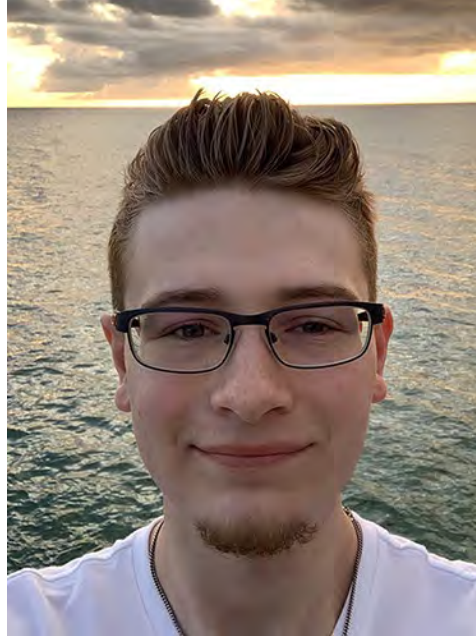# Towards Development of a Digital Twin for Simulation of Underwater Robotics

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FLORIDA ATLANTIC UNIVERSITY
Institute for Sensing and Embedded
Network Systems Engineering

FAU
CENTER FOR CONNECTED AUTONOMY
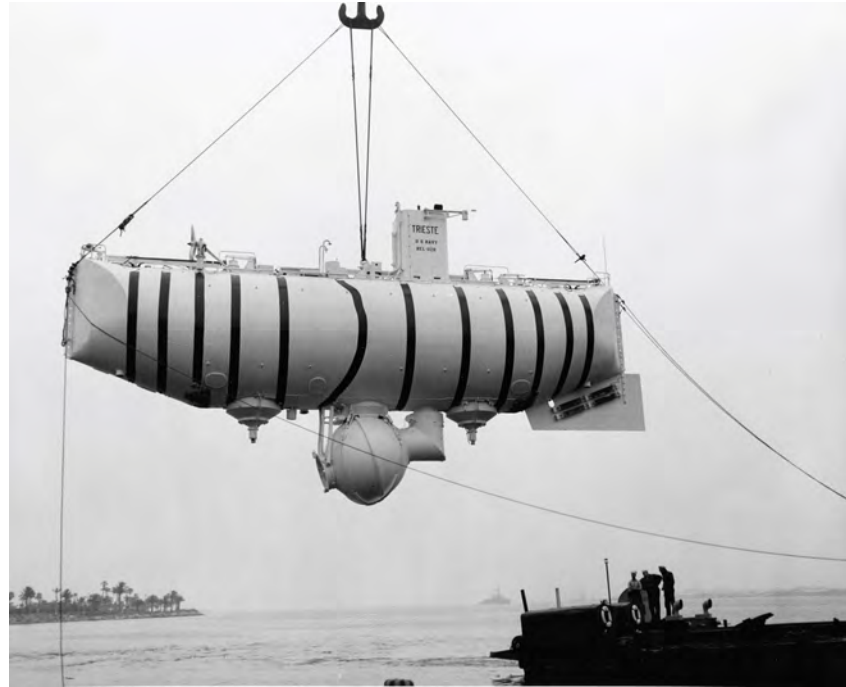AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
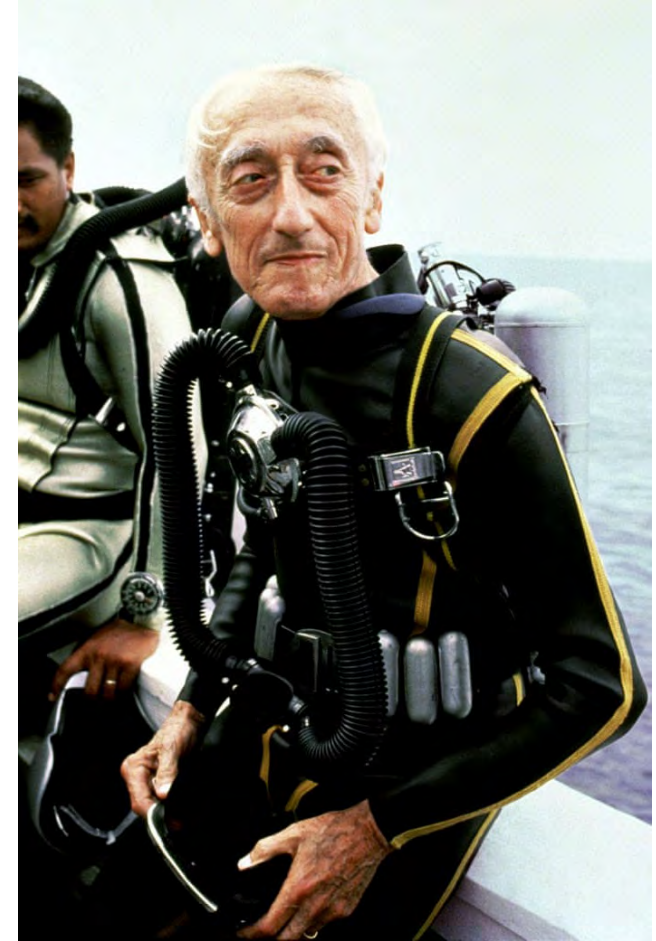Florida Atlantic University

(8/1/2024)

Motivation

Bathysphere, early days of deep sea exploration

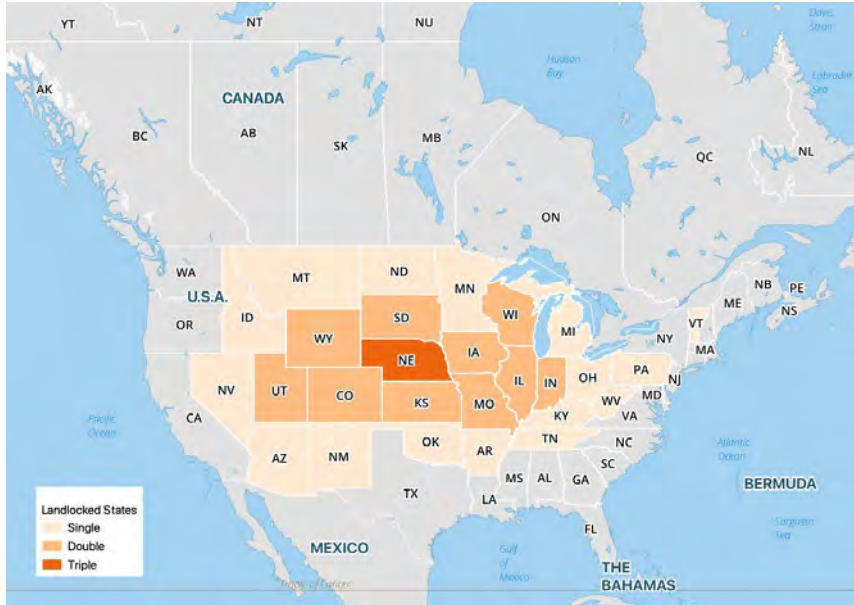
Trieste, first submersible to journey to the Mariana Trench about 10,916 meters or 35,813 feet (1960)
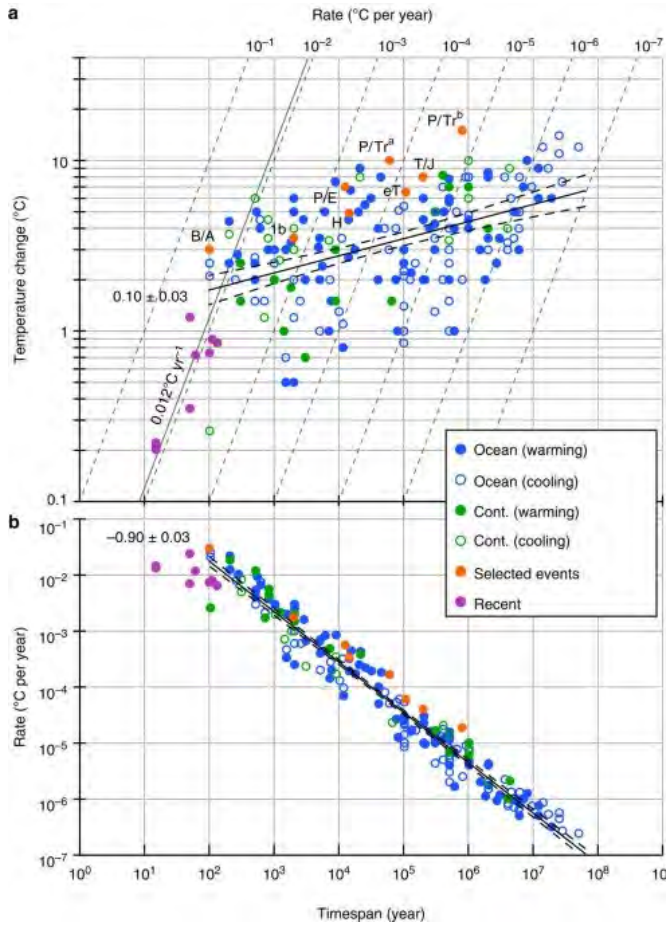

Jacques Cousteau, pioneer of modern day scuba

Problem

Inaccessibility

Variation

Expense

Solution
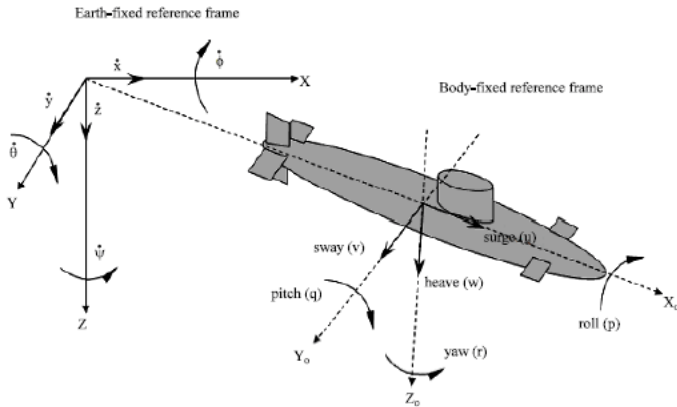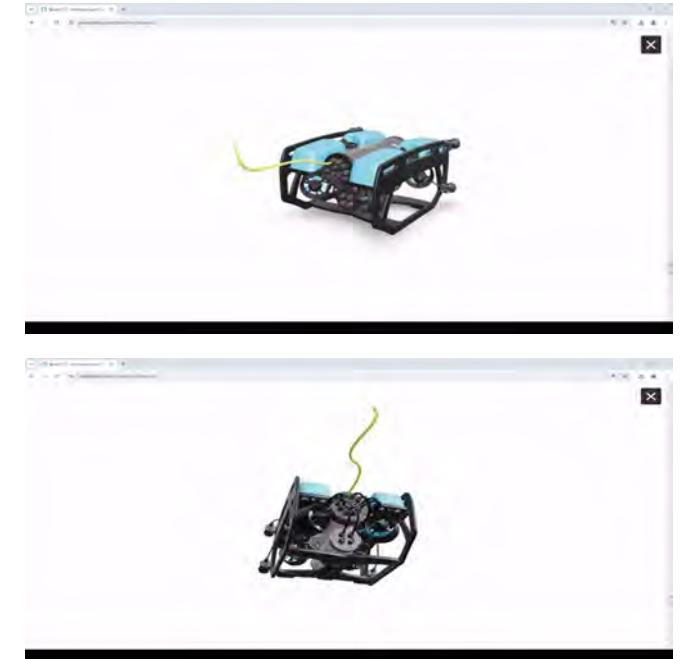
What Does a Simulation Need
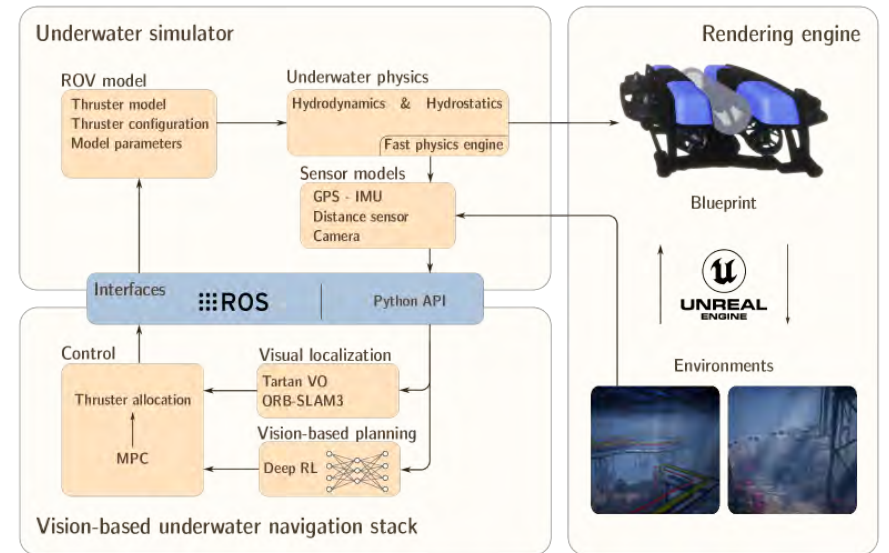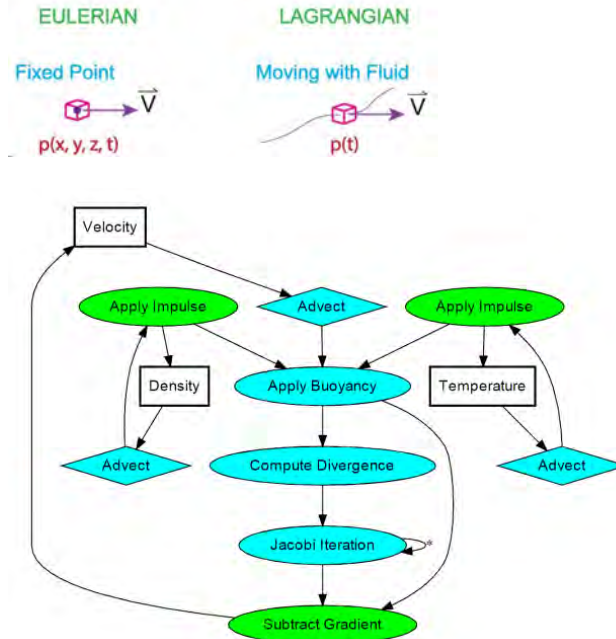
Dynamics
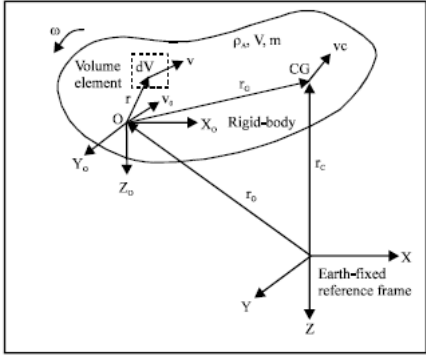
Environment

Underwater currents are always changing and can vary in speed and direction

A submarine does not have a fixed frame of reference relative to the Earth's surface

Its frame of reference is relative to the moving water mass

THE VELOCITY FIELD

Pugh Chart – Comparison of Simulators

Degree of agreement		Point
High	Appropriate	Three points
Moderate	Needs amendment	Two points
Low	To be omitted	One point

Criterion	Weight	HoloOcean	UNavSim	Marus
Developer Support	20	3	1	1
Operating System	10	3	3	3
Middleware	15	1	1	2
Rendering	25	2	3	1
Physics	30	3	2	3
Score		12	10	10
Weighted Score		245/300	200/300	195/300
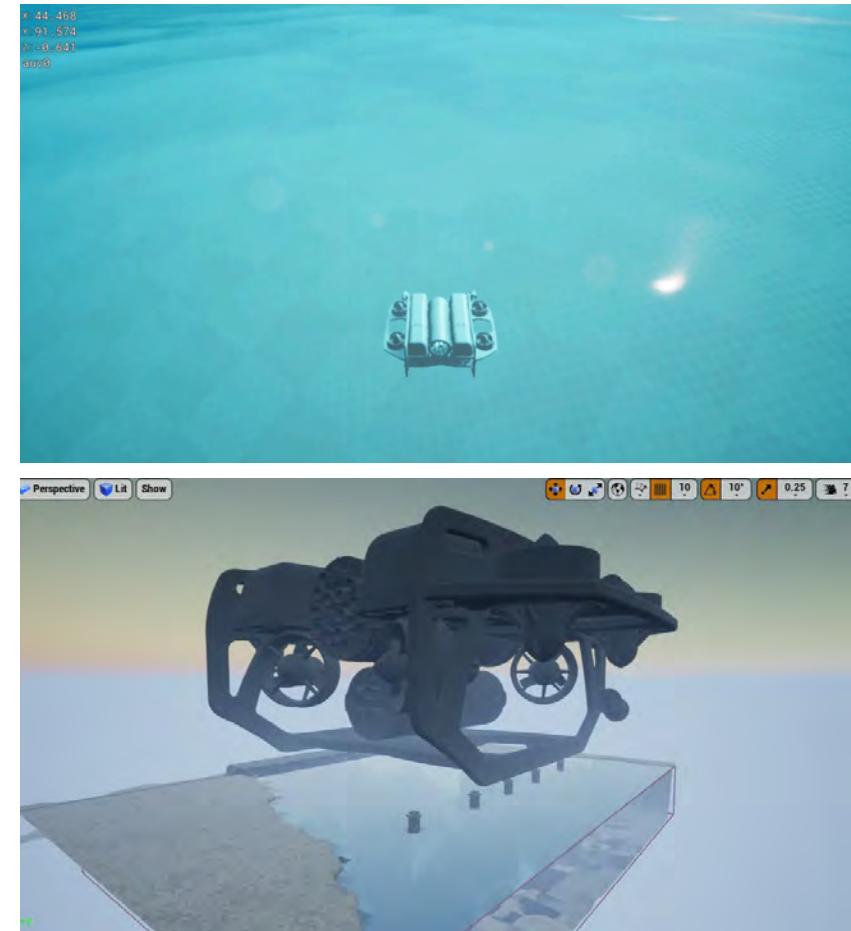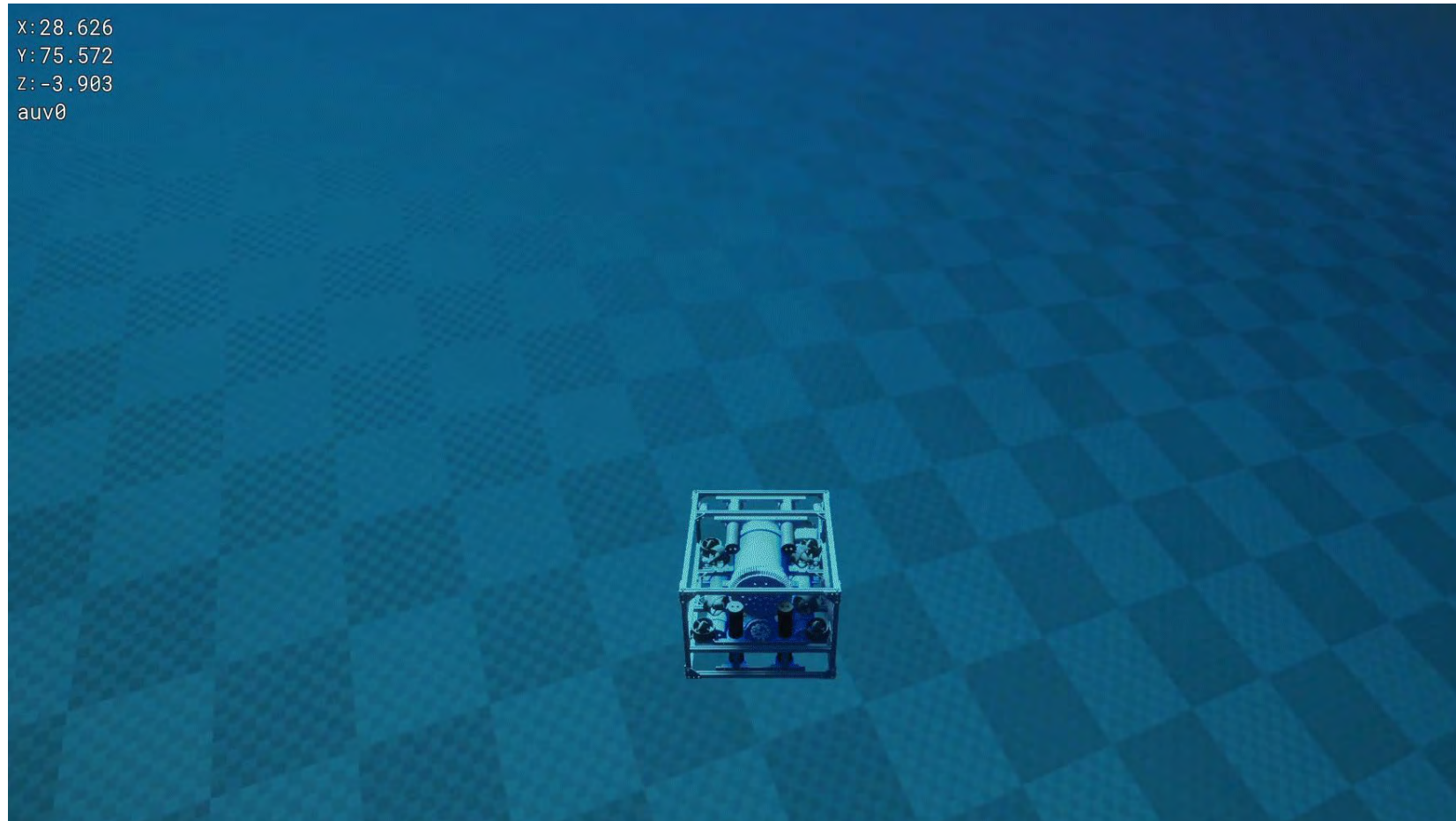
Bullet Physics   Unity Physics

Simulators

Hardware

Desktop prototyping

Robotics System Toolbox

Controls

Perception

Planning and decision making

Deployment

ROS Nodes (C++, Python, Lisp, etc.)

Traditional Workflow   MATLAB & Simulink

Developing HoloOcean

How to do

```
+package.zip
+-- config.json
+-- materials.csv
+-- WorldName-ScenarioName.json
+-- LinuxNoEditor
    + UE4 build output
```
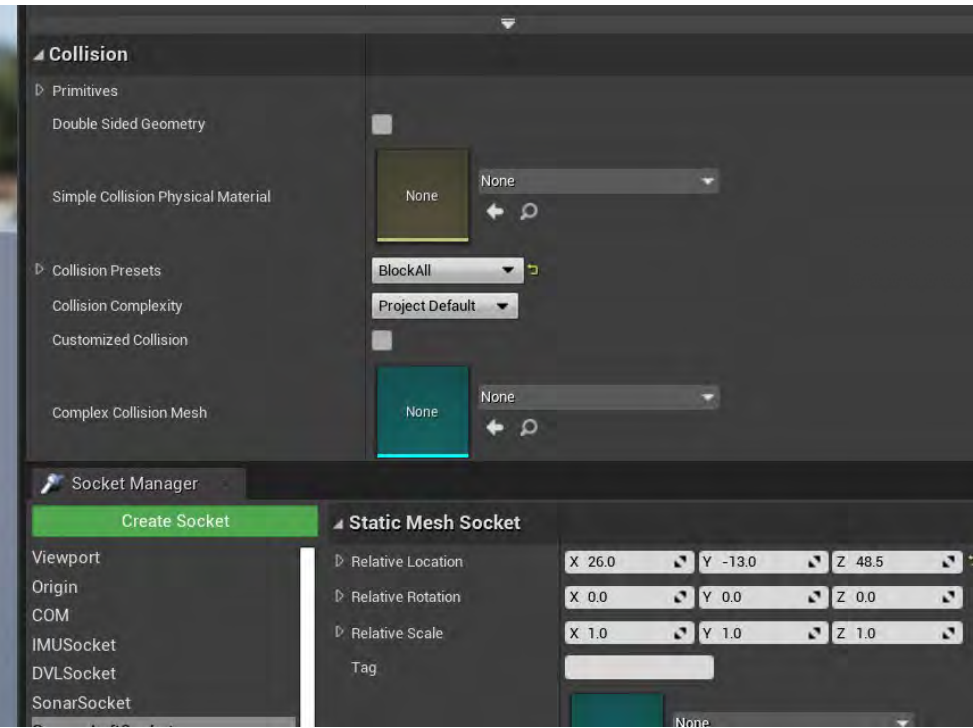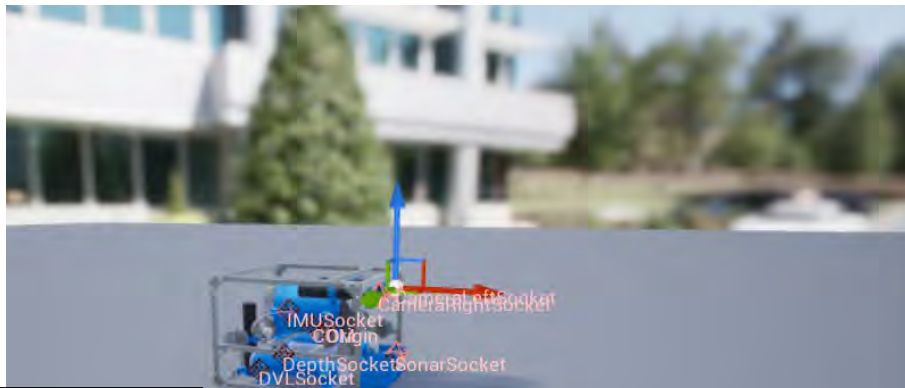
If you are using Terminal, use the command below.

`mkdir TestWorld`

Type `ls` to see that the new folder has been created. It starts with L, but lowercase. Short for list.

```
jeremy@jeremy-MS-7C77:~/.local/share/holoocean/1.0.0/worlds$ ls
Ocean  TestWorld
```

Now change directory into the TestWorld folder. Type this command below

`cd ~ && cd ~/.local/share/holoocean/1.0.0/worlds/TestWorld/`

You will be making three different files. In the image to the right. You will be creating both json files and the csv file. You can use gedit like before.

```
+package.zip
+-- config.json
+-- materials.csv
+-- WorldName-ScenarioName.json
+-- LinuxNoEditor
    + UE4 build output
```

Type what's in the box below and save it as materials.csv in the TestWorld folder

```
Material, Density kg/m^3, Speed of Sound m/s
M_Landscape, 3200, 4500
M_URockA, 3000, 5000
```
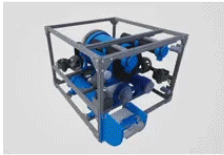
Next, make the World-Scenario json file. You should probably name it ExampleLevel-Hovering.json
The reason for this is because the Holodeck.uproject by default loads a level called ExampleLevel.
Second, Hovering is a description of the agent inside the json file. HoloOcean labels the agent below the HoveringAUV.

The code below will be saved as ExampleLevel-Hovering.json

```
{
"name": "Hovering",
"world": "ExampleLevel",
"main_agent": "auv0",
"ticks_per_sec": 200,
"frames_per_sec": true,
"octree_min": 0.02,
"octree_max": 5.0,
"agents":[
{
"agent_name": "auv0",
"agent_type": "HoveringAUV",
"sensors": [
```
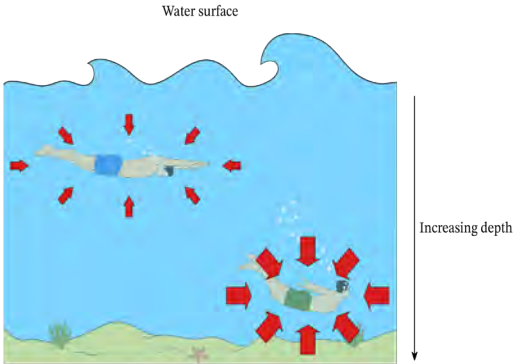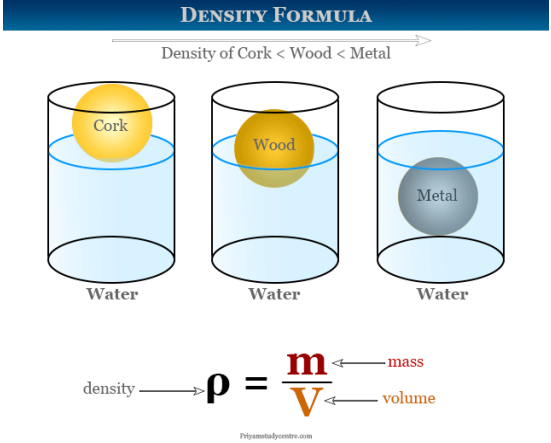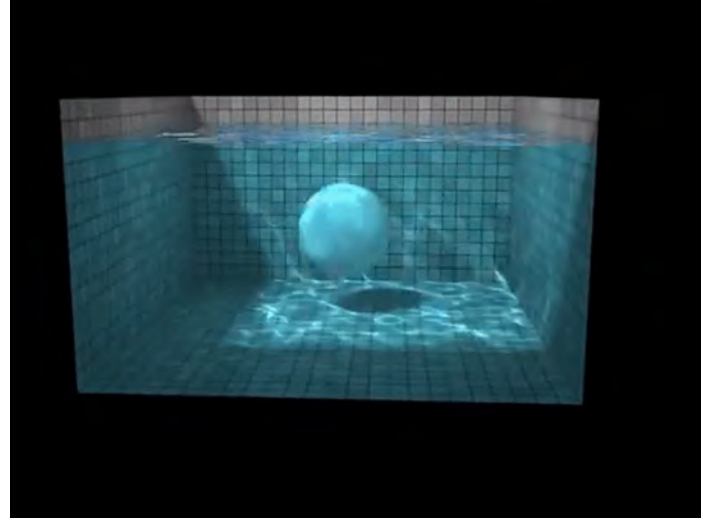
Collision

Primitives		
Double Sided Geometry	☐	
Simple Collision Physical Material	None	None
Collision Presets		BlockAll
Collision Complexity		Project Default
Customized Collision	☐	
Complex Collision Mesh	None	None

Socket Manager

Create Socket

Viewport
Origin
COM
IMUSocket
DVLSocket
SonarSocket

Static Mesh Socket

	X	Y	Z
Relative Location	26.0	-13.0	48.5
Relative Rotation	0.0	0.0	0.0
Relative Scale	1.0	1.0	1.0

Tag

Gantt Chart – Project Planning

June 3 – June 7 — Week 1 — ROS Tutorials
June 10 – June 14 — Week 2 — System Setup, Unix Operating System, Supplemental Software
June 17 – June 21 — Week 3 — Simulation Research and Final Decision
June 24 – June 28 — Week 4 — HoloOcean, Level Design and Development
July 1 – July 3 — Week 5 — Presentation Preparation
July 8 – July 12 — Week 6 — Multi-Agent Development and Manual Control
July 15 – July 19 — Week 7 — Windows Development
July 22 – July 26 — Week 8 — Finalization of Simulation
July 29 – Aug 1 — Week 9 — Documentation and Presentation Preparation

2024 | June | July | August
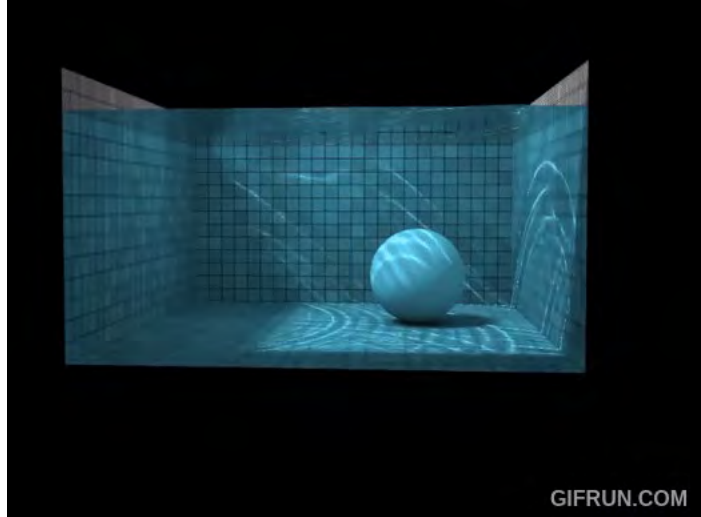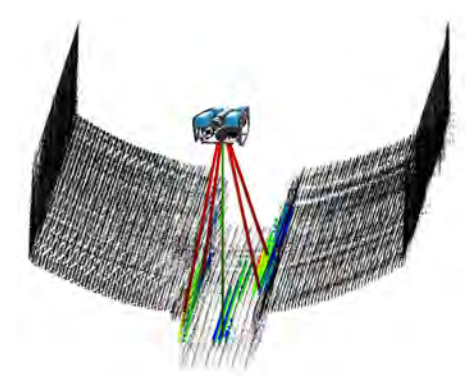
Today

Future physics

How to draw on the water to make ripples
Ripple are little waves on the surface of water caused by the wind or by something moving in or on the water
How to add light rays which have been reflected or refracted by a curved surface or object

DENSITY FORMULA

Density of Cork < Wood < Metal

Cork   Wood   Metal

Water   Water   Water

density → $\rho = \dfrac{m}{V}$ ← mass
← volume

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Water surface

Increasing depth

Future sensors

A simulation of a modified example package that I used with HoloOcean Library.
Below displays a HoveringAUV with a left camera output.

Conclusion