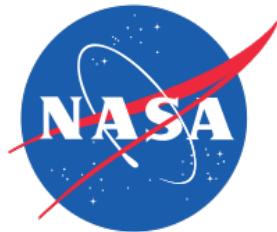
- AoA effect sound loop
  - Programming audio behavior
  - Designing sound loop
- Additional chair shake
- Additional screenshake



# Lessons Learned



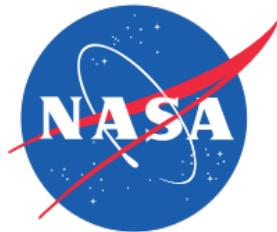
- Always test your project before demoing
- Organize code and project files for future interns
- Writing scalable code to make it easier to add features without refactoring everything
- Don't interrupt, help, or give advice to testers mid-test
- Use all the resources available to you (ask for help when you need it)



# Future Work



- New motion chair
- Port office and runway scene to Meta Quest 3 for Osh Kosh



# Special Thanks

- **Aamod Samuel** for making the project possible
- **Alexandria Pompeii** for providing many test subjects
- **Jeff Ray** for helping us with math whenever we got stuck
- **Jason Underwood & Richard Hertzburg** for saving us whenever our motion base or computer decided to stop working
- **Erik Waite** for making a custom tracker attachment
- **Steve Freeman** for the panoramic photo
- **Jason Gutierrez** for frequent collaboration and moral support
- The rest of **Code 630** for being genuinely pleasant, patient and welcoming



# Q&A

## Contact:

[mattchalabian@gmail.com](mailto:mattchalabian@gmail.com)

[sonia.lin.144@gmail.com](mailto:sonia.lin.144@gmail.com)



## Recap

Integrate Position Tracker

Refactor Input Code

Add Autopilot Mode & VR Controller Pilot Mode

Complete Office Scene

Test with test pilots, employees, tour guests, etc.

Add more instructional cues and user guidance

Simulate more gauges

General Programming, Polish, and Bug Fixing

Add Settings Menu

Operator QoL Improvements

Add Visual Warning Cues

Improve Earth, stars, atmosphere

Improve Start Menu Scene Environment

Double Compile Godot

Add AOA effect modifier