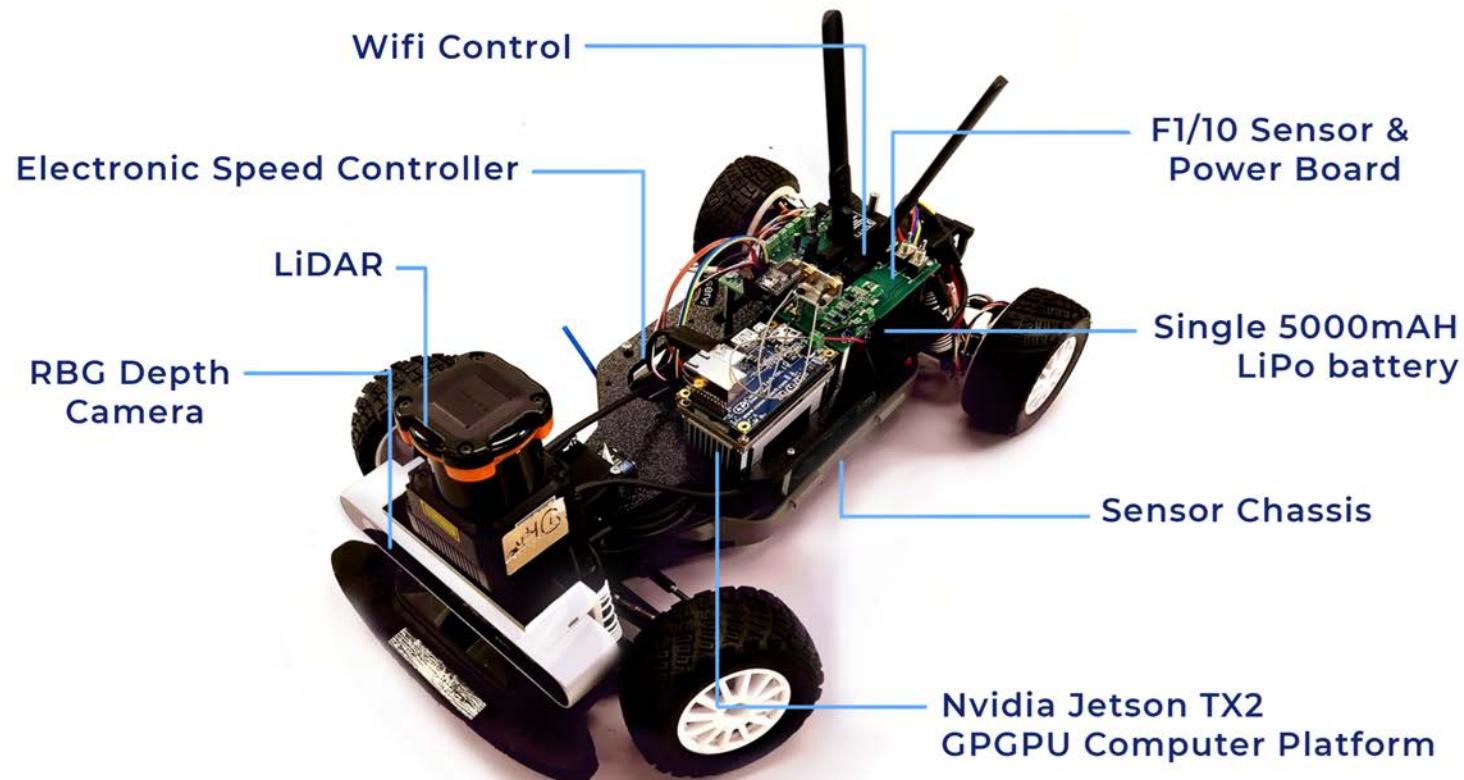


# F1/10

## Autonomous Racing



# F1/10

## Working with the Cars

Varundev Sukhil  
Sandesh Banskota  
Mert Karakas  
Madhur Behl

Rice Hall 120

From

**AUTONOMOUS TURTLES**

To

**AUTONOMOUS CARS**

To

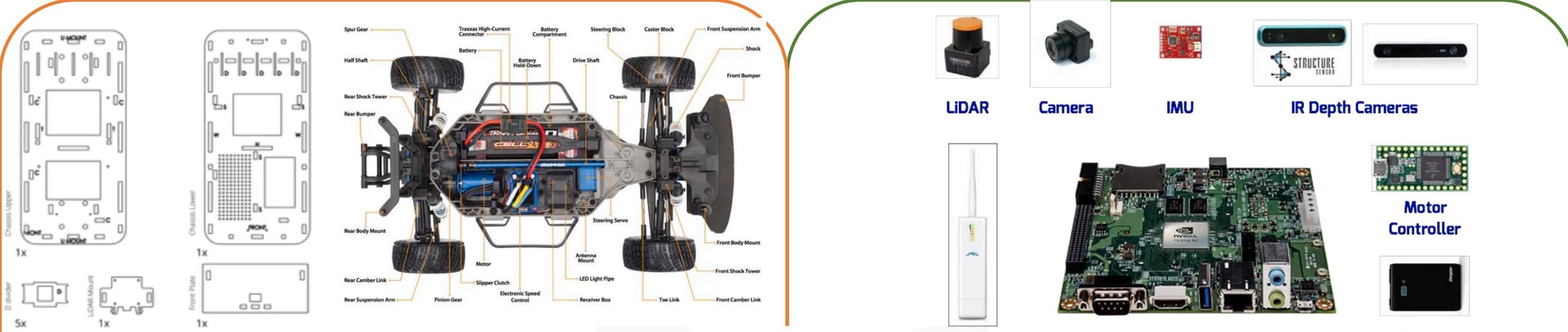
**AUTONOMOUS RACING CARS !!**

F1  
TENTH



UNIVERSITY  
*of*  
VIRGINIA

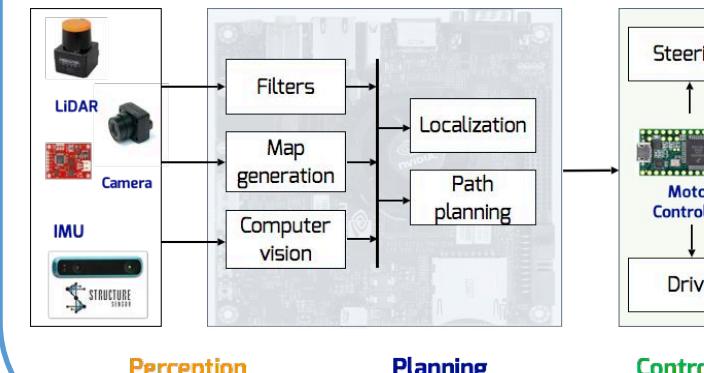




## Chassis Design

## Software System Architecture

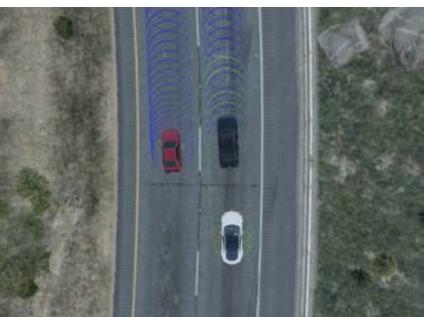
ROS



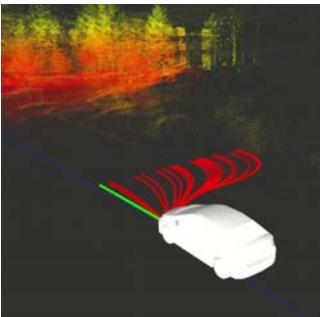
## GPU accelerated libraries



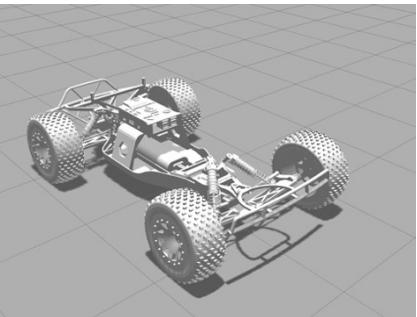
## Scenario Sim



## ROSbag data



Vehicle and environment models in Gazebo



## Sensor Integration

Wi-Fi Telemetry



Onboard Computer



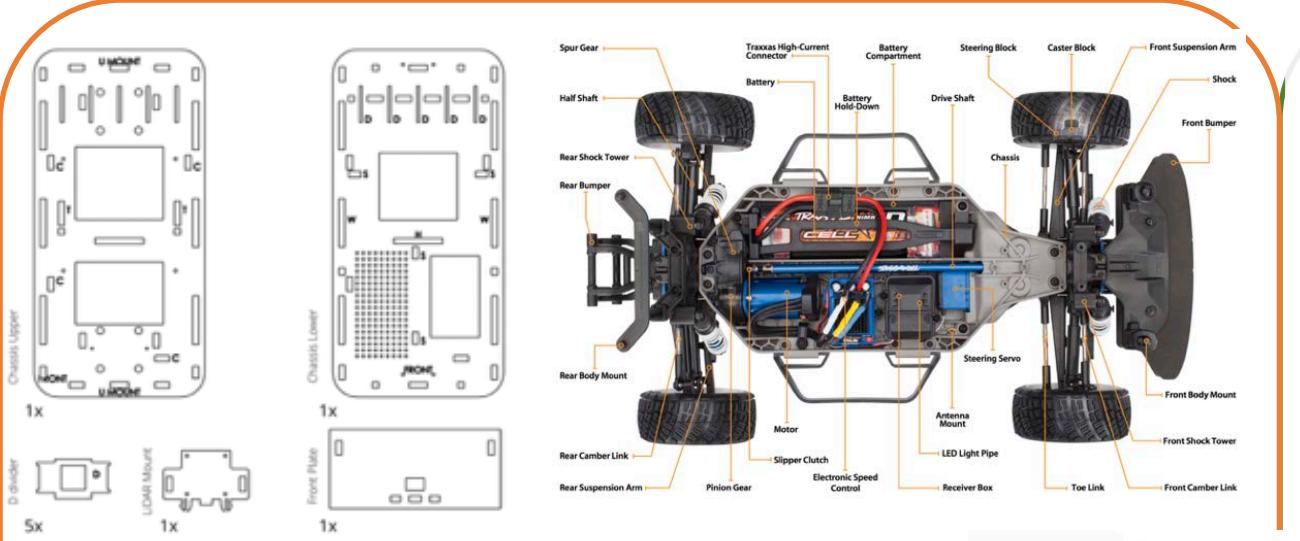
Battery



Motor Controller



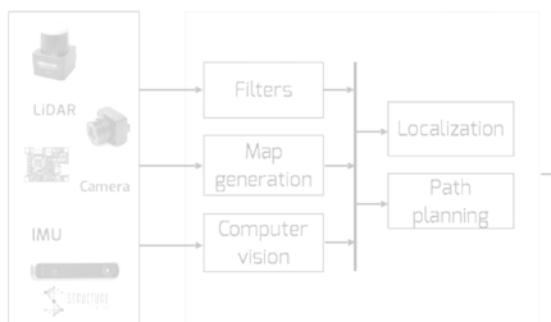
IR Depth Cameras



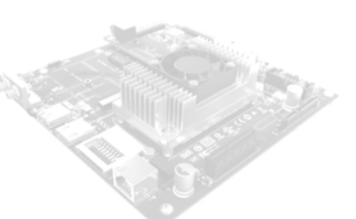
## Chassis Design

## Software System Architecture

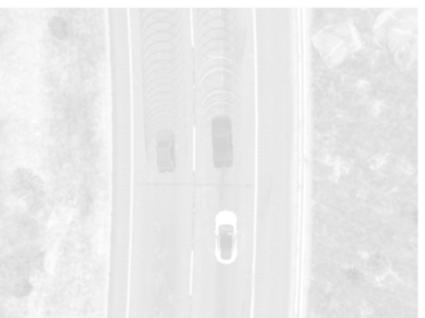
ROS



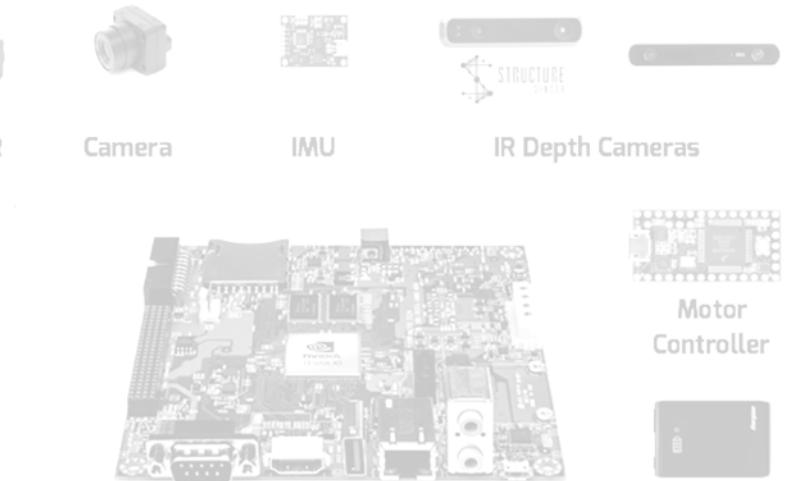
GPU accelerated  
libraries



Scenario Sim



ROSbag data



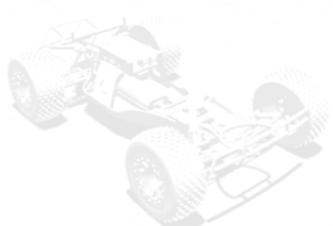
Wi-Fi Telemetry

Onboard Computer

Sensor Integration

Cloud-Based Simulation Tool

Vehicle and  
environment  
models in Gazebo



# Work in Teams from now onwards..

- 8 total teams
- 4 members per team

# Work in Teams from now onwards..

A	B	C	D	E	F
Vehicle Number	Vehicle N/W SSID	Member 1 (First + Last Name)	Member 2 (First + Last Name)	Member 3 (First + Last Name)	Member 4 (First + Last Name)
1	team_1	Raghava Pamula	Catherine Bradberry	Logan Hylton	Matthew Carey
2	team_2	Ryan Kann	Wyatt Joyner	Corey Lando	Jack Herd
3	team_3	Rahul Batra	Rashid Lasker	Stephen Shiao	Adeet Patel
4	team_4	Bradley Knaysi	Peng Zhang	Emory Ducote	Trevor Bedsaul
5	team_5	Jaspreet Ranjit	Jack Schumann	Hsing Chun Lin	Micah Harris
6	team_6	Sean Shih	Chris Han	Misran Dolan	Cem Kutay
7	team_7	Kaiying Shan	Hanzhi Zhou	Damon Cestaro	Pearak "Derek" Tan
8	team_8	Michael Tang	Catherine Im	Austin Bunting	Sri Jayakumar

# Each team will setup a webpage and a Github page



Use private git repositories and invite the instructor and the TA to the repo.



- Update the webpage regularly for each lab assignment:
  - Videos and pictures of progress
  - What you tried, what worked, what did not work.
  - Videos of your demo and practice run. (use as backup in case of trouble during the lab demos)

[Teams](#)[Home](#)[Logistics](#)[Syllabus](#)[Resources](#)

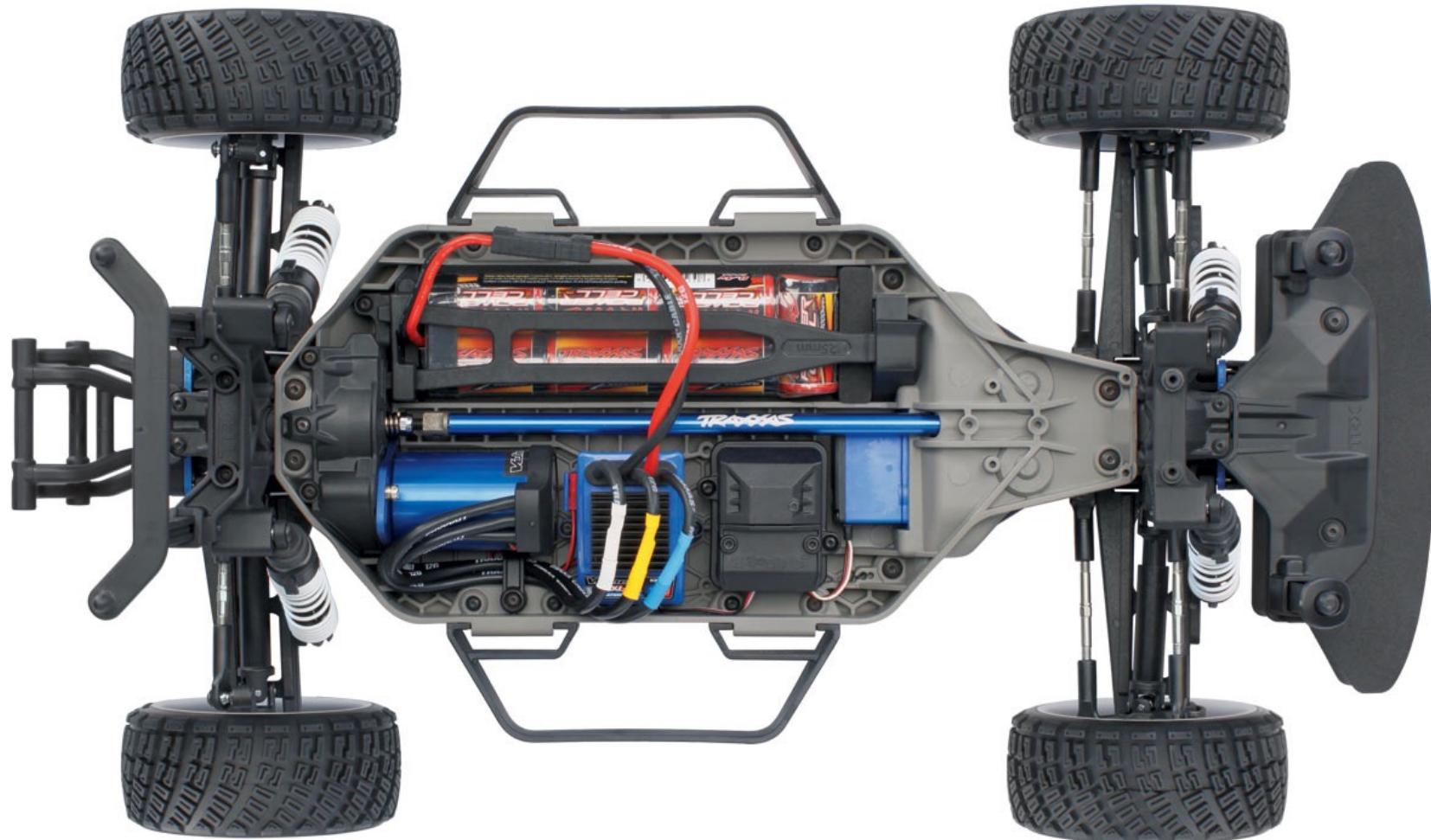
# F1/10 Autonomous Racing

Build. Drive. Race!  
Perception. Planning. Control

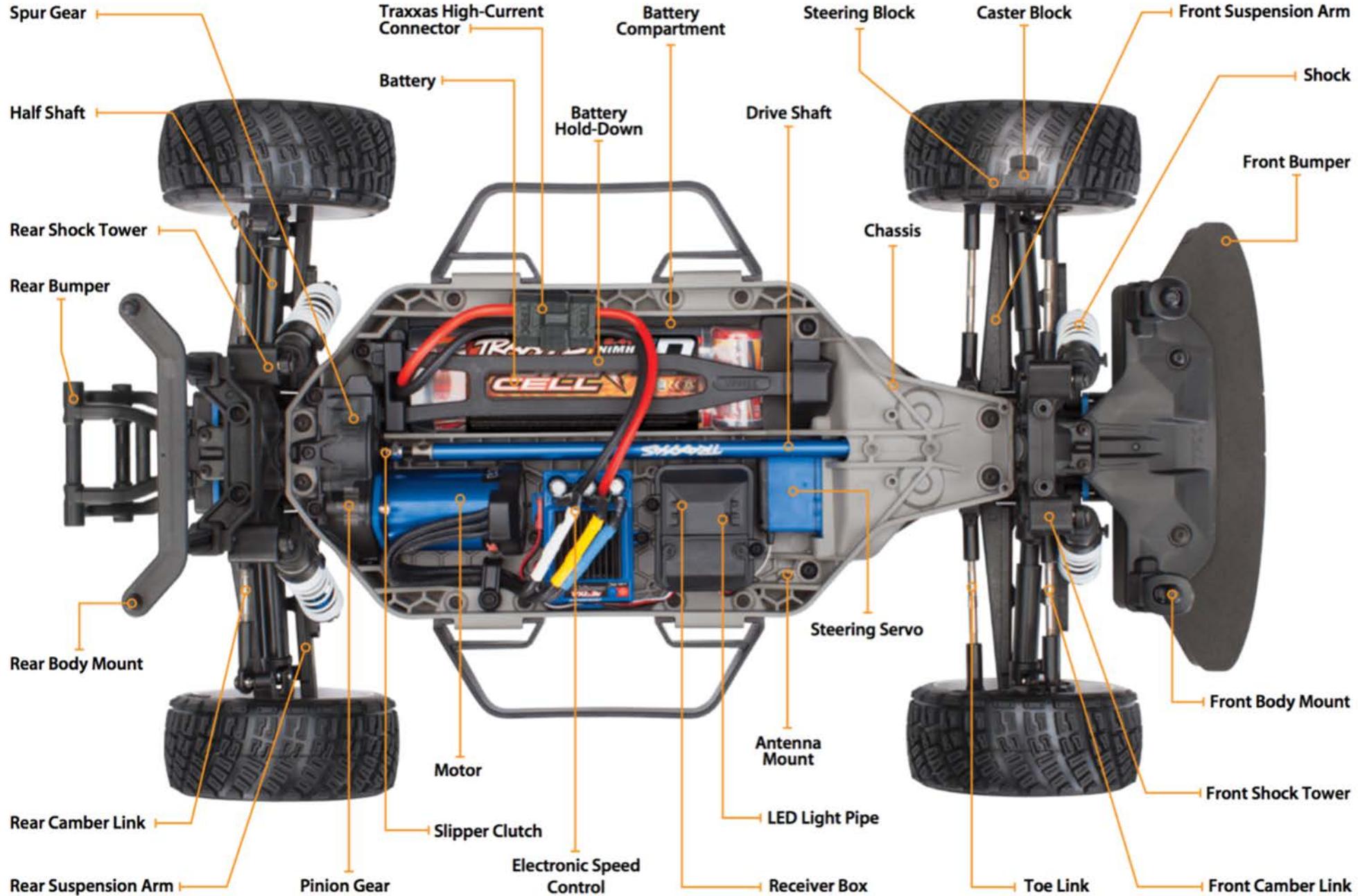
1/10 the scale. 10 times the fun!

[GET STARTED](#)

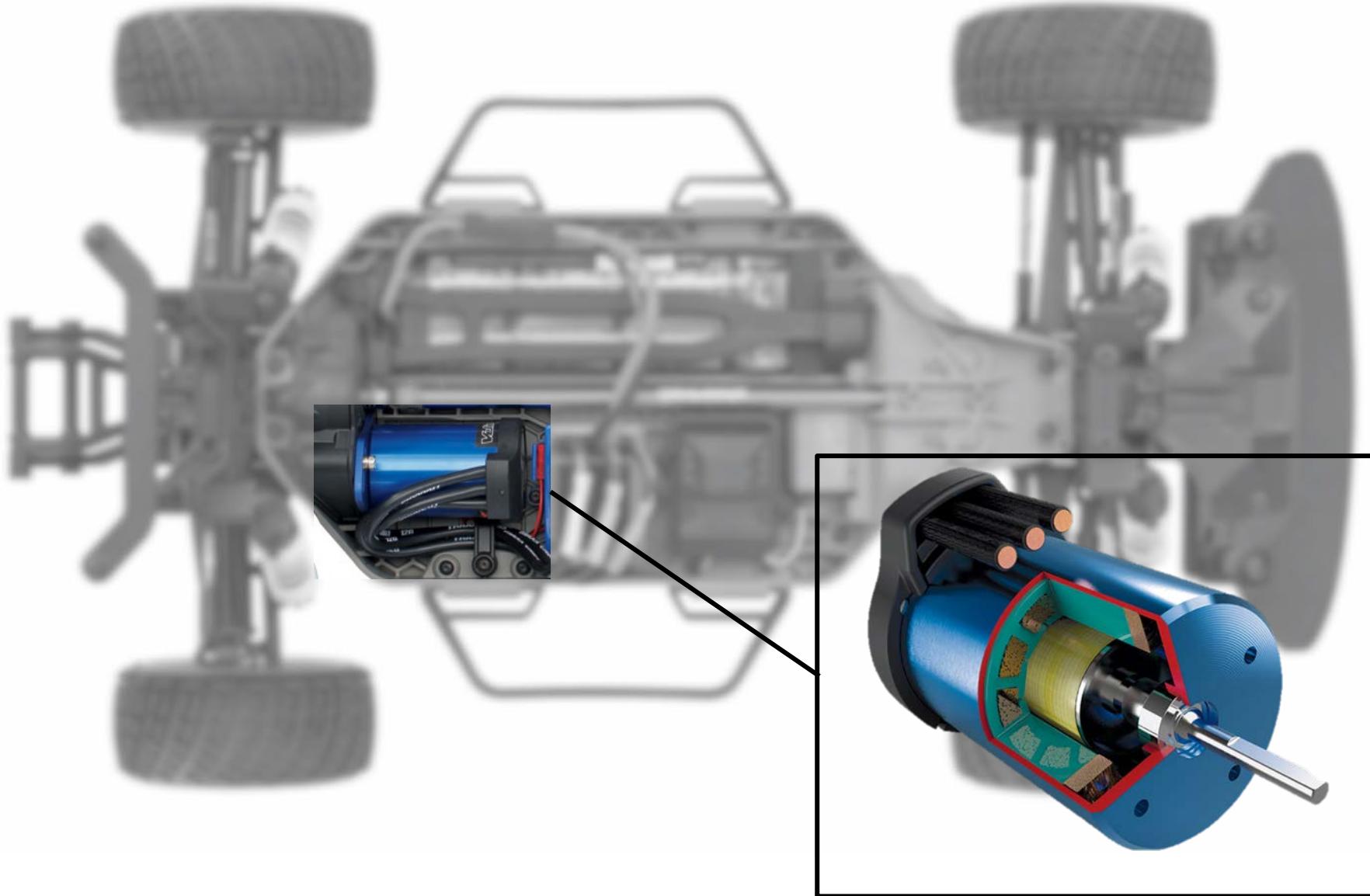
# Traxxas 1/10 scale RC race car



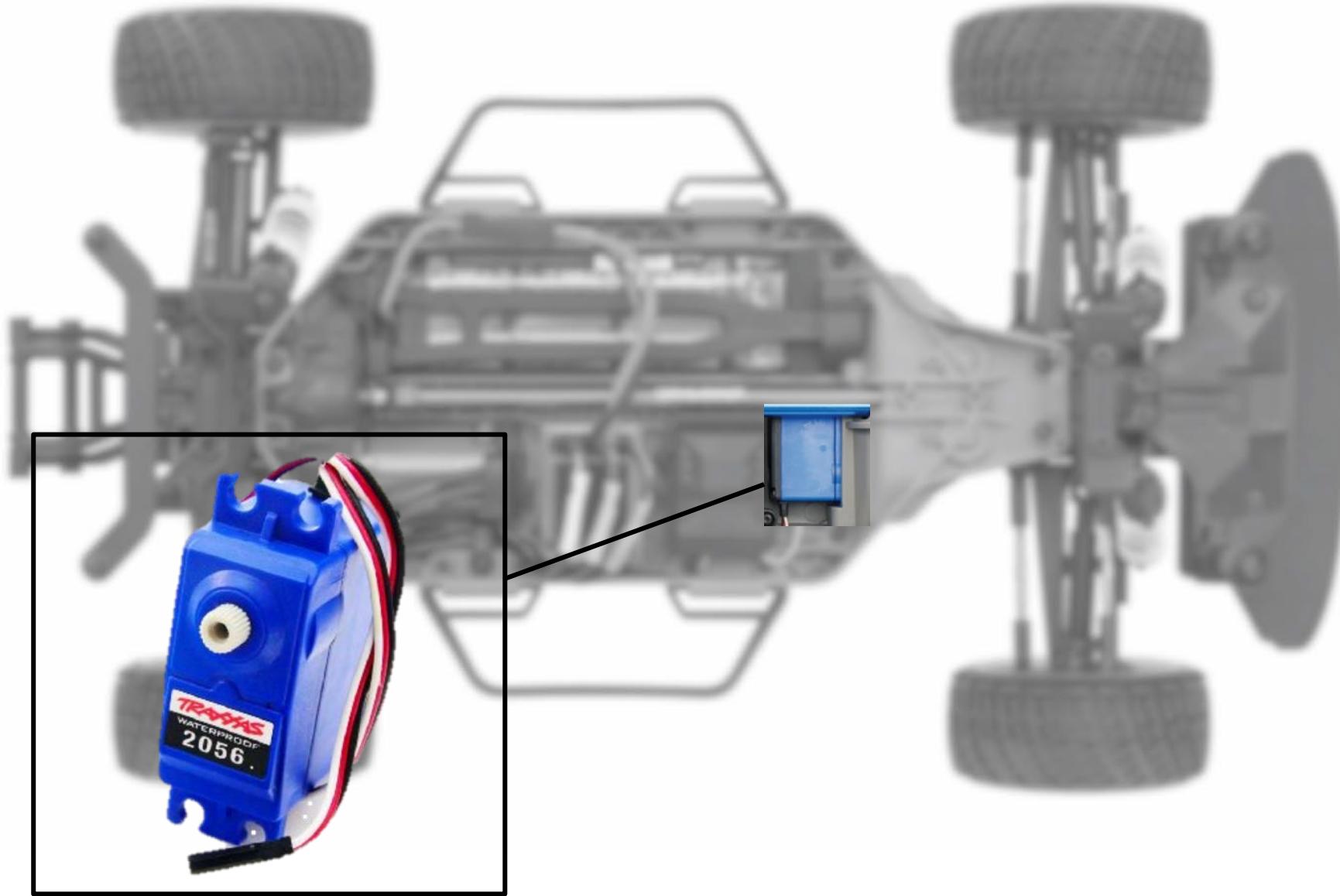
# Traxxas 1/10 scale RC race car



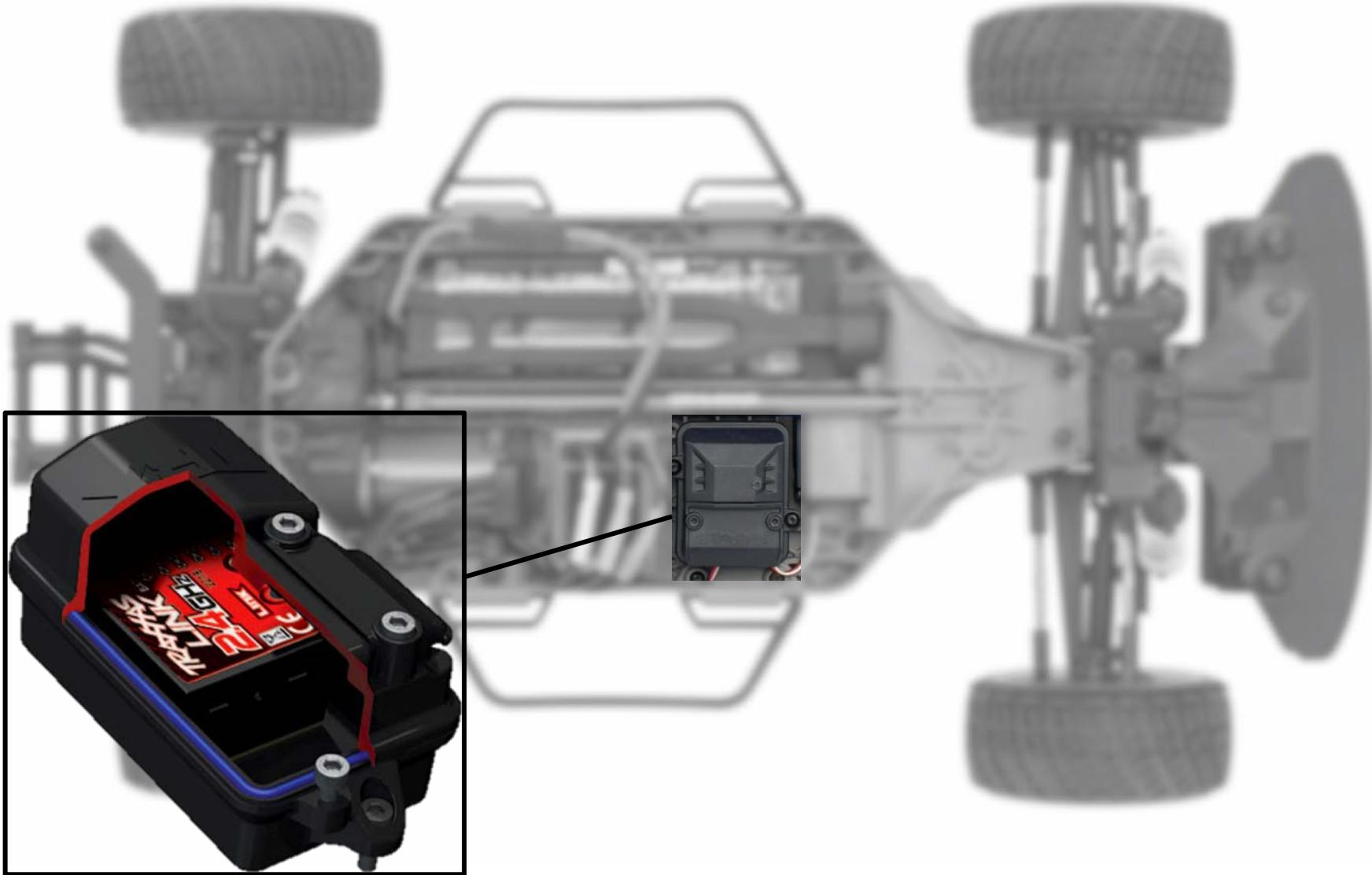
# Brushless DC motor



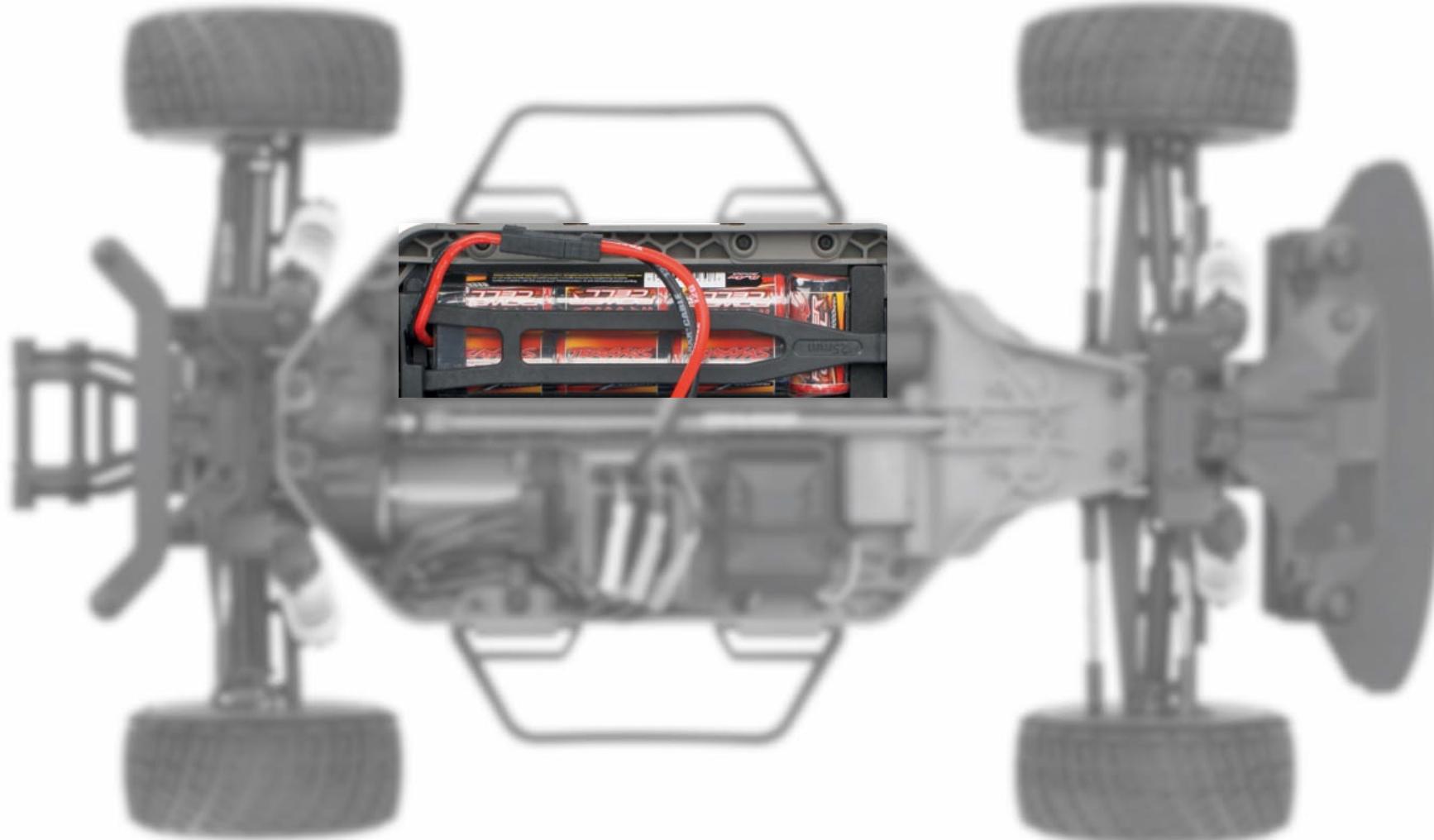
# Servo motor for steering



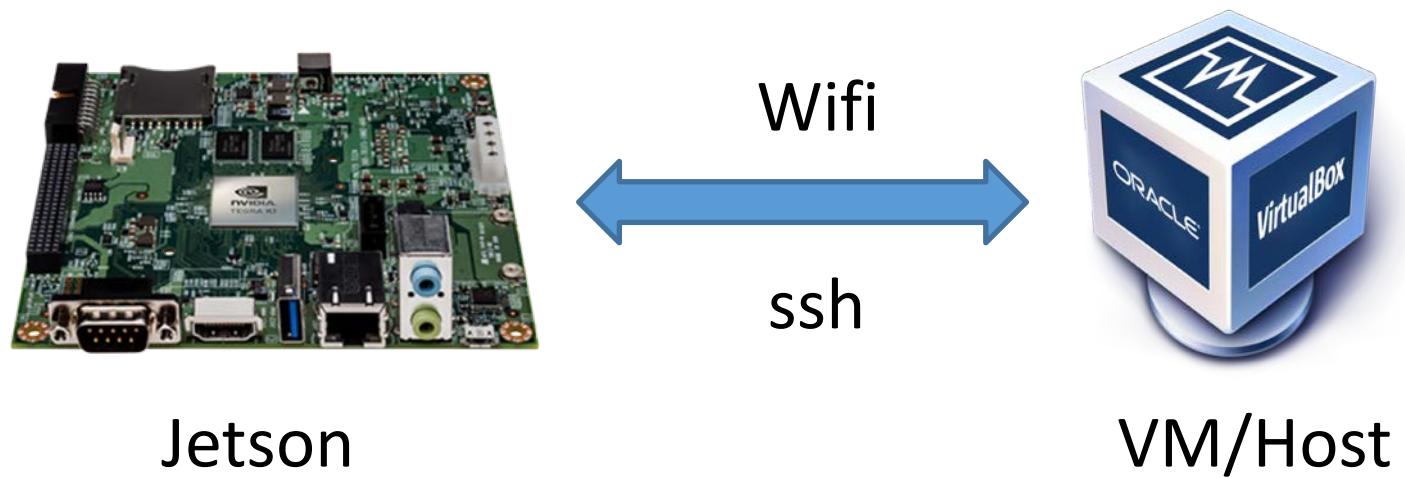
# Radio receiver



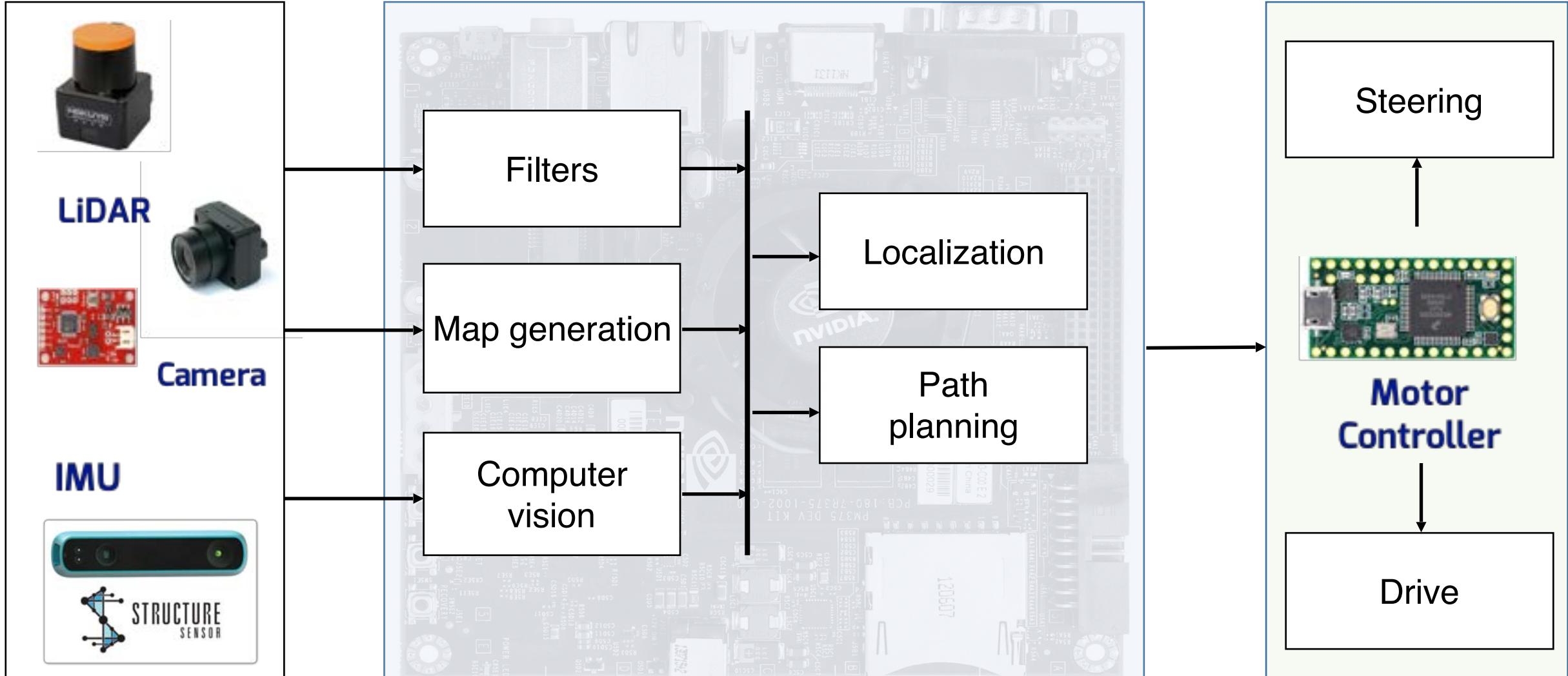
# Battery pack



# Connection Diagram



# System Architecture

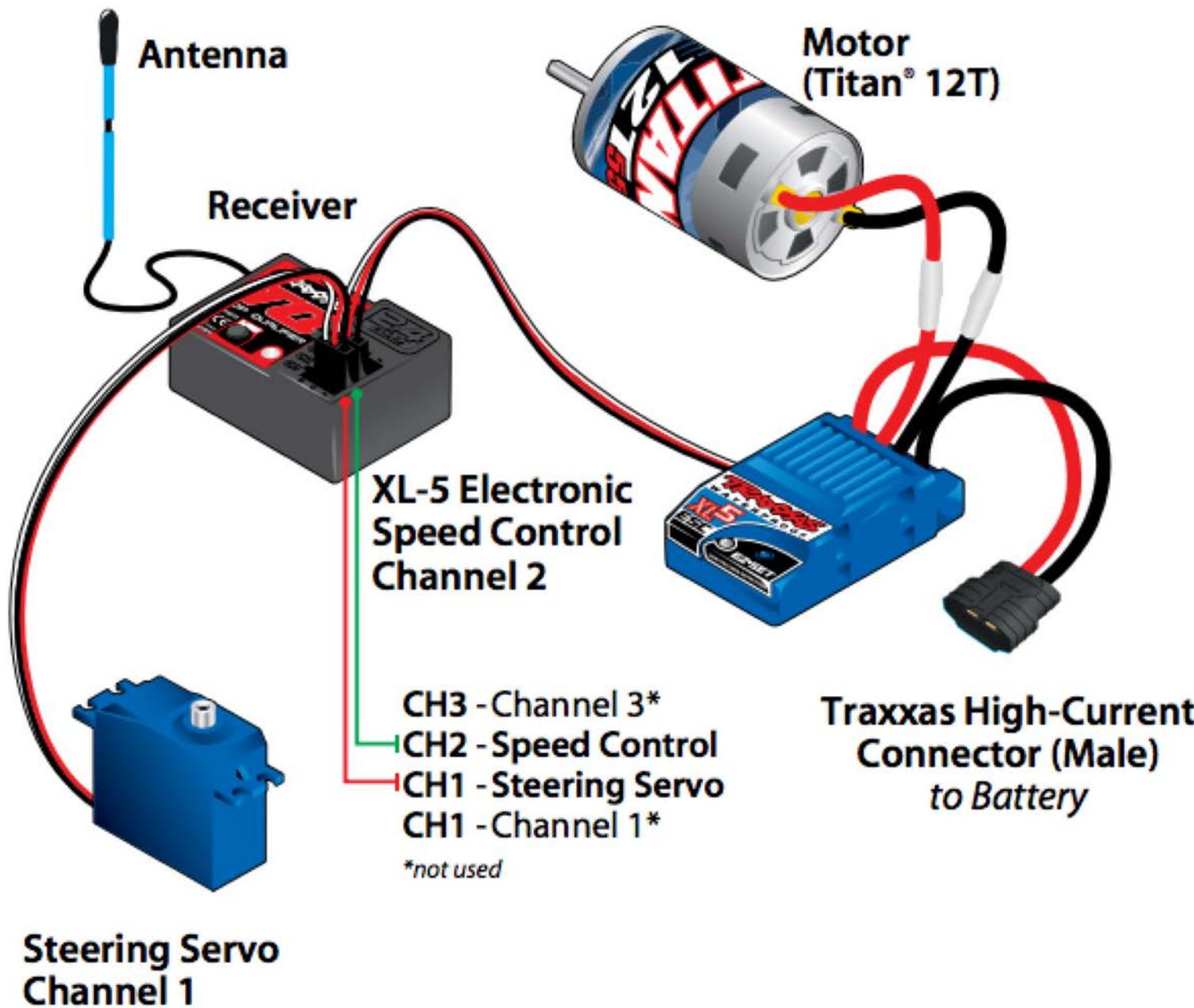


Perception

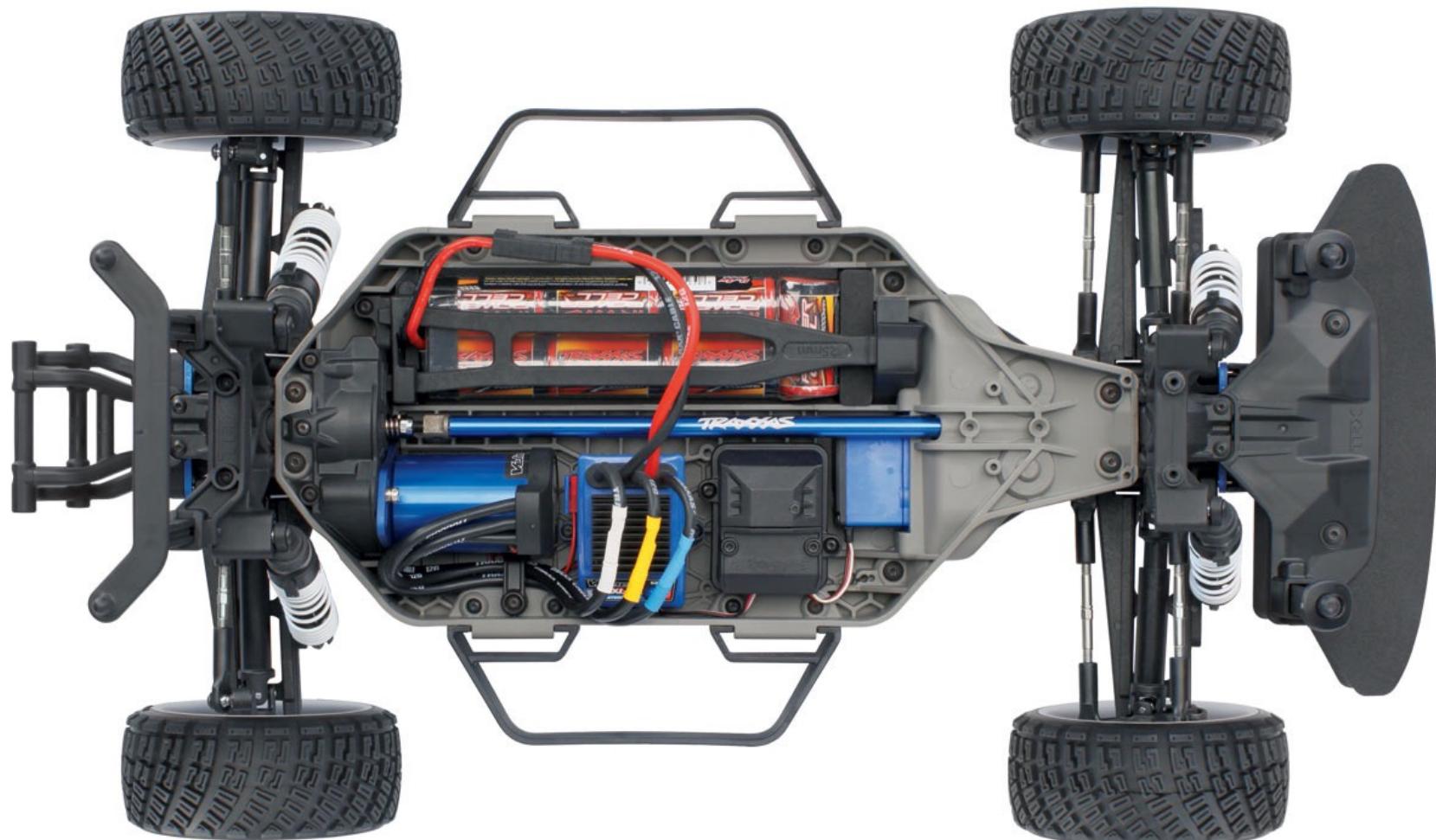
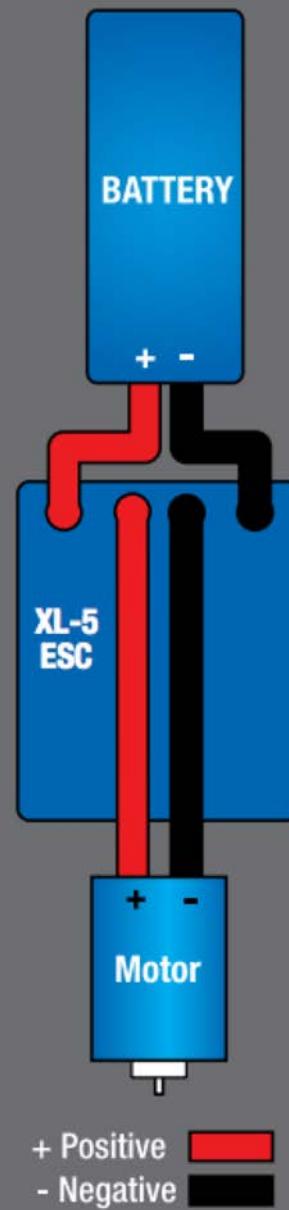
Planning

Control

## MODEL WIRING DIAGRAM



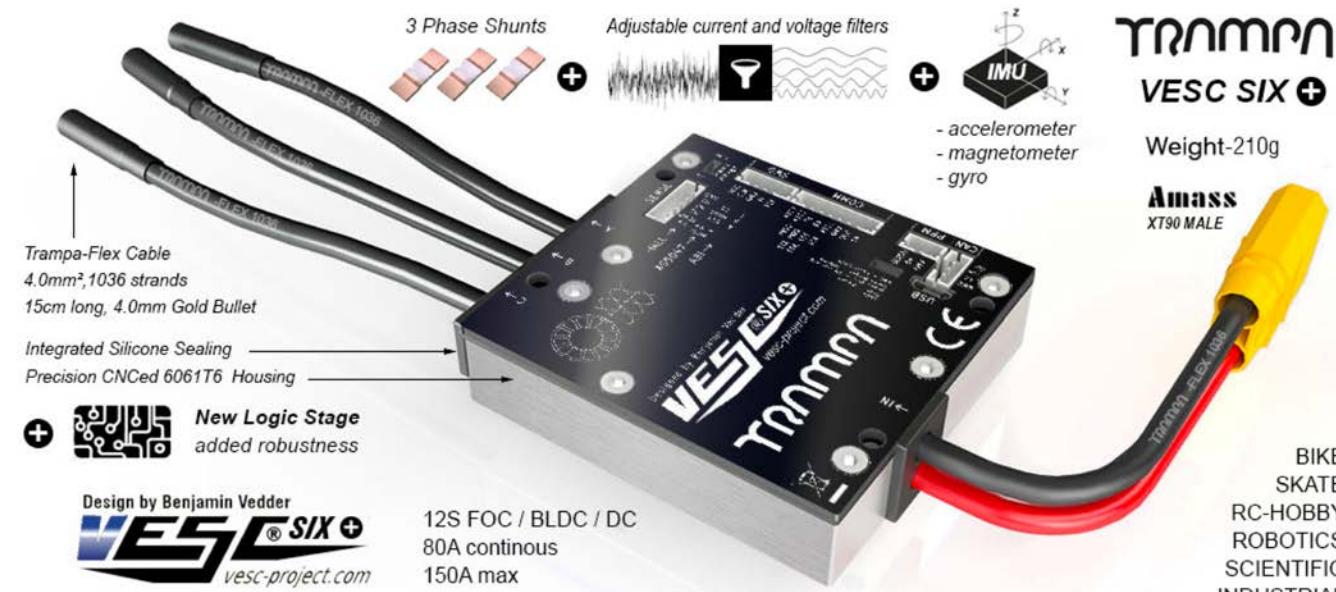
## XL-5 Wiring Diagram



# VESC: Vedder – Electronic Speed Controller

Current and voltage measurement on all phases (three phase shunts)

- Adjustable current and voltage filters
- **built in IMU chip (accelerometer, gyro, compass)**
- Regenerative braking
- Traction control (single and twin setup)
- Configurable RPM-, power limits
- Communication ports: USB, CAN, UAVCAN, UART
- Separate throttle curves for acceleration and brakes
- Real time data analysis
- Adjustable protection against:
  - Low input voltage
  - High input voltage
  - High motor current
  - High input current
  - High regenerative braking current (separate limits for the motor and the input)
  - High RPM (separate limits for each direction).
  - Over temperature (MOSFET and motor)



## Each Kit Contains:

1. 1 fully assembled F1/10 Autonomous Racecar
2. 2 Batteries - 2Cell LiPo (Blue), and 3Cell LiPo (Red)
3. 1 Traxxas battery charger with a large outer box
4. 1 LiPo safety ‘silver’ bag
5. 1 Logitech wired Joystick controller

# Complete battery pack

Practice LiPo safety !



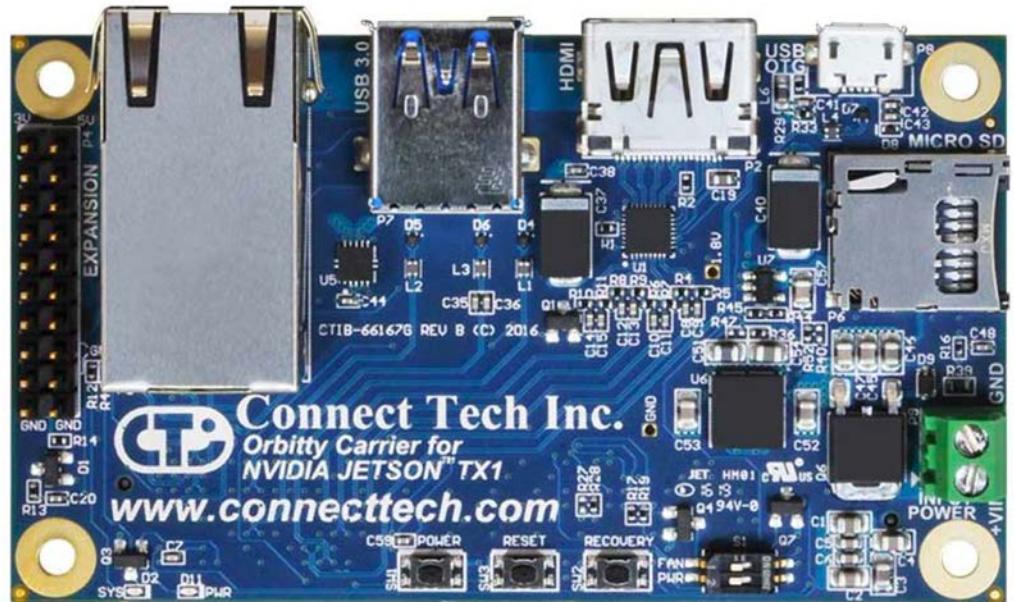
## Nvidia Jetson TX2

- NVIDIA Pascal™ architecture with 256 NVIDIA CUDA cores 1.3 TFLOPS (FP16)
- 4GB memory
- Dual-core Denver 2 64-bit CPU and quad-core ARM A57 complex
- 16 GB eMMC 5.1



# Orbitty Carrier for NVIDIA® Jetson™ TX2/TX2i/TX1

- Extremely Small Size: 87mm x 50mm (3.425" x 1.968")
- 1x GbE, USB 3.0, USB 2.0, 1x HDMI, 1x MicroSD, 2x 3.3V UART, I2C, 4x GPIO
- +9V to +14V DC Nominal (+19V Peak)



## 6400mAh 11.1v 3-Cell 25C LiPo Battery

Engineered specifically to fit Traxxas models  
and maximize their full performance potential

**Charge only using the provided charger**



Type	Total Capacity	Voltage	C Rating	Length	Height	Width	Weight
LiPo	5800 mAh	7.4 V	25	135 mm	25 mm	45 mm	10.2 oz

## 5800mAh 7.4v 2-Cell 25C LiPo Battery



## Sabrent 4-Port USB 3.0 Hub with Individual LED Power Switches

Supports Transfer Speeds up to  
5Gbps (USB 3.0), 480Mbps (USB  
2.0), 12Mbps (USB 1.1)



# Hokuyo URG-04LX-UG01 Scanning Laser Rangefinder

## Product Highlights

- Hokuyo's **URG-04LX-UG01** detectable range is **20mm to 5600mm**
- 100msec/scan
- 5V operating voltage
- 240° area scanning range with 0.36° angular resolution

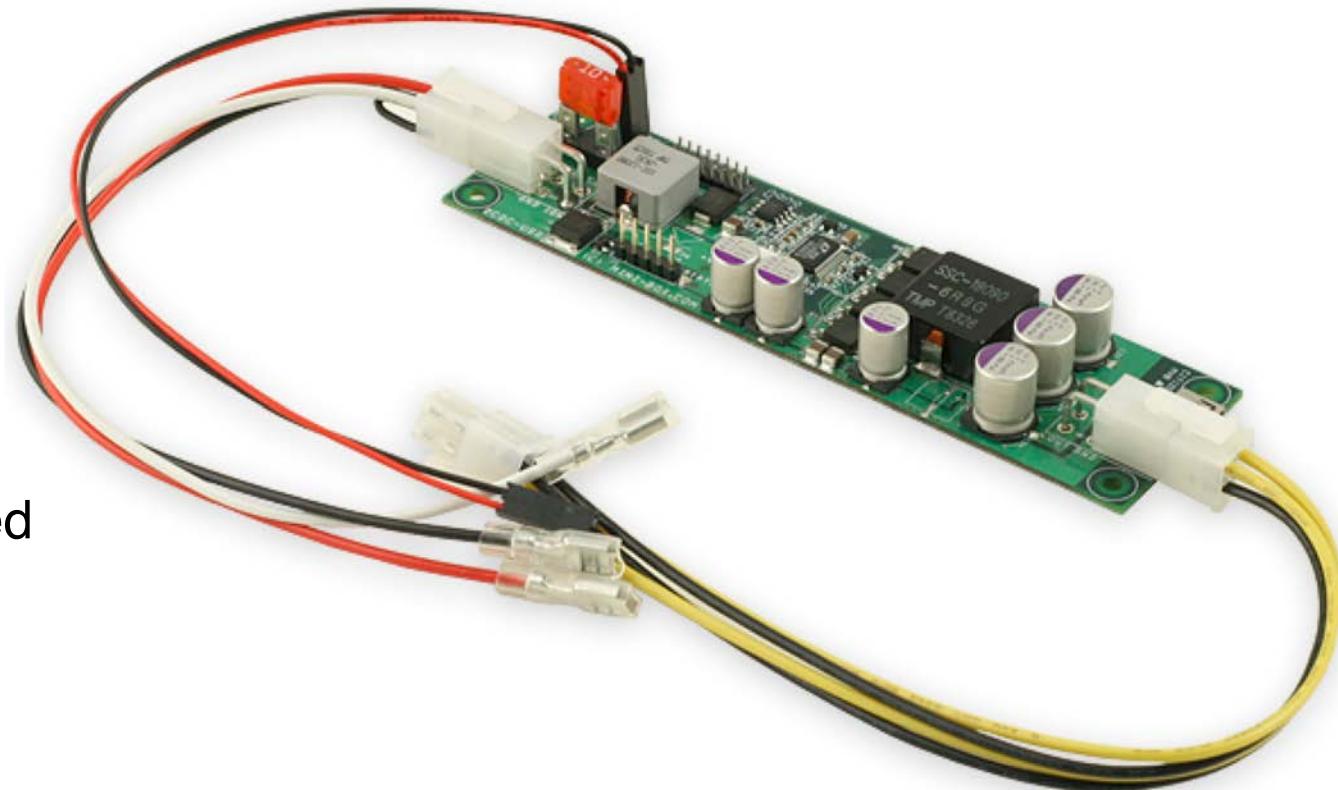


## **Intelligent DC-DC converter with USB interface**

DCDC-USB is a high power buck-boost microcontroller DC-DC converter.

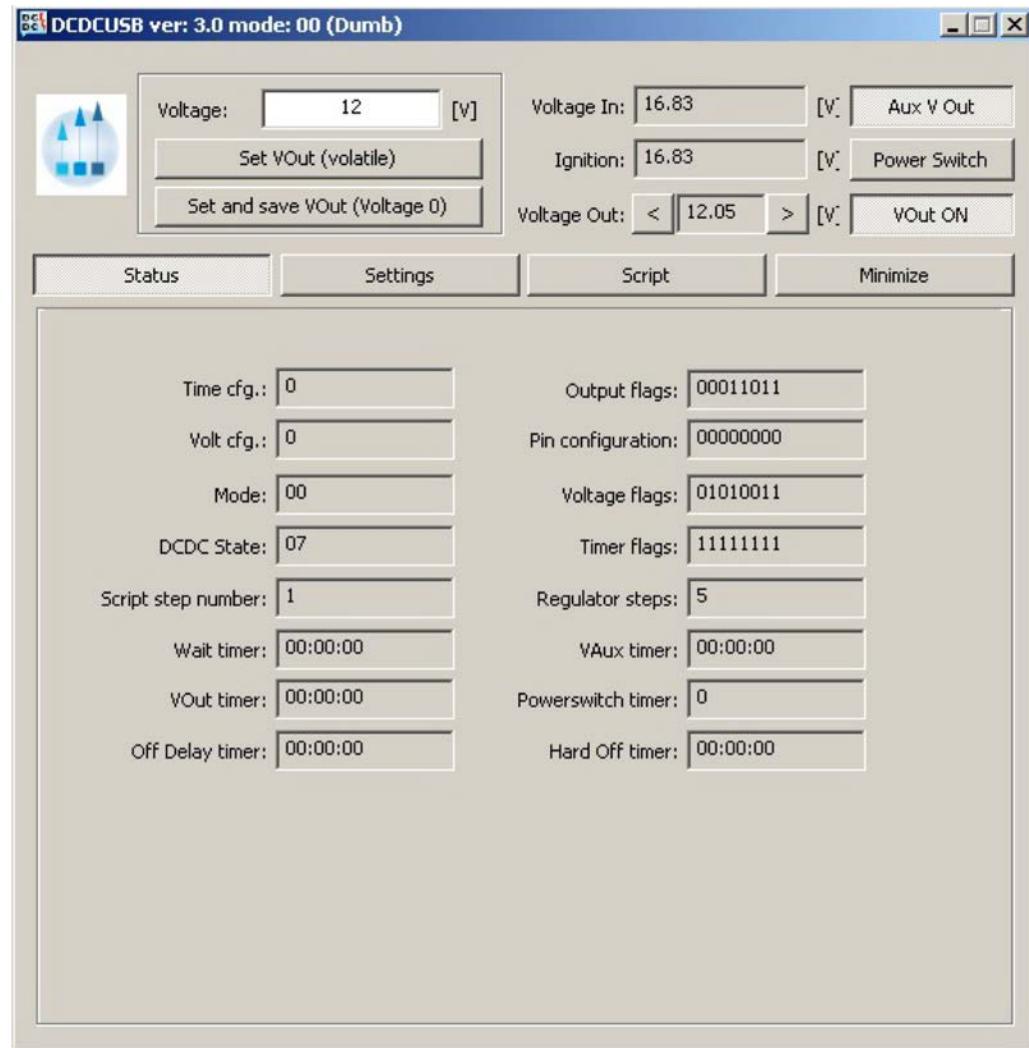
Unit accepts any input ranging from 6-34V.

Output is 12V regulated or output can be changed with simple jumper settings to 5V, 6V, 9V, 12V, 13.5V, 18V or 24V or via USB in fine increments (0.25V) anywhere from 5-24V.

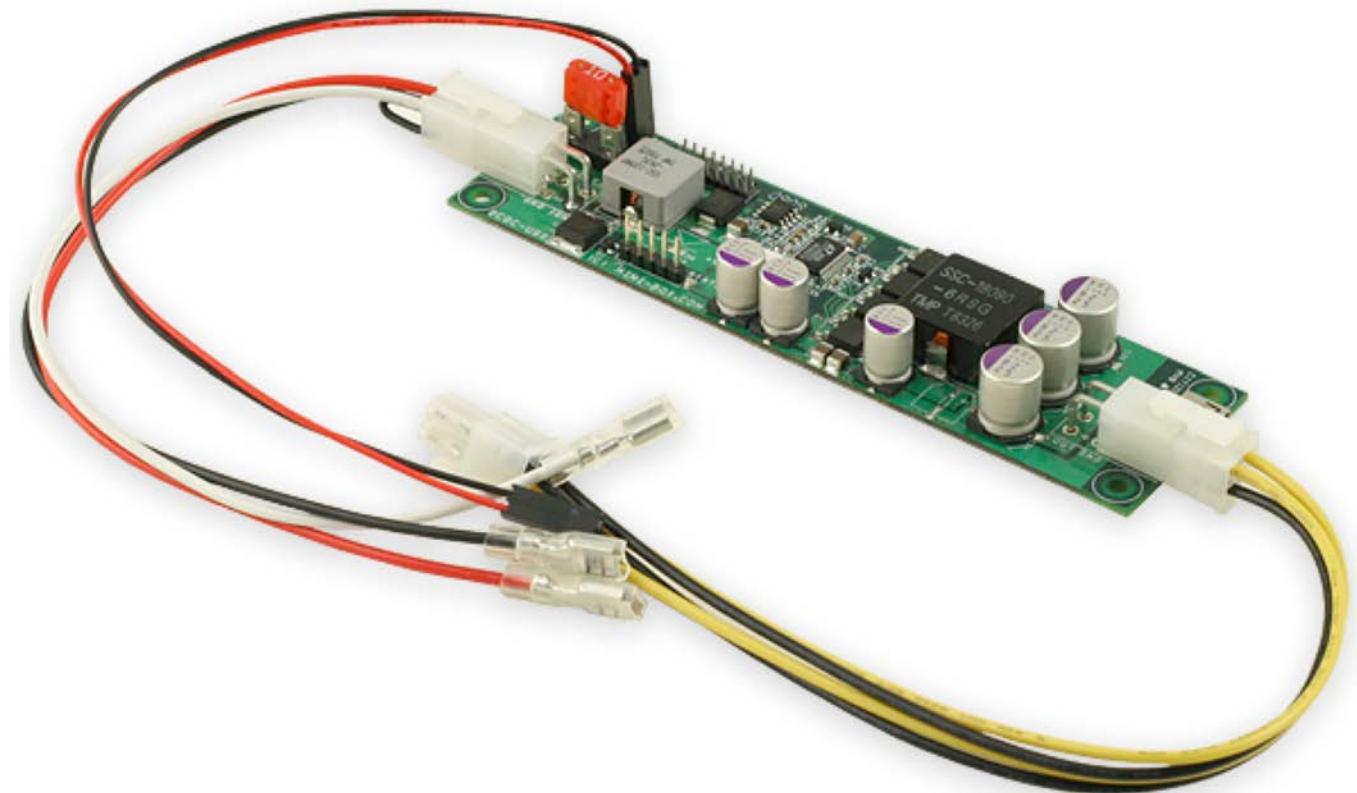


**This module can be used to convert any voltage ranging 6-34V to any output from 5-24V.**

# Intelligent DC-DC converter with USB interface



DCDC-USB Status



# Ubiquiti Pico Station

## Wifi telemetry

Acts as an access point

Each car has its own Wifi network

The PicoStation M delivers up to 100+ Mbps  
real TCP/IP throughput.

360° coverage at a range of up to 500 m



## **Velineon 3500 Brushless Motor (BLDC)**

RPM/volt: 3500

Max RPM: 50,000.

Wire Size: 12-gauge



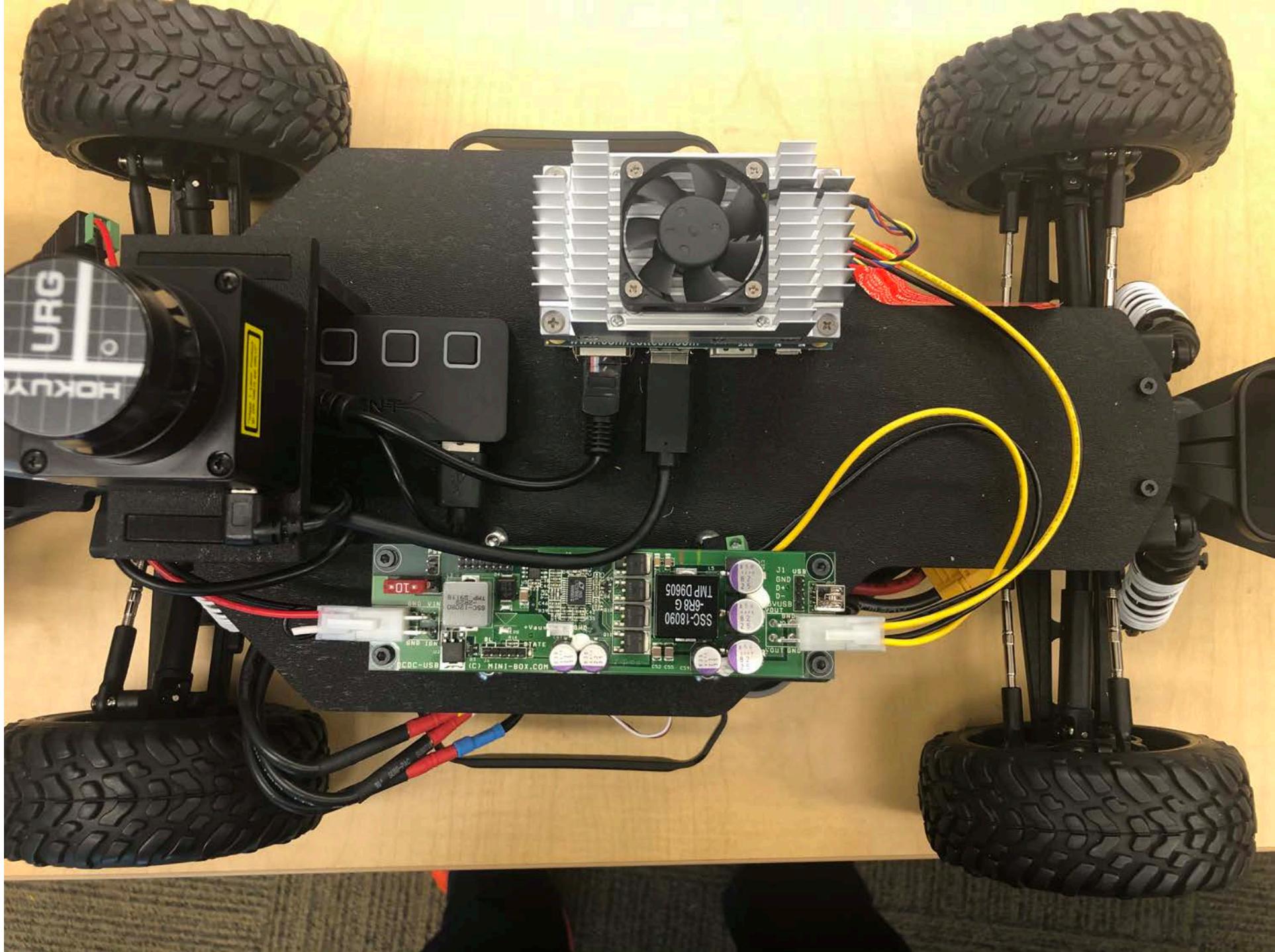
Ultra high-temperature sintered Neodymium magnets provide massive torque and linear power  
Optimized for power and efficiency in 1/10th scale vehicles  
Low-maintenance, unique Traxxas design with efficient, high-speed ball bearings  
10-Turn, 3500Kv  
Precision-balanced rotor with protective end cap

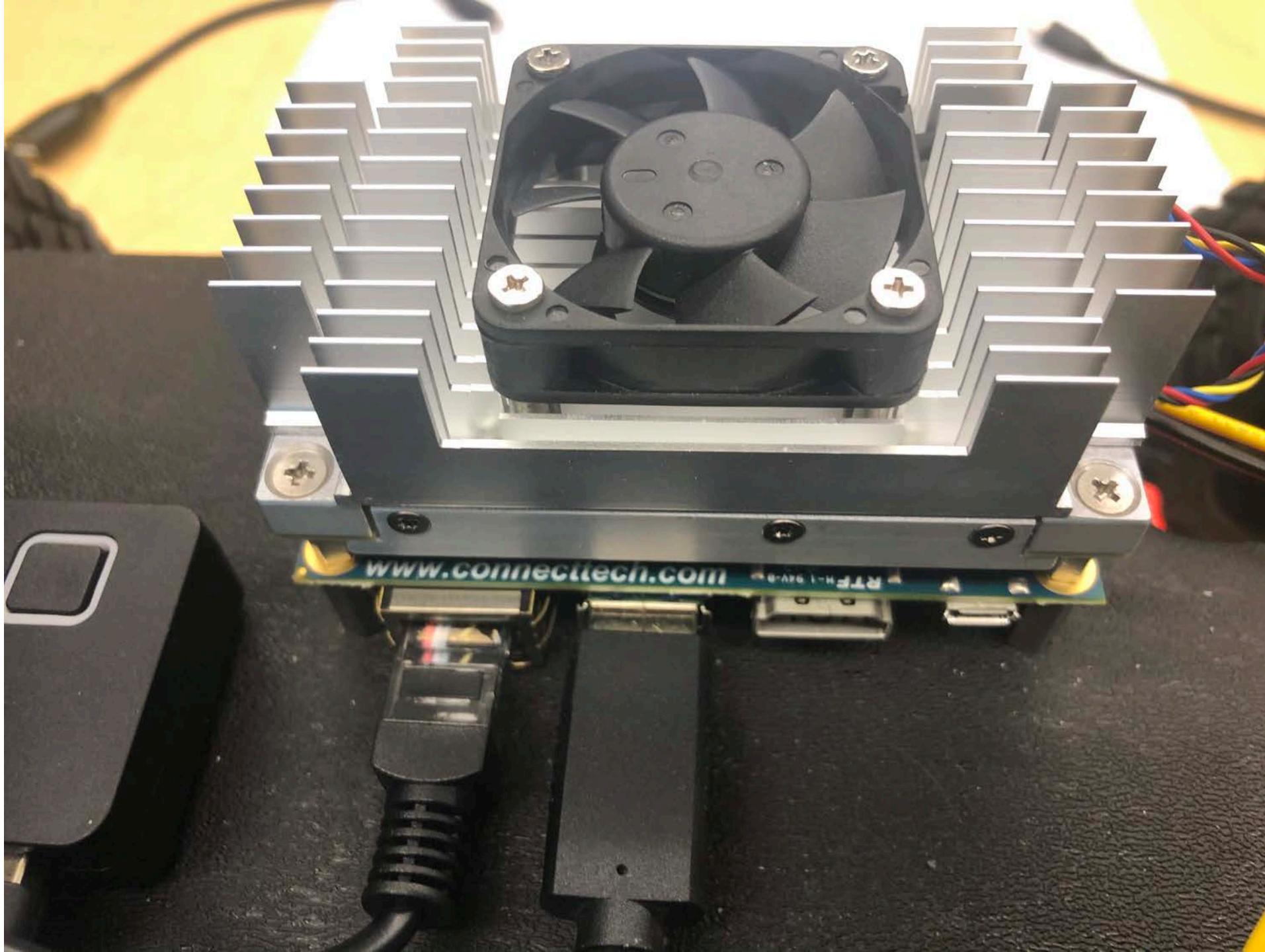
## Traxxas 2056 High-Torque Waterproof Servo

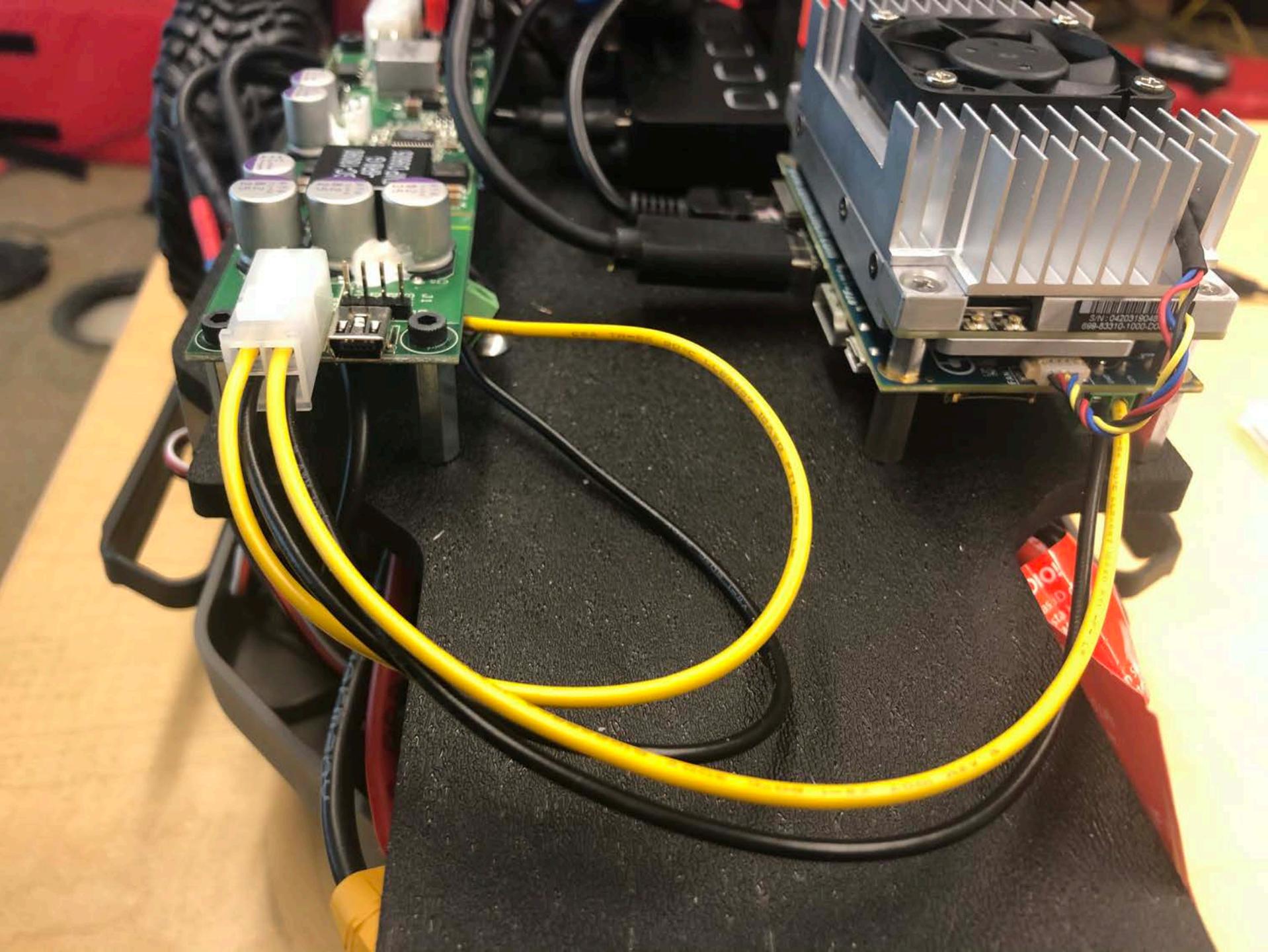
- High torque waterproof servo
- 80 oz-in torque
- Transit time 0.23 sec/60
- Transit time 0.23 sec/60
- 86 oz-in torque, Transit Time 0.23 sec/60\*
- Dimensions: 40.5 x 20.5 x 36mm, 45g
- 25T Spline, Futaba style servo lead



Lets study the connections before powering  
the car

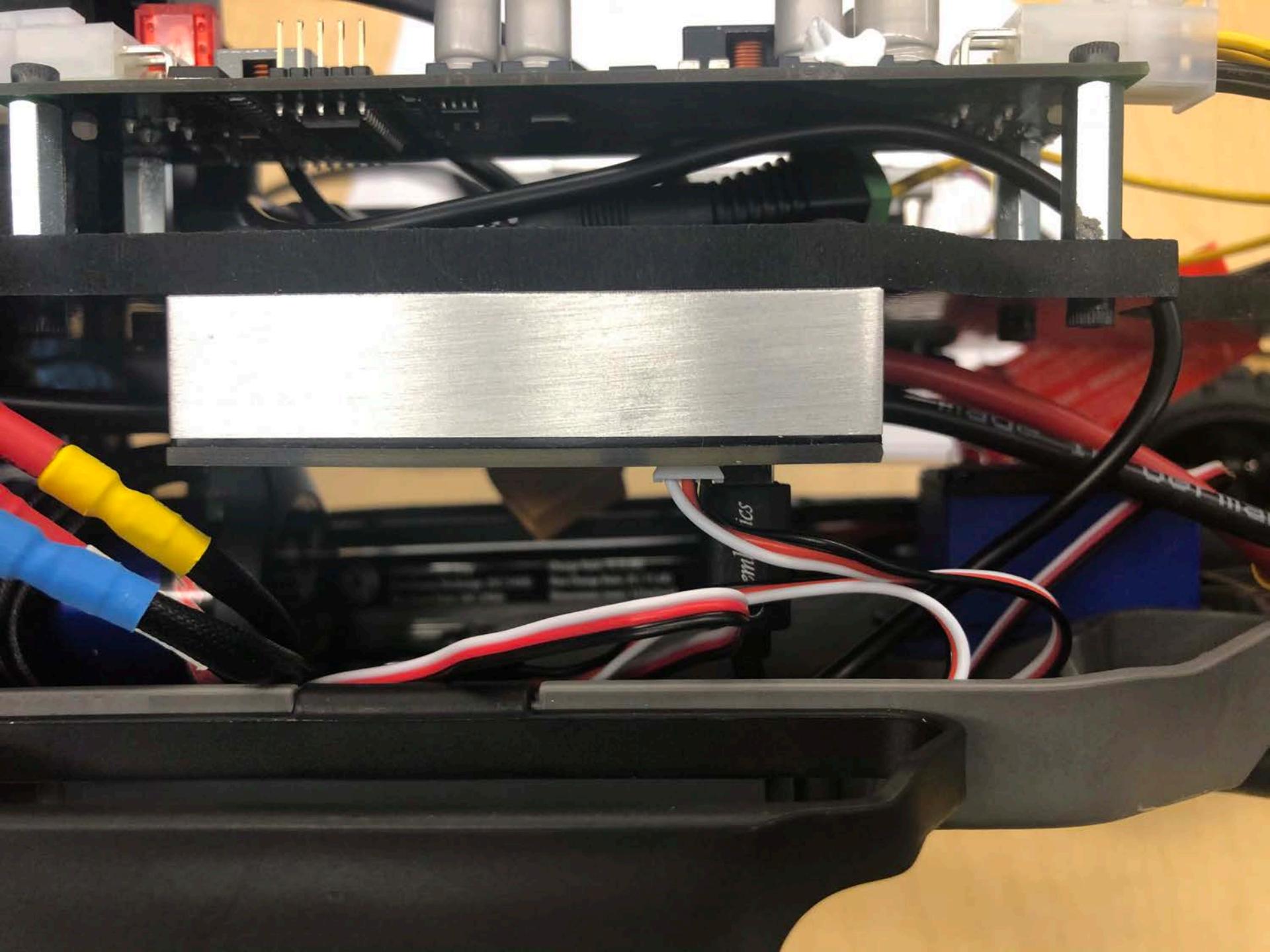




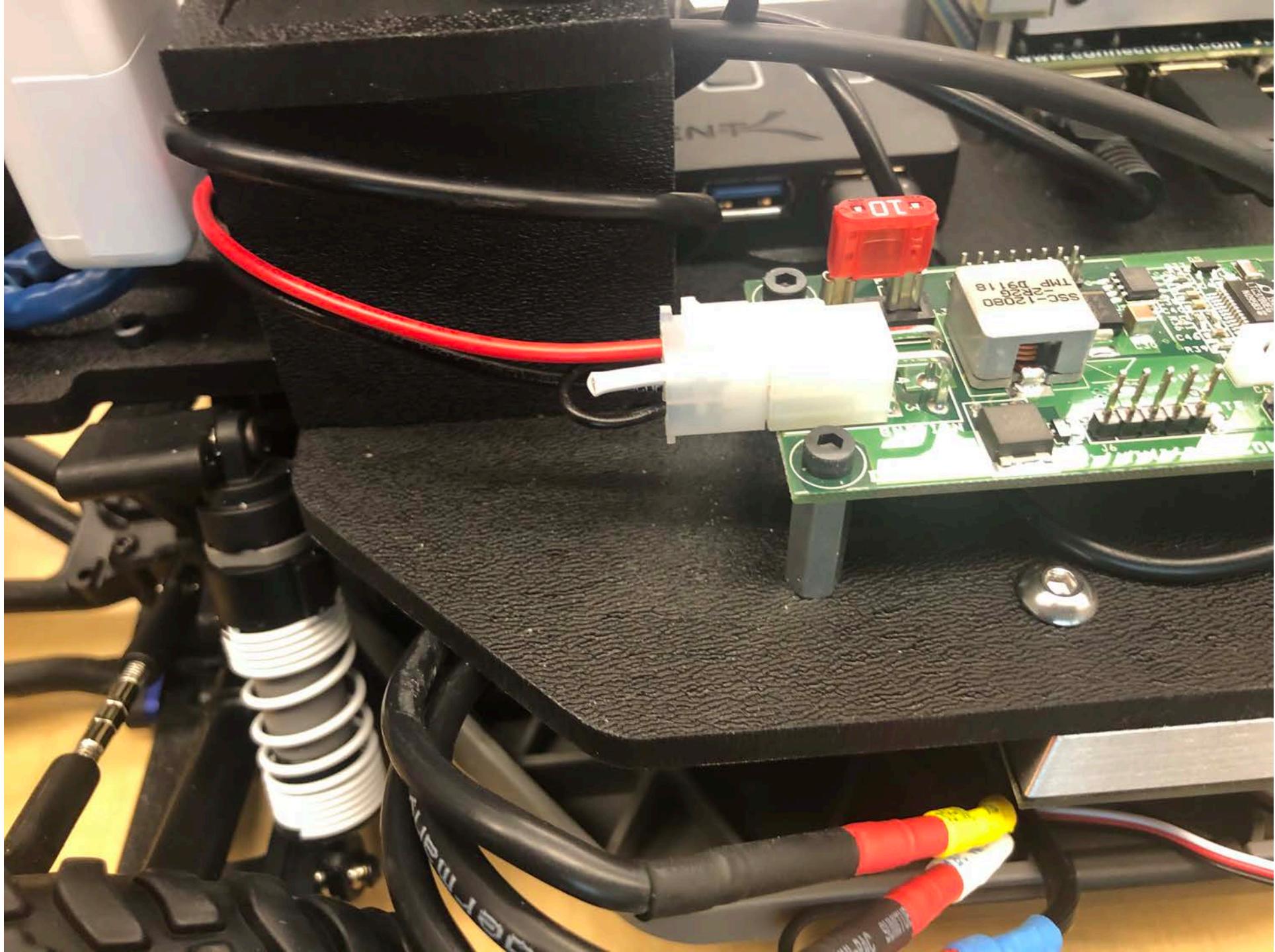












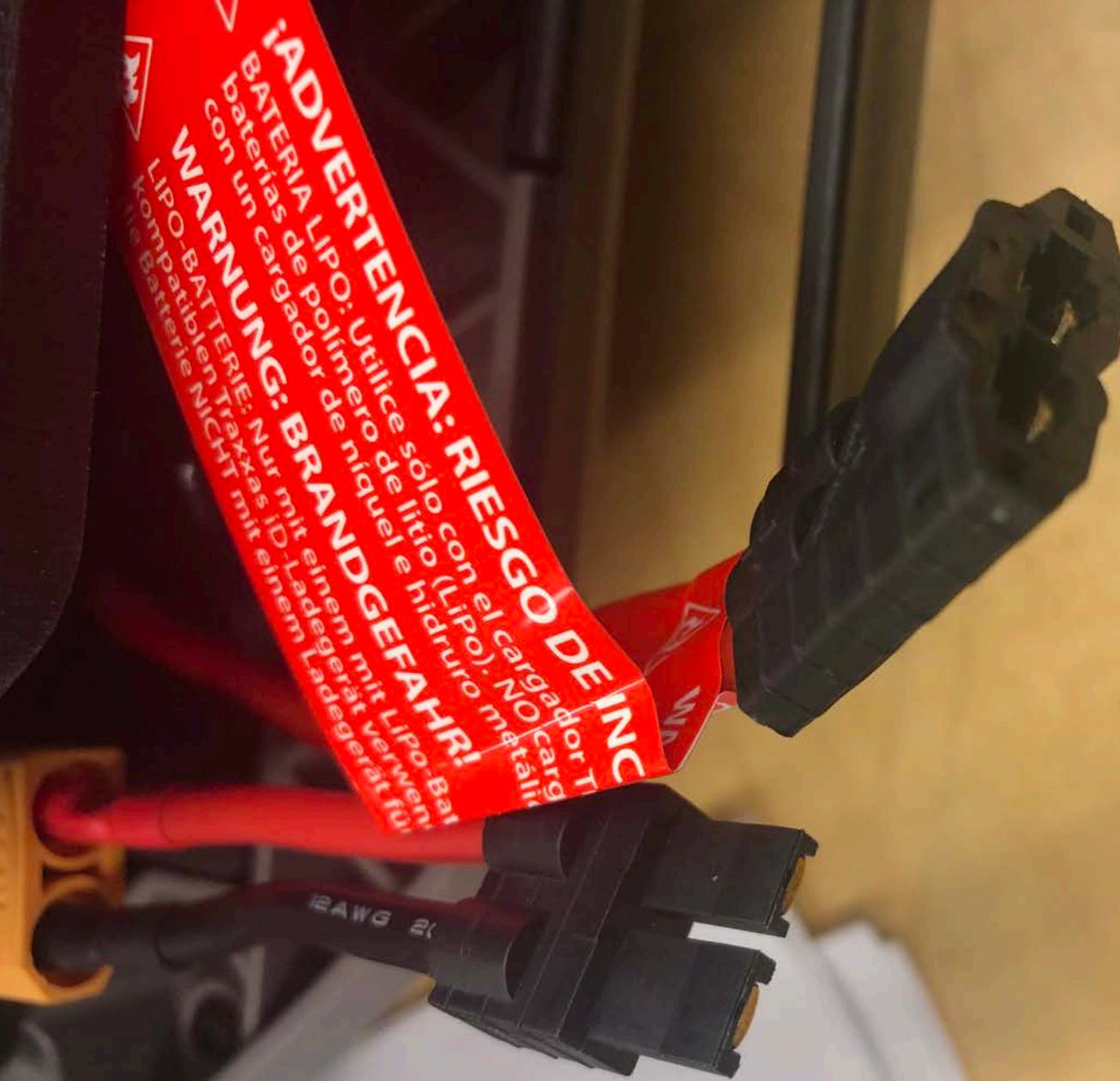








**!ADVERTENCIA: RIESGO DE INCENDIO**  
Utilice sólo con el cargador iD. NO cargar con otro cargador.  
BATERIA LIPO: Utilice sólo con el cargador iD. NO cargar con otro cargador.  
**WARNUNG: BRANDGEFAHR!**  
BATTERIE LIPO: Utilize nur mit dem Ladegerät iD. Nicht mit anderen Ladegeräten laden.  
Baterías cargadas con un cargador de polímero de níquel e hidruro de litio (LiPo) solo con el cargador iD. NO cargar con otro cargador.  
**WARNING: FIRE HAZARD!**  
Lipo batteries charged with an iD charger only. Do not charge with another charger.  
LIPO-BATTERIE: Nur mit einem Ladegerät mit iD-Ladealgorithmus laden. NICHT mit einem anderen Ladegerät laden.





**Use caution at all times**



**The F1/10 car is capable of very high speeds.**

**Pay special attention to the handling of Li ion high current batteries**

**When in doubt; ask the instructor**

# One time setup on your Remote Machine/VM

Install and catkin\_make the **move\_base** package

```
cd ~/catkin_ws/src  
git clone https://github.com/linklab-uva/move_base  
cd ~/catkin_ws  
catkin_make  
source ~/.bashrc
```

# One time setup on your Remote Machine/VM

Install the joy package (for joystick interface)

```
sudo apt-get install ros-kinetic-joy
```

# One time setup on your Remote Machine/VM

Verify that joystick is seen by the VM

- ls /dev/input/
- The output should contain an entry for JS0
- You will need to configure USB devices inputs for the VM.

# One time setup on your Remote Machine/VM

## Configure ROS\_OVER\_NETWORK

Open `~/.bashrc` on the remote machine using text editor, and add the following lines at the end

```
export ROS_IP=192.168.1.100
```

```
export ROS_MASTER_URI=http://192.168.1.1:11311
```

# Milestone 1: Connecting to your car

1. Powering ON the Jetson TX2
2. Connecting to your car's Wifi Network
3. ssh into the Jetson TX2

# Milestone 1: Powering ON the Jetson TX2

Use the barrel jack connector on the rear of the car to power ON the Jetson

# Milestone 1: Configure your remote machine – Part 1

## 1. Connect to your **team\_x** Wifi Network:

You need to assign a static IP on the remote machine manually for this to work

Password: f110uva123

Use the following IPv4 settings:

**IP: 192.168.1.100**

**Subnet: 255.255.255.0**

**Gateway: 192.168.1.1**

# Milestone 1: ssh into the TX2 on the car

## Remote Login

```
ssh nvidia@192.168.1.1  
password: nvidia
```

**Note:**

‘nvidia’ is the default password

**(Do NOT change this password)**

# Milestone 2: TeleOp control using joystick

1. Place the care safely on the box provided so the wheels do not touch any surface.
2. Launch remote\_control node on the Jetson TX2
3. Start TeleOp control on the remote machine

## Milestone 2:

Place the care safely on the white cardboard box provided so  
the wheels do not touch any surface

## Milestone 2: Launch `move_base` node on the Jetson

- ssh into the TX2 : ssh [nvidia@192.168.1.1](https://nvidia@192.168.1.1)
  - Pass: nvidia
- roslaunch move\_base move\_base.launch

## Milestone 2: Launch remote\_teleop on the remote machine/VM

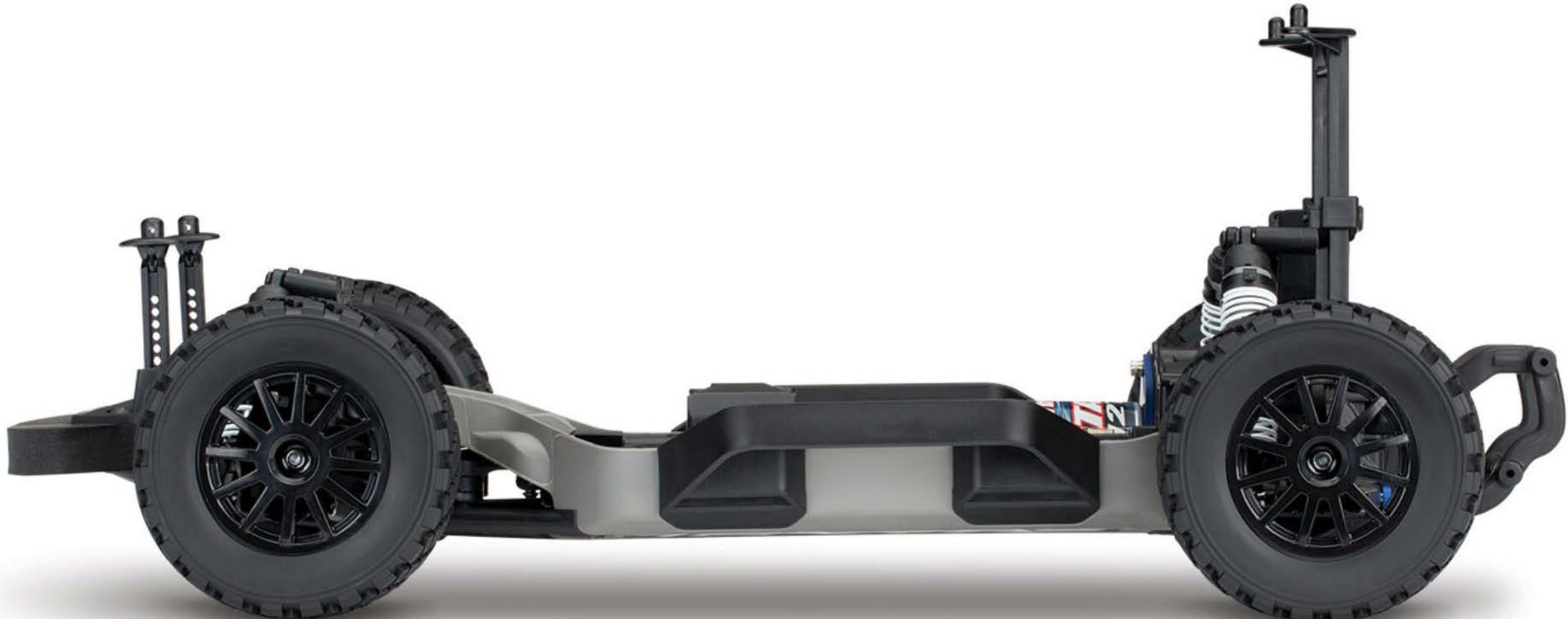
- In a separate terminal instance on the remote machine run:

```
roslaunch move_base remote_teleop.launch
```

## Milestone 2: Teleop control

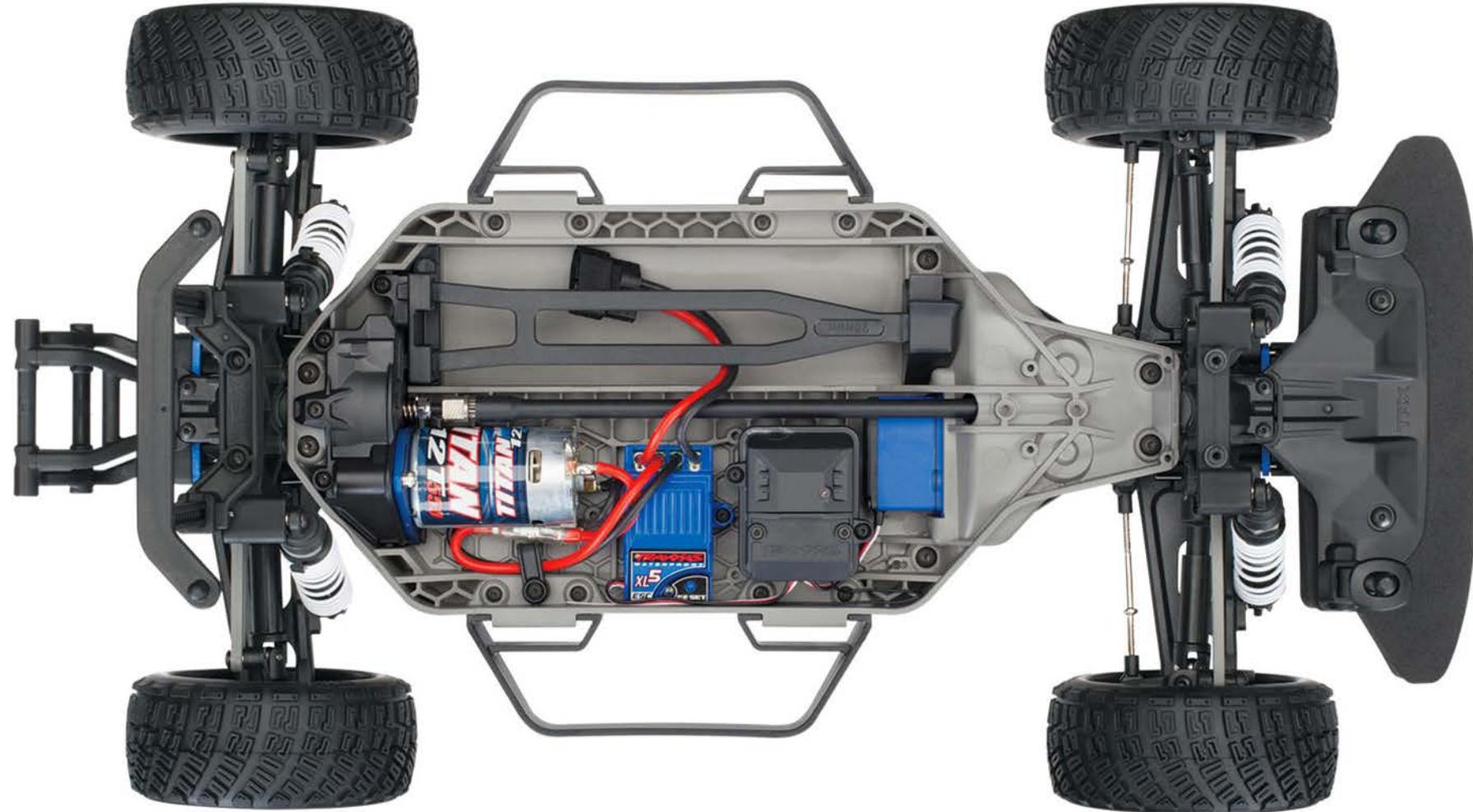


# Low center of gravity



# Perfect weight bias

The bulk of the mass is distributed down the centerline of the chassis for smooth, stable cornering.



# **Oil filled Shocks**

fully tunable with a wide range of oils, springs, and pistons.



# Differential



# Drive shaft

telescoping, universal-joint driveshaft



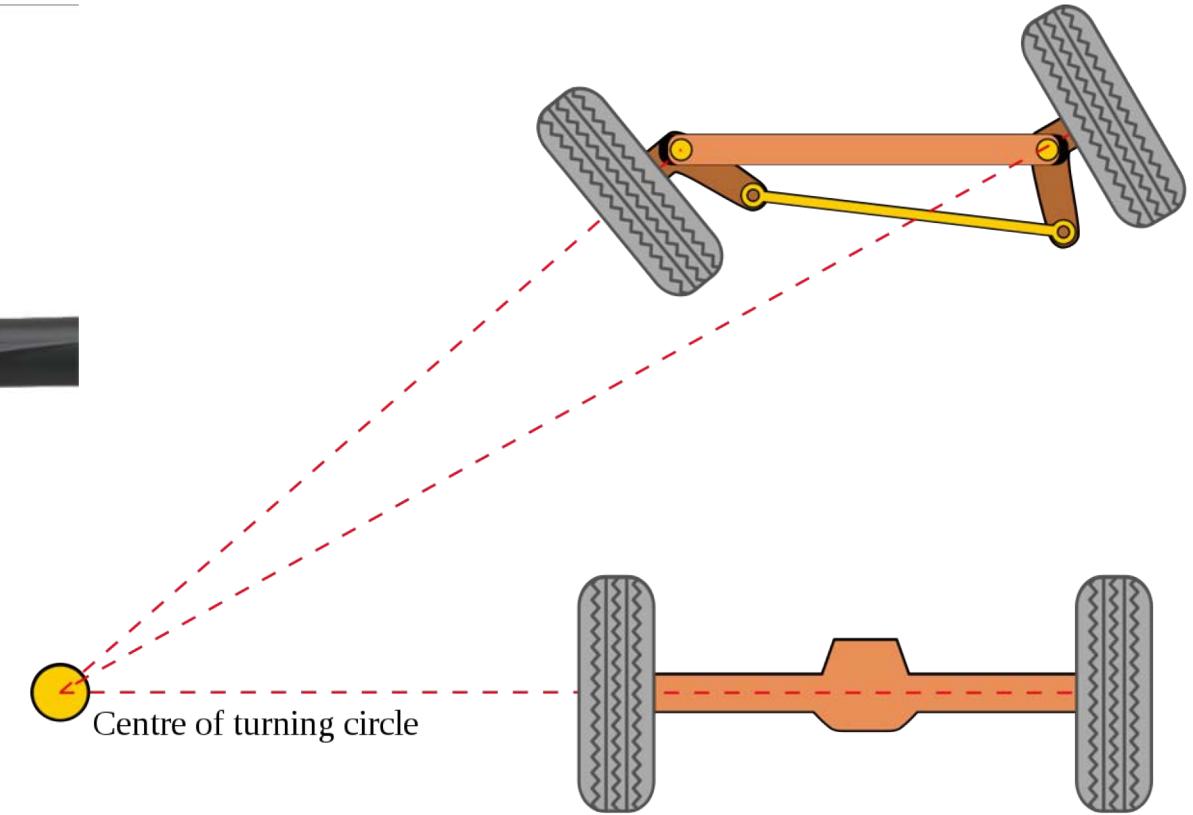
# Long travel suspension



# Long travel suspension

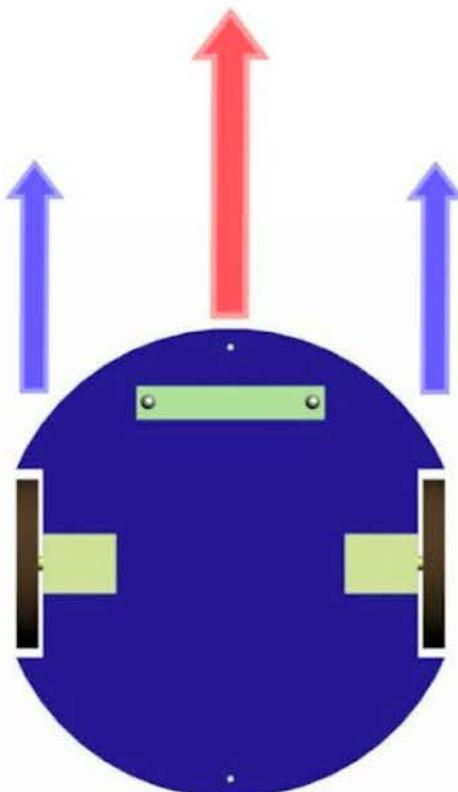


# Ackerman steering

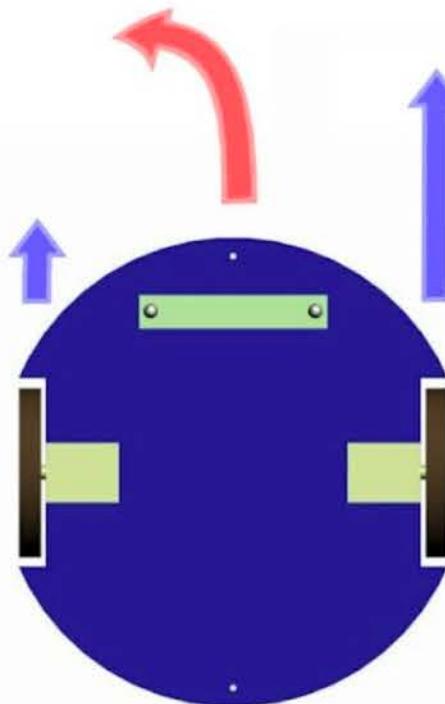


As opposed to differential drive robots..

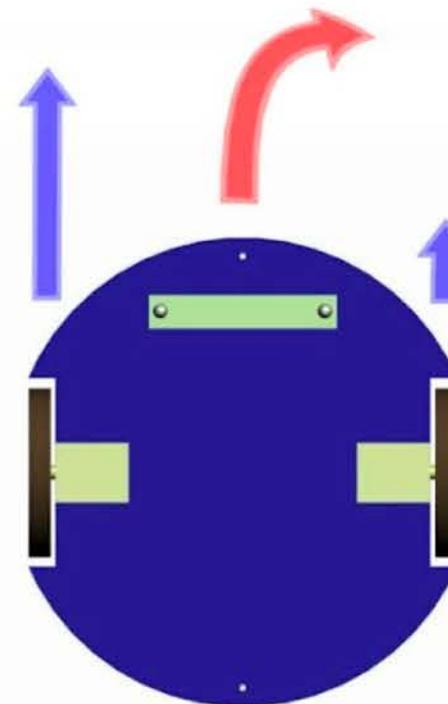
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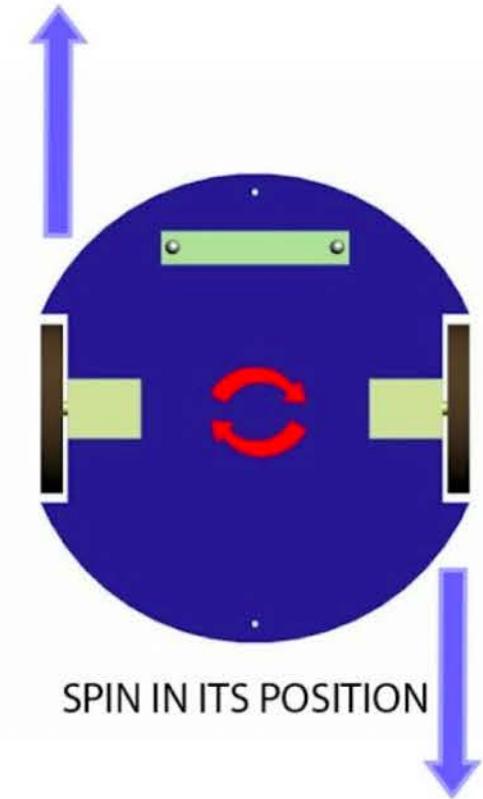
STRAIGHT



TURN LEFT



TURN RIGHT



SPIN IN ITS POSITION

# Race inspired tires and wheels



Store your F1/10 car in the Rice 120 Cabinets:

Cabinets 1, 10, and 11 are assigned for the course

Access Code: 2-3-4-5 (BEHL ☺ )

To Lock/Unlock:

- Press C (lower left on the access pad)
- Enter the code
- press the key button