Memorandum

To: Kimberly Lemieux

From: Alex Klouda, Greyson Stelmaschuk

Date: October 30th, 2022

Re: Marine Data Tracking Device

Summary

Hi Kimberly, we hope you are well; the NMEATrax group has made excellent progress on our project. Our group has managed to meet all design goals within the time allocated. Major milestones met so far include:

- Successfully capturing and processing both NMEA0183 and NMEA2000 data.
- Designing and ordering the PCB for our device.
- Accurately logging information to an SD card.
- Providing proof of our concept by capturing data from a real NMEA2000 network onboard a vessel.

In the coming weeks, our group will manufacture our device's enclosure and create our desktop application to view recorded information. We look forward to meeting the rest of our design goals and are excited to share our product at the December 15th symposium.

Background

NMEATrax began in September of 2022 as a project group at Camosun College in Victoria, B.C. Canada with the expressed goal of creating an accessible, high-quality marine information display.

Inspiration

Electronics have become ubiquitous in modern boating; many boaters rely on networked instruments for recreation and to fulfill the essential needs of navigation, communication, and safety [1]. Unfortunately, networked displays come with a prohibitive cost. Our group, NMEATrax, proposes a solution to the high expenses preventing boaters from accessing their networked data.

Opportunity

Despite many other proprietary standards, NMEA protocols have become fixtures onboard vessels, with uses ranging from industrial marine to pleasure craft operation. Created by the National Marine Electronics Association (NMEA), the current NMEA2000 marine data protocol and its predecessor, NMEA0183, provide a framework for ship electronics to communicate without compatibility issues [2]. Improving upon the low bitrate and one-way communication of NMEA0183, NMEA2000 provides a high-speed CAN bus that allows any device to send and receive data [3].

Vision

Our product, NMEATrax, is a device that allows low-cost access to the information related to the operation and position of any vessel. Design choices, including utilizing mobile devices already owned by users as high-definition displays, have been incorporated as a new, low-cost way to display marine information. Our device is self-contained, requiring no external services while offering features not found in other information displays, including our voyage replay feature.

Progress

Our group has already completed many of our design goals. As a result, our group's product development is in line with our projected timeline and budget. Figure 1. shows a timeline of the significant milestones completed by our group so far.

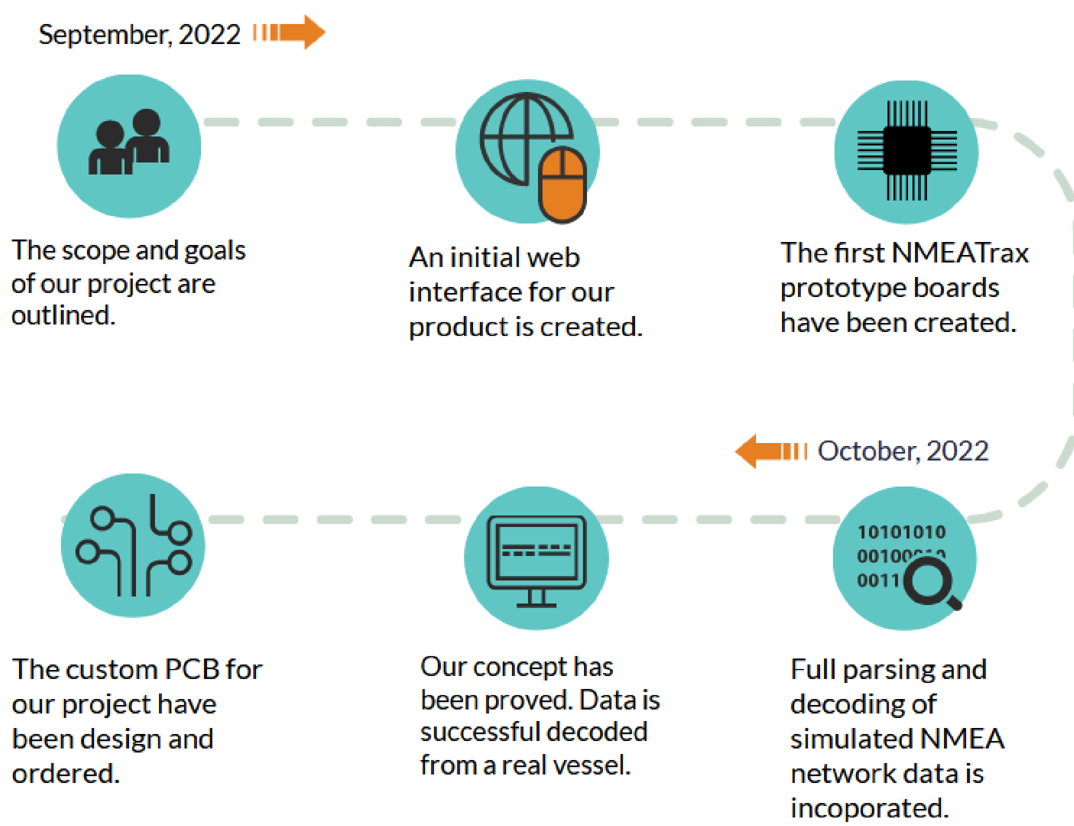

Figure 1. A brief overview of completed product design goals.

The NMEATrax team will maintain our current schedule through dedication and structured designed practices. We expect product development to be complete before the December 2022 deadline.

Hardware Design

To create a device suitable for a competitive market, NMEATrax has carefully considered each design choice to maximize the cost-effectiveness of our PCB.

As a result, we have selected an ESP32-based design. The ESP32 is one of the highest cost to performance System On Chips (SOCs) available [4]. In addition, the ESP line of SOCs are simple to program with their vast availability of libraries making them the optimal choice for this project.

PCB

To include all the features required for our product, we have created a custom 4-layer PCB that will be manufactured in China by JCLPCB. With the help of Justin Curran, our PCB design stage was a smooth process, with a total development time of two weeks.

Figure 2. shows our complete design; we are awaiting the arrival of our PCB and PCB-mounted components. Once all necessary hardware has arrived, we will begin assembly. We expect to have our finished PCB assembled by mid-November.

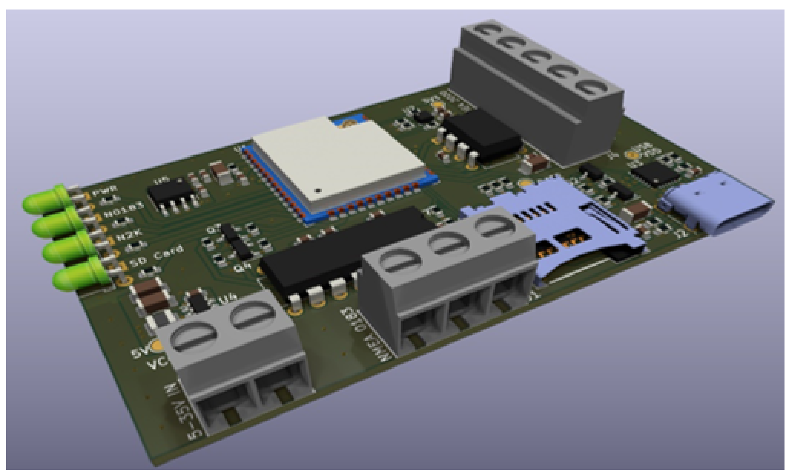

Figure 2. A 3D rendering of our complete PCB design.

Enclosure

Our group determined that a small form factor is essential to creating a low-cost product. From inception, our team has considered this and created a PCB with a small footprint of less than 5cm by 10cm that can be sheltered even in the smallest marine electronics cabinet. The protection provided by the electronics cabinet allows our device to avoid the harsh ocean environment, forgoing the need for an expensive, corrosion-proof, and waterproof design.

Our enclosure is in the initial stages of design. Our group envisions a 2-piece design that provides impact protection, vibration damping and multiple mounting options, all while allowing easy access to all connectors and LED indicators. Figure 3. depicts a rendering of a potential enclosure design.

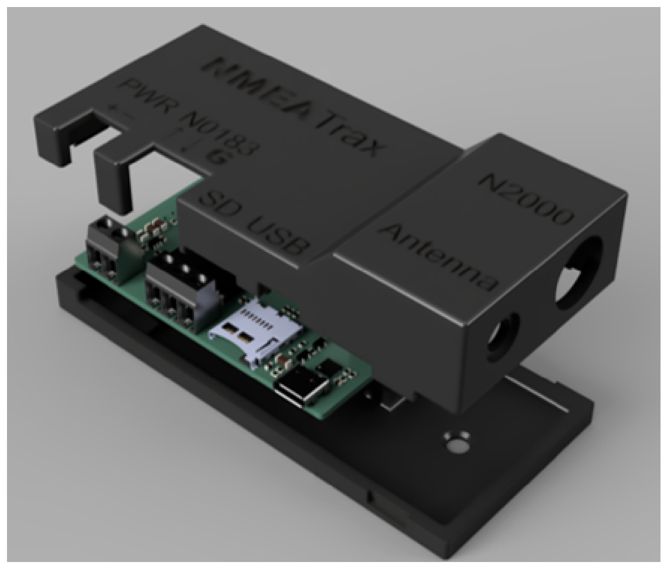

Figure 3. A 3D rendering of an early enclosure designed for our device.

Accelerometer

Our PCB will eventually incorporate an accelerometer to record encounters with large waves. We are waiting on the production of the PCB to allow us to develop accurate and properly calibrated accelerometer wave recognition software. By using the Adafruit LIS3DH accelerometer library, we expect development to be simple and appropriate for our design timeline [5].

Firmware Design

Our device prototype, driven by an ESP32 SOC, provides the firmware necessary for us to easily interface with the low-level data in our system.

Data

Due to the vast amount of information flowing through a NMEA network, displaying all information simultaneously would lead to a convoluted and confusing user experience. We have identified the most relevant information to our users' needs through real-world testing. Appendix A. shows the marine network data our group has selected to be read and processed.

NMEA2000

The highest priority and purpose of this project is to read and decode NMEA2000 data from a vessel's network. Completing one of our primary goals, our group has successfully implemented this feature. Figure 4. shows a small portion of NMEA2000 data captured by our device from a real vessel.

NMEATrax achieved this by using an extensive *NMEA2000* library developed by Timo Lappalainen and Kave Oy. This library is licensed under the MIT license providing free use. The *NMEA2000* library manages the parsing of incoming data [6]. Our code then takes the decoded data and sends it to the web server and the SD card.

```
In Main Handler: 127488
Engine rapid params: 0
  RPM: 618.00
  boost pressure (Pa): not available
  tilt trim: 0
In Main Handler: 127493
Transmission params: 0
  gear: forward
  oil pressure (Pa): not available
  oil temperature (C): not available
  discrete status: 0
```

Figure 4. A text file containing parsed and decoded vessel network NMEA2000 information.

NMEA0183

Our device is now able to decode all information contained in NMEA0183 sentences. Easy to use, adaptable, and available for free use under GNU licensing, the *Tiny GPS Plus* library created by Mikal Hart is an excellent fit for our project [7]. This library provides ESP devices an interface to easily parse and decode any data on NMEA0183 networks.

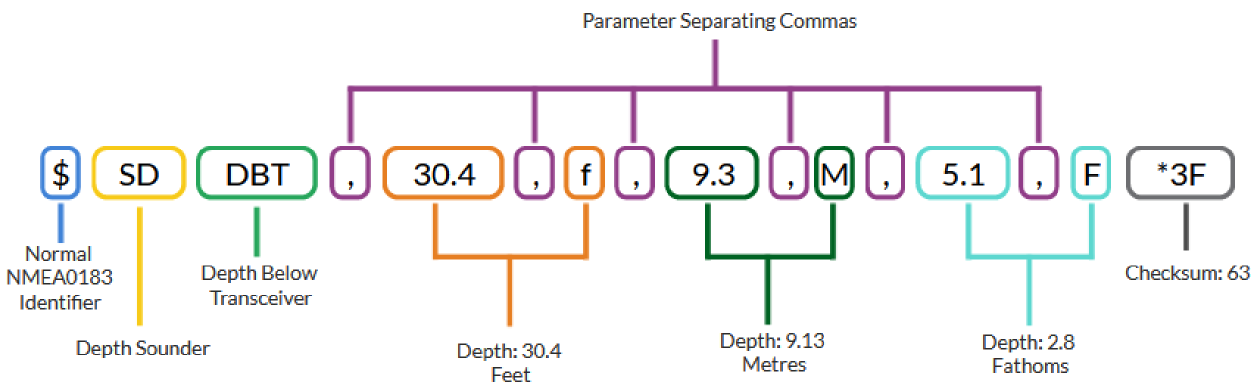

Figure 5. A parsed NMEA0183 sentence with a brief description of the meaning of each parameter.

NMEA0183 data is encoded as simple-to-understand ASCII characters arranged into NMEA0183 sentences. Figure 5. demonstrates how NMEA0183 sentences displayed in ASCII can be simply understood without the use of a computer [8]. The ESP32 incorporated in our device can quickly extrapolate information from this format translating obfuscated strings into digestible information.

Web Server

Our web interface allows users to view the NMEA data as gauges or as text in a table, with the latter designed and tailored to the specific needs of mobile users. In addition, our web server is now customizable; users can modify settings, including local WiFi SSID and password, recording intervals, and units. Figure 6. is the current mockup of our potential gauge-driven interface.

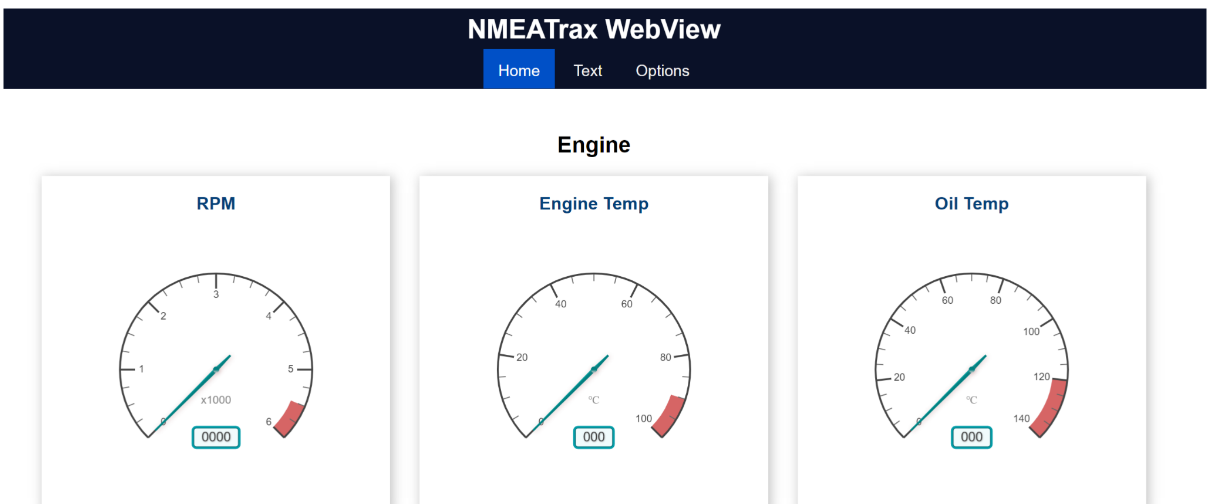

Figure 6. A current image of our device's gauge-based information display.

The ESP32 on the NMEATrax device will host a local web page for the user to connect to and view live NMEA data. The web server works by sending a JavaScript Object Notation (JSON) string containing all of the NMEA data to the client device when requested. The JavaScript embedded on the web page then breaks the JSON string into individual variables used to display the data. The user is given a choice for NMEATrax to connect to an existing wireless network or broadcast its own.

SD Card

The NMEATrax device implements an SD card to allow the user to store parsed NMEA data for review. The user can control the rate at which memory is written by configuring the speed at which their data is logged. Our device creates a file storing the information as a list of JSON strings. This file will be available for download from our web server or to be retrieved from the onboard SD card for replay on our desktop app.

Integration

Our project currently exists as two separate prototype boards with two individual code bases. We await the arrival of our custom PCB; once it arrives, a final prototype will be built. Our group will work to integrate NMEA0183 parsing and decoding into the NMEA2000 project containing the web display and data logging code, creating a complete design. Combining these two platforms is an exciting step for our group and the beginning of the evaluation process for our potential final symposium-ready product.

Media

Without a boat, our NMEATrax device is a small box containing electronics. To prepare our project presentation for the December symposium, we must create media to highlight our device's capabilities. To showcase the exciting features of our device, a video of actual captured vessel data will be presented along with print media that outlines our device's available features. In addition, if our group continues to meet design deadlines, we will have the opportunity to create more forms of supplementary media to incorporate into our presentation.

Conclusion

Our group is currently on budget and has already completed most of our primary goals outlined for our product's design. However, despite considerable progress, continued effort is necessary to create the most refined product possible. In the immediate future, we will assemble our prototype, including our custom-made PCB, integrate NMEA0183 information and begin to lay out design specifications for our desktop replay application.

While our group still has future goals to meet, we look forward to achieving them as we prepare to reveal our product.

References

[1] K. Englert, "The Basics of NMEA 2000," Boating Mag, 21 November 2014. [Online]. Available: https://www.boatingmag.com/gear/basics-nmea-2000/. [Accessed 30 October 2022].

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[4] I. Hübschmann, "ESP32 for IoT: A Complete Guide," nabto, 28 August 2020. [Online]. Available: https://www.nabto.com/guide-to-iot-esp-32/. [Accessed 30 October 2022].

[5] C. Nuson, "Arduino Library for Adafruit LIS3DH breakout board," 7 July 2022. [Online]. Available: https://github.com/adafruit/Adafruit_LIS3DH. [Accessed 30 October 2022].

[6] T. Lappalainen and K. Oy, "NMEA2000," 27 October 2022. [Online]. Available: https://github.com/ttlappalainen/NMEA2000. [Accessed 30 October 2022].

[7] M. Hart, "TinyGPSPlus," 20 September 2022. [Online]. Available: https://github.com/mikalhart/TinyGPSPlus. [Accessed 30 October 22].

[8] E. S. Raymond, "NMEA Revealed," 9 October 2022. [Online]. Available: https://gpsd.gitlab.io/gpsd/NMEA.html. [Accessed 30 October 2022].

[9] "NMEA 0183 Rx Sentence to NMEA 2000 Tx PGN List," ONWA Marine Electronics, 26 January 2022. [Online]. Available: https://onwamarine.com/nmea-0183-rx-sentence-to-nmea-2000-tx-pgn-list/. [Accessed 30 October 2022].

Appendix A.

Table 1. An overview of imported networked information [9].

NMEA2000 PGN	NMEA0183 Identifier	Name	Description
127250	HDG, HDM, HDT, VHW	Vessel Heading	Direction the vessel is facing
127488	RPM	Engine Parameters, Rapid Update	Frequent updates of RPM and leg tilt
127489	—	Engine Parameters, Dynamic	Oil pressure, oil temp, engine temp, etc.
127493	—	Transmission Params	Forward, Neutral, and Reverse
127505	—	Fluid Level	Fuel level
128267	DBT, DPT	Water Depth	Water depth with optional offset
129025	—	Position, Rapid Update	Frequent update of location
129026	VTG	COG & SOG, Rapid Update	Speed over ground and course over ground
129029	GGA, GLL, RMC, ZDA	GNSS Position Data	Satellite data with position and time
129283	APB, XTE	Cross Track Error	Distance from guided route
130312	MTW	Temperature	Sea temperature
130316	—	Temperature, Extended Range	Exhaust temperature