



ME 218c Spring 2023: Call Me Fishmael The Last Of Us: Marine Edition

Project Preview on May 29 from 1-5 pm. Grading Session on May 30 from 1-5 pm.

Project Presentation on May 31 starting at 5:00 pm.

Revision 0: 5/3/23

Goal:

The goal of this project is to provide a framework in which you can apply your knowledge of microcontrollers and multi-processor communications to a task that will provide an enjoyable experience for users and observers alike!

Purpose:

The underlying purpose of this project is to provide you with an opportunity to integrate all that you have learned in the ME218 course sequence, with an emphasis on the new material in ME218c.

The Task:

Design and build a BYT(ER) Operator And Transporter (BOAT), which is a watercraft capable of navigating up to 18-inch-deep blue waters, and an accompanying BAY Over-Seas Yeoman Navigator (BOSYN), composed of one Standardized Wireless Yaw and Momentum CONtroller (SWYMCN) and one Connected High-Output Marine Persuasion CONsole (CHOMPCON), each constructed and operated by your team. All of the BOATs will navigate in the BAY. During play, each team will attempt to control their wirelessly paired BOAT to either hunt, or avoid falling prey.

Specifications

General:

- Each team will construct a BOAT and a BOSYN.
- The BOSYNs are I/O devices which control various aspects of the BOAT functions, and will contain an SPDL supplied XBee radio module to communicate wirelessly between BOSYNs and BOATs.
- The class Communications Committee will draft a class-wide standard communications protocol that will permit any BOSYN to effectively control any BOAT with which it is paired.

Basic Game Play:

- At the beginning of each game, the participating BOATs will be assigned the role of PREI or HNTR, at the discretion of the teaching staff, by way of its BAYT's inflation status.
- A game round consists of an attempt by all BOATs with the role of Pollock Rescue Express Initiative (PREI) to cross the length of the BAY, while those BOATs with the role of Haddock aNd Trout Revolution (HNTR) pursue them with impunity.
- A game round ends when each and every PREI has either made the crossing, or fallen victim to the HNTRs.
- Each BOAT will be randomly assigned to a BOSYN, and the pairing process is to take place, prior to each round.
- All HNTRs start each round at the centerline of the BAY. All PREIs start each round at one edge of the BAY.
- A game round proceeds in real time, with no turn-taking.
- Each game round, the PREIs must cross the length of the BAY before being overcome by one or more HNTRs.
- The HNTRs must attempt to pursue, capture and convert PREIs to the HNTR cause by puncturing a PREI's Balloon Attached Yn Tow (BAYT) using the BAYT Yngestion Tool (Extended Reach) (BYT(ER)) on each BOAT.

- A HNTR may convert a PREI by way of puncturing the BAYT of the PREI's BOAT using a BYT(ER).
- When a PREI's BAYT is deflated, the BOAT that was formerly a PREI is now aligned with the HNTRs.
- Upon deflation, a BOAT formerly aligned with the PREIs must un-pair from its existing BOSYN and must not accept pairing requests from that BOSYN for 5 s. During this period, it must accept a pairing request from any other BOSYN. After this period, it may accept a pairing request from any BOSYN, including the one that was formerly controlling it as a PREI.
- The overall game ends when there is only one PREI left that successfully crosses the BAY, or when there are no PREIs remaining.
- The ultimate goal of the game is to be the team operating the BOSYN paired to the last living PREI that makes the BAY crossing, or to be the team operating the BOSYN paired to the HNTR that captured the last PREI before it could complete its journey.

The BAY:

- The BOAT Arena, Ynot? (BAY) is located adjacent to Thornton (SPDL) and forms the body of water in which your BOAT is expected to operate.
- The approximate depth of the water in the BAY is 18 in.
- The fountains in the BAY shall be disabled for the duration of play.
- A BOAT may venture into any part of the BAY, but must not exit the water.
- PREIs will attempt to cross the BAY length-wise, that is, starting at one short edge and traversing along the long edge to arrive at the other short edge.

The BOAT:

- Each BOAT is a watercraft capable of operating in the BAY.
- Each BOAT shall be equipped with a propulsion and maneuvering system controlled by the BOSYN.
- Each BOAT shall mount a BYT(ER) designed and built by the BOAT's crew.
- Each BOAT shall mount a BAYT designed and supplied by the teaching staff.
- There is no constraint on the type of propulsion system used, nor on achievable speed, nor on total mass of the BOAT.
- Each BOAT shall have around its largest perimeter, at the waterline, a SPDL-issued closed-cell foam bumper.
- Each BOAT is limited to a total waterline circumference of 6 ft.
- Each BOAT must implement an electromechanical indication of its state of association with a BOSYN.
- No part of the BOAT may protrude beyond the circumference of the foam bumper, with exception of the puncturing end of the BYT(ER) while in its extended position.
- Each BOAT may only be powered by SPDL-supplied 7.2V NiMH and 5V LiIon battery packs. Up to 2x 7.2V NiMH packs and 1x 5V LiIon pack may be used.
- The enclosure of each BOAT's sensitive instrumentation and propulsion systems must be protected against damage from ingress of objects and water to a rating of IP-24.
- Each BOAT shall contain a SPDL-issued XBee radio module used to communicate with a BOSYN.
- Each BOAT must implement the class-wide protocol for coordinating game information (See [Communications](#)).

The BAYT:

- The BAYT consists of a sensor-equipped mount into which an inflatable bladder is placed.

- The BAYT and its bladder will be supplied by the teaching staff.
- An inflated BAYT bladder is the primary means of association with the PREIs.
- A deflated BAYT bladder indicates association with the HNTRs.
- The BAYT must be mounted to a BOAT opposite the BOAT's primary forward movement vector. Alternately stated, the BAYT is to be installed at the very aft of a BOAT.
- The BAYT's inflated bladder must be tangent with, but not extend past, the outermost perimeter of a BOAT's foam bumper.
- The center of mass of the BAYT's bladder must be 20 cm above the waterline.
- The BAYT will have a standardized interface to detect the inflation status of its bladder. This sensor must be read and correctly interpreted by the BOAT pursuant to gameplay.

The BYT(ER):

- The BYT(ER) is a mechanism mounted at the perimeter of a BOAT, capable of puncturing a BAYT.
- The BYT(ER) must, in its retracted state, be fully enclosed within the perimeter of the foam bumper around the BOAT. That is, no portion of the BYT(ER) may extend beyond the bumper while the BYT(ER) is retracted.
- The BYT(ER) must be capable of extending beyond the perimeter of the foam bumper upon receiving an appropriate command from the CHOMP CON by way of the BOSYN.
- The maximum distance that a BYT(ER) may extend beyond the foam bumper of a BOAT is 10 cm.
- The maximum time that a BYT(ER) may remain extended, at any distance beyond the bumper, is 4 s.
- After extension, the BYT(ER) may not extend again until 3 s have elapsed in the retracted state.
- The BYT(ER) must not be extended more than 3 times in any 24 s period.
- Enforcement of the required BYT(ER) timing must be implemented as part of the BOAT. Any BYT(ER) activation attempt by the BOSYN's CHOMP CON that is disallowed by timing must be reported back to the crew member at the CHOMP CON.
- Any element of a BYT(ER) designed to puncture a BAYT must be made of non-composite polymer. Materials including, but not limited to, glass, metal, wood, ceramic, and plasma are prohibited.
- The BYT(ER) may only extend in a direction opposite a BOAT's own BAYT, as drawn through the BOAT's center of mass. Alternately stated, the BYT(ER) must extend along the BOAT's primary forward movement vector. Rotary motions of the BYT(ER) are acceptable as long as their plane of rotation is vertical.

The BOSYN:

- Each team will construct a BOSYN composed of a SWYM CON and a CHOMP CON.
- Each BOSYN may only be powered by SPDL-supplied 7.2V NiMH and 5V LiIon battery packs. Up to 2x 7.2V NiMH packs and 1x 5V LiIon pack may be used.
- The SWYM CON and CHOMP CON of a BOSYN may be connected by one or more cables.
- The BOSYN must provide the user controls for all required functions determined in the class-wide communications protocol.
- The SWYM CON and CHOMP CON shall each be operated by different crew members. One crew member alone may not operate both the SWYM CON and CHOMP CON simultaneously. It is encouraged to make such simultaneous operation physically impractical.
- Each SWYM CON and CHOMP CON must provide their crew member a display of information relevant to that crew member's role.
- BOSYNs must incorporate at least 1 analog input and at least 1 electromechanical output.

- The user at the SWYMCN is granted complete control over the paired BOAT's propulsion and maneuvering systems.
- The actions required by the user of the SWYMCN to issue movement commands to the BOAT should be inventive and interesting for the audience to watch.
- The user at the CHOMPON has control over the paired BOAT's BYT(ER) only.
- The CHOMPON interface must implement an action consisting of large-scale human body movements. Use of actions that make the CHOMPON operator look and feel foolish are encouraged.
- The required CHOMPON action must last continuously for at least a second.
- The CHOMPON must include, at minimum, an indicator to display whether an attempted BYT(ER) activation was successful.
- Each BOSYN shall contain a SPDL-issued XBee radio module used to communicate with a BOAT.
- Each BOSYN must implement the class-wide protocol for coordinating game information (See [Communications](#)).
- Both crew members at a BOSYN should stay within shouting range of each other during play in order to coordinate actions.
- The size, shape and mass of the BOSYN and its associated SWYMCN and CHOMPON are constrained only to what is portable by your team, from one end of the BAY to the other.

Game Details:

- The game progresses in real time.
- Messaging between BOSYNs and BOATs is limited to 5 Hz. That is to say that a single BOSYN shall transmit one message every 0.2 s, with the paired BOAT transmitting one message also during this period.
- Because of the inherent unpredictability in wireless latency, BOSYNs and BOATs must be able to accept any message at any time, and may not have a fixed time window in which they are open to message reception.
- Human inputs, such as button presses and direction changes, may only take effect on the following transmitted message. Extra messages (and thus a greater than 5 Hz message rate) may not be generated as a result of a human action.
- Collisions between BOATs will be unavoidable. Ensure that your BOAT is designed to robustly absorb crash energy at the waterline bumper.

Communications:

- Communications between BOATs and BOSYNs will take place over the airwaves using SPDL-supplied XBee radio modules in API mode.
- Each BOSYN and BOAT **shall** communicate with the XBee over an asynchronous communications channel using 9600 baud, 8N1 at 3.3V levels.
- Any other hardware or implementation requirements or recommended practices are left to the Communications Committee.
- The details of the communications protocol will be defined and specified by a Communications Committee, which will consist of a designated representative of each project group. The specification must be in a written form and with sufficient detail that someone skilled in ME218 material could implement it.
- The class communications protocol must be defined to support the functional requirements listed earlier in this document. The Communications Committee is free to write a protocol of any complexity

that fulfills the functional requirements. If a particularly clever messaging definition reduces overhead while maintaining the required functionality, this is perfectly acceptable. Or, if the Communications Committee implements a superset of the functionally required messaging, that would also pass.

- The communication protocol must define any addressing and packet formats if required.¹
- The communication protocol shall cover all communication handled through the XBee, including pairing, operation, unpairing, and exception handling between a BOAT and a BOSYN. Interruptions in wireless communication are frequent and occur at irregular intervals, and the protocol should include some robustness against such interruptions.
- While a clear division of labor is not obvious, we strongly encourage making an effort to have the team members who did not serve on the Communications Committee implement the majority of the communications in software.

General Requirements:

- Automation of the setting of any BOSYN input is prohibited. That is to say that an algorithm shall not set thrust magnitude, direction, extend the BYT(ER), etc. An algorithm may advise the human operator of a BOSYN how to set the various controls to achieve a desired outcome, however, in the end it is the human who must dial the setting, using the inputs provided, that generates a measurable effect in the BOAT.
- There is no class-imposed upper limit on the number of processors employed; however, you must use only the PIC32MX170F256B or PIC10F322. Tivas, Arduinos, Raspberry Pis, Teensys, Jetsons, and other microcontrollers are not permitted.
- You are limited to an expenditure of **\$150.00/team** for all materials and parts used in the construction of your project. Materials supplied to each team by SPDL, from the lab kit, or the Cabinet Of Freedom do not count against the limit. All other items count at their fair market value. **If it's an issue with something from the kit, we will provide a replacement for free, but we can't guarantee latency. Be careful with your components.**
- A project logbook must be maintained for each group. A blog is appropriate to meet this requirement as long as it is made available to the teaching staff for review. This log should reflect the current state of the project, planning for the future, results of meetings, designs as they evolve, etc. The project logbook will be reviewed at irregular intervals for evaluation.
- A report describing the technical details of the system will be required. The report should be of sufficient detail that a person skilled at the level of ME218c could understand, reproduce, and modify the design. The report must be in website format, and be suitable for posting on the SPDL site.
- BOSYNs or BOATs based substantially on purchased platforms are not allowed.
- All projects must respect the spirit of the rules. If your team is considering anything that may violate the spirit of the rules, you must consult a member of the teaching staff.

Safety:

- The BOSYNs should be safe, both to the user and the spectators.
- Caution: being on a BOAT may cause motion sickness.
- Warning: no virtual lifeguard on duty in the BAY.
- Intentionally ramming other BOATs is encouraged. However, prohibited actions include, but are not limited to, spraying water on to BOATs or BOSYNs, fouling the propulsion systems of BOATs, and/or jamming communications between BOSYNs and BOATs. Unless it's raspberry.
- No part of the BOAT may become ballistic.

¹That is, Layer 3 of the OSI model.

- Approved small portable electronic devices may now be used while away from harbor.
- There have been no proven negative health effects due to radiation from XBee networks.
- The teaching staff reserves the right to disqualify any device considered unsafe.

Checkpoints

Design Review:

On 5/9/23 we will conduct a design review, one team at a time. Each team should prepare a few images showing your proposed designs for the BOSYNs. You will have 5 minutes to walk us through your ideas. **The focus should be on system level concepts², not detailed hardware or software.** We will spend the balance of the time giving feedback and asking questions. In addition to your concepts, you must present, as a PDF, your plan for the development, integration and testing steps that you will follow to complete the project. The plan must identify what functionality you will demonstrate at the two checkpoints and the project preview along with the test procedures that you will use to prove that your team has met the checkpoint. Checkpoint tests must follow an incremental integration strategy with each successive checkpoint demonstrating all of the functionality of the prior checkpoint(s) as well as the new functionality. This plan must be approved by the teaching staff. If we feel that it is seriously flawed, we will ask you to revise and resubmit the following day.

It is the winnowing fan of death that makes for the development of animal life.

Chapman Cohen

First Draft of Communications Standard:

Due by 5:00 pm on 5/11/23. This draft will be made available to the entire class, so that everyone is ready to deliver feedback at the in-class review.

May I suggest that we no longer belabor the question of whether or not we should have gone after the creature? The matter has now been rendered academic. The creature is now after us.

Spock

In-Class Communications Standard Review:

In class on 5/12/23 we will conduct a top-to-bottom review of the Communications Committee's draft protocol. Bring your prepared questions, concerns, and suggestions for improvement! Everyone should attend, if possible—the more eyes we can put on the protocol early, the earlier we can catch the weird edge cases.

It is only in deep waters that a fish knows how strong it is.

Matshona Dhliwayo

Communications Standard:

Due by 5:00 pm on 5/13/23. This is the working draft of the communications standard.

As for me, I am tormented with an everlasting itch for things remote. I love to sail forbidden seas, and land on barbarous coasts.

Herman Melville

First Checkpoint:

On 5/15/23, you must demonstrate your approved 1st checkpoint functionality according to your defined testing procedure. Note: this is a functional evaluation only. The focus should be on demonstrating functional hardware and software. You may submit for approval a final revision of your checkpoint plan at this time.

The final working version of the communications standard is due. No further changes are allowed to the standard. This protocol will be evaluated with respect to its completeness and suitability for the proposed system.

Just keep swimming. Just keep swimming, swimming, swimming. What do we do? We swim, swim.

Dory

²I/O, signal conditioning architecture, etc.

Second Checkpoint:

On 5/22/23, you must demonstrate your approved 1st and 2nd checkpoint functionality according to your defined testing procedure. The functionality demonstrated at this time must include full implementation of the communications protocol.

Fishes live in the sea, as men do a-land; the great ones eat up the little ones.

William Shakespeare

Project Preview:

At the Project Preview on 5/29/23, each team must demonstrate (in addition to the 1st & 2nd checkpoints' functionality) your approved project preview functionality. The functionality demonstrated at this time must include a demonstration of interaction between at least 2 teams' BOATs and BOSYNs.

You're gonna need a bigger BOAT.

Chief Brody

Grading Session:

During the Grading Session on 5/30/23, each team will be required to demonstrate the ability to successfully participate in a game. This will include

1. Pairing with, and successfully operating, at least one other BOAT constructed by another team;
2. Demonstrating all required functionality of the BOSYN, including user interface and implementation of the Communications Committee-designed communications protocol, including:
 - (a) All functionality of the SWYMCN.
 - (b) All functionality of the CHOMPEN.
3. Demonstrating all required functionality of the BOAT, including propulsion, operation of the BYT(ER), and reading the inflation status of the BAYT.
4. Successful execution of at least sixty seconds of play, including at least one BAYT deflation event as PREI.

A detailed grading check-off procedure will be published at a later date.

When I left you I was but the learner, now I am the master.

Darth Vader

Public Presentation:

This will take place on 5/31/23 starting at 5:00 pm at the BAY (outside of Thornton). At this event, members of the public will be encouraged to watch you fight for shipping dominance of the Terman Harbor.

...because sharks have been around for a very long time. There were sharks before there were dinosaurs, and the reason sharks are still in the ocean is that nothing is better at being a shark than a shark.

Douglas Adams

Report:

Draft due on 6/6/23 by 4:00 pm. The final version (with revisions incorporated) is due by 5:00 pm on 6/9/23.

Fish are friends, not food.

Bruce

Celebration:

A celebration of the past 3 quarters of ME218 will take place at the Alpine Inn on 06/13/2022 starting at 3:00 pm. Mark your calendars now and save the date.

The wildebeest! They're changing colors!

Hyena In A Supporting Role

Performance Testing Procedures:

Each team will demonstrate their BOSYN and BOAT during the first & second checkpoints and project preview. Members of the teaching team will randomly assign a BOAT to each BOSYN during the grading session.

Grading Criteria:

- Concept (10%)** This will be based on the technical merit of the design and coding for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- Implementation (15%)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true aesthetics, but will concentrate on craftsmanship and finished appearance.
- First Checkpoint (10%)** Based on the results of the performance demonstrated on 5/15/23.
- Second Checkpoint (10%)** Based on the results of the performance demonstrated on 5/22/23.
- Preliminary Performance (10%)** Based on the results of the performance demonstrated during the Project Preview.
- Performance (20%)** Based on the results of the performance testing during the Grading Session.
- Report (10%)** This will be based on an evaluation of the report. It will be judged on clarity of explanations, completeness and appropriateness of the documentation.
- Report Review (5%)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work?
- Log Book (5%)** This will be evaluated by the evidence of consistent maintenance as well as the quality and relevance of the material in the log book.
- Housekeeping (5%)** Based on the timely return of SPDL components, cleanliness of group workstations as well as the overall cleanliness of the lab. No grades will be recorded for teams who have not returned all loaned materials.

Resources**Websites:**

SparkFun	Seed Studio	Jameco	Mouser
Newark	Ponoko	Adafruit	Hackaday
DigiKey	McMaster-Carr	HobbyKing	ServoCity

You may also find [PlantUML](#) and [PlantText](#) helpful for creating message sequence diagrams.

Local Stores (Not applicable while quarantine is in effect):

[J&M Hobby House](#) in San Carlos
[Jameco](#) in Belmont
[TAP Plastics](#) in various locations

Gems of Wisdom:

Be sure to check out [The ME218 Archive](#) for guidance from past generations.

Communication is relatively more fundamental this year than most years; however, keep in mind that there's still plenty to be doing while one of your teammates is getting the Comm Protocol sorted. Make effective use of this time to develop and test other systems.

Revision 0: Initial (5/3/23)