# UGV Design
# Modular Mobile Platform

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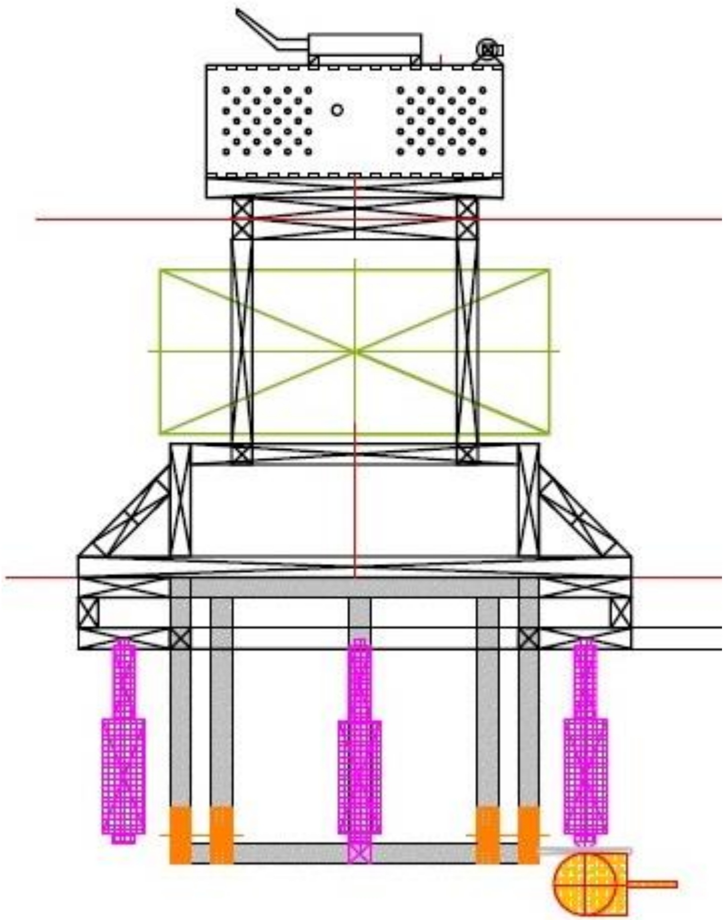
# Outline

- Overview
- Quiz
- UGV system
    - General hardware
    - Interface and control
- Variations
    - Drive systems
    - Applications
- Available platforms
- Off-the-shelf
- Challenges
- SOC solution
- Features
- Credits
- Answer



# Quiz

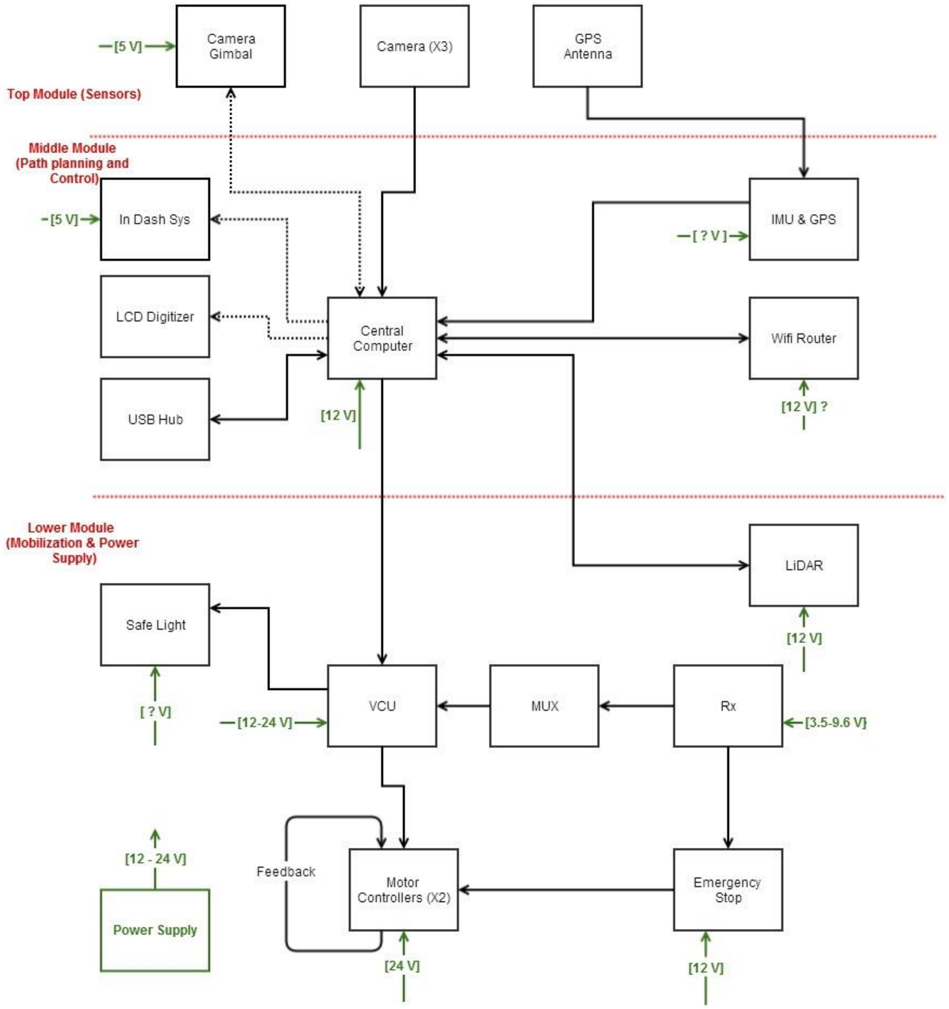
Why?

# UGV Application

- Military
- Agriculture
- Police
- Warehouse automation
- Local logistics
- Hospital logistics
- Human transportation networks

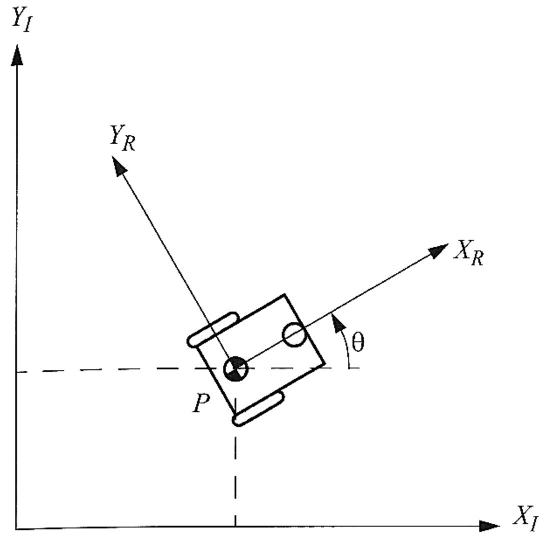
# Hardware

- Motors and encoders
- E-Stop
- Safety light
- Satellite receiver
- VCU
- SBC (VNU)
- Sensor package
- Power system

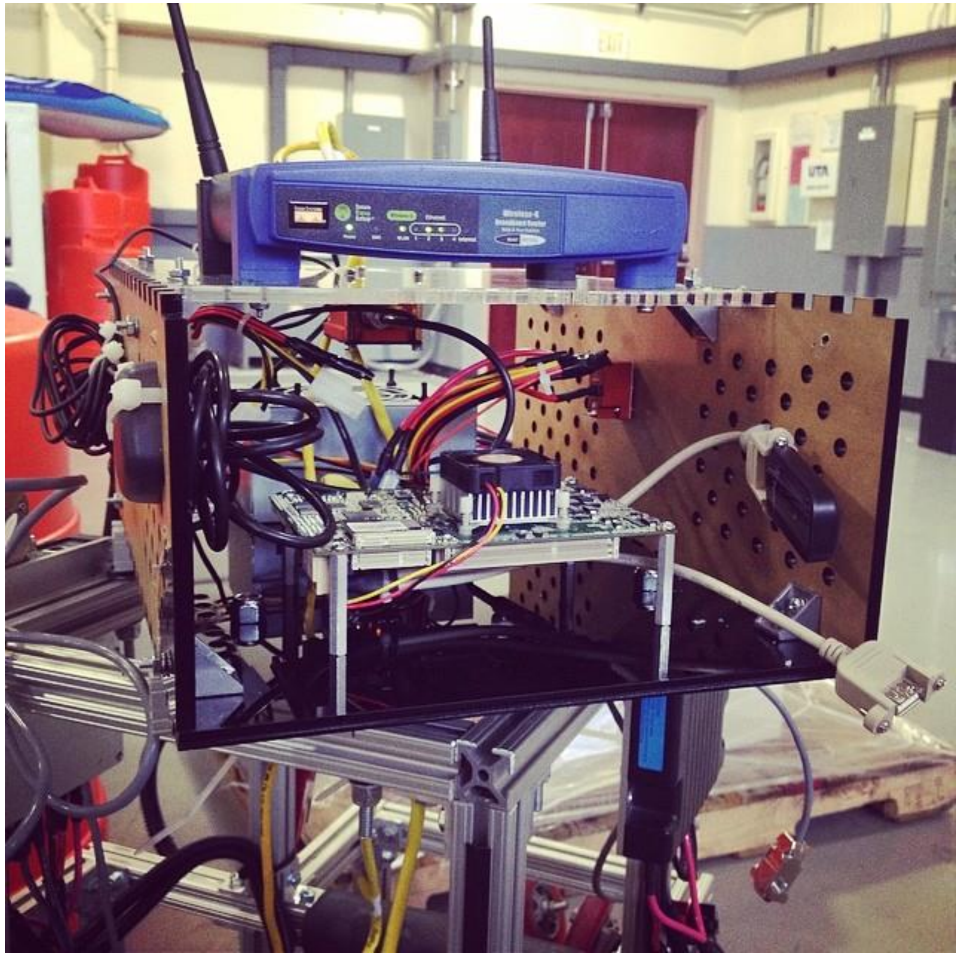


# Interface & Processing

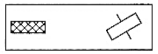
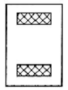
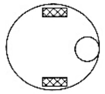
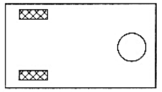
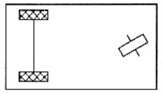
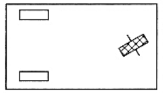
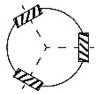
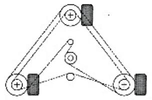
- Platform
  - 100 Mbit/s 802.3 Ethernet
  - 802.11b/g wireless data link
- VCU (Vehicle Control Unit)
  - RS232 serial DB9
  - Ethernet RJ45
  - UART for DSMX remote receiver
  - JTAG IC debug port for on-board programming
- SBC
  - USB, SATA, Mini-PCIe, GLAN, LVDS, VGA, HDMI
  - Quad core AMD
  - 60GB SSD
  - 4GB RAM

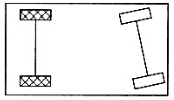
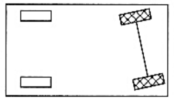
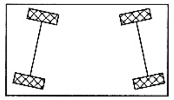
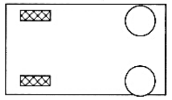
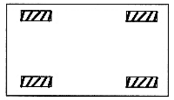
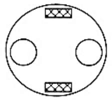
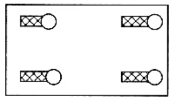


# Upper Module

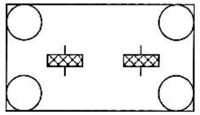
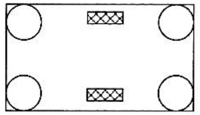


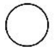
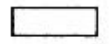
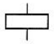
# Drive Systems (1/2)

| # of wheels | Arrangement | Description | Typical examples |
|---|---|---|---|
| 2 |  | One steering wheel in the front, one traction wheel in the rear | Bicycle, motorcycle |
| |  | Two-wheel differential drive with the center of mass (COM) below the axle | Cye personal robot |
| 3 |  | Two-wheel centered differential drive with a third point of contact | Nomad Scout, smartRob EPFL |
| |  | Two independently driven wheels in the rear/front, one unpowered omnidirectional wheel in the front/rear | Many indoor robots, including the EPFL robots Pygmalion and Alice |
| |  | Two connected traction wheels (differential) in rear, one steered free wheel in front | Piaggio minitrucks |
| |  | Two free wheels in rear, one steered traction wheel in front | Neptune (Carnegie Mellon University), Hero-1 |
| |  | Three motorized Swedish or spherical wheels arranged in a triangle; omnidirectional movement is possible | Stanford wheel Tribolo EPFL, Palm Pilot Robot Kit (CMU) |
| |  | Three synchronously motorized and steered wheels; the orientation is not controllable | "Synchro drive" Denning MRV-2, Georgia Institute of Technology, I-Robot B24, Nomad 200 |

| # of wheels | Arrangement | Description | Typical examples |
|---|---|---|---|
| 4 |  | Two motorized wheels in the rear, two steered wheels in the front; steering has to be different for the two wheels to avoid slipping/skidding. | Car with rear-wheel drive |
| |  | Two motorized and steered wheels in the front, two free wheels in the rear; steering has to be different for the two wheels to avoid slipping/skidding. | Car with front-wheel drive |
| |  | Four steered and motorized wheels | Four-wheel drive, four-wheel steering Hyperion (CMU) |
| |  | Two traction wheels (differential) in rear/front, two omnidirectional wheels in the front/rear | Charlie (DMT-EPFL) |
| |  | Four omnidirectional wheels | Carnegie Mellon Uranus |
| |  | Two-wheel differential drive with two additional points of contact | EPFL Khepera, Hyperbot Chip |
| |  | Four motorized and steered castor wheels | Nomad XR4000 |

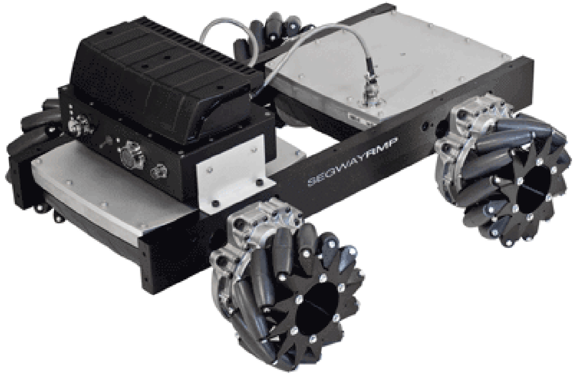
# Drive Systems (2/2)

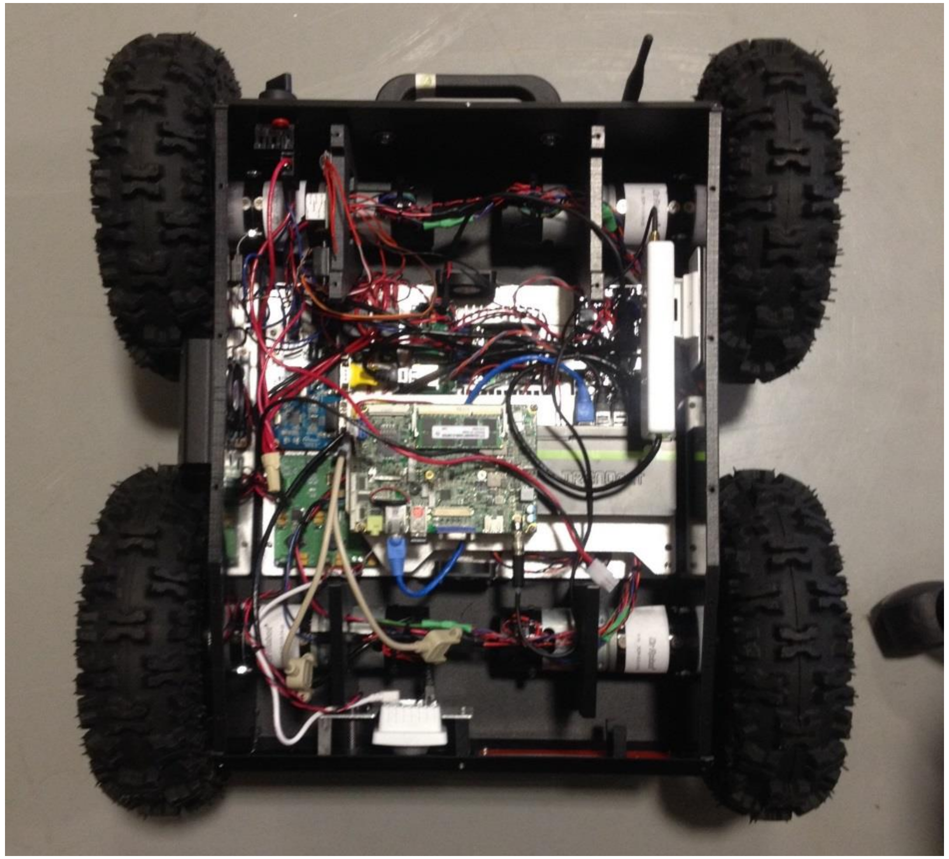
| # of wheels | Arrangement | Description | Typical examples |
|---|---|---|---|
| 6 |  | Two motorized and steered wheels aligned in center, one omnidirectional wheel at each corner | First |
| |  | Two traction wheels (differential) in center, one omnidirectional wheel at each corner | Terregator (Carnegie Mellon University) |

| Icons for the each wheel type are as follows: | |
|---|---|
|  | unpowered omnidirectional wheel (spherical, castor, Swedish) |
|  | motorized Swedish wheel (Stanford wheel) |
|  | unpowered standard wheel |
|  | motorized standard wheel |
|  | motorized and steered castor wheel |
|  | steered standard wheel |
|  | connected wheels |

# Other Platforms

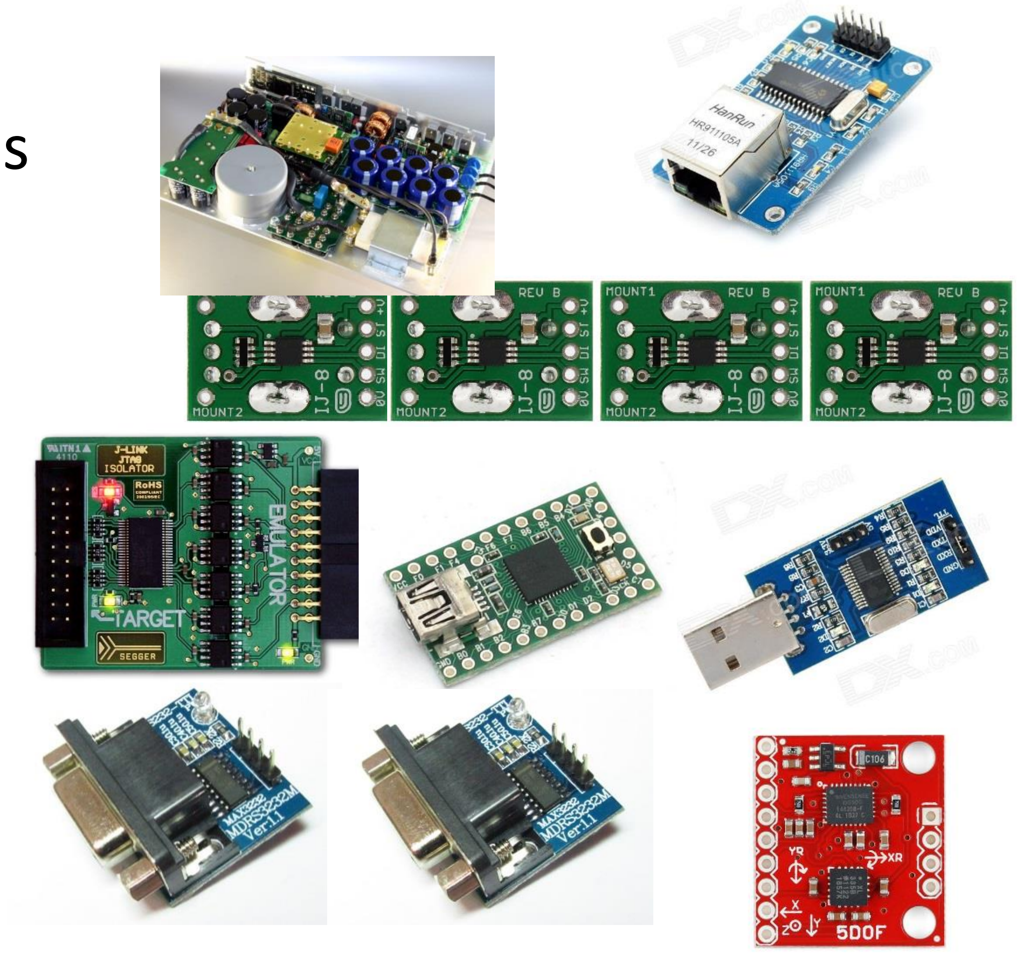
- Jaguar 4x4
- Segway



# Off-The-Shelf

- Need to integrate many subsystems
- More possible bugs and hardware issues
- More expensive
- Take more space
- Interfacing
- More parts to go burn and go wrong
- Harder to prototype
- Takes longer to assemble

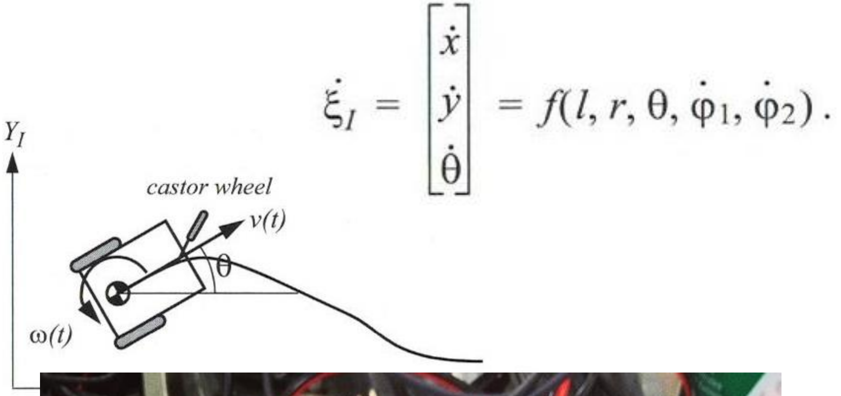


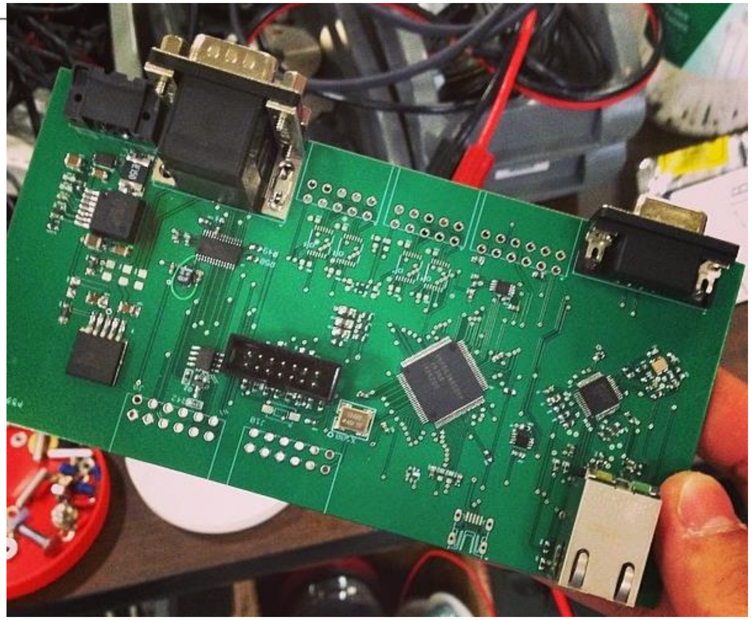
# Challenges

- Interconnectivity
- Industry standards
- Developer tool kit
- Too many variations and so different

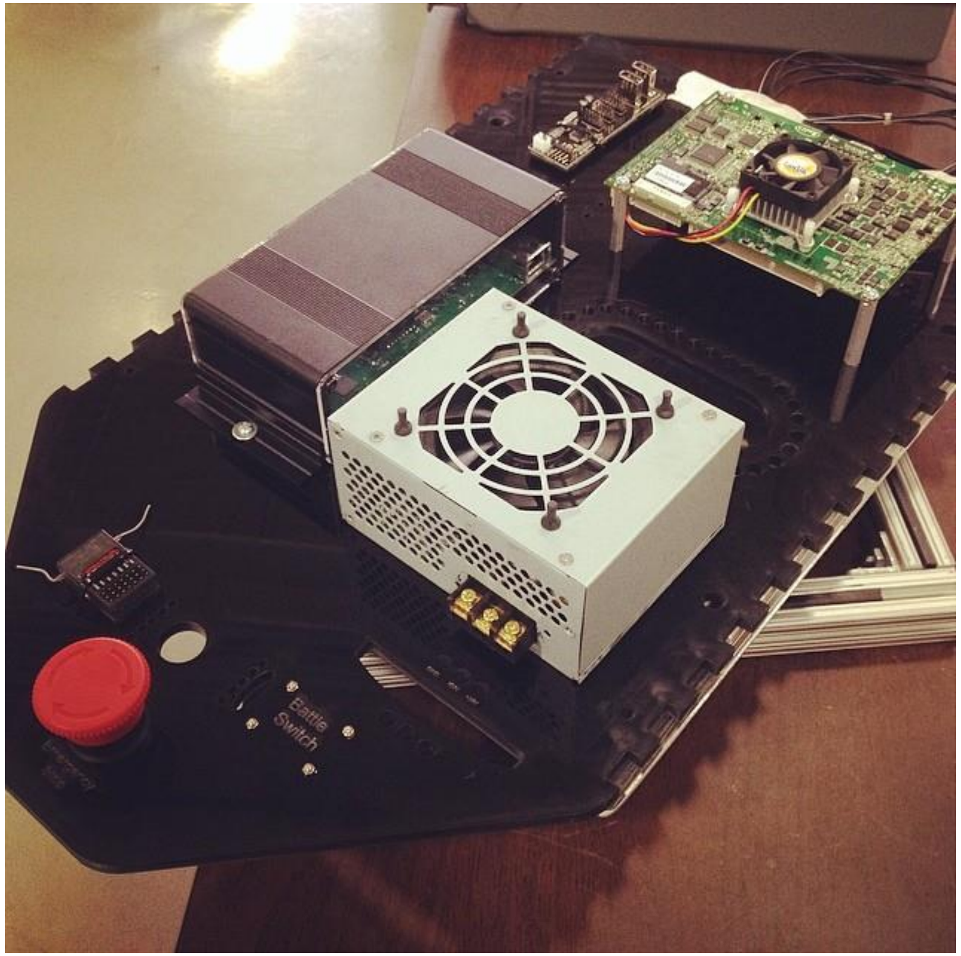
# VCU

- Standard input/outputs
- Adaptable to many drive systems
- SOC solution
- More affordable
- More robust
- Input = $[x', y', \theta']^T$ --- world frame translation and rotation
- Output = $[\dot{\varphi}_1, \dot{\varphi}_2, \dot{\varphi}_3, \dot{\varphi}_4]^T$ --- velocity control for each motor
- Magnetic encoders feedback
- On-board IMU
- Robust power distribution



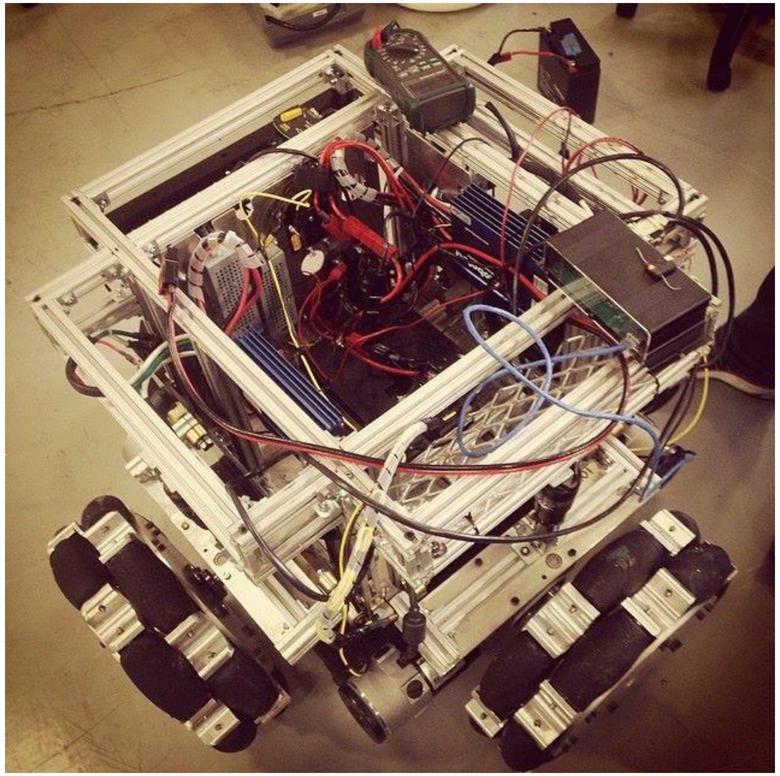



# Less Parts



# Features

- Tele-op ready
- Encoder feedback
- Independent mobile platform
- Tele-op not vulnerable if SBC crashes
- No need for Voltage step down
- Tested and proven
- Ease of use and compatibility



# Credits

- VCU: Matt Middleton
- Autonomous Mobile Robots, The MIT Press
- Google!!

# Quiz: Answer

- Good potential
- Encourage open discussion and reasoning with the team
- Constructive feedback
- Ideas spark ideas

# Questions

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