Occupancy Detection and Distraction Detection with a Passive Sensor System Configuration

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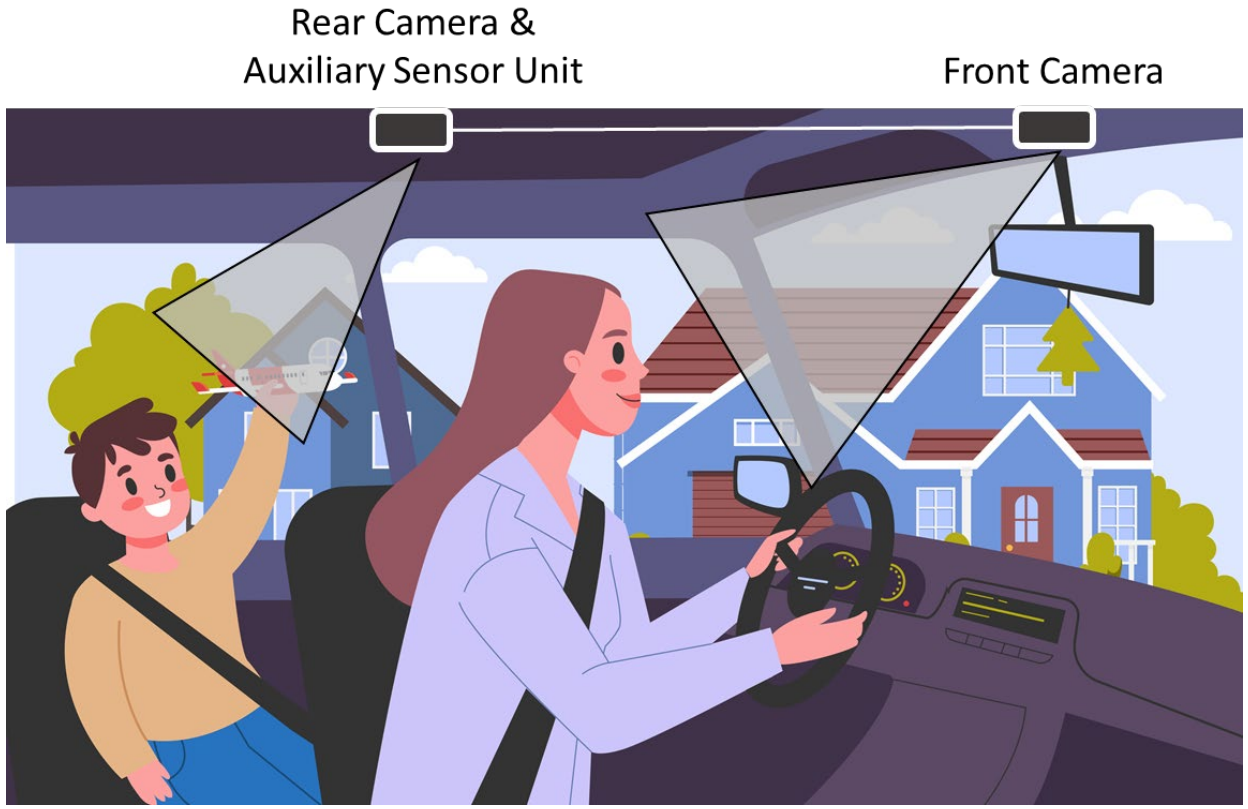
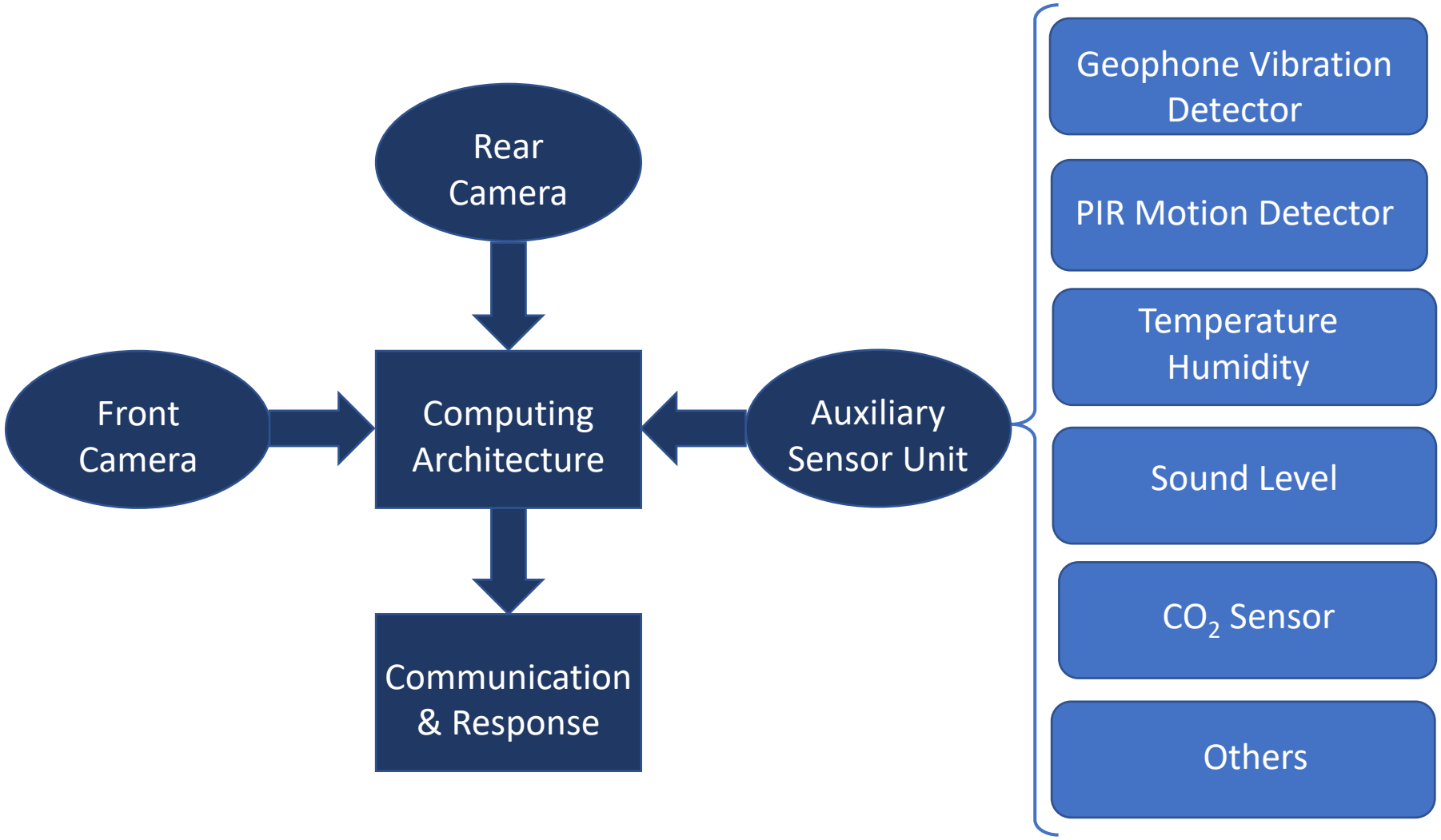
System Concept

- Occupant(s) presence
- Presence of unattended children
- Safe Driving Settings
- Seat belt (non)-use, misuse
- Occupants in unsafe positions
- Drowsy drivers
- Distracted drivers



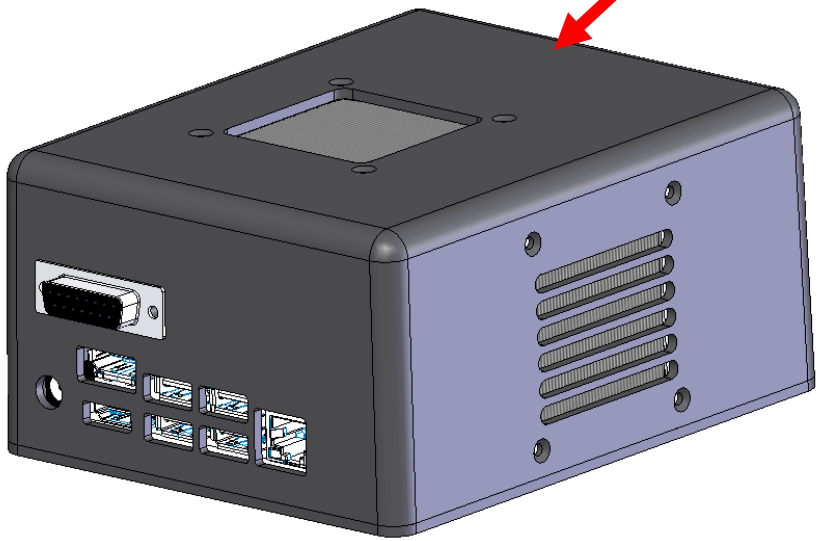
Architecture

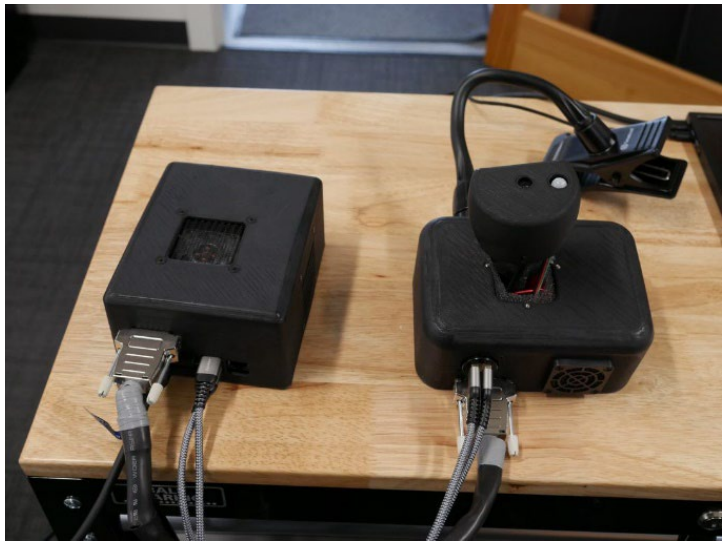


Occupant Sensing Unit System

Sensor unit,
Located in
rear cabin

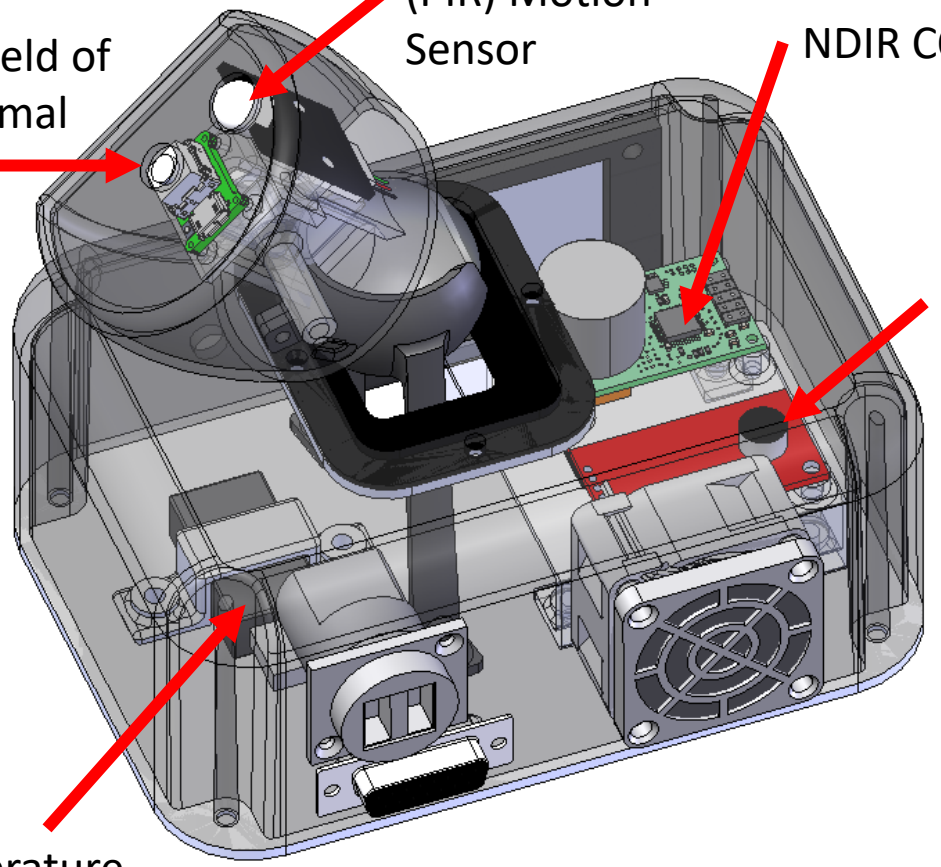
Hub unit, power supply to
Sensor unit and
data/alarm processing

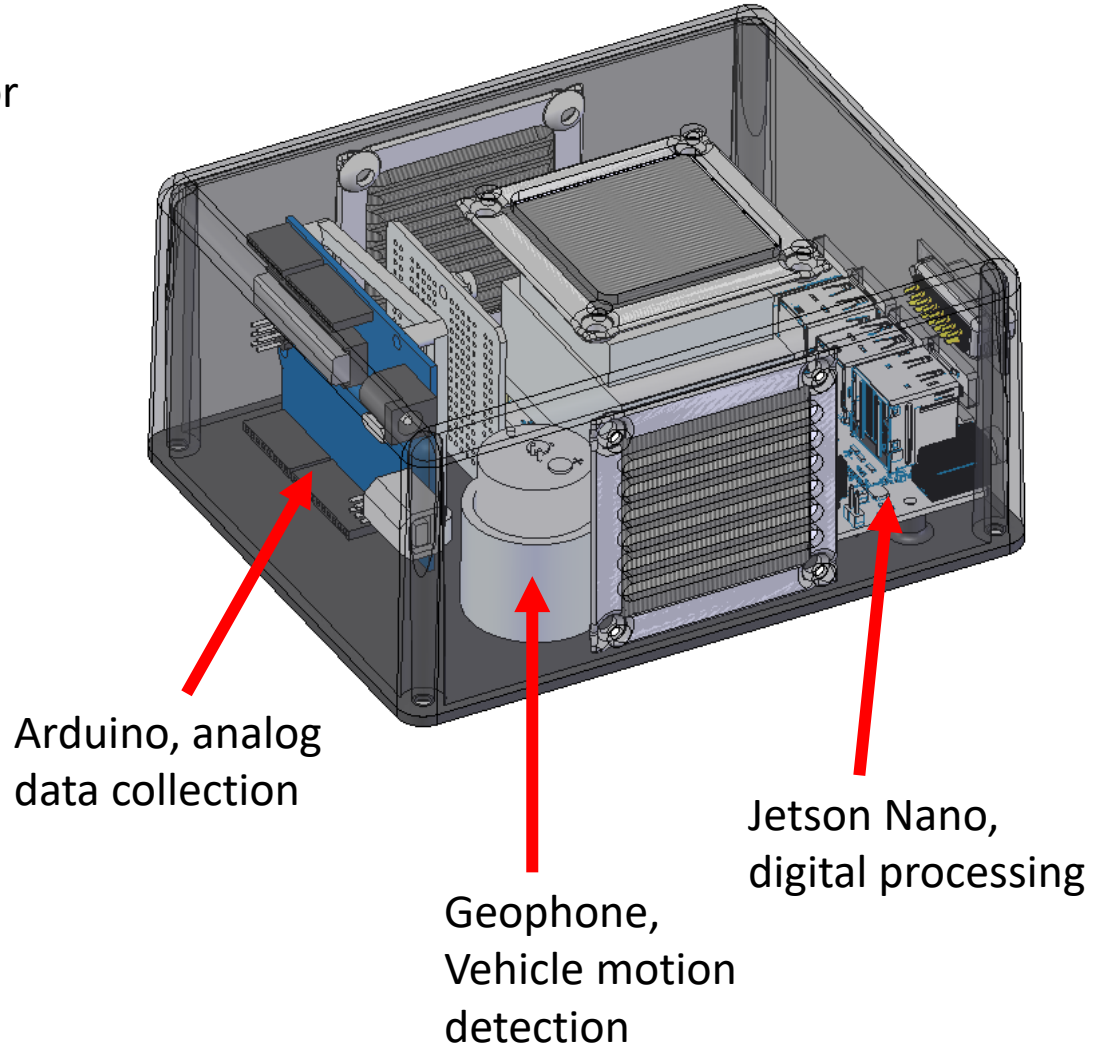




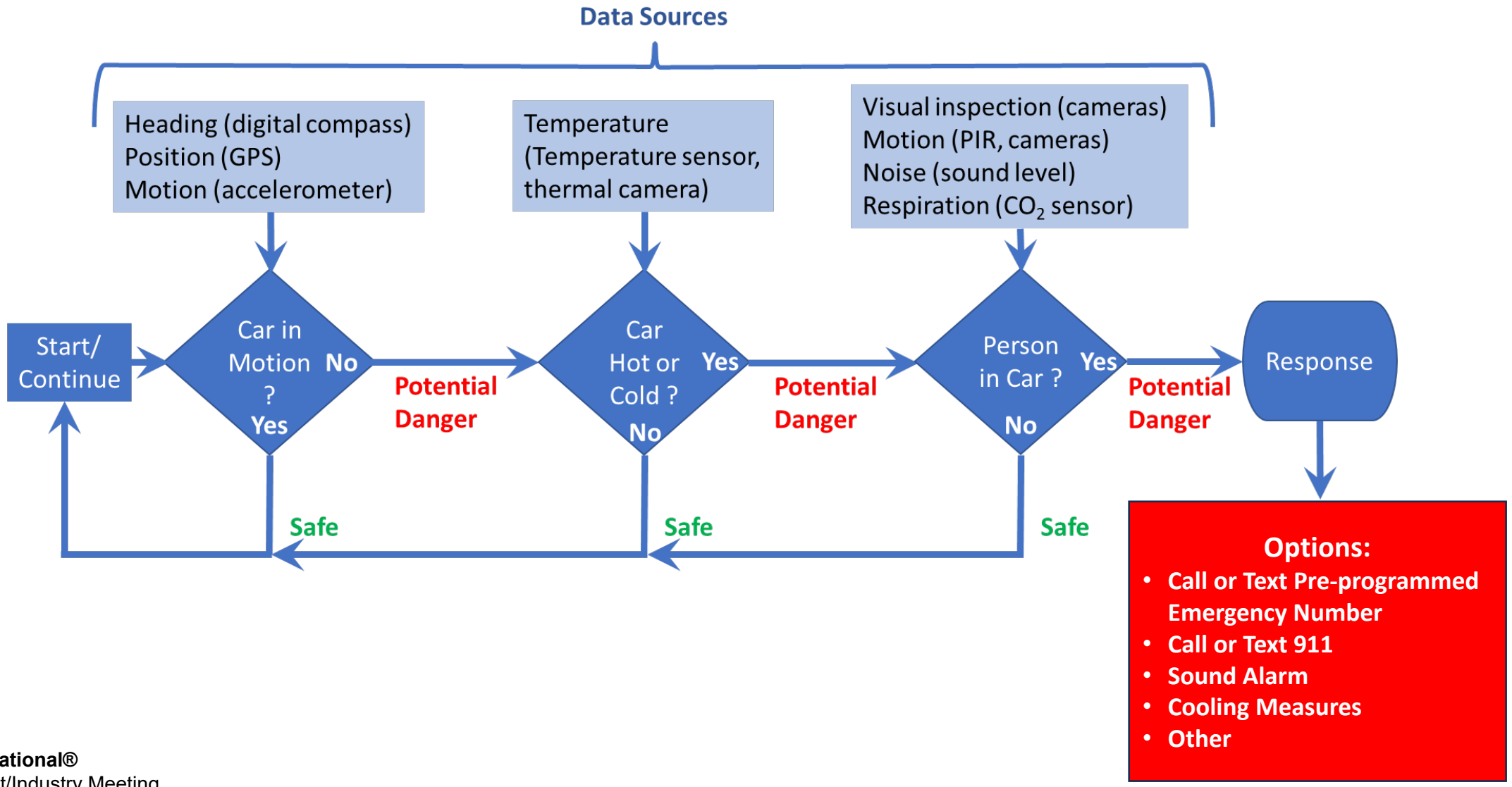
Connected System

Internal Views

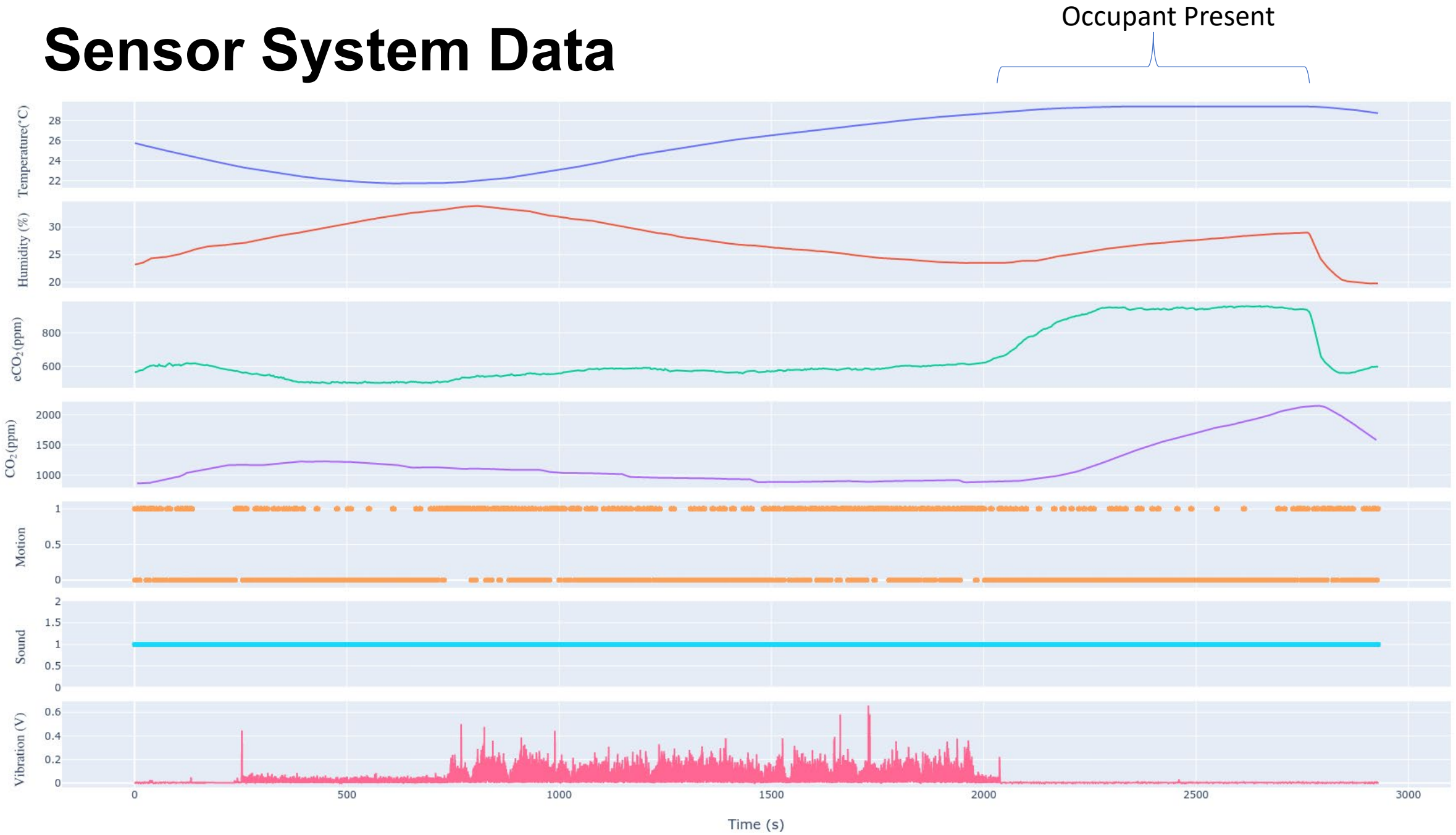




Occupant Detection Algorithm

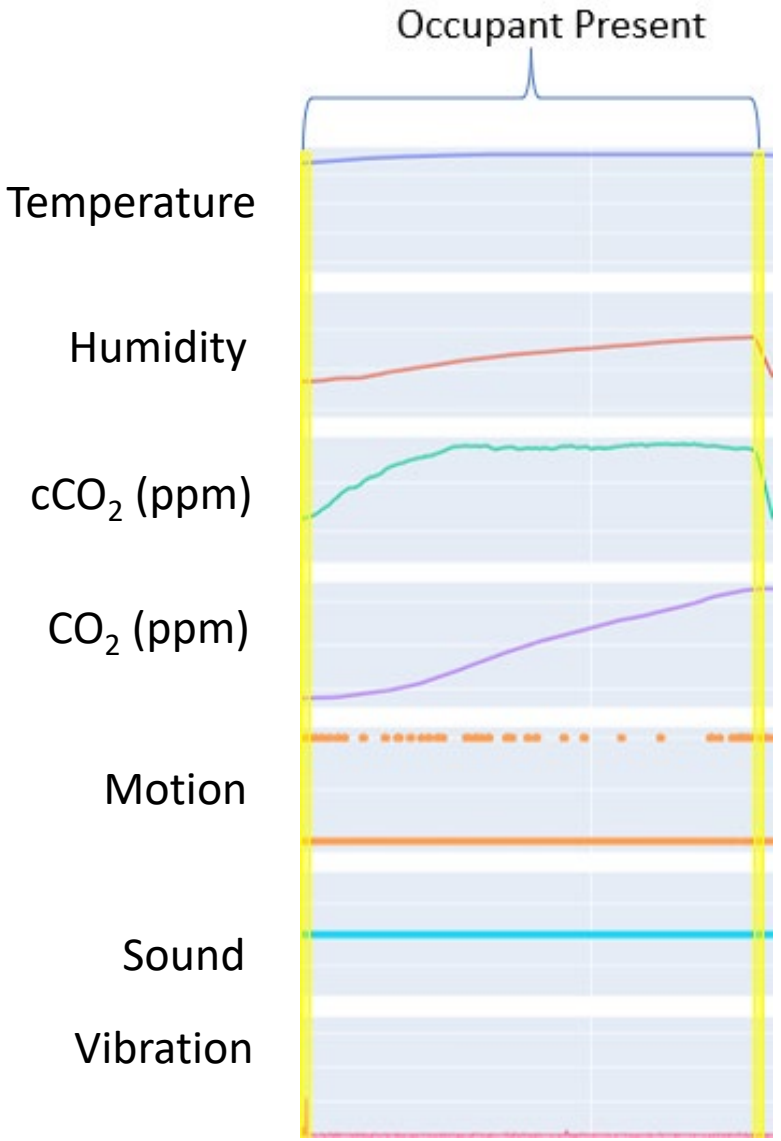


Sensor System Data



Occupant Detection

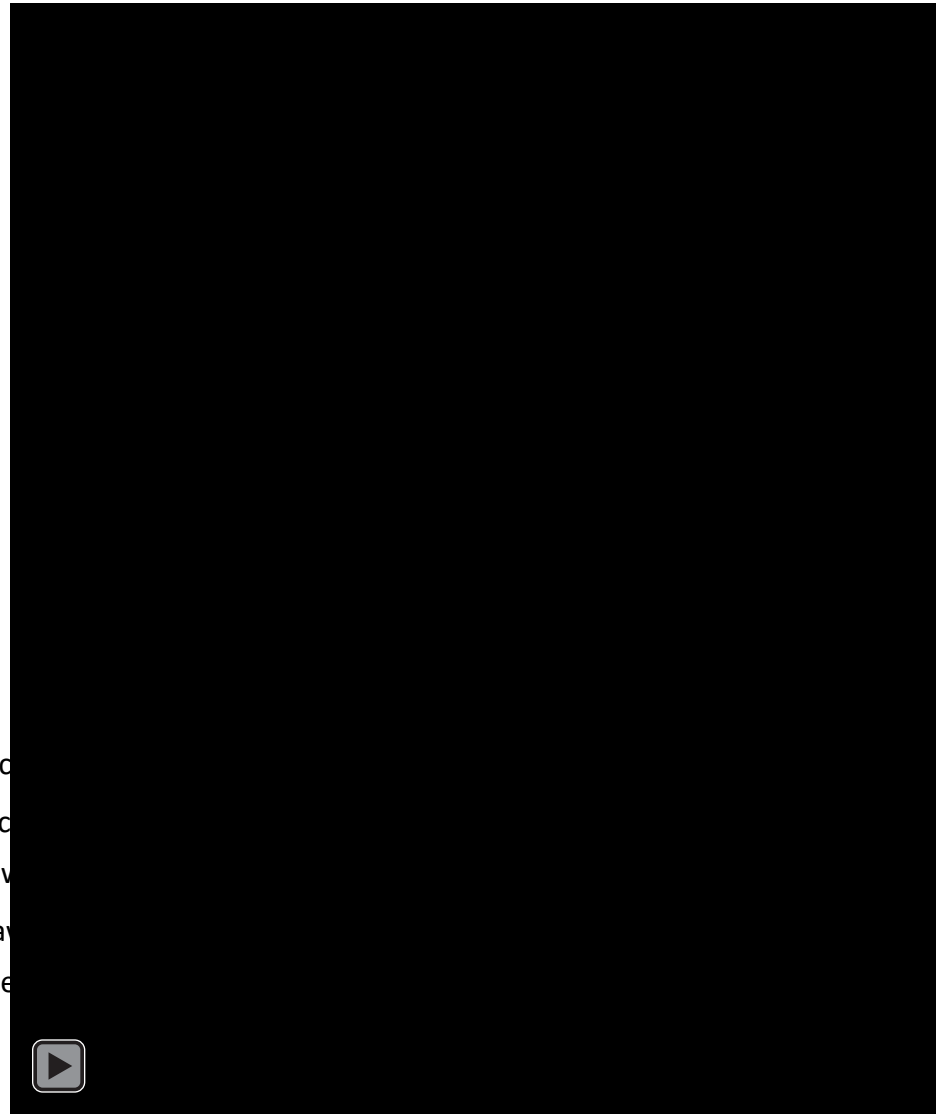
- The inputs to the algorithm that show an occupant are shown in the figure on the right
- The sound, vibration, and motion go to zero when the vehicle is stationary
- CO_2 and cCO_2 become elevated rapidly
- Humidity increases
- Temperature remains high
- Our algorithm reports this as there being an occupant present



Simulated Thermal Imaging to Detect Child Presence

- **Hardware: Jetson Nano, Lepton thermal infrared camera**
- **Synthetic thermal software models of infant and child developed**
- **Utilizes RGB configuration of FLIR camera**
- **Detection algorithm detects thermal contrast and match to synthetic model with green bounding box**
- **Timing critical in positive detection before thermal contrast is lost with ambient rise in surrounding temperature**

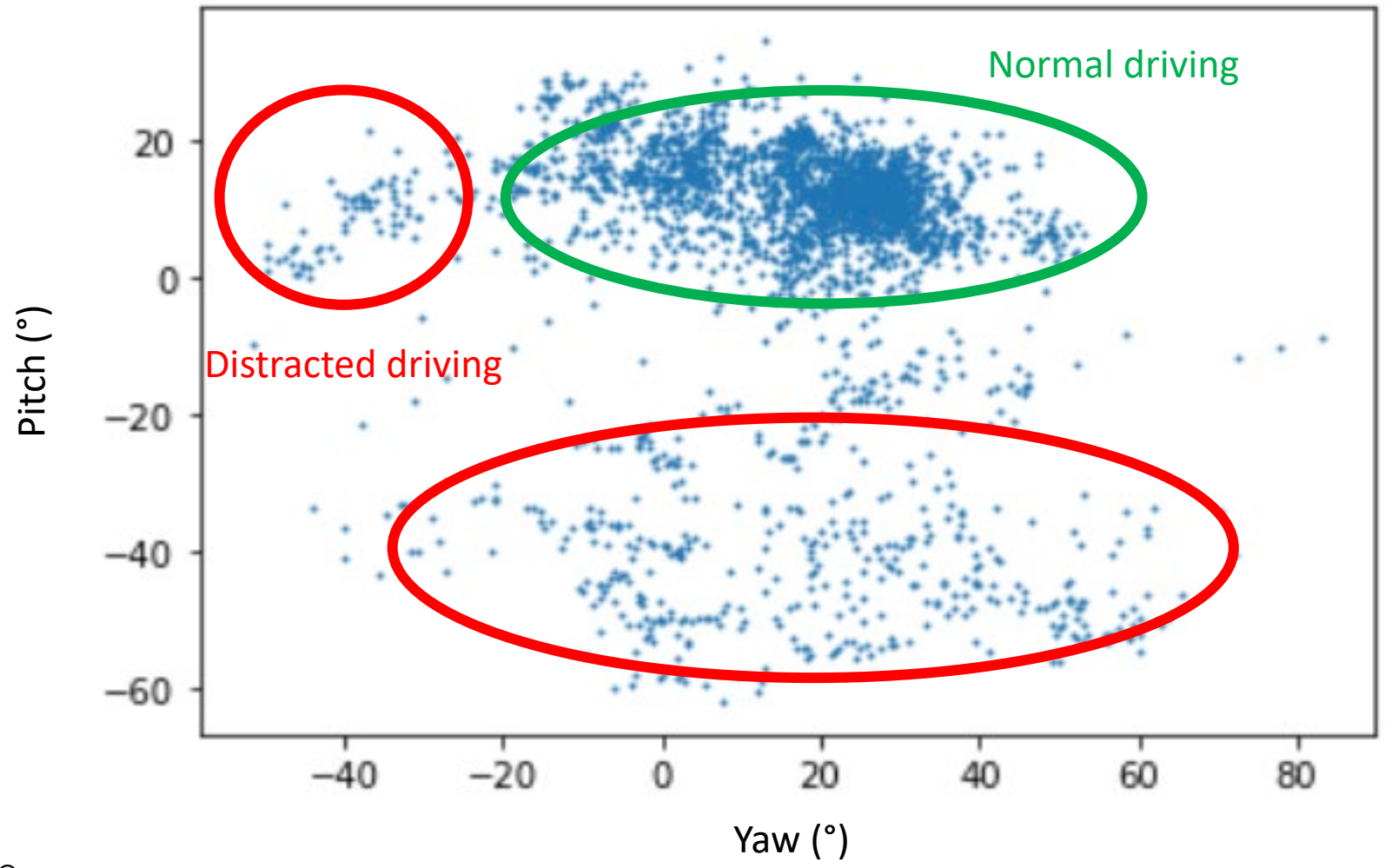
Distraction Detection Demo



- Hardware: Jetson Nano, Visible and IR-illuminated camera
- Seatbelt Presence Model:
  - Mturk – Static image classifier via Google images
  - ResNet-50 neural network used to train data
  - Network training time was 20 epochs, with learning rate of 10^{-5}
- Driver Distraction Model:
  - ETH-Xgaze – gaze angle with pitch and yaw from face tilt and eye position detected
  - Cumulative sum (CUSUM) value applied to detect changes in eye and head tilt position over time

Distractedness Prediction from Gaze

Example Distribution of Pitch and Yaw while Driving (measurements on single subject



Next-Generation Design

Size reduction

- Replace current FLIR board with miniature version in the swivel component (about half the size of the current board)
- Assess possibility of using smaller format computer such as Raspberry Pi/Arduino

Mounting mechanism

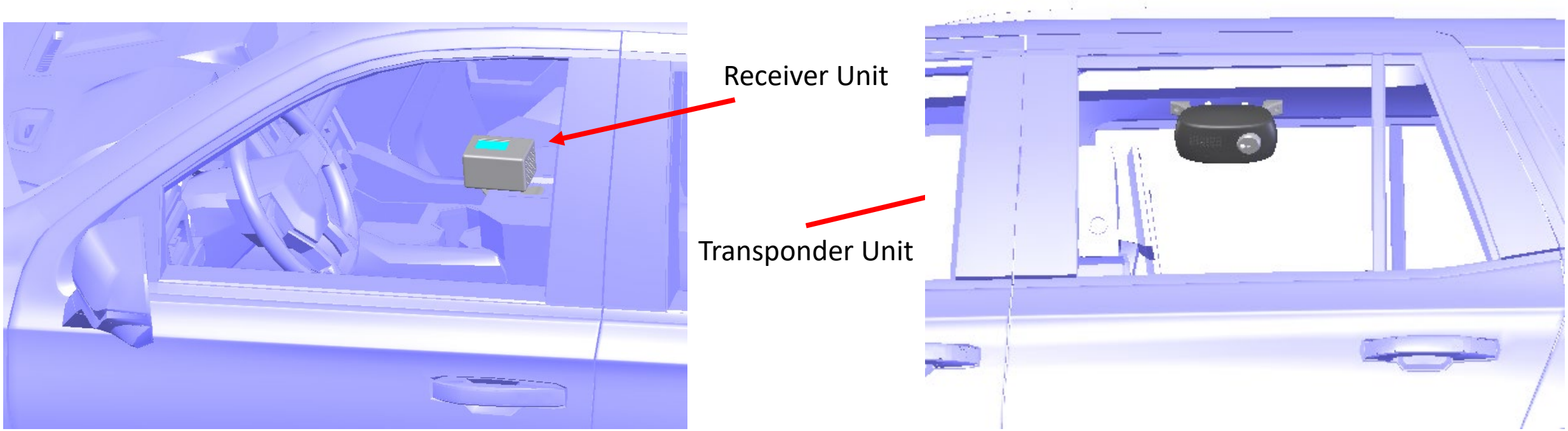
- Out of field of view of driver
- Out of passenger space

Improved Appearance

- OEM package
- Aftermarket sensor design

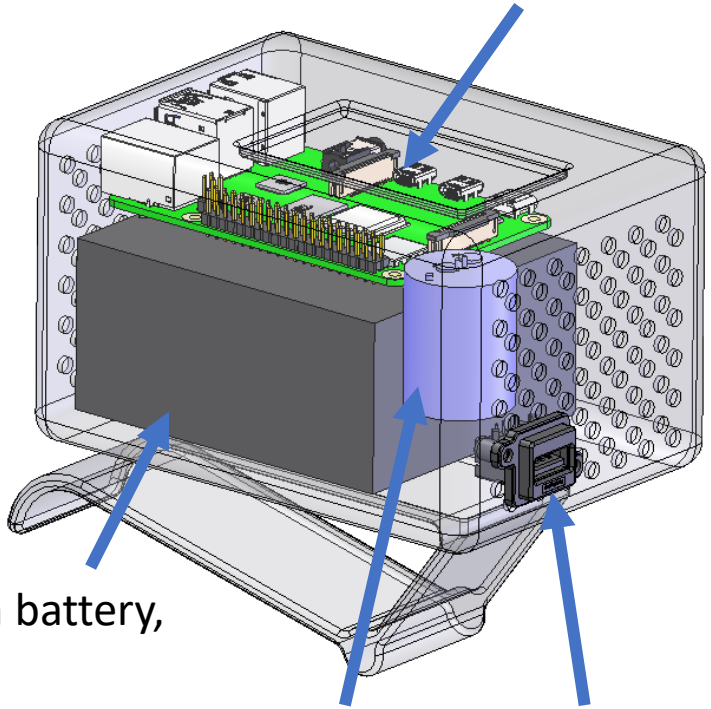
A Two-Part System

- Receiver Unit collects geophone data, collates data from the Transponder Unit, and runs the detection algorithm
- Transponder Unit collects CO_2, sound and passive infrared motion data
  - Thermal camera turns on if algorithm detects an occupant



Receiver Unit

Motherboard: includes Bluetooth radio, processor, battery charging circuit

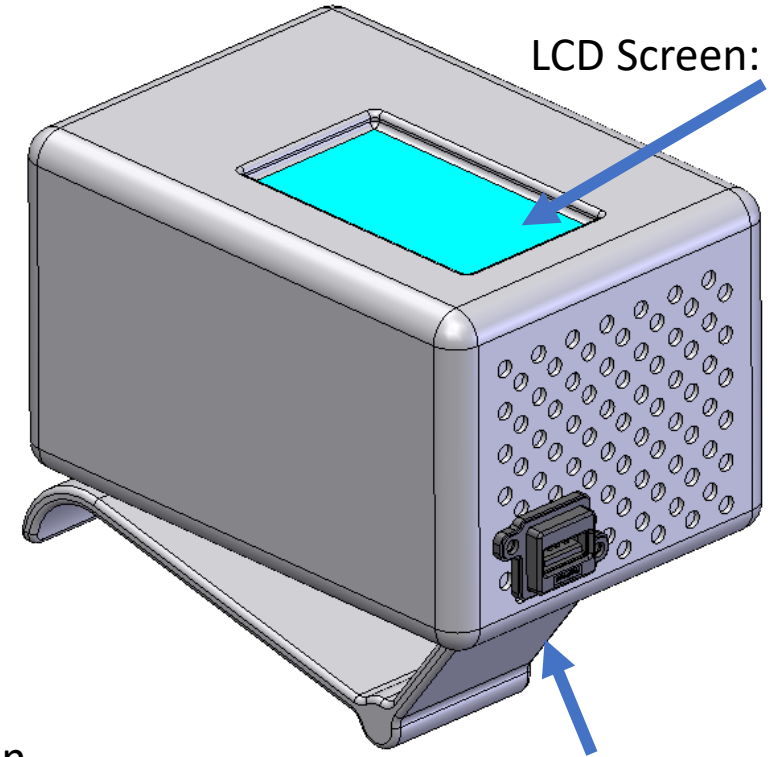


Lithium battery, 5.8AH

Geophone

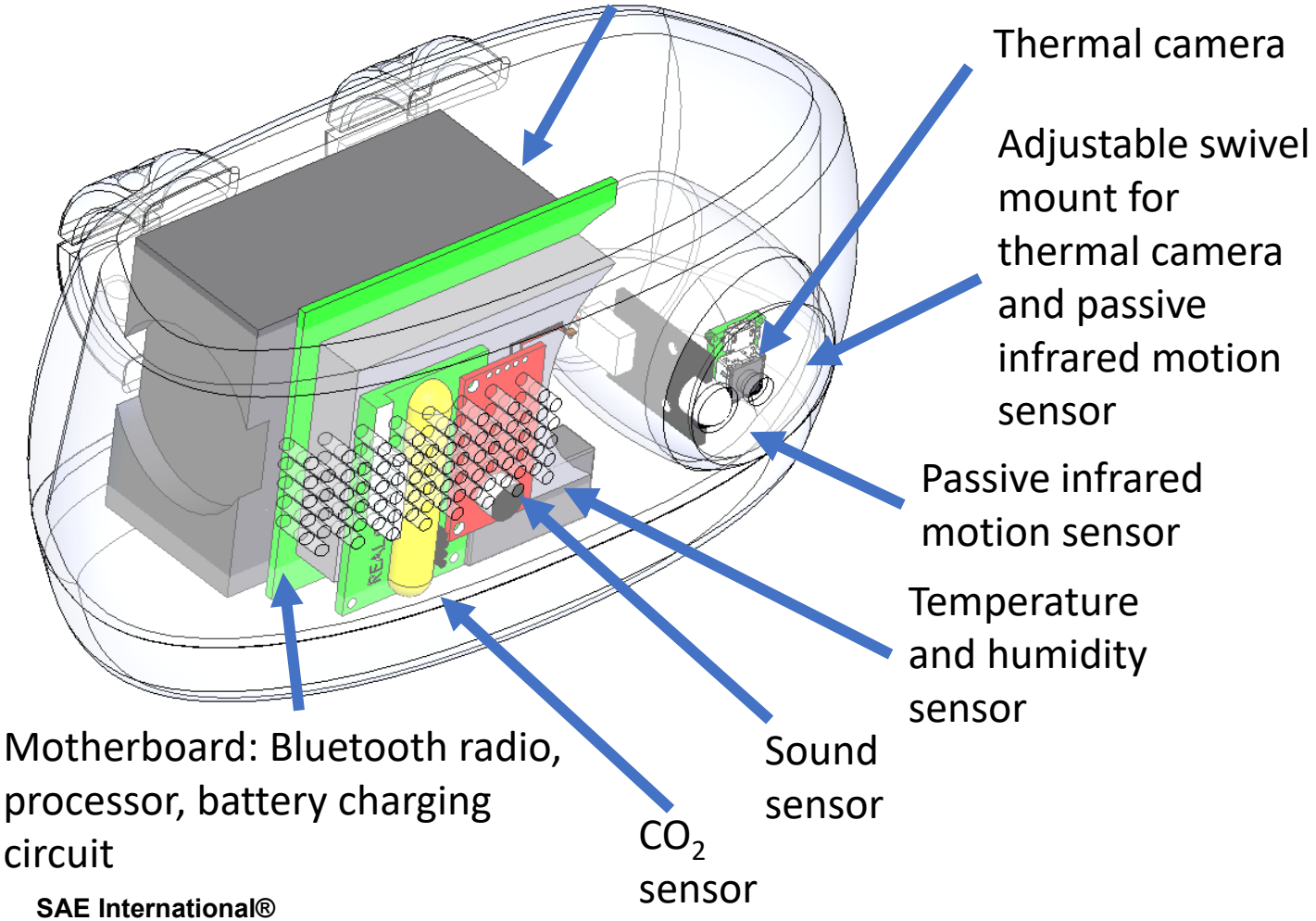
Power cord connection

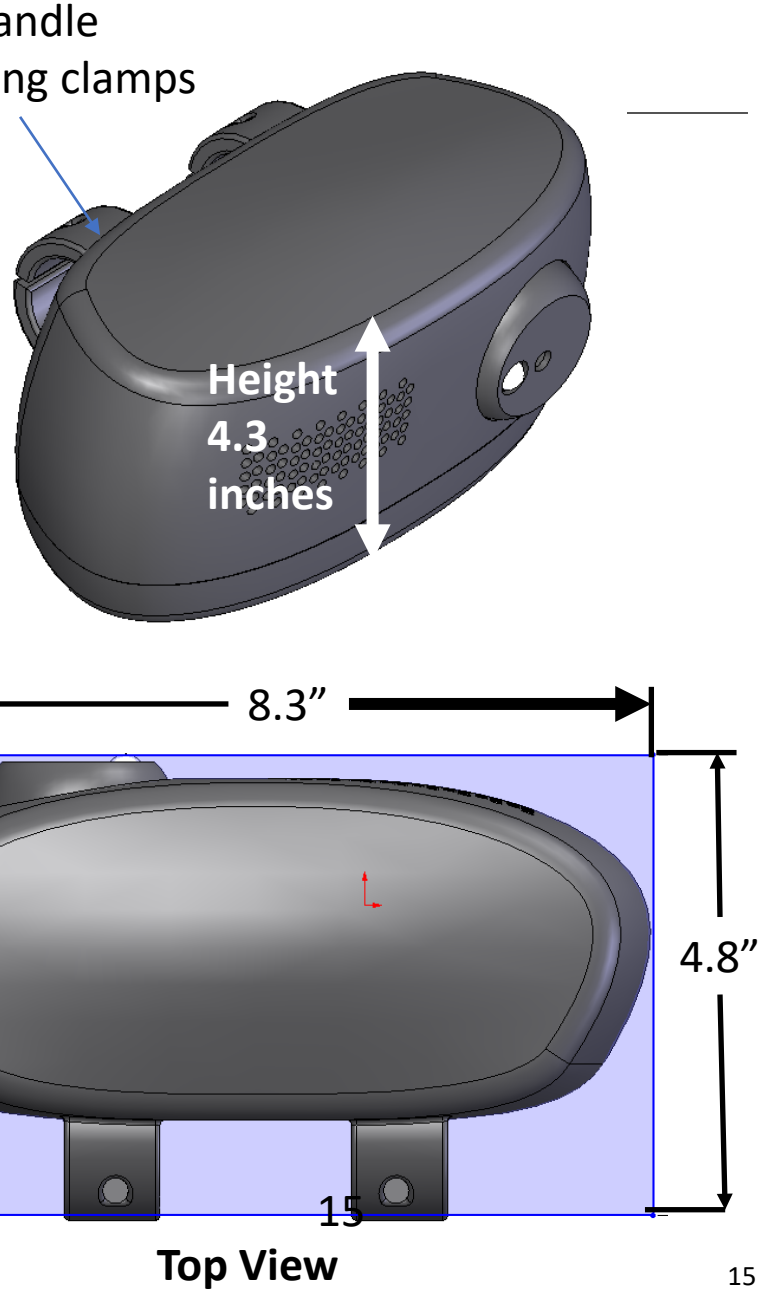
LCD Screen: Battery and alarm status



Center Console Mounting Clip

Transponder Unit





Conclusions

- The AI/ML system provided critical information to detect distracted driving but needs further development and testing to refine detection accuracy
- The low-cost sensor system for detection of a vulnerable person in an unsafe situation worked with 100% accuracy in limited testing:
  - CO_2 was the key sensor for occupancy
  - Temperature and Relative Humidity were needed to assay safety
  - The geophone vibration sensor provided high sensitivity detection of vehicle motion
- A range of response options were explored ranging from sounding vehicle alarm to actively calling 911. These response options can be modified by the end user.

Contributors

- Lara Moore, ZT Mechanical Engineer, Principal Investigator
- Jonathan Nusbaum, ZT Mechanical Engineer
- Ross Kliegman, ZT Physicist, previous Principal Investigator
- Tom McCreery, ZT Biologist, Program Manager
- Synaptiq, Distracted Driving Algorithms
- CVEDIA, Infrared imaging software simulations and algorithms

Contact Info and Acknowledgments

Thank you

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This work was funded by NHTSA under SBIR Contract #6913G621C100008