Autonomous Device For Ground-Based Warfighter Protection

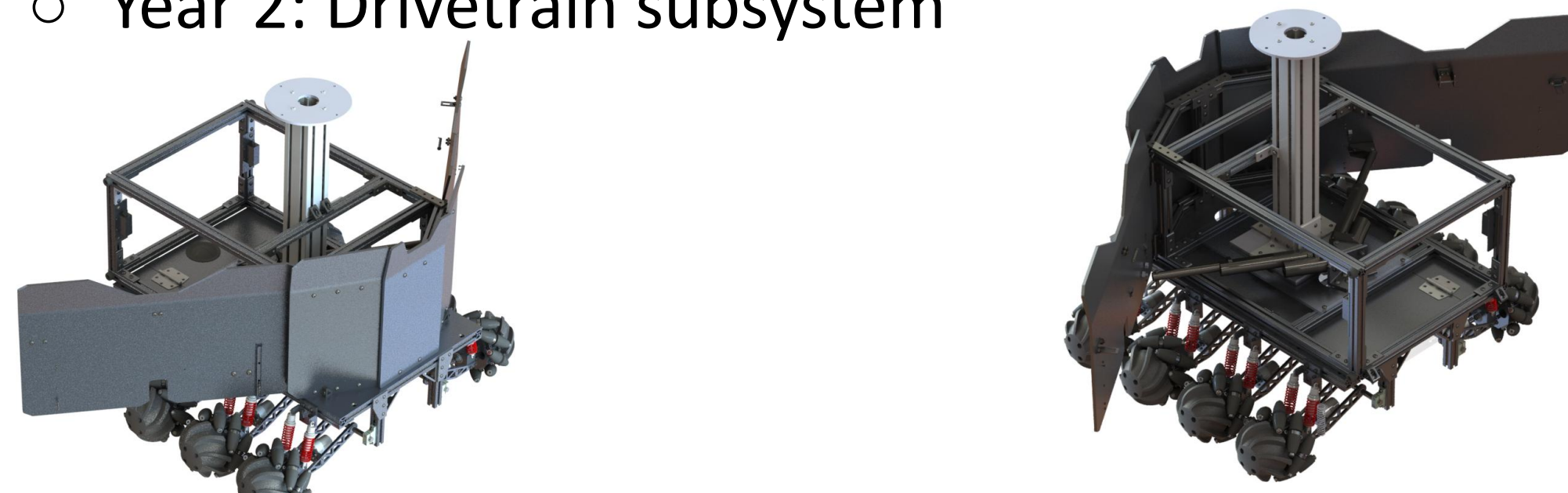**dc | DESIGN CENTER COLORADO**

United States Army Research Office • University of Colorado Boulder

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Background

- Proof of concept on viability of an autonomous vehicle with active protection systems
- Prior Design Center Colorado projects:
  - Year 1: Deployable shield subsystem
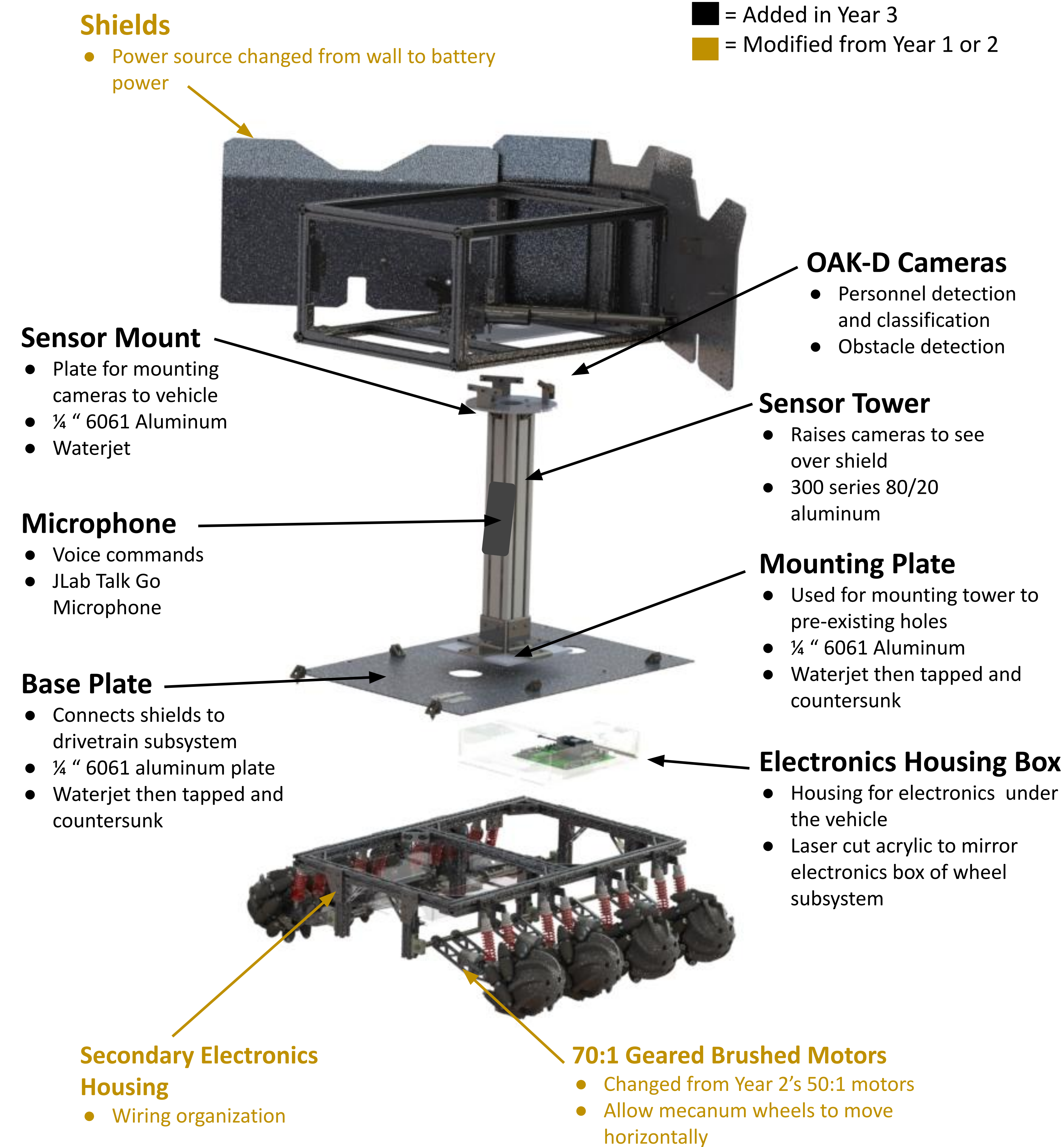 - Year 2: Drivetrain subsystem

Objectives

- ✅ Physically integrate projects from Years 1 & 2
- ✅ Autonomous Movement
- ✅ Obstacle Avoidance
- ✅ Personnel Detection and Identification
- ✅ Speech Commands
- ✅ Arm Signal Commands
- ❌ Follows GPS Waypoints
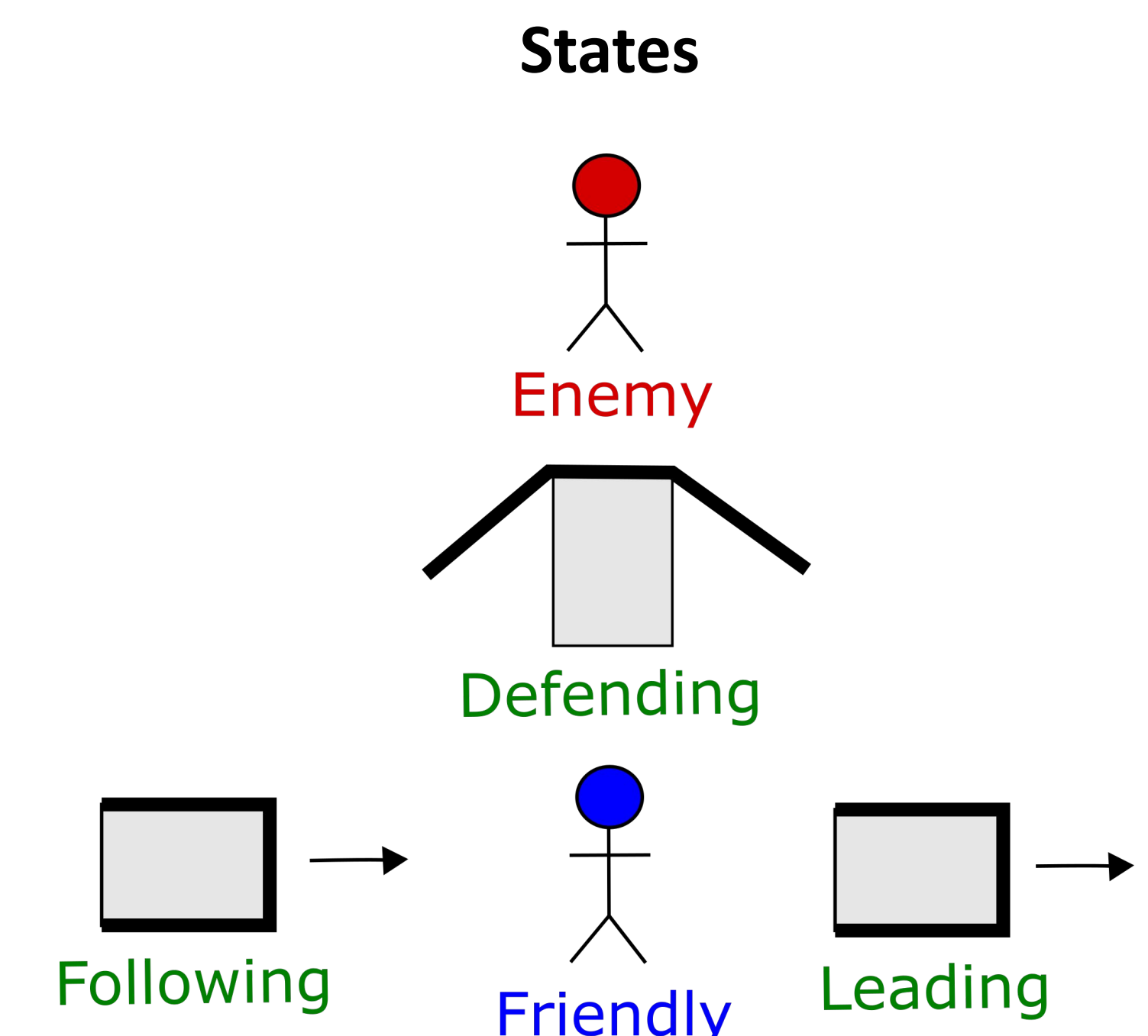
Stereo Vision Cameras

- Luxonix Oak-D
  - Global Shutter Stereo Vision
  - 4k Color Camera
  - 9 DOF IMU with Magnetometer, Accelerometer and Gyroscope
  - Onboard VPU

Exploded View

- ■ = Added in Year 3
- ■ = Modified from Year 1 or 2

Shields
- Power source changed from wall to battery power

Sensor Mount
- Plate for mounting cameras to vehicle
- ¼" 6061 Aluminum
- Waterjet

Microphone
- Voice commands
- JLab Talk Go Microphone

Base Plate
- Connects shields to drivetrain subsystem
- ¼" 6061 aluminum plate
- Waterjet then tapped and countersunk

OAK-D Cameras
- Personnel detection and classification
- Obstacle detection

Sensor Tower
- Raises cameras to see over shield
- 300 series 80/20 aluminum

Mounting Plate
- Used for mounting tower to pre-existing holes
- ¼" 6061 Aluminum
- Waterjet then tapped and countersunk

Electronics Housing Box
- Housing for electronics under the vehicle
- Laser cut acrylic to mirror electronics box of wheel subsystem

Secondary Electronics Housing
- Wiring organization

70:1 Geared Brushed Motors
- Changed from Year 2's 50:1 motors
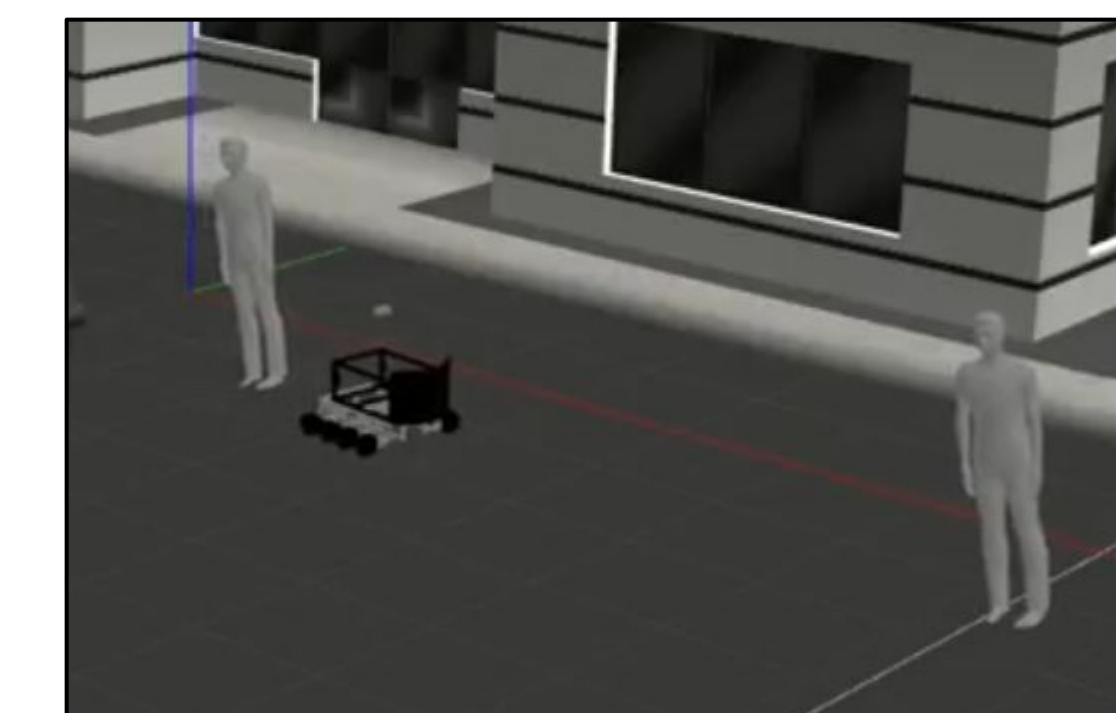- Allow mecanum wheels to move horizontally
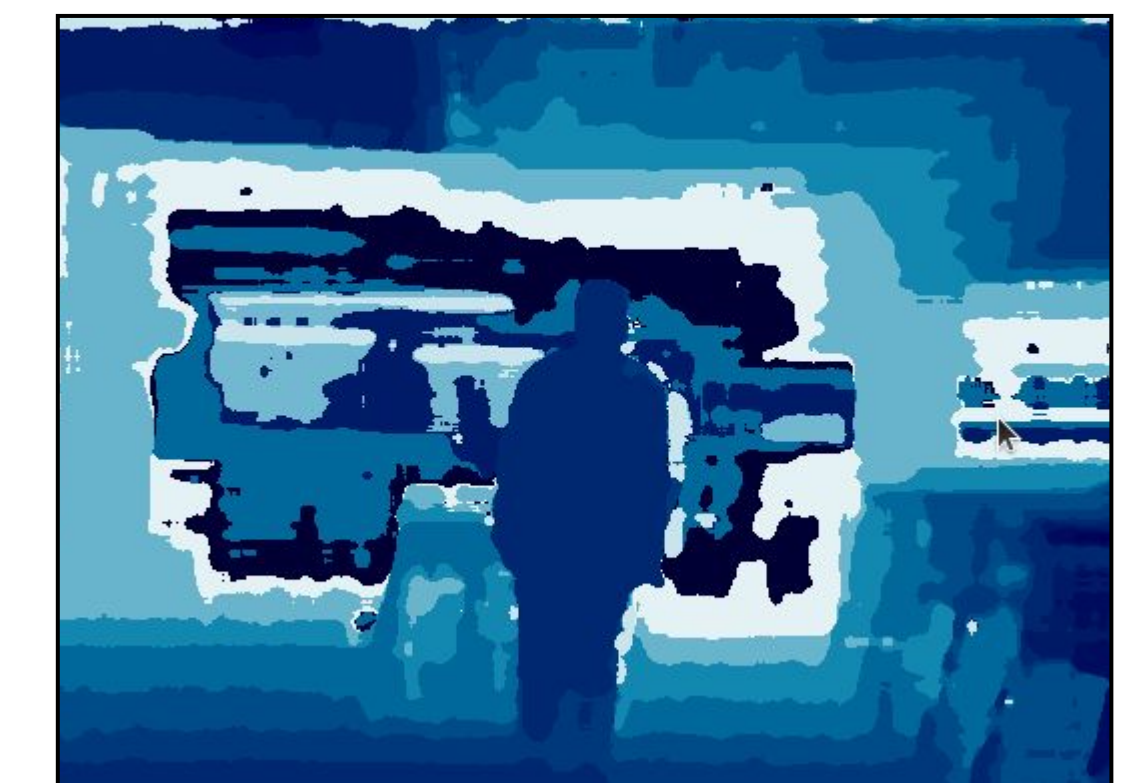
Software

- Implements custom Robot Operating System (ROS2) nodes
  - Simulation
  - Motor Controller
  - Camera
  - Speech Recognition
  - Robot Controller
- State Machine
  - Defending
  - Following
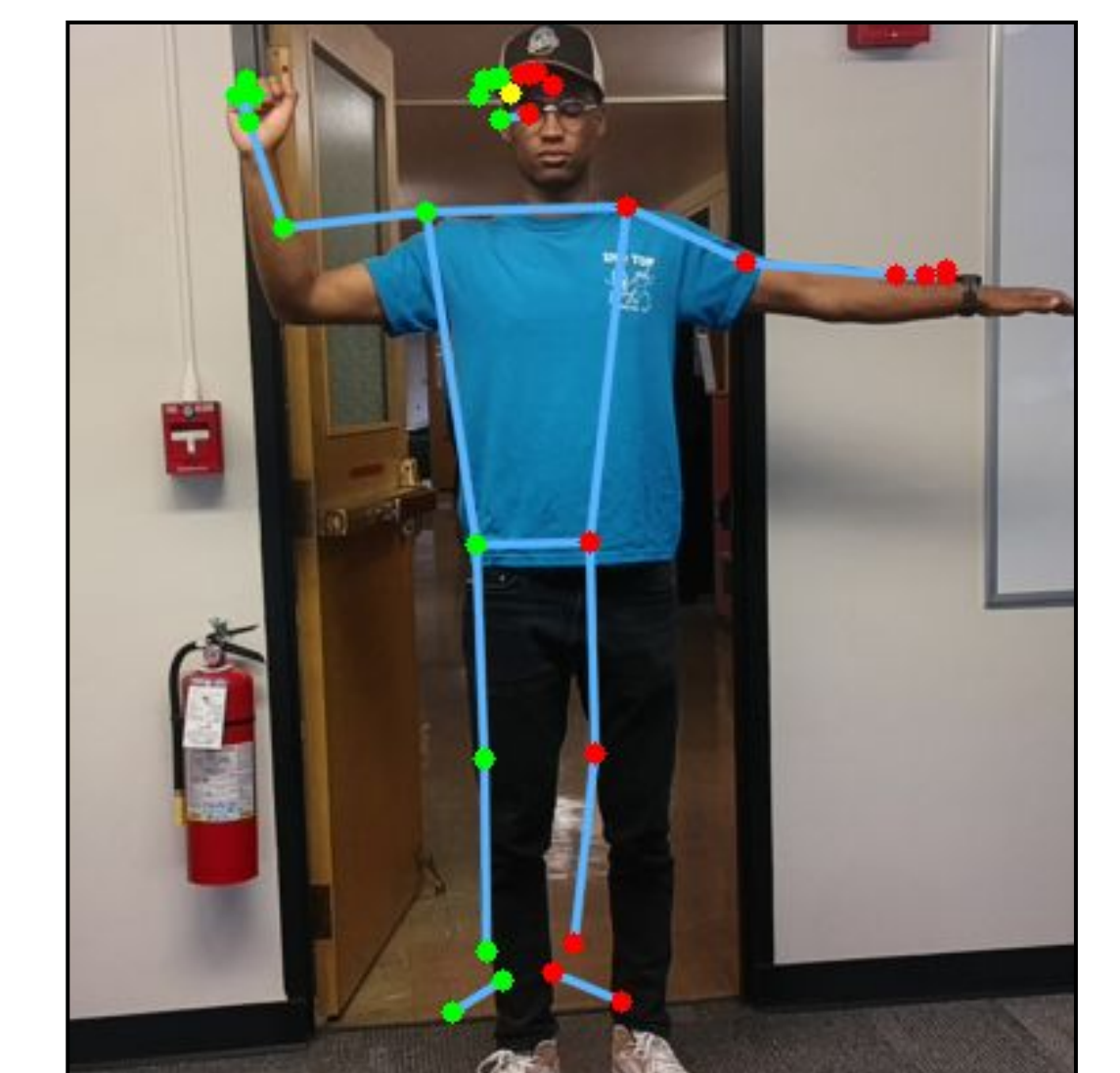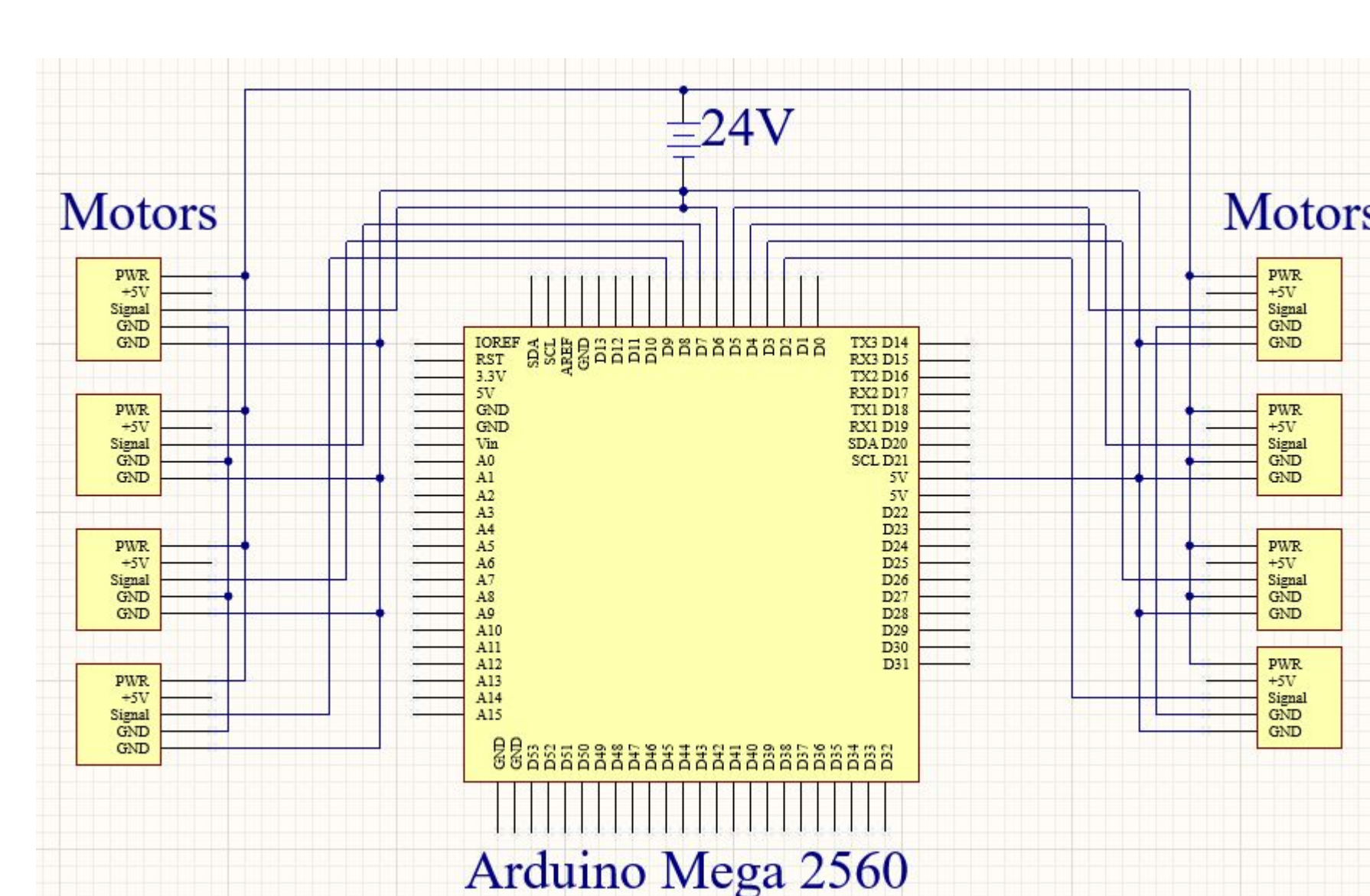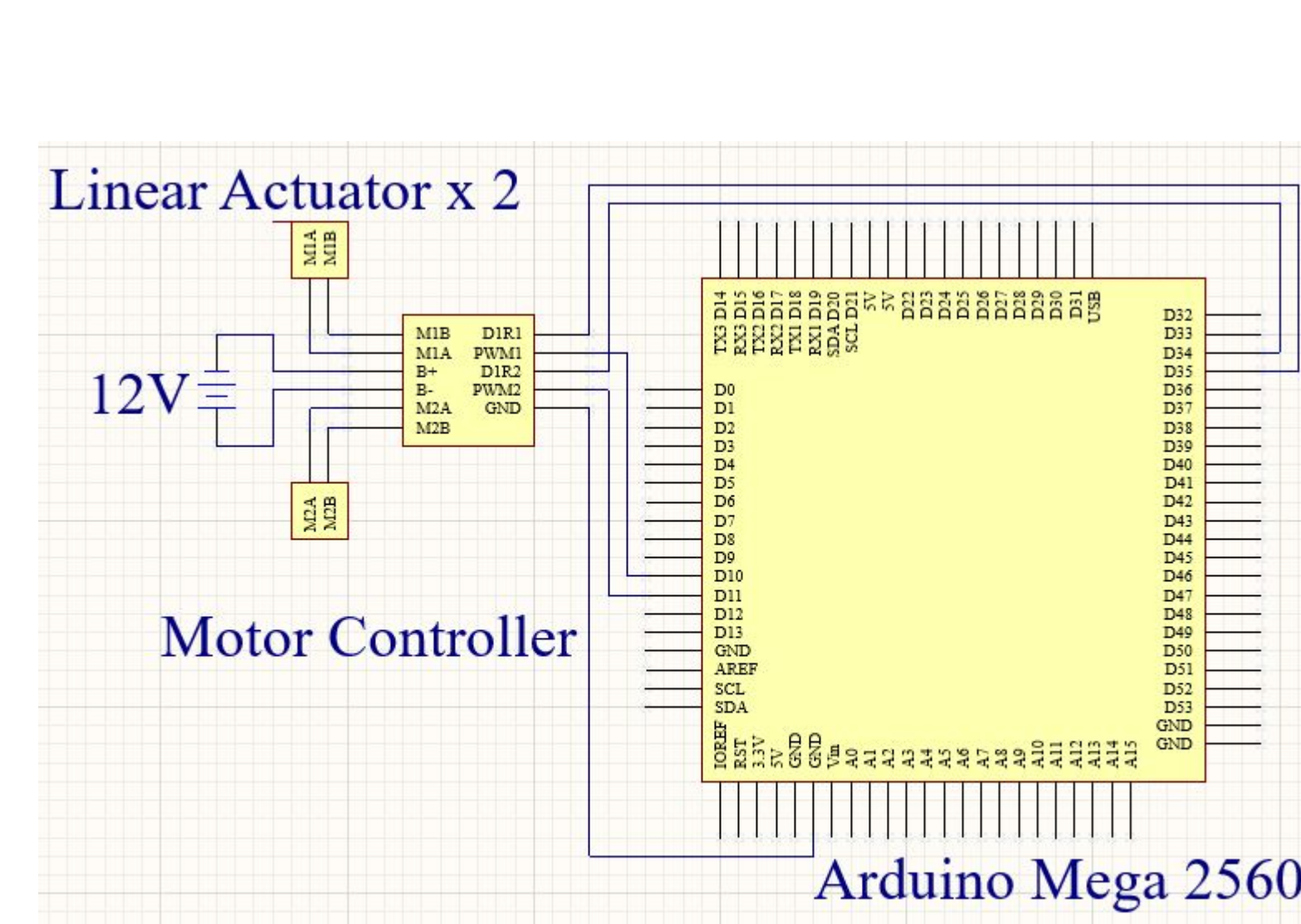 - Leading
  - Navigate Alone

States

Enemy — Defending — Following — Friendly — Leading

Simulation

Disparity Map

Person Detection and Classification

Human Pose Detection

Electronics

Mic — HP Elitebook
OAK D x 3
Arduino Mega 2560

Linear Actuator x 2
12V
Motor Controller
Arduino Mega 2560

24V
Motors — Motors
Arduino Mega 2560

Testing

- Autonomous Capabilities
  - Navigation/Obstacle Avoidance
  - Threat Detection
- Command Capabilities
  - Speech/Visual Recognition
  - Autonomous Following
- Defensive Capabilities
  - Defensive Deployment
  - Movement
- Redundancy
  - Mechanical
  - Electrical

Lessons Learned

- Flexibility is crucial, team needed to adapt to new challenges
- Fully research any work done by past teams

Future Work

- Use high end computer for image processing and decision making
- Increase motor power rating and battery capacity
- Implement dedicated magnetometer