Upright Sensor Module

A Custom PCB for Wheel-Speed and Inertial Data Acquisition on Orion

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Fall 2025 – Spring 2026

The Upright Sensor Module (USM) is a custom printed circuit board developed to measure per-wheel rotational speed and three-axis inertial data on Orion, Longhorn Racing's Formula SAE electric vehicle. Four Hall effect sensors arranged in a precise 45° arc detect magnets embedded in each upright; wheel speed is computed from the time interval between signal peaks. An on-board inertial measurement unit captures gyroscopic data, and a CAN transceiver streams combined sensor output to the vehicle's data acquisition network alongside the Thermal Sensor Module (TSM) and Corner Sensor Module (CSM). Two complete design revisions (A and B) were developed and validated, producing a race-ready module that now provides live wheel-speed and IMU telemetry to the vehicle's main controller.

1. Introduction

The front upright is a critical node in the Orion data acquisition chain, providing raw per-wheel rotational data required for vehicle dynamics analysis and active systems tuning. The USM replaces earlier wheel-speed measurement approaches with a compact, sensor-rich PCB that integrates both Hall effect rotational sensing and on-board inertial measurement into a single module with CAN output. This report describes the design rationale, two-revision development process, and final integrated hardware.

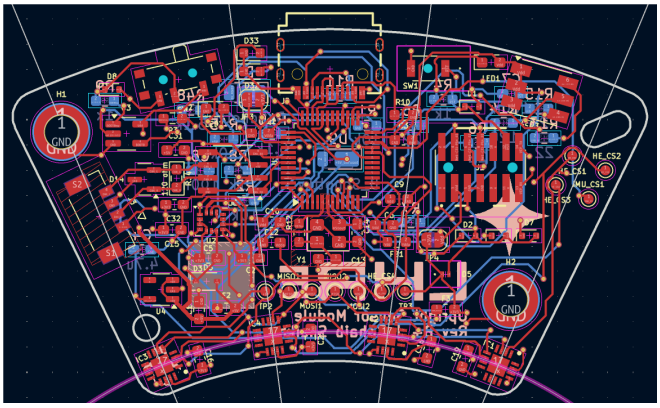
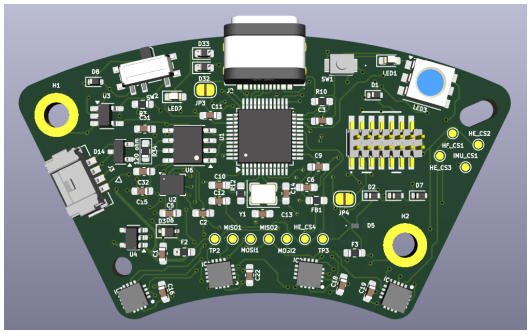
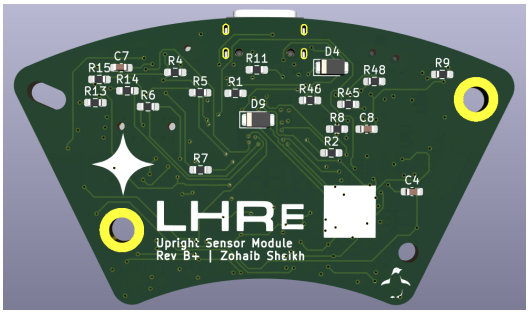


Figure 1. Revision B PCB layout. Four Hall effect sensors sit on a 45° arc with exact 15° spacing, matched to the upright magnet geometry.

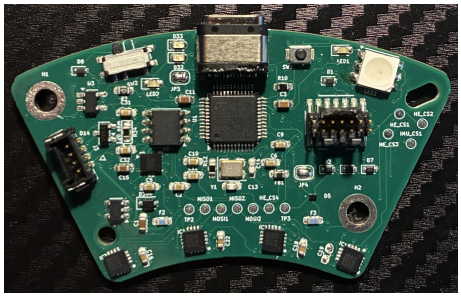
2. Revision B: Race-Ready Module



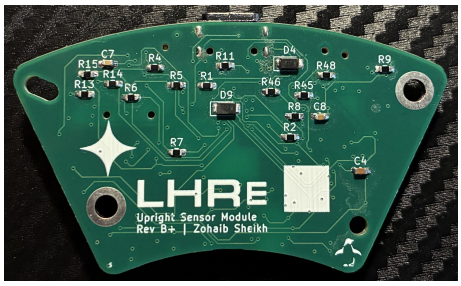
(a) 3D render, front side.



(b) 3D render, back side.



(c) Assembled (front).



(d) Assembled (back).

Figure 2. Revision B: renders and populated hardware.

Rev B is the production revision integrated onto the vehicle. It carries four Hall effect sensors on a curved outline matched to the upright geometry, a single IMU, and a CAN transceiver. Wheel speed is derived from the temporal spacing of Hall sensor signal peaks, a method robust to individual sensor orientation since only peak timing is used.

3. Engineering Approach

Design & Iteration

I took ownership of the project at the start of the Fall semester and moved through multiple schematic and layout revision cycles. Rev A was manufactured on 10/25/25 and fully assembled by the end of the semester. A schematic-level pin mismatch on the RGB LED delayed validation, but testing over winter break confirmed that the Hall effect sensors functioned correctly, clearing the path to begin Rev B with an informed redesign.

Rev B was manufactured on 2/12/26 and reached full assembly, validation, and vehicle integration, including working firmware, by 4/7/26. The module currently streams live wheel-speed and IMU acceleration data over CAN, with ongoing tuning of the wheel-speed extraction algorithm.

Mechanical Constraints & Coordination

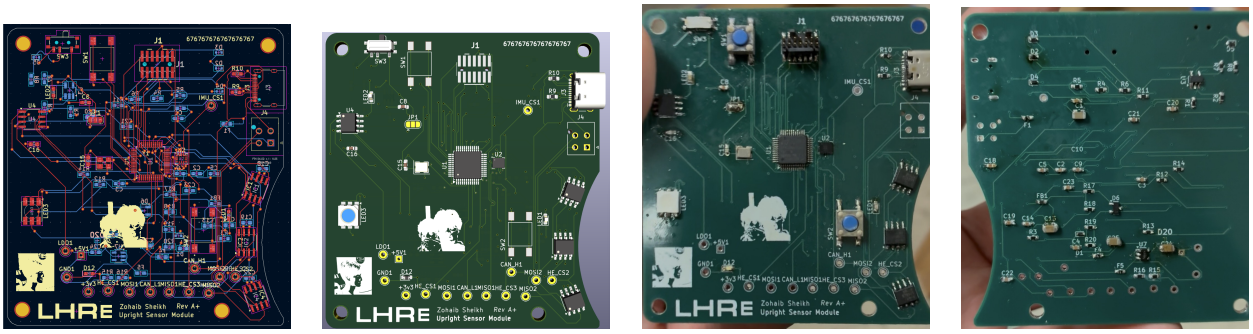
The Rev B layout was the most demanding phase of the project. I coordinated directly with the enclosure team to adjust board outline, swap footprints, and negotiate connector placement so that the USB-C port and MOLEX connector would not interfere with the Dynamics or Body subsystems. A defining

constraint was the placement of the four Hall effect sensors at exact 15° intervals spanning a 45° arc, a geometric requirement driven by the upright magnet spacing that tightly bound the allowable component placement.

Harness Integration

Beyond the PCB itself, I minimized downstream harness complexity by specifying a four-pin connector interface and coordinating the USM's pinout with the broader vehicle harness I authored in RapidHarness, which connects 33 PCBs and over 180 meters of wiring across the car.

4. Revision A: Preliminary Prototype



(a) PCB layout. **(b)** 3D render. **(c)** Assembled (back). **(d)** Assembled (front).

Figure 3. Revision A: layout, render, and populated hardware.

Rev A was the initial design iteration, serving as the functional proof-of-concept. Microcontroller, CAN transceiver, IMU, and power regulation blocks were all validated, establishing the electrical foundation carried into Rev B.

5. Manufacturing & Delivery

A production batch of four assembled Rev B boards, one per wheel, was delivered for vehicle integration. Each board is mechanically and electrically identical, simplifying installation and spares handling across the four corners of the car.

(a) Assembled Rev B boards staged for integration. **(b)** Rev B installed on the rear upright assembly.

Figure 4. Rev B from assembled batch to vehicle integration.