Memorandum

To: Kimberly Lemieux

From: Alex Klouda, Greyson Stelmaschuk

Date: September 15, 2022

Re: Marine Data Tracking Device

Summary

NMEATrax is a small device that pairs with an existing NMEA network to allow for the complete monitoring of vessel data wirelessly through a web interface. By increasing the availability of information and providing the ability to log, analyze, and replay data, NMEATrax can provide users with the knowledge required to optimize their boating experience. For this project to proceed, we need your approval by Monday, September 26, 2022.

Background

The internals of many modern boats more closely resemble a server room than an 18th-century sailboat. Boaters have come to rely upon marine electronics to fulfill the essential needs of navigation, communication, and safety. Today, many modern boats contain a complex network of instruments, sensors and displays. With the growing prevalence of networked devices, there has become a need for a unifying communication standard between these devices.

In 1983, The National Marine Electronics Association (NMEA) created the NMEA 0183 protocol to provide one-way communication for devices [1]. This standard served as a solution to the previous issues with standards and was quickly adopted by manufacturers gaining mainstream popularity.

By the year 2000, the needs of boaters had changed. The capabilities of computers have been doubling approximately every two years. With the developments of computing came an evolution of marine technology. With this, there became a need for a faster and more robust transfer protocol for marine data. To keep up with consumer needs, the National Marine Electronics Association again created a

new standard, named NMEA 2000. This new communication standard is a high-speed CAN bus supporting multiple talkers and listeners.

Competing marine manufacturers have also tried to make their own communication networks, such as Raymarine's SeaTalk, Simrad's Simnet, and Furuno CAN [2]. These systems closely resemble NMEA 2000 networks but utilize different connectors.

Proposed Solution

Our solution, NMEATrax, is a device that allows complete access to all the information related to the operation and position of your boat. It does this by reading data from NMEA compatible marine electronics. An easy-to-access web-based interface will be available from our device to allow users to quickly view readings on their smart devices. By displaying intuitive numerical readings and gauges, NMEATrax will allow you to make informed decisions while out on the water quickly.

A unique feature of the NMEATrax solution will be its ability to replay logged data. An additional desktop app we create will allow the user to import the information recorded from our device. This creates an opportunity for in-depth analysis and performance tracking over time.

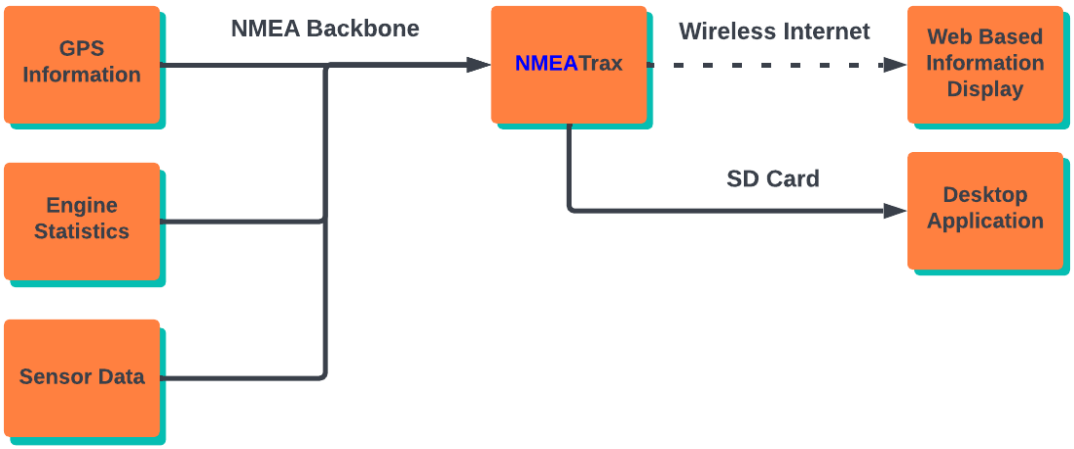

Figure 1. A Simplified Overview of NMEATrax interacting with a ship's network

Figure 1. shows the flow of information throughout a NMEA networked boat. The sensors and the ship's major systems generate data that then travels down the NMEA backbone to our device. Appendix. A illustrates an example of how a NMEA network could be implemented on a boat. Once received, the device interprets this data before being displayed on our web interface and saved to an SD card for desktop application use.

Product Goals

NMEATrax, as a group, is dedicated to creating a high-quality product. To create a successful and unique product, our team has identified several key goals that must be met:

1. To accurately read boat sensor data from a NMEA network.
2. To display this information clearly and wirelessly on a web interface.
3. To store historical trip data to allow users to replay previous trips.
4. To use cost-effective solutions to solve design challenges.

Timeline

Our group has created a timeline to organize our tasks to meet the project deadline of December 16 required for our product reveal. Milestones we look forward to include the creation of our proof of concept by October 10, 2022, the completion of our PCB design by October 21, and the completion of the final versions of our information displays by November 18. Appendix. B outlines a complete timeline of planned tasks for our team.

Past Milestones

Despite only recently coming together as a group, NMEATrax has completed several tasks necessary for the completion of our product.

I. Group Contract

In September of 2022, the members of NMEAtrax came together to create a contract outlining our values as a team. As a group, NMEATrax has pledged to uphold fair work standards relying on responsibility and collaboration and will strive to uphold our group values of cooperation, integrity, and optimism.

II. Declaration of Scope

Throughout early September the members of NMEATrax have worked collaboratively to determine the scope of this project. In order to differentiate our design from other devices we have determined that backwards compatibility, the logging of NMEA data, and convenience to be priorities.

III. Requirements and Tests

On September 21, 2022, the technical specifics and necessities for our device were decided upon. In addition, our group outlined the standards needed to create a high quality product and laid out the criteria for thorough testing procedures.

Technical Information

Data

As a complete NMEA monitoring system, our device has uses beyond displaying GPS data. The current NMEA standard is robust and capable of interfacing with marine electronics and the major systems of boats, allowing for monitoring speed, engine data, voltage levels, and more [3]. NMEATrax also contains an onboard LIS2HH12TR accelerometer used to detect waves to complement the data received from networked sensors.

Protocols

To allow for compatibility with most boats, our device interfaces with both NMEA 2000 and its predecessor, NMEA 0183. These communications standards are unique from one another, utilizing both different hardware and data structures [4]. To achieve backward compatibility, separate connections will be available for each standard.

NMEA 0183 is an asynchronous serial standard that allows for one way communication at a data rate of 4800 bits per second [4]. Boats utilizing NMEA 0183 can connect to our device through a screw terminal. This terminal directly interfaces the NMEA network with a MAX232 transceiver, where our device converts NMEA 0183's RS232/RS422 communication standard to a Transistor-Transistor Logic (TTL) level that is compatible with the ESP32 microcontroller inside of the device.

Improving upon NMEA 0183, NMEA 2000 utilizes a Controller Area Network (CAN bus) creating a network where information is shared in either direction at a speed of 250 kilobytes per second. On top of allowing for back-and-forth inter-device communication, the new bus topology also allows for devices to simply be added in parallel along the backbone [5]. Like other NMEA 2000 devices, our device can connect directly to the NMEA backbone using an M12 5-pin (micro-c) connector, allowing for plug-and-play connectivity.

ESP32

For our live data user interface to be displayed on mobile devices, WiFi must be used. The ESP32 microcontroller was selected for this purpose. They are powerful, cost-effective System-on-Chips capable of transmitting WiFi 802.11b/g/n [6].

Our group has selected an ESP32-WROOM-32UE-N16 module. During testing, we found that PCB based antennas did not provide adequate access point range. This led to the choice of the ESP32-WROOM-32UE; this chip is offered at a low price and interfaces with an external antenna powerful enough to meet our WiFi needs. Additional considerations applied to choosing which ESP32-WROOM-32UE model to use in our project. Despite having the highest price point, the largest memory model (N16) was chosen. Our choice will allow for unrestricted prototyping on our web interface, including the ability to add graphics and improve the user

experience. If the additional memory is unnecessary, an ESP32-WROOM-32UE-N8 will be substituted for the ESP32-WROOM-32UE-N16 microcontroller at a slightly lower price point.

User Interfaces

By connecting to the access point, users are able access the NMEATrax WebView. WebView is an interface created using JavaScript. It contains text-based information and gauges to present sensor and system information in a digestible format. This web page is powered by the ESP32 onboard the device.

An additional user interface is also available. Our device has been outfitted with a micro SD card to provide additional storage space required for logging voyage data. This information can then be retrieved for review by a desktop application. NMEATrax offers users a scrollable timeline of all recorded data including GPS location overlaid on top of a map with additional data displayed as text and gauges.

Logistics

The global supply chain has been plagued with issues creating shortages and creating long shipping times for electrical components. To deliver a high-quality product on time NMEAtrax has decided to source all components locally or from Digikey, a reputable US based electronics retailer. This will allow high-quality parts to be sourced quickly with little lead time, allowing time for the prototyping of the device.

The process required for official NMEA 2000 certification is both time consuming and prohibitively expensive. Because of this, we have opted not to have our product NMEA 2000 Certified.

Financial Information

NMEA related technology is considered a luxury for pleasure craft operators and with this comes a high price. A goal of NMEATrax is to increase accessibility by providing a device at a lower price point than devices currently available on the market. Through design consideration and the careful selection of components a low-cost product has been designed.

Forgoing the need for an expensive display, our product utilizes the owners' mobile devices to display the information. This provides a convenient and portable high-definition display, allows for multiple displays to be connected simultaneously and significantly reduces the manufacturing cost of the system.

Comparative NMEA data displays can retail for over $600 CAD [7][8]. With a total component cost of $48.12 CAD. NMEATrax brings to market a device that can be manufactured with a component cost. Table. 1 includes the price of all major components outlining the price necessary to build this device.

Table 1. A Cost Breakdown of Major Components

Hardware		
Description	Component	Cost
ESP32 Wifi Module	ESP32-WROOM-32UE-N16	**CA$5.46**
SD Card Socket	MEM2051-00-195-00-A	**CA$1.71**
Accelerometer	LIS2HH12TR	**CA$2.84**
Can Transceiver	MCP2562-H/P	**CA$2.17**
RS323 Transceiver	MAX232ECN	**CA$2.62**
16 Pin USB-C Connector	USB4105-GF-A	**CA$1.15**
2 Port Screw Terminal	691137710002	**CA$0.41**
Micro-C Connector	M12 5-pin	**CA$25.00**
WiFi Antenna	Glue rod antenna(IPEX-1)	**CA$1.77**
Print Circuit Board	Custom PCB	**CA$5.44**
TOTAL COST:		**CA$48.58**

Conclusion

Information is an important commodity. By combining backwards compatibility with low production costs, NMEATrax allows access to information that boaters would have been previously inaccessible to. Fast product approval will help create the best possible product.

References

[1] K. Betke, “The NMEA 0183 protocol,” TRONICO, Aug-2001. [Online]. Available: https://tronico.fi/OH6NT/docs/NMEA0183.pdf. [Accessed: 23-Sep-2022].

[2] Paul, “Beginners Guide to NMEA 2000, NMEA 0183, and Bridging,” *Boat Projects*, 04-Dec-2012. [Online]. Available: http://boatprojects.blogspot.com/2012/12/beginners-guide-to-nmea-2000-nmea-0183.html. [Accessed: 23-Sep-2022].

[3] K. Englert, “The basics of NMEA 2000,” Boating Mag, 26-Mar-2022. [Online]. Available: https://www.boatingmag.com/gear/basics-nmea-2000/. [Accessed: 23-Sep-2022].

[4] “Interfaces; RS-232, RS-422, NMEA 0183,” NoLand Engineering. [Online]. Available: https://www.nolandeng.com/downloads/Interfaces.pdf. [Accessed: 23-Sep-2022].

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[6] Texas Instruments, “2.4 GHz WiFi + Bluetooth ® + Bluetooth LE module,” *ESP32WROOM32E ESP32WROOM32UE datasheet*, 18-May-2020 [Revised 20-July-2022]. [Online]. Available: https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32e_esp32-wroom-32ue_datasheet_en.pdf. [Accessed: 24-Sep-2022].

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[8] “Multifunction NMEA 2000, Simnet & SeaTalk NG,” *Wema UK*. [Online]. Available: https://wema.co.uk/products/nmea-2k-multi-function-display-7-touch-screen. [Accessed: 23-Sep-2022].

[9] By Femnett/Maretron, LLP - Maretron, LLP, CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=9815260

Appendix. A

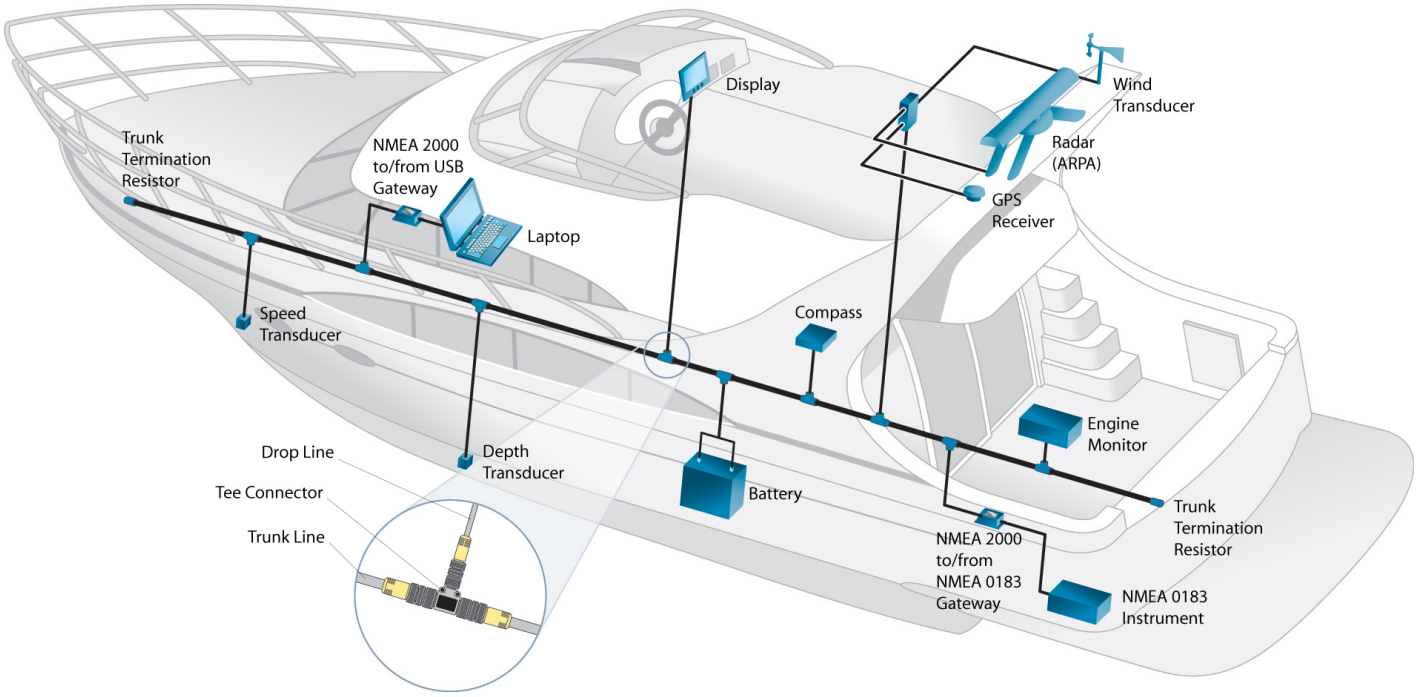

Figure 2. Example NMEA 2000 Integration [9].

Appendix. B

ESP32 Web App	50 days	Mon 9/12/22	Fri 11/18/22		Alex Klouda[10%]
ESP32 Data Input	50 days	Mon 9/12/22	Fri 11/18/22		Alex Klouda[10%],Greyson Stelmaschuk[20%]
Replay App	40 days	Mon 9/26/22	Fri 11/18/22		Alex Klouda[10%],Greyson Stelmaschuk[20%]
Order Parts	0 days	Fri 9/16/22	Fri 9/16/22		
Proof of Concept Prototyping	21 days	Mon 9/12/22	Mon 10/10/22		Alex Klouda[70%],Greyson Stelmaschuk[60%]
Build Schematic	5 days	Tue 10/11/22	Mon 10/17/22	5	Alex Klouda[70%],Greyson Stelmaschuk[60%]
PCB Layout	4 days	Tue 10/18/22	Fri 10/21/22	6	Alex Klouda[70%],Greyson Stelmaschuk[60%]
Order PCB	2 days	Mon 10/24/22	Tue 10/25/22	7	Alex Klouda[70%]
Assemble PCB	5 days	Tue 11/15/22	Mon 11/21/22	8FS+14 days	Alex Klouda[70%],Greyson Stelmaschuk[60%]
Testing	14 days	Tue 11/22/22	Fri 12/9/22	3,1,2,9	Alex Klouda,Greyson Stelmaschuk
Capstone Presentation	0 days	Fri 12/16/22	Fri 12/16/22	10	Alex Klouda,Greyson Stelmaschuk

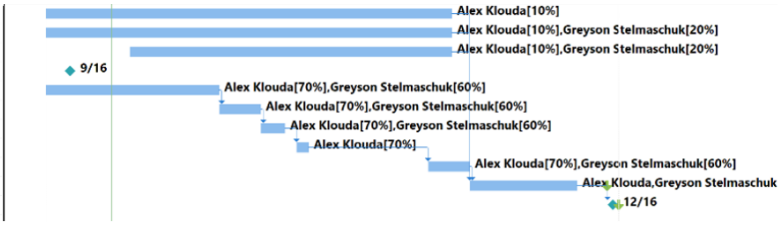

Figure 3. A gantt chart created by NMEATrax outlining our expected schedule.