RoboSub Autonomous
Inertial Measurement Unit Calibration

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Background
IMUs are a complex combination of sensors commonly used in robotics to create a positional reference using a body’s specific force, angular rate and surrounding magnetic field. Because of the complicated signal processing that takes place onboard an IMU, they need to be calibrated very often. This is due to misalignment of sensors on the physical board, bias voltages that exist in the surrounding magnetic field.

Technical Description
The IMU Calibration system is comprised of three distinct systems. A central computer serves as the master CU, overseeing the entirety of the calibration process. An Arduino Mega serves as the motor control electronics for when autonomous calibration is performed, and the system lastly interfaces with the UUV’s onboard TRAX IMU.

Manual Calibration
The IMU table affords the user the option of completing a calibration routine manually by physically maneuvering the table. Though this process is tedious, it assures that the user may utilize the table even if the automated system cannot support any specific routine. It is important to note that the manual calibration system will still report an accuracy score from the TRAX once the routine has finished. Thus, no virtual features which enhance the accuracy of the system will be lost.

Automated Calibration
Arduino Mailbox: USB serial class to handle communication to and from Arduino. Built-in CRC, loss of com and general error checking is included. Integrated with a multi-threaded RTOS to efficiently handle serial RX events and update all other components of the automated system.

Threaded Stepper Control:
To further compliment the autonomous systems present within the Arduino’s UART communications, threading was integrated into the software drivers for each stepper motor as well. This allows for robust control over the accuracy and speed of the motors. The figure to the right depicts the initialization of one stepper instance.

Results
The team was able to consistently perform successful manual calibrations of both the accelerometer and magnetometer. According to the TRAX IMU user guide a successful calibration for the accelerometer has a calibration score of under 1.0 and a successful calibration for the magnetometer has a calibration score of under 2.0. If the system is not calibrated steadily it will result in either a failed accelerometer score or a failed magnetometer score. The team was unable to test automated calibrations due to lack of motors.

Future Work
Robosub will need to have the mounts for the motors designed and then installed onto the table. The automation software will need to be fully integrated with the manual calibration software in order to complete dual-mode functionality. Although live stepper motor data, the club will have to edit pieces TRAX mailbox software in order to implement the live data output from the TRAX. The team recommends that research be done on a C++ GUI library that contains support for Linux operating systems at the very least, but supports multi-platforming if possible. This will allow the GUI to be integrated with the software without library/language conflicts.

Glossary
CRC: Cyclic Redundancy Check
CU: Commanding Unit
IMU: Inertial Measurement Unit
RTOS: Real-Time Operating System
UART: Universal Asynchronous Receiver/Transmitter
UUV: Unmanned Underwater Vehicle
USB: Universal Serial Bus

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Design Objectives
• Calibrate the TRAX IMU to within 2 degrees accuracy
• Expandability for various calibration routines
• Safe to use
• Perform manual and automated calibration routines

Broader Impacts
Cheaper/faster alternative to conventional calibrations
• Able to calibrate IMU while in system
• No wasted man hours
Making IMU calibration more accessible to board range of applications and industries