

MIT 2.680
UNMANNED MARINE VEHICLE AUTONOMY,
SENSING, AND COMMUNICATIONS

Lecture 1: Introduction 2.680
February 6th, 2024


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Email:
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2.680 Spring 2024 – Marine Autonomy Autonomy Sensing and Communications

Photo by Arjan Vermeij, CMRE

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Lecture 1 Overview: Introduction to MIT 2.680



Robot Architectures: The focus of 2.680 in the larger context of mobile robot technologies

Skills Progressions: The parallel progression of skills expected during 2.680 and labs.



2.680 Learning Resources: Beyond lectures: MIT 2.680 labs, office hours (in-person and virtual), 2.680 Website, 2.680 Piazza page.

Marine Autonomy Lab Overview: An introduction to existing robotic platforms and projects related to MIT 2.680

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Robot Architectures


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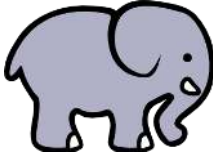

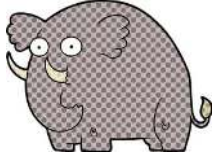
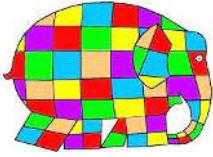
Robot Components/Architecture Perspectives



Reality




Multiple Perspectives


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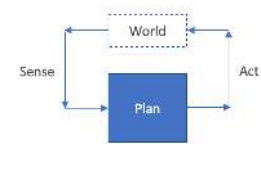
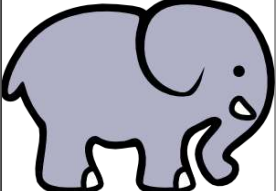
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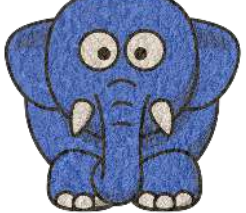
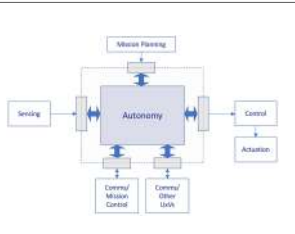
Robot Components/Architecture Perspectives



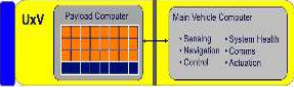
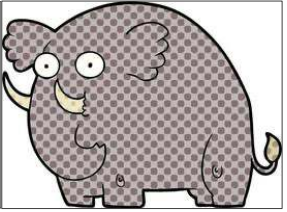
Sense-Plan-Act

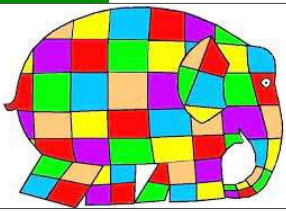
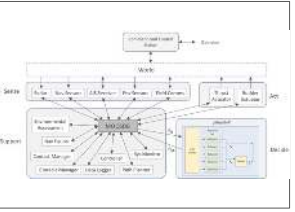
Functional Components

Backseat Autonomy

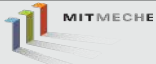



MOOS-IvP





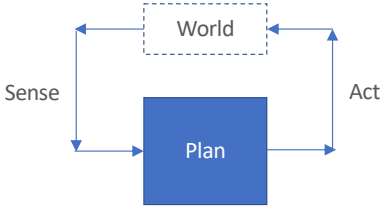
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Sense – Plan - Act






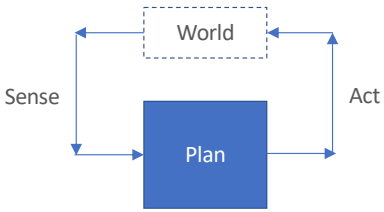
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Sense – Plan - Act






Virtually any robot can be described as sense-plan-act at some level.







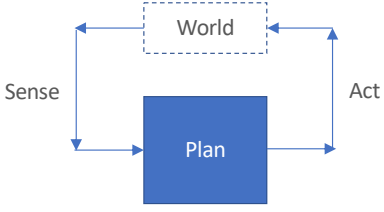
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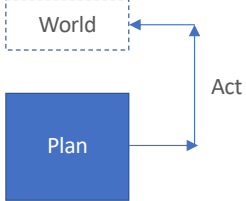


Closed Loop vs Open Loop






Closed Loop: The system has the ability to self-correct.




Open Loop: No position feedback, no sensed information of the environment.

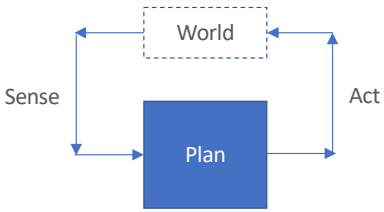
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Closed Loop vs Open Loop






Closed Loop: The system has the ability to self-correct.


The Robots we consider in this class are all Closed Loop Systems

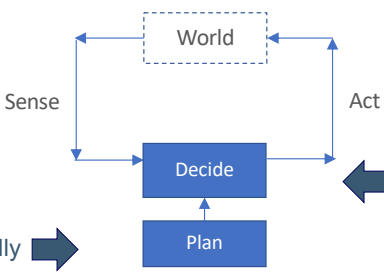
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Decision-Making vs Planning





Plans: generally, set prior to the beginning of the mission, occasionally adjusted along the way

Decisions: Based on the given plan, and current state of the world. Produced continuously during the mission

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The WAM-V Unmanned Surface Vehicle



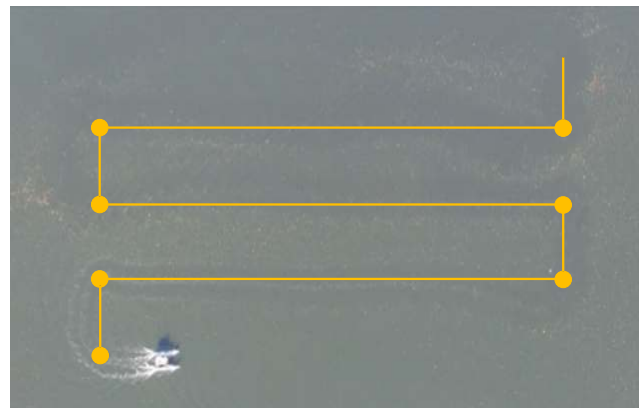
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The WAM-V Unmanned Surface Vehicle




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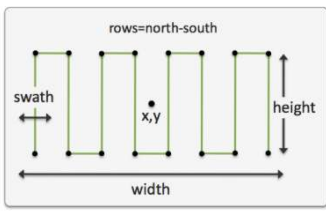
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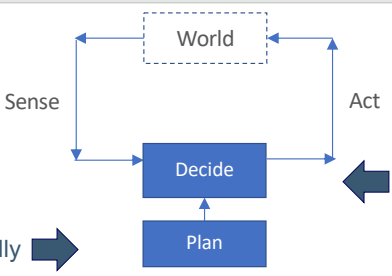


Decision-Making vs Planning

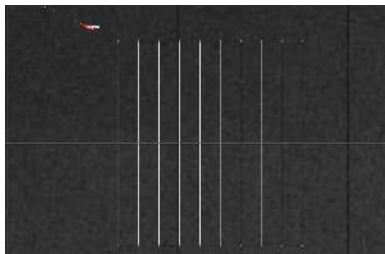


Plans: generally, set prior to the beginning of the mission, occasionally adjusted along the way





Decisions: Based on the given plan, and current state of the world. Produced continuously during the mission




Plans?

Decisions?


Actions?

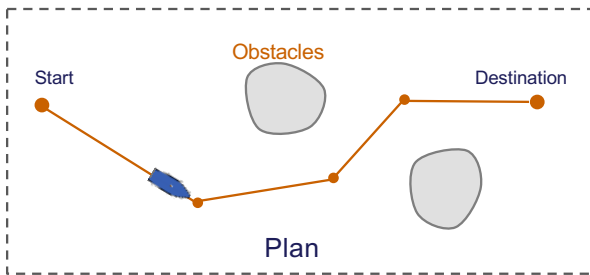
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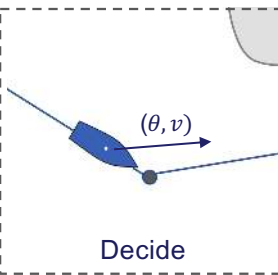


Plans, Decisions and Actions

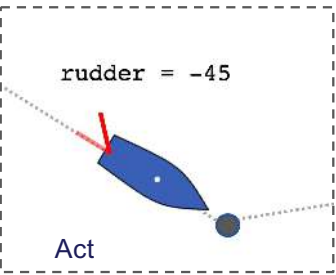




Waypoints



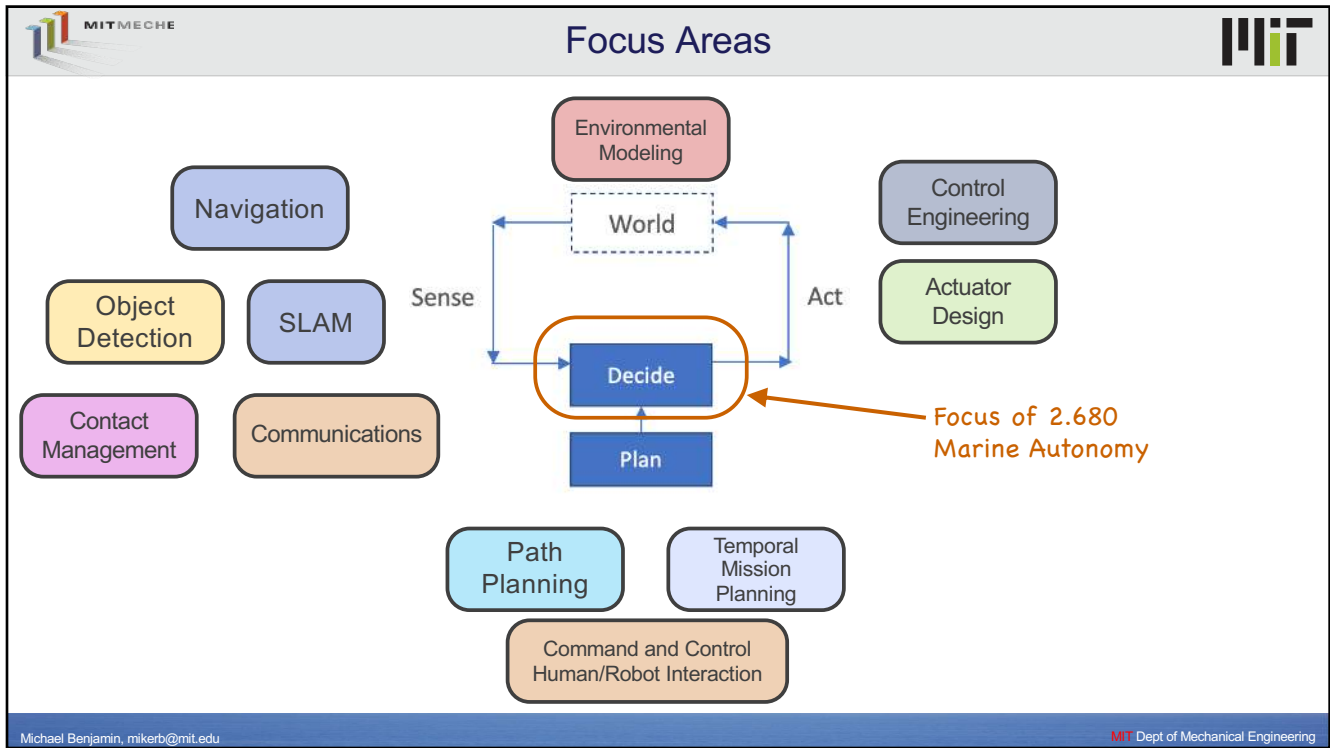
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DESIRED_SPEED



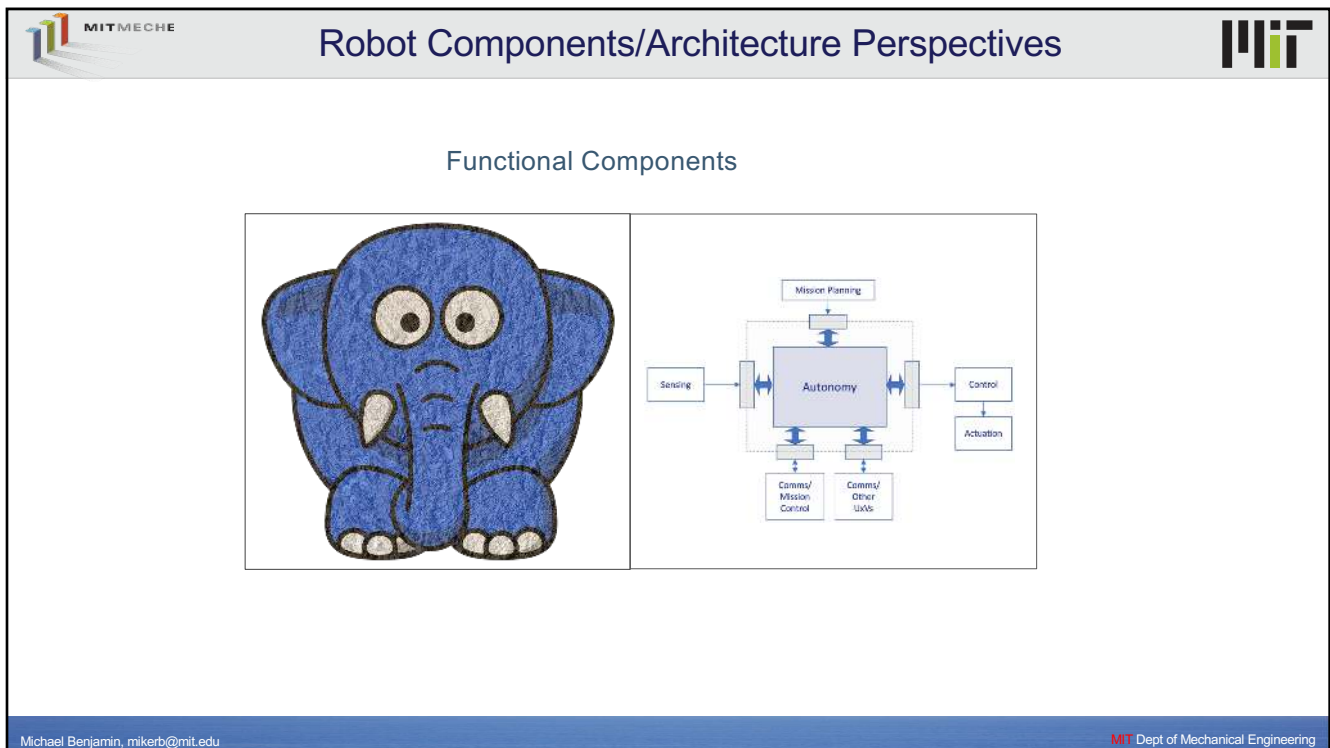
DESIRED_RUDDER
DESIRED_THRUST

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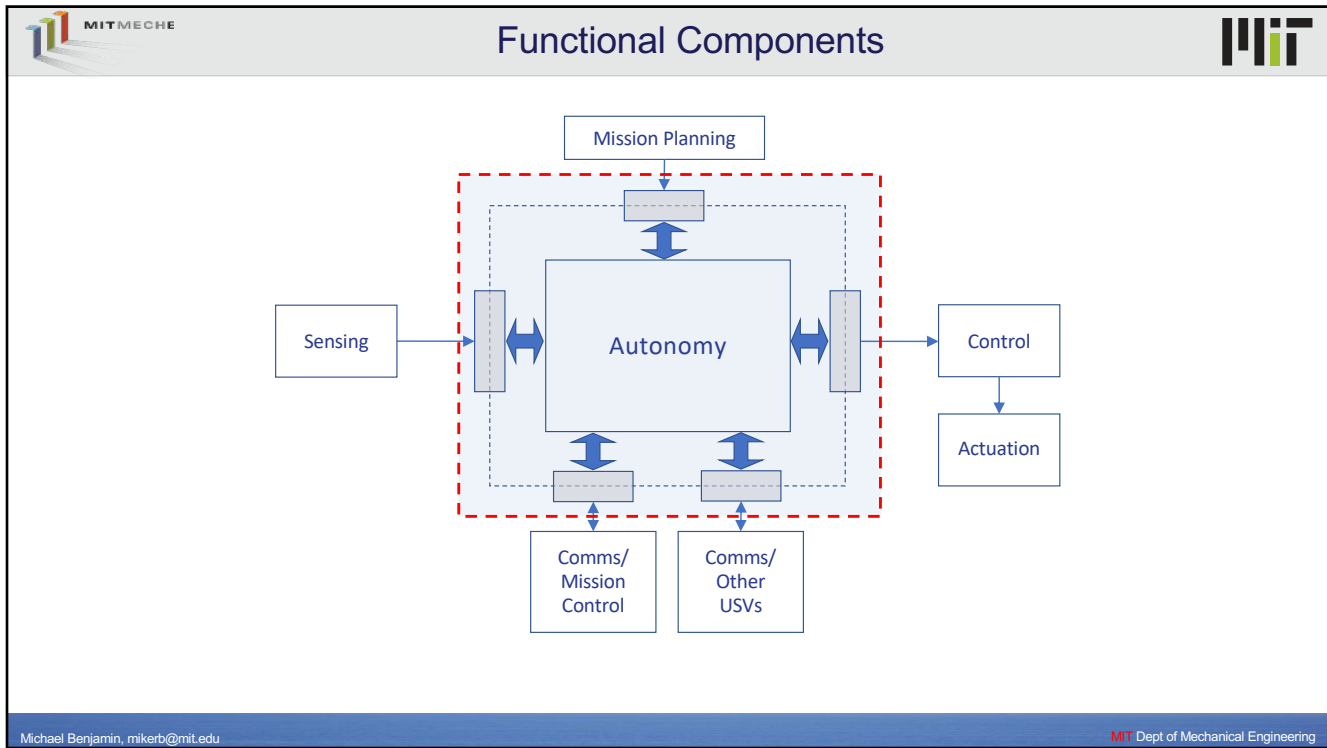
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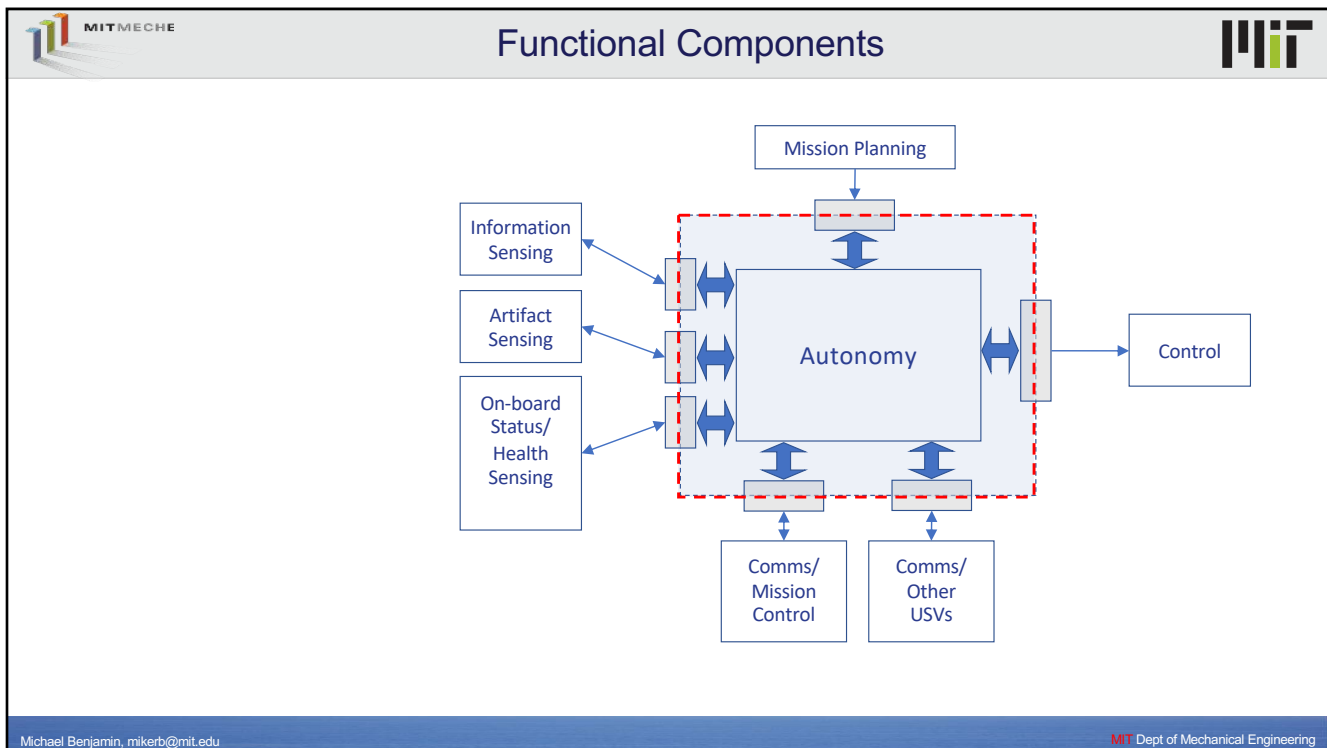
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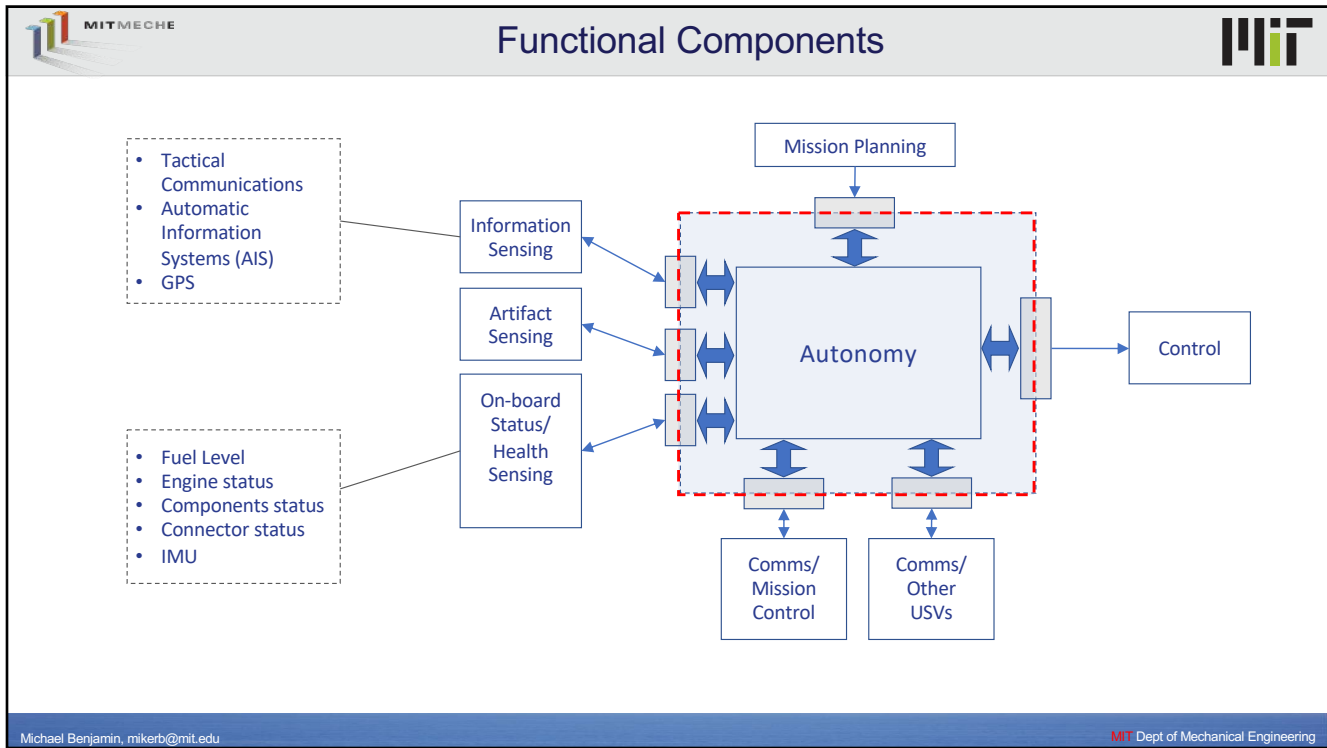
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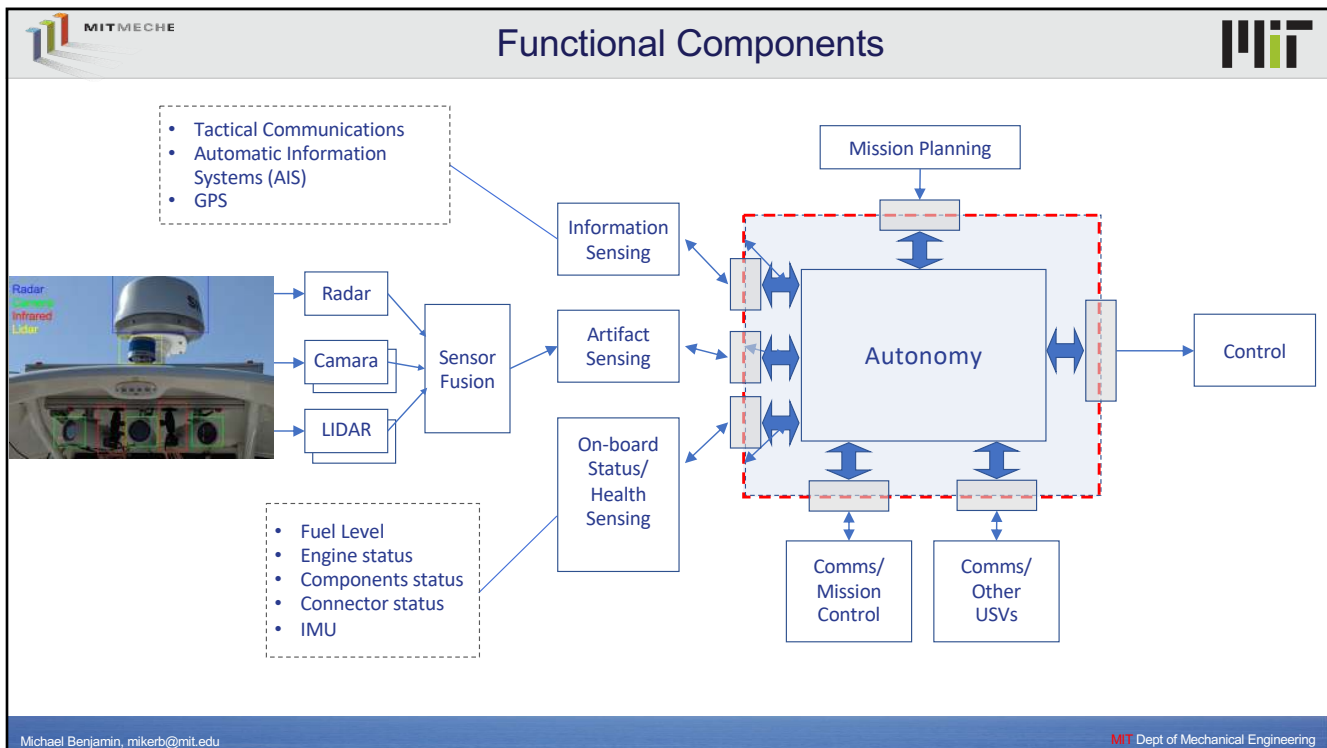
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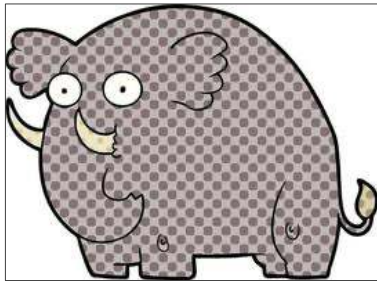
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Robot Components/Architecture Perspectives



The Backseat Autonomy Paradigm



UxV

Payload Computer	Main Vehicle Computer
	<ul style="list-style-type: none"> Sensing Navigation Control System Health Comms Actuation

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Early Commercial Marine Vehicles



At the turn of the century, there were essentially TWO commercial marine vehicles for sale:



1930




Massachusetts Institute of Technology





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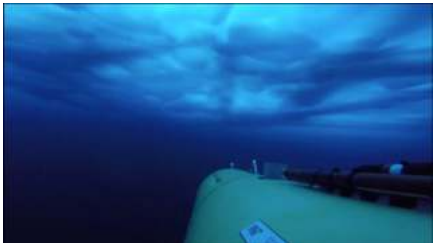
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MIT and Payload Autonomy





MIT Laboratory for Autonomous Marine Sensing Systems bought 2 Bluefin-21 UUVs






ICEX 2016, ICEX 2020

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Early Days of Marine Autonomy





If you have REMUS vehicle,
then you have REMUS Autonomy




If you have a Bluefin vehicle,
then you have Bluefin Autonomy


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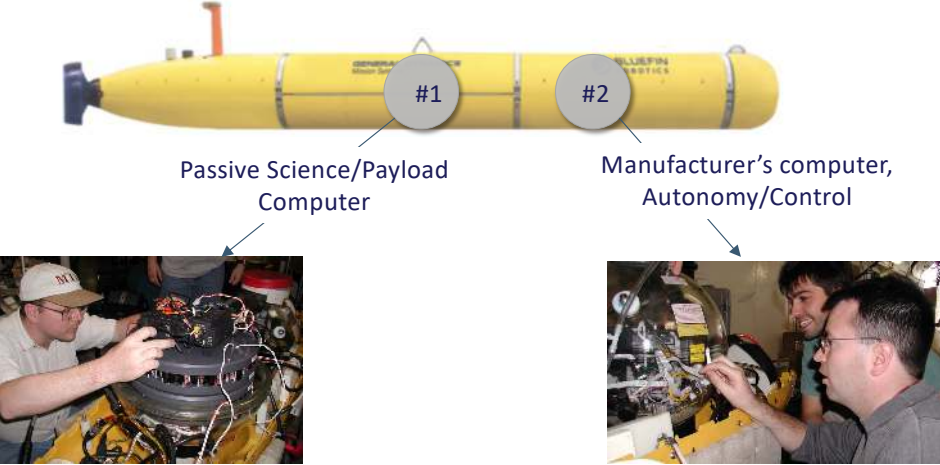
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Early Autonomy




- The Bluefin-21 has two computers in two separate pressure vessels (the BF-21 is a flooded vehicle)
- In the early years, the second (science) computer was passively collecting data.







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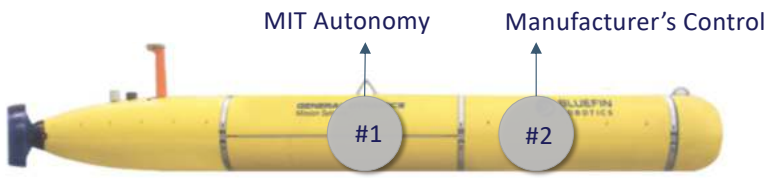
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Autonomy Independence



- The MIT/LAMSS was not content to be limited to the vehicle manufacturer's autonomy system.
- A goal was formed to run the autonomy system from the payload computer, i.e., Payload Autonomy



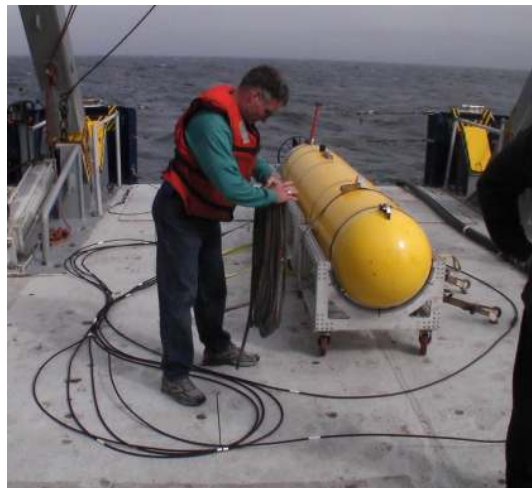
Hurdle: Autonomy is complex and losing a UUV like the BF-21 may set a lab back many years.

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Monterey Bay 2006



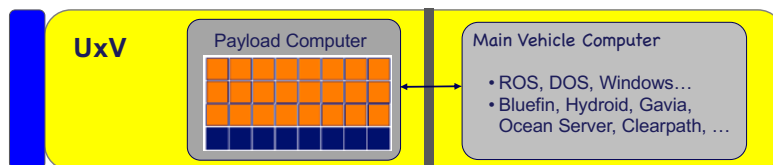
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Payload Autonomy (Architecture Principle #1: Payload Autonomy)




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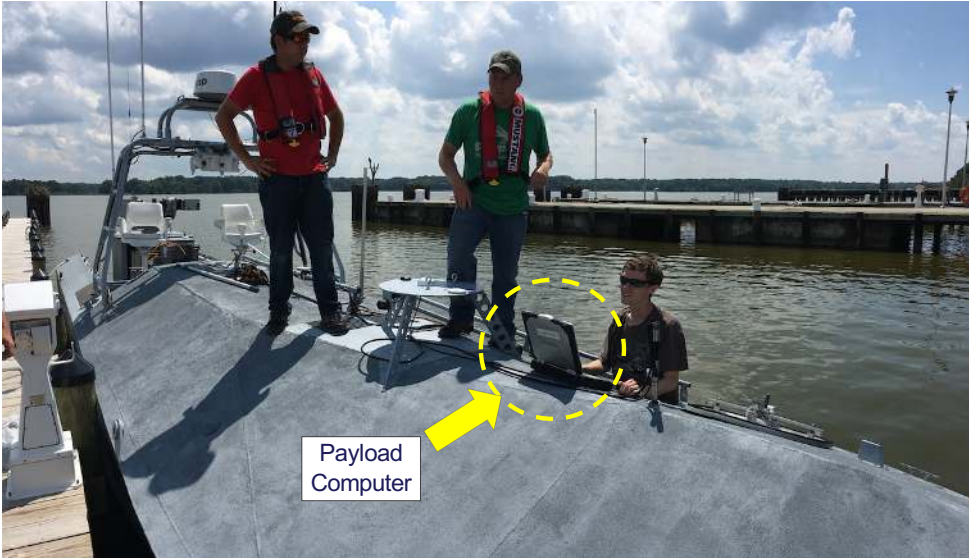
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Payload Autonomy on the Textron CUSV

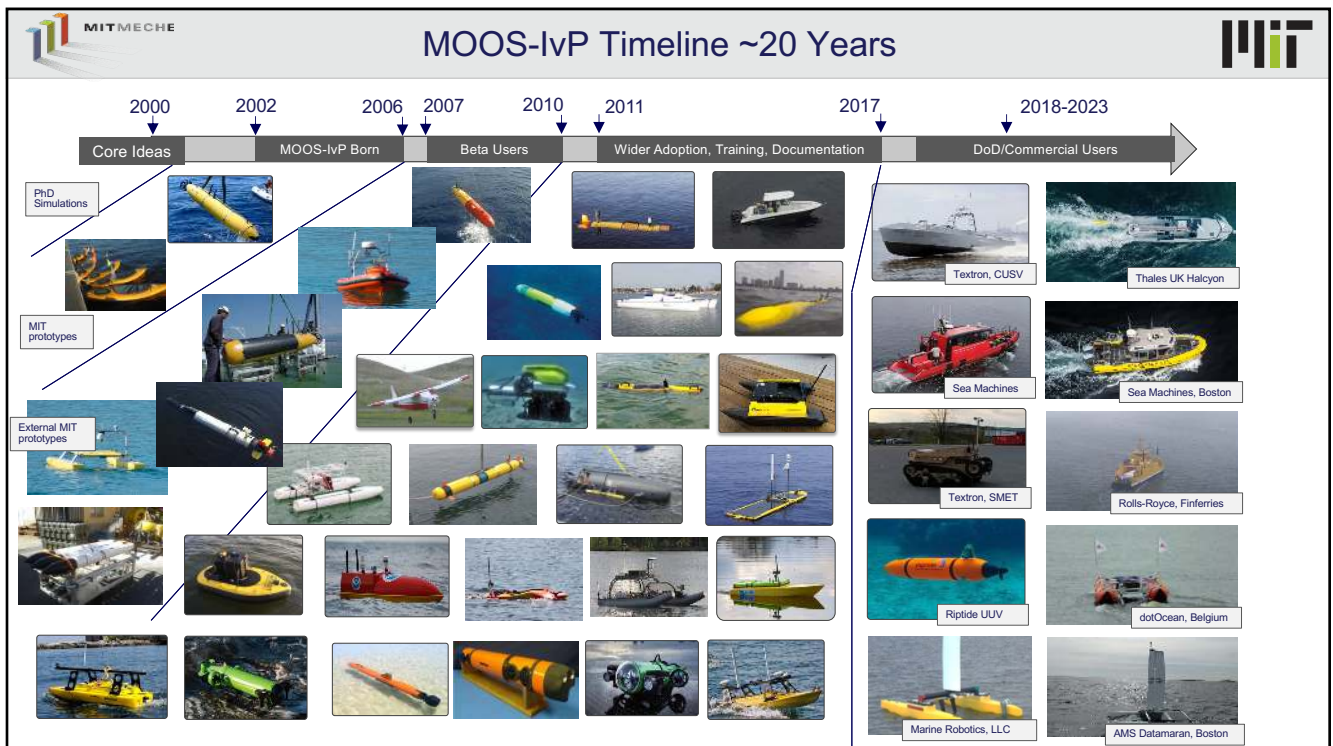




Payload Computer

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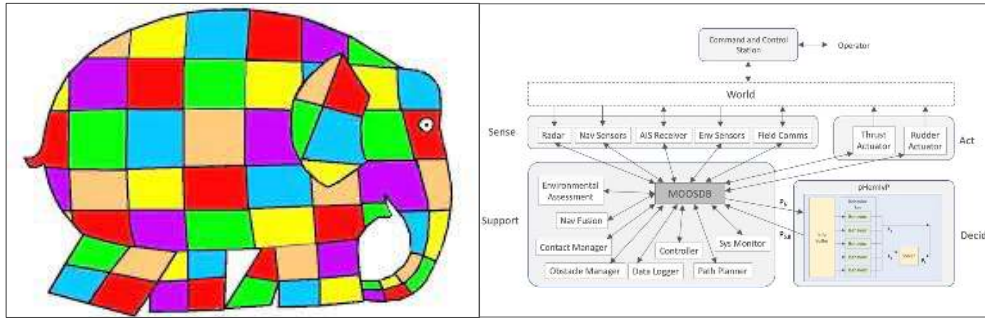
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Robot Components/Architecture Perspectives



The MOOS and MOOS-IvP Architectures



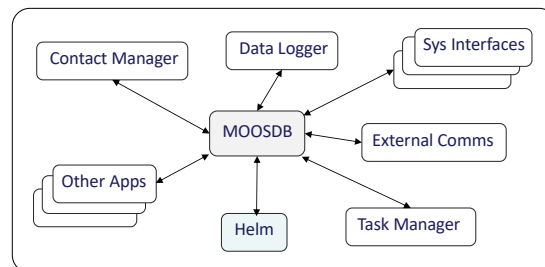
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MOOS and MOOS Apps



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Example Mission Alpha




```
$ cd moos-ivp/ivp/missions/sl_alpha
$ ./launch.sh 10
```




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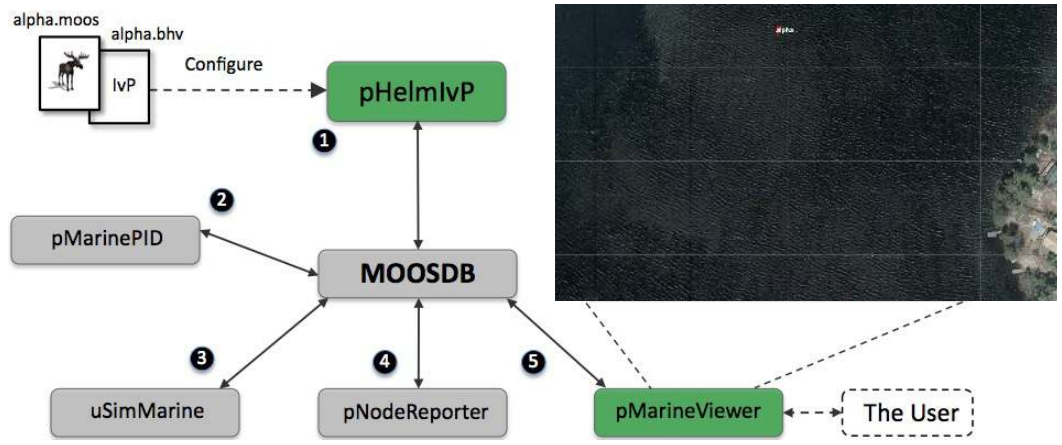
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Example Mission Alpha

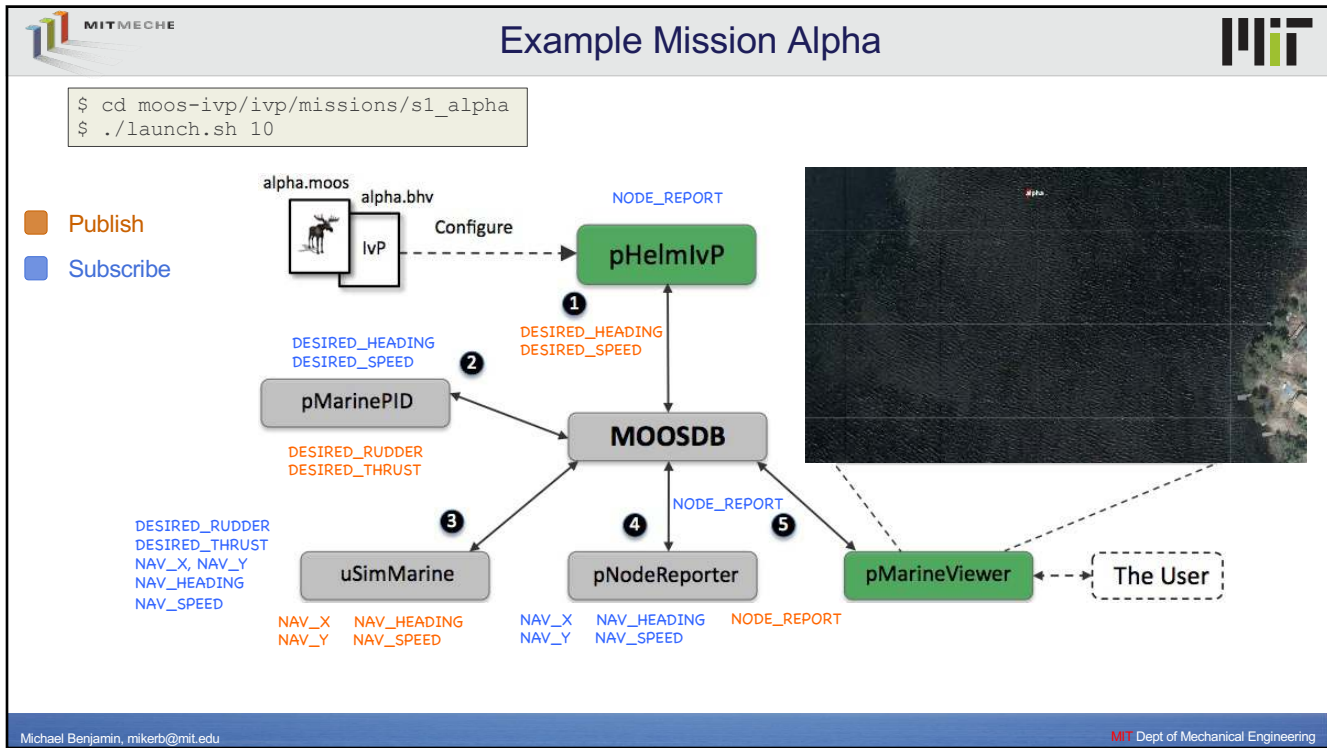


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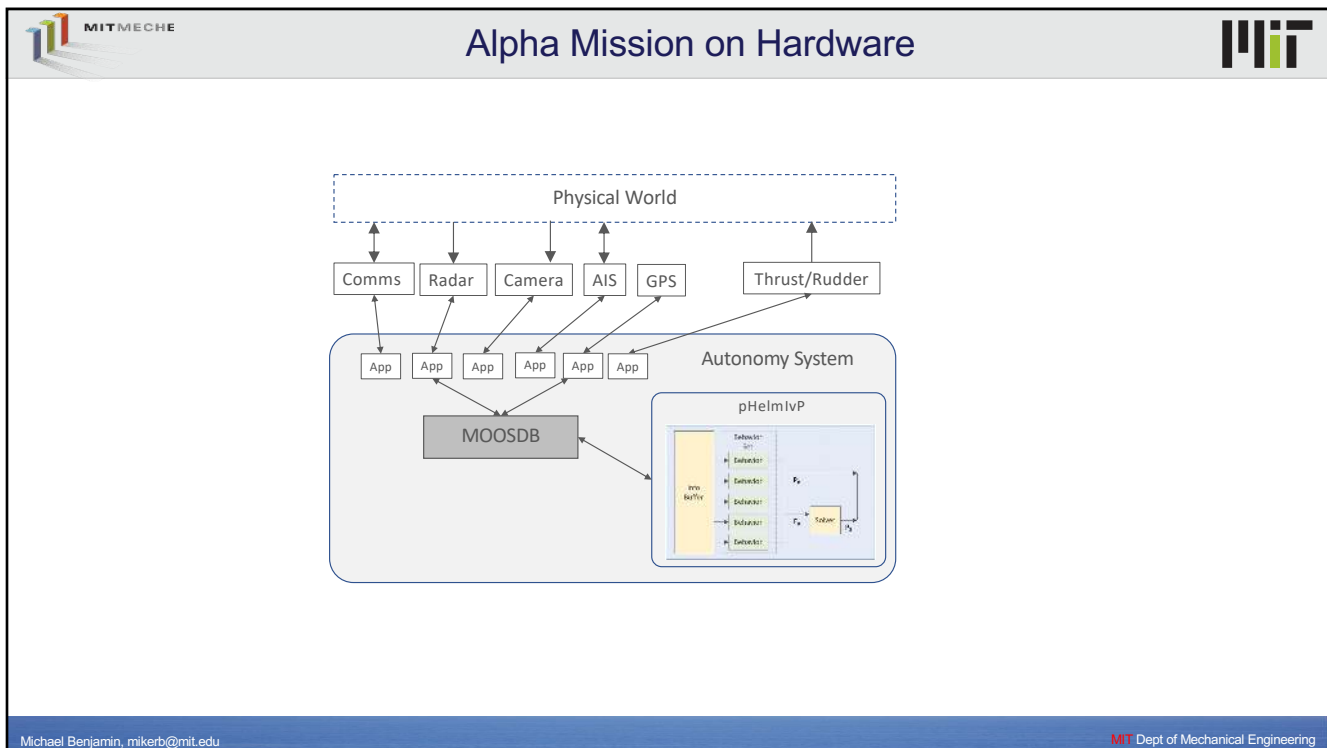


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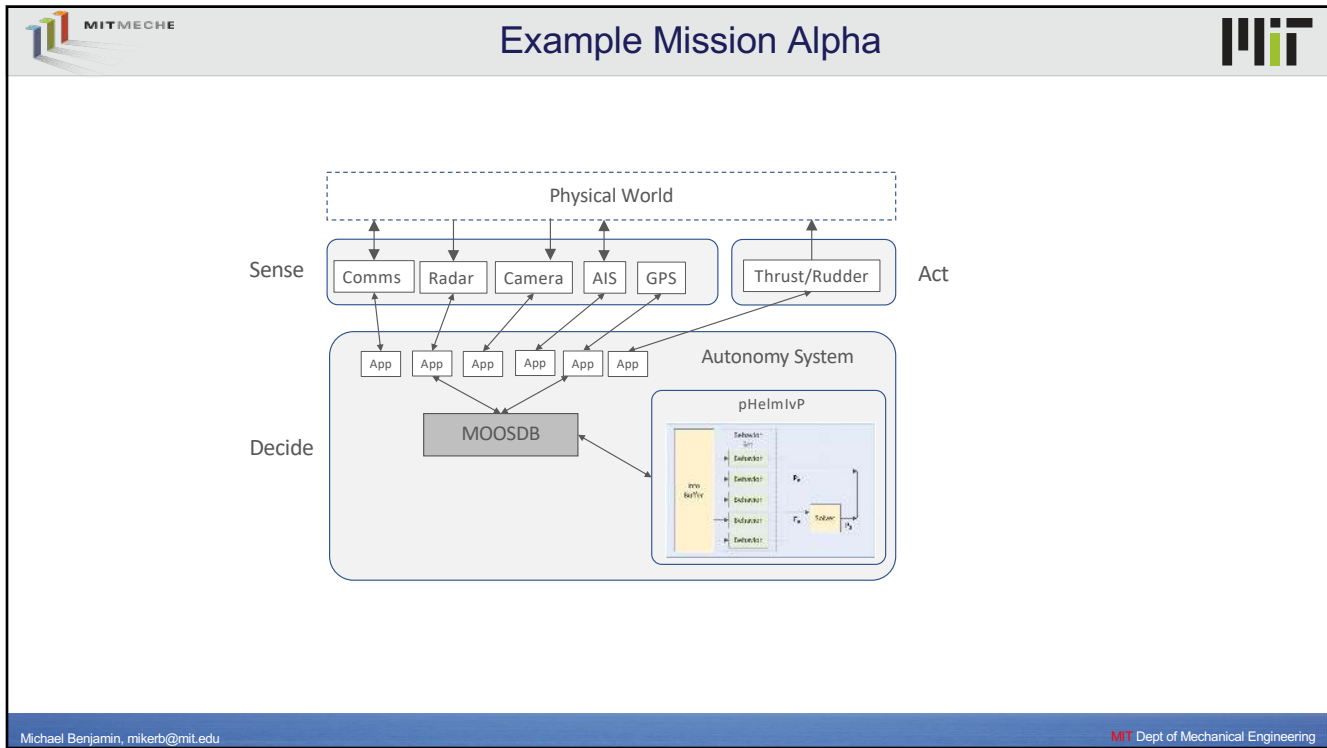
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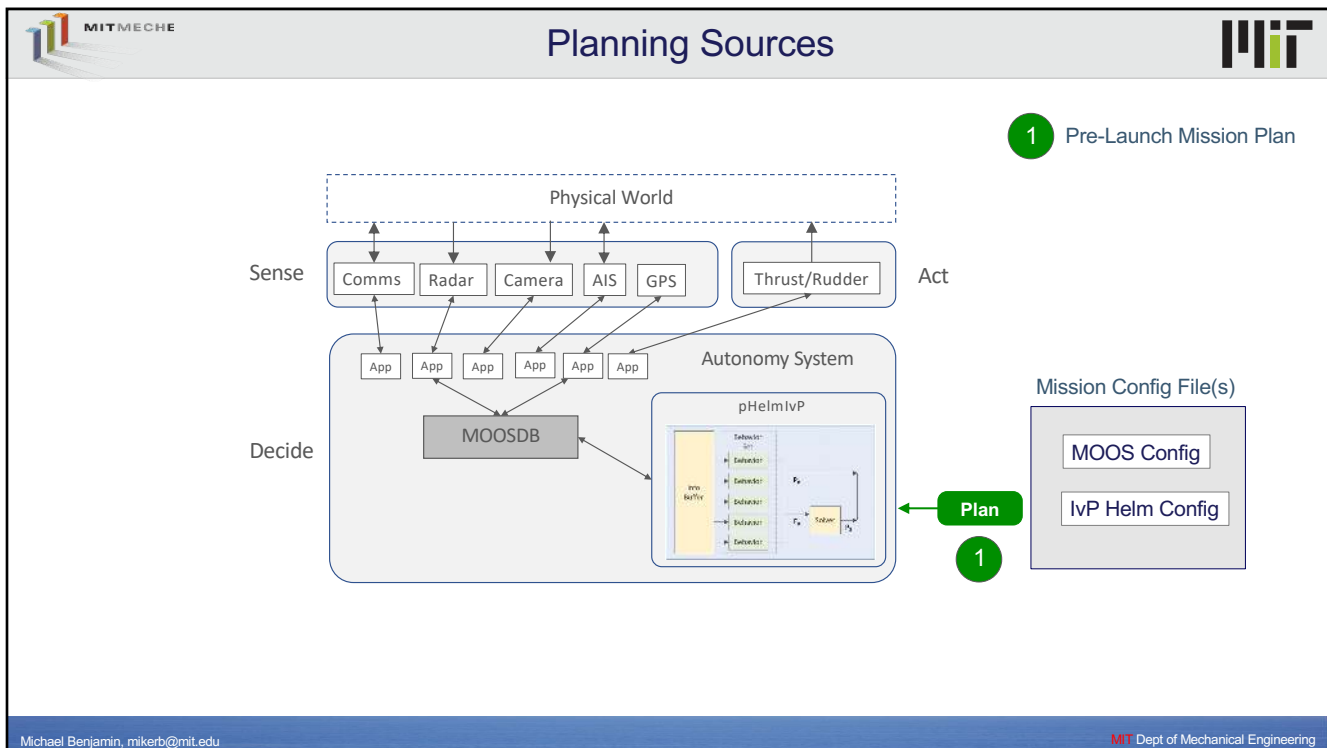
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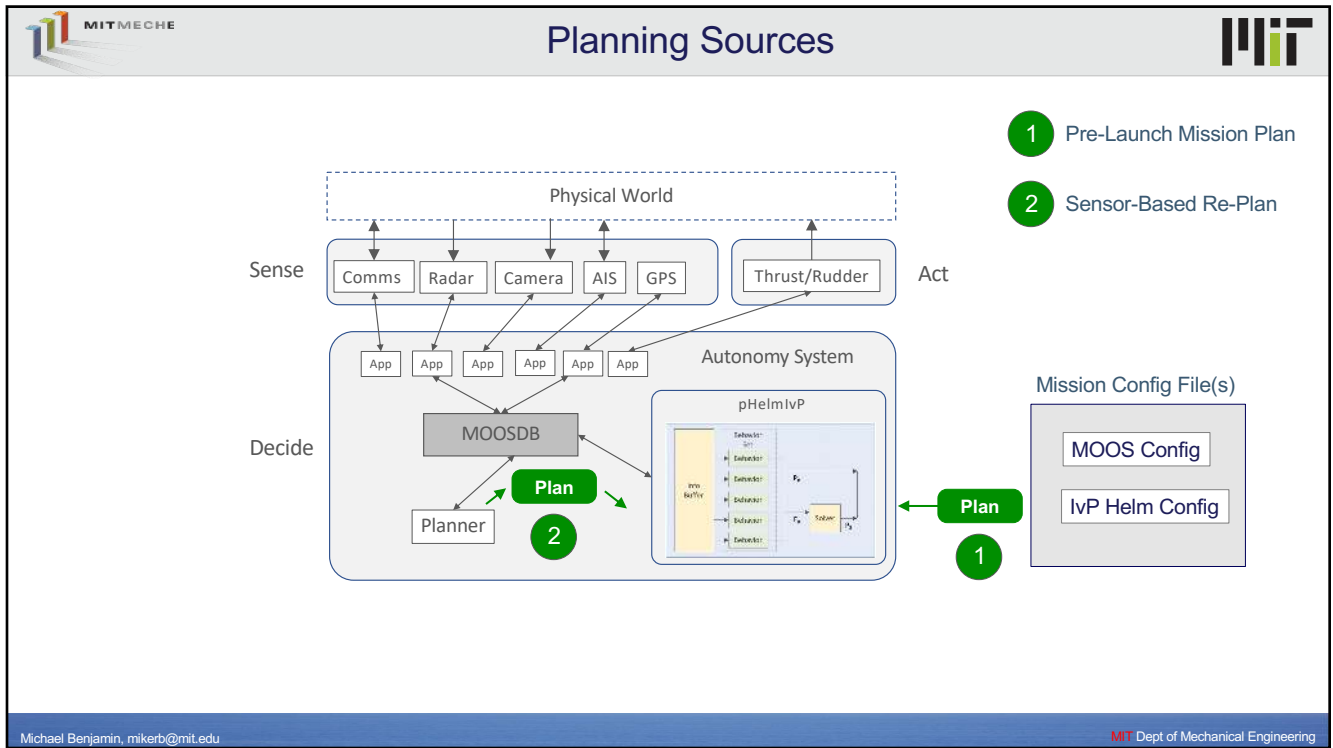
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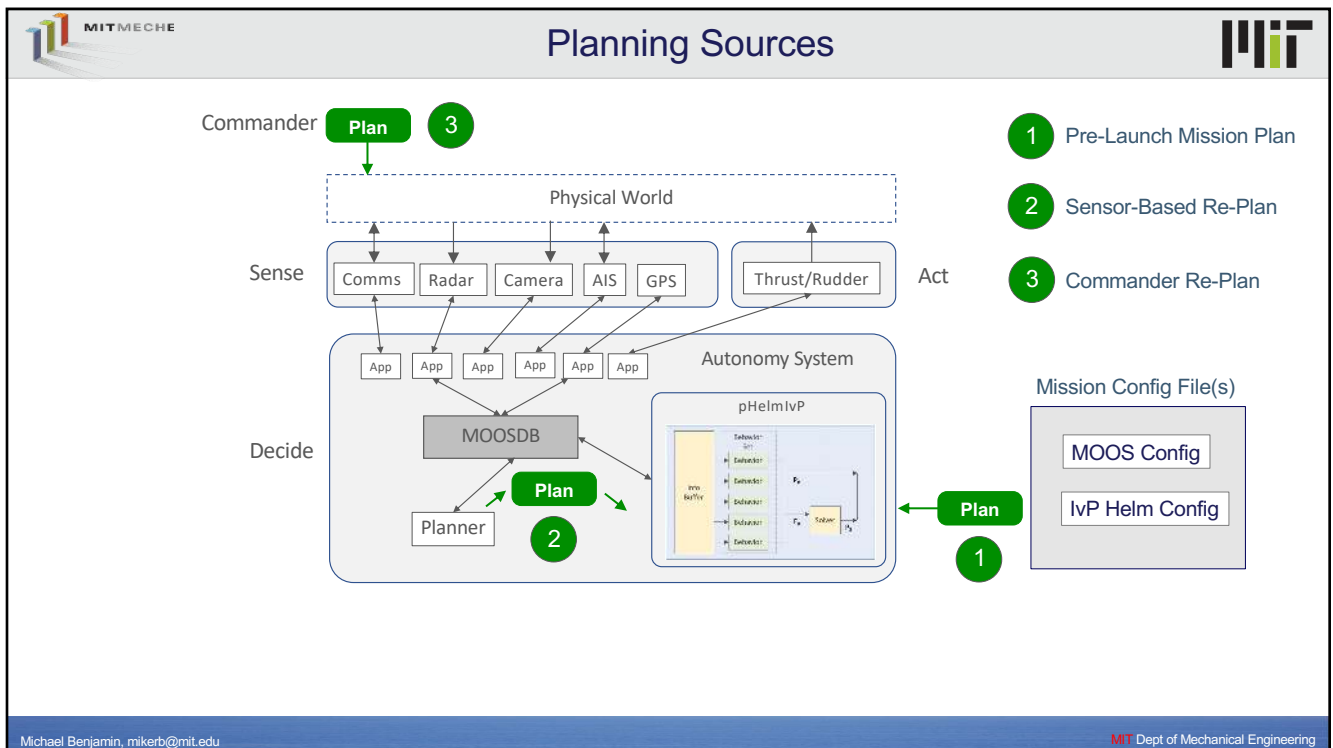
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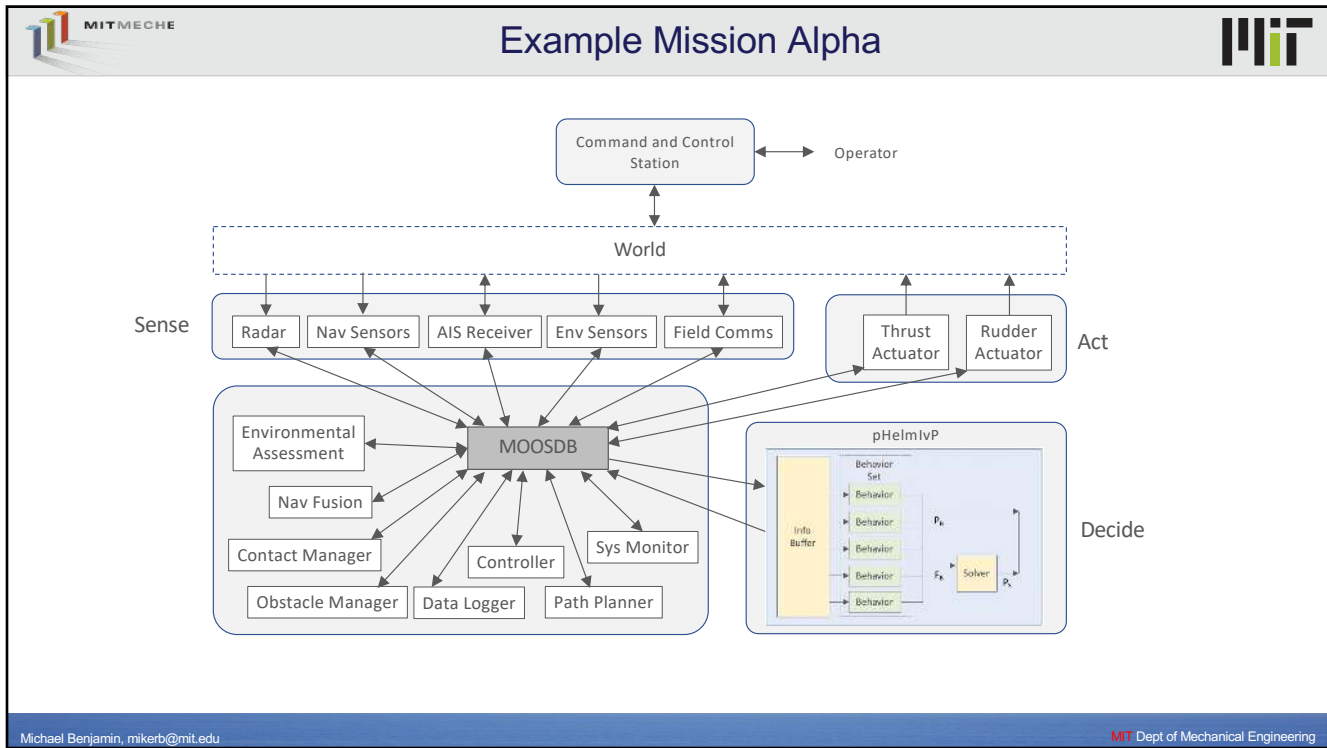
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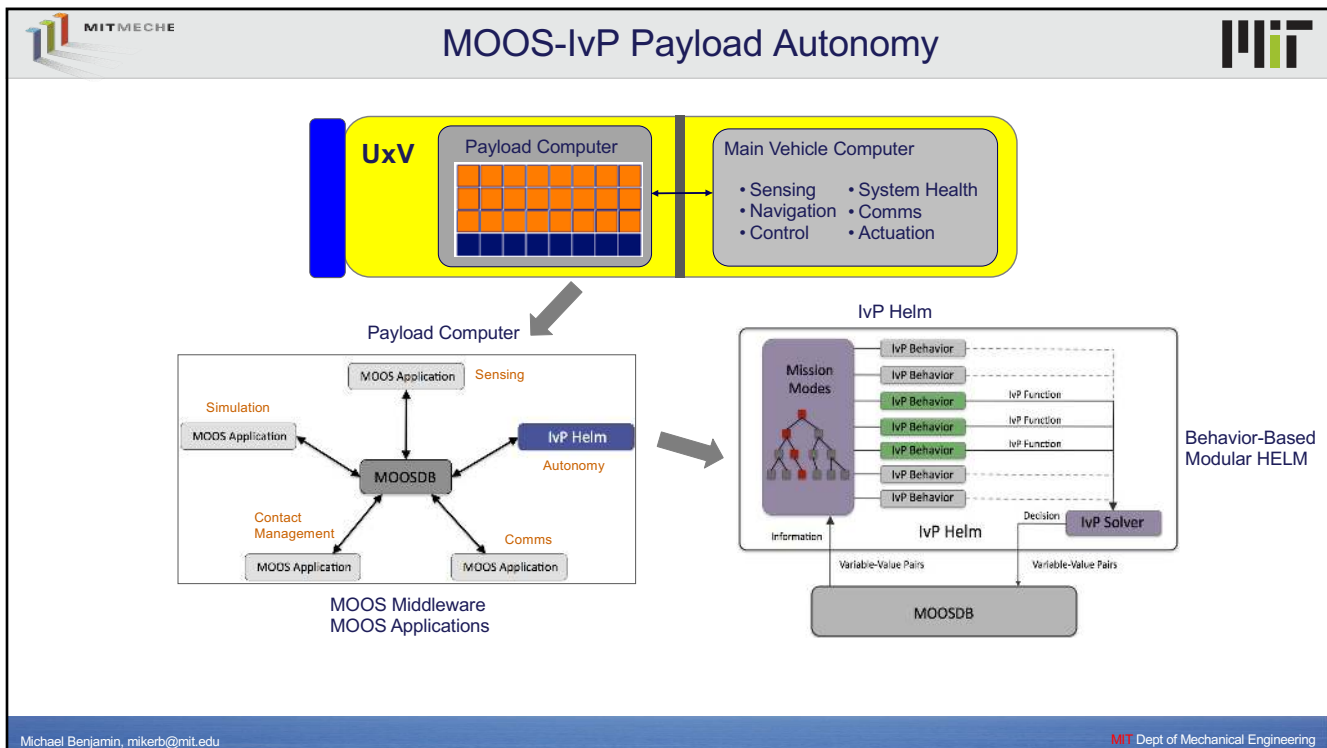
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Lecture 1 Overview: Introduction to MIT 2.680




Robot Architectures: The focus of 2.680 in the larger context of mobile robot technologies

Skills Progressions: The parallel progression of skills expected during the course of 2.680 and labs.

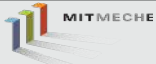
2.680 Learning Resources: Beyond lectures: MIT 2.680 labs, office hours (in-person and virtual), 2.680 Website, 2.680 Piazza page.

Marine Autonomy Lab Overview: A introduction to existing robotic platforms and projects related to MIT 2.680




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Skills Progressions




Skills Progressions

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Core Skills




- **C++:**
All software in 2.680 (MOOS Apps, Helm Behaviors) is written in C++. You will be a functional C++ programmer at the end of 2.680, and proficient coder of autonomy modules.
- **Command-line:**
The command-line (shell) environment is essential for development of software and operation of robotic platforms in 2.680.
- **Text editors:**
Proficiency and comfort with your text editor is essential for (1) code development, (2) mission configuration files, and (3) launch file editing.
- **Version Control:**
C++ code development and mission file development will be under (remote) version control, to enable (1) backup and restore capability for yourself, (2) sharing/collaboration with a lab partner, and (3) migration onto your robots for in-water labs.

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Core Skills




- **C++:**
All software in 2.680 (MOOS Apps, Helm Behaviors) is written in C++. You will be a functional C++ programmer at the end of 2.680, and proficient coder of autonomy modules.
- **Command-line and Shell Scripts:**
The command-line (shell) environment is essential for development of software and operation of robotic platforms in 2.680.
- **Text editors:**
Proficiency and comfort with your text editor is essential for (1) code development, (2) mission configuration files, and (3) launch file editing.

Initial Lab Focus


- **Version Control:**
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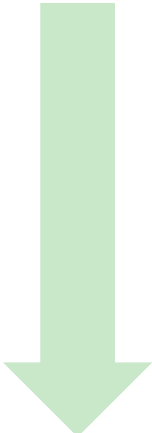
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Mission Progression




- **Simple scripted mission**
Vehicle performs a set task, no variations
- **Dynamic Mission**
Vehicle will vary the trajectory and autonomy mode depending events
- **Multi-vehicle Independent**
Multiple vehicles deployed, oblivious to one another
- **Multi-vehicle Collaborative**
Multiple vehicles deployed, in comms with each other, cooperating on share goals




Over the semester, the complexity of the autonomy mission will evolve from simple scripted single-vehicle missions to highly coordinated multi-vehicle dynamic missions

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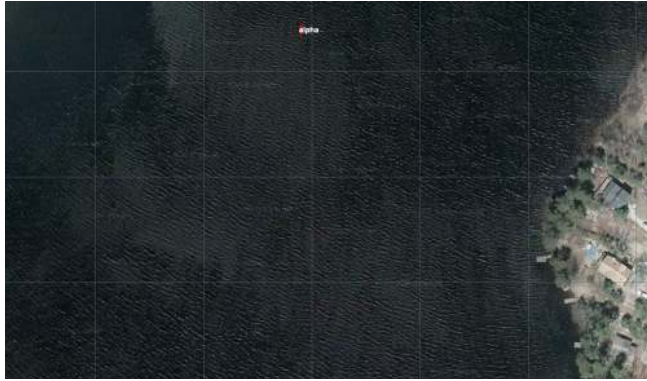
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Mission Progression




- **Simple scripted mission**
Vehicle performs a set task, no variations
- **Dynamic Mission**
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- **Multi-vehicle Independent**
Multiple vehicles deployed, oblivious to one another
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Mission Progression




- **Simple scripted mission**
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autonomy mode depending
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Bravo Loiter UUV


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Mission Progression




- **Simple scripted mission**
Vehicle performs a set task,
no variations
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Henry Gilda Baseline


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Mission Progression



- **Simple scripted mission**
Vehicle performs a set task, no variations
- **Dynamic Mission**
Vehicle will vary the trajectory and autonomy mode depending events


- **Multi-vehicle Independent**
Multiple vehicles deployed, oblivious to one another

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Mission Progression



- **Simple scripted mission**
Vehicle performs a set task, no variations
- **Dynamic Mission**
Vehicle will vary the trajectory and autonomy mode depending events


- **Multi-vehicle Independent**
Multiple vehicles deployed, oblivious to one another

- **Multi-vehicle Collaborative**
Multiple vehicles deployed, in comms with each other, cooperating on share goals




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Run-Time Structure Progression




- **Single MOOS community**
All robot and mission control in a single community
- **Multiple MOOS communities**
Each vehicle has its own MOOS community and dedicated shoreside community on one laptop
- **Distributed MOOS communities**
Simulations distributed over many laptops on the network
- **Deployed multi-vehicle ops**
Multiple vehicles deployed, on the water, connected to shoreside command-and-control




Over the semester, way missions are run will evolve from a single MOOS community simulated on a single to multiple coordinated MOOS communities over several laptops or robots.

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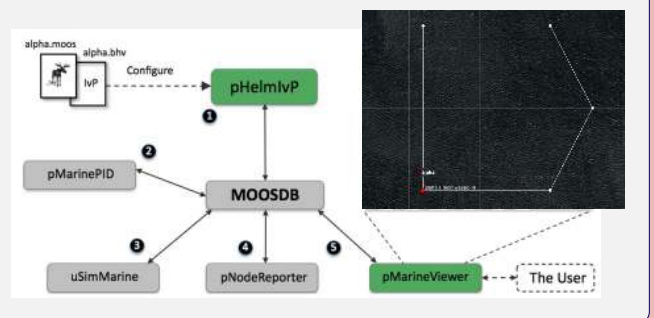
Run-Time Structure Progression (1)



- **Single MOOS community**
All robot and mission control in a single community
- **Multiple MOOS communities**
Each vehicle has its own MOOS community and dedicated shoreside community on one laptop
- **Distributed MOOS communities**
Simulations distributed over many laptops on the network
- **Deployed multi-vehicle ops**
Multiple vehicles deployed, on the water, connected to shoreside command-and-control


One Laptop

One MOOS Community




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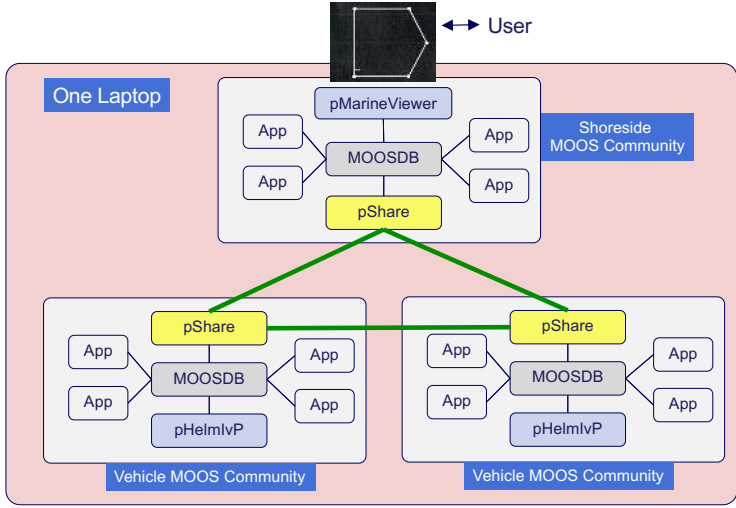
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Run-Time Structure Progression (2)




- **Single MOOS community**
All robot and mission control in a single community
- **Multiple MOOS communities**
Each vehicle has its own MOOS community and dedicated shoreside community on one laptop
- **Distributed MOOS communities**
Simulations distributed over many laptops on the network
- **Deployed multi-vehicle ops**
Multiple vehicles deployed, on the water, connected to shoreside command-and-control




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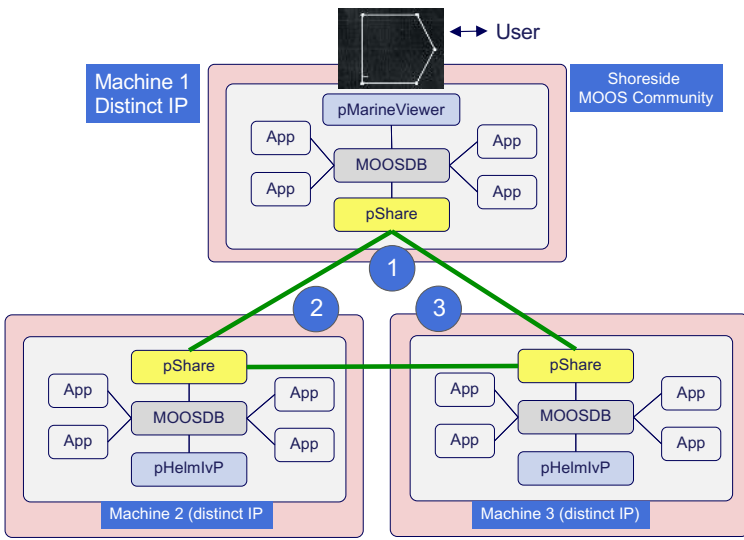
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Run-Time Structure Progression (3)




- **Single MOOS community**
All robot and mission control in a single community
- **Multiple MOOS communities**
Each vehicle has its own MOOS community and dedicated shoreside community on one laptop
- **Distributed MOOS communities**
Simulations distributed over many laptops on the network
- **Deployed multi-vehicle ops**
Multiple vehicles deployed, on the water, connected to shoreside command-and-control




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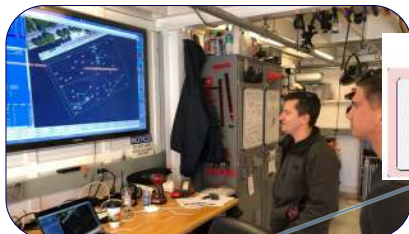


Run-Time Structure Progression (4)




- **Single MOOS community**
All robot and mission control in a single community
- **Multiple MOOS communities**
Each vehicle has its own MOOS community and dedicated shoreside community on one laptop
- **Distributed MOOS communities**
Simulations distributed over many laptops on the network

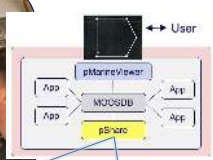
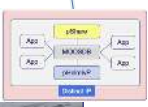
- **Deployed multi-vehicle ops**
Multiple vehicles deployed, on the water, connected to shoreside command-and-control



Shoreside




Charles River





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2.680 Learning Resources



- **Course Website:**
<https://oceanai.mit.edu/2.680>
- **Course Schedule**
<https://oceanai.mit.edu/2.680/schedule>
Note the schedule is updated as the semester progresses.
The current content/links for future lectures/labs are best projections.
The lecture and lab content for future lectures/labs may show the previous year until replaced.
- **Course Lectures**
<https://oceanai.mit.edu/2.680/lectures>
Lectures are online (usually posted day-of). Printed handouts usually also brought to class
- **Course Labs**
<https://oceanai.mit.edu/2.680/labs>
Labs are online (usually posted day-of). Printed handouts usually also brought to class

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Help Outside of Class

- Piazza:**
<https://oceanai.mit.edu/piazza>
 Or
<https://piazza.com/class/lbtu17k3gzv3h>
 Please post technical questions or lab bugs here. The first person on the teaching staff to see it will try to respond. Others may benefit from your question and TA answer.
- Office Hours**
 TAs will schedule online office hours. These will be over zoom unless otherwise arranged.
- Online documentation**
 For much of the software in this class, there is extensive online documentation.
<https://oceanai.mit.edu/ivpman>

 For any given app, e.g., pNodeReporter, just type “pNodeReporter -w” on the command line.

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Grading

Grades are based on Lab Work and Attendance

Most labs are graded by:

- (a) meeting functional criteria
- (b) completion by deadline
- (c) Head-to-head competition results may also factor

Lab Partners:

- After roughly mid-semester, we will work in teams of two
- We suggest keeping this in mind in the early part of the semester
- If you have not found a partner, don't worry we will help you partner up!

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