

# F1/10

## Autonomous Racing

### F1/10 Build

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Varundev Sukhil

CS 4501/SYS 4582  
Spring 2019  
Rice Hall 120

# So far..

- What is ROS.
- ROS workspaces
- ROS packages and build
- ROS nodes
- ROS topics
- ROS messages
- Publishers, and Subscribers
- ROS Services
- ROS Launch files
- rqt\_graph
- Turtlesim
- ROS Time
- ROS bags
- Rviz
- ROS namespaces
- Gazebo
- ROS tf
- ROSwtf
- ROS over Network

Trusty [Running]

racing@racing-VirtualBox: ~



```
[ INFO] [1525588100.905515878]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]
```

```
turtlesim_
lesim with
le [turtle
0000]
tlesim.
```

0027cb1d51

1

racing@racing-VirtualBox:~\$

racing@racing-VirtualBox:~\$



From

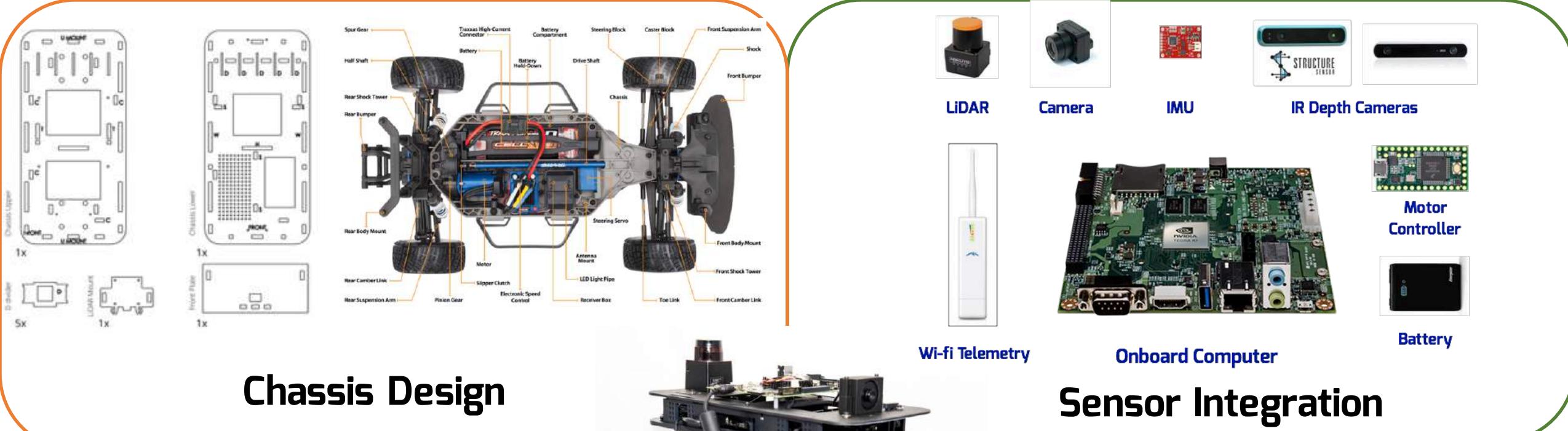
**AUTONOMOUS TURTLES**

To

AUTONOMOUS CARS

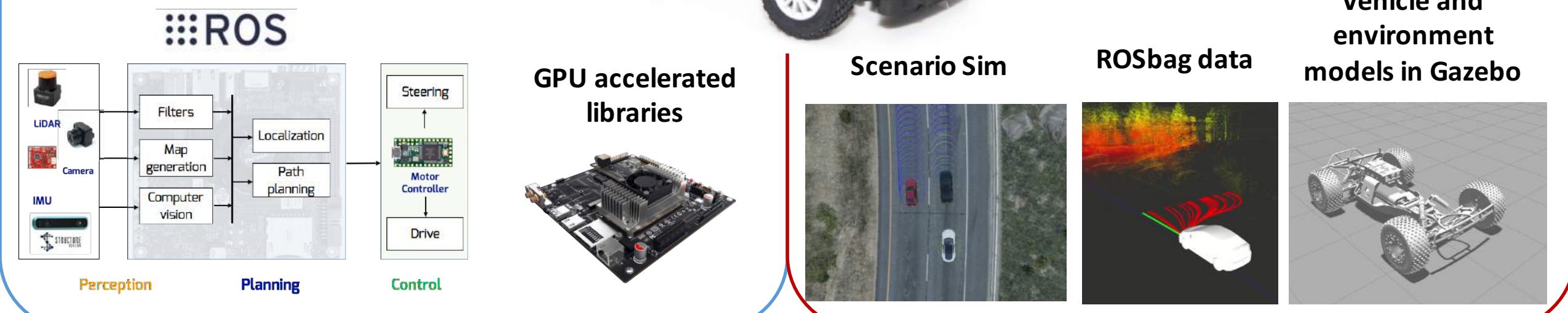
To

**AUTONOMOUS RACING CARS !!**



## Chassis Design

## Software System Architecture

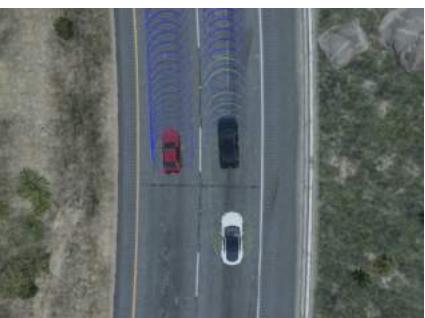


## Sensor Integration

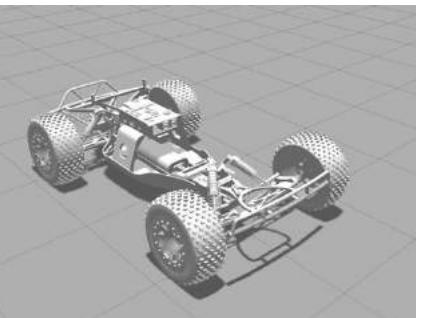
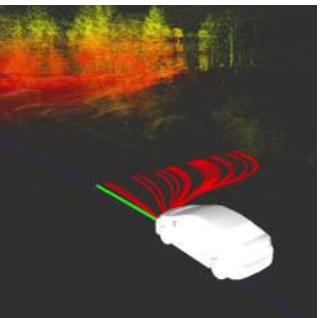
## Cloud-Based Simulation Tool

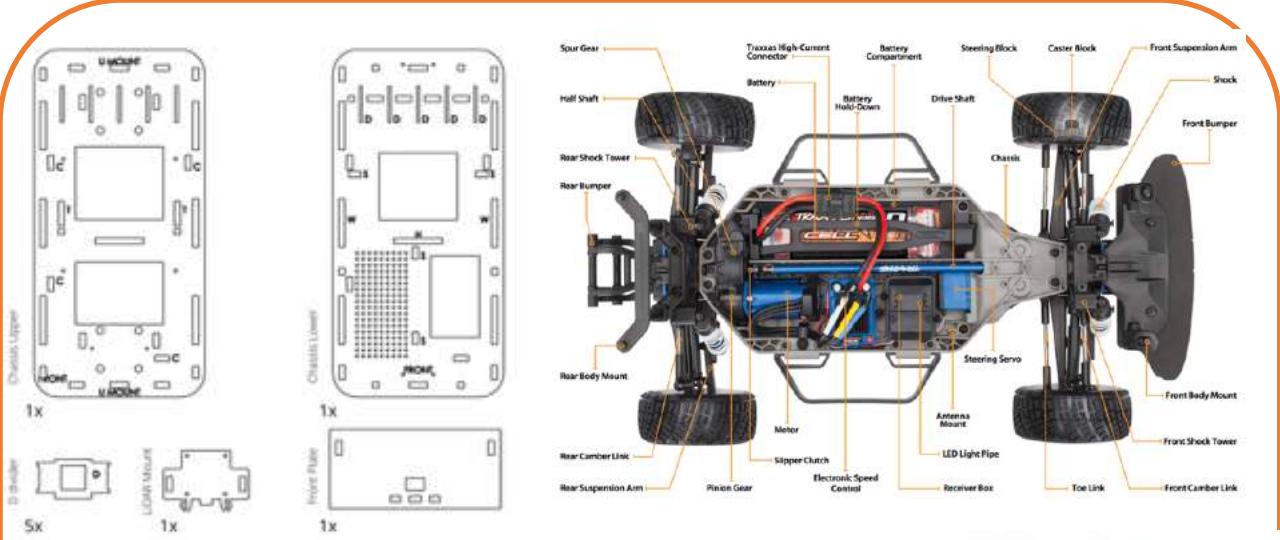
Vehicle and environment models in Gazebo

### Scenario Sim



### ROSbag data

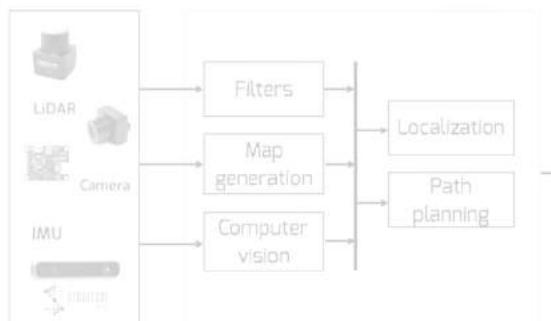




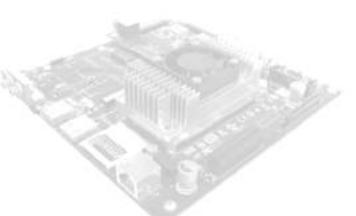
## Chassis Design

## Software System Architecture

ROS



GPU accelerated  
libraries



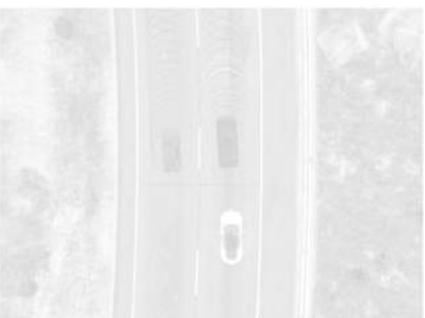
Wi-fi Telemetry



## Sensor Integration

## Cloud-Based Simulation Tool

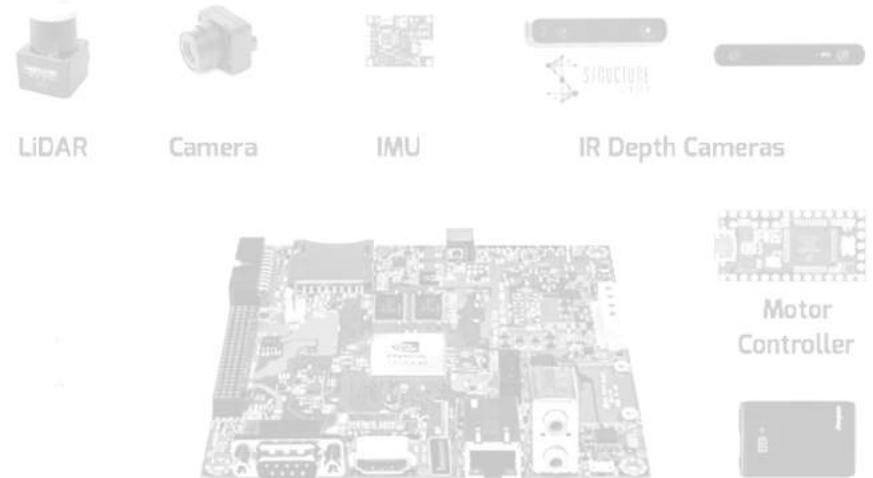
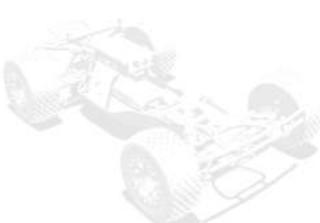
Scenario Sim



ROSbag data



Vehicle and  
environment  
models in Gazebo



Battery

# Lab exercises

P1

19°C

88%

P2

19°C

88%

Q

24°C

55%

R

24°C

0%

**Practice Session 1:**  
**Understanding ROS | Setting up the Car**

**Practice Session 2:**  
**Perception/Sensing | Driving Straight**

**Practice Session 3:**  
**Driving in a loop | Visual Odometry**

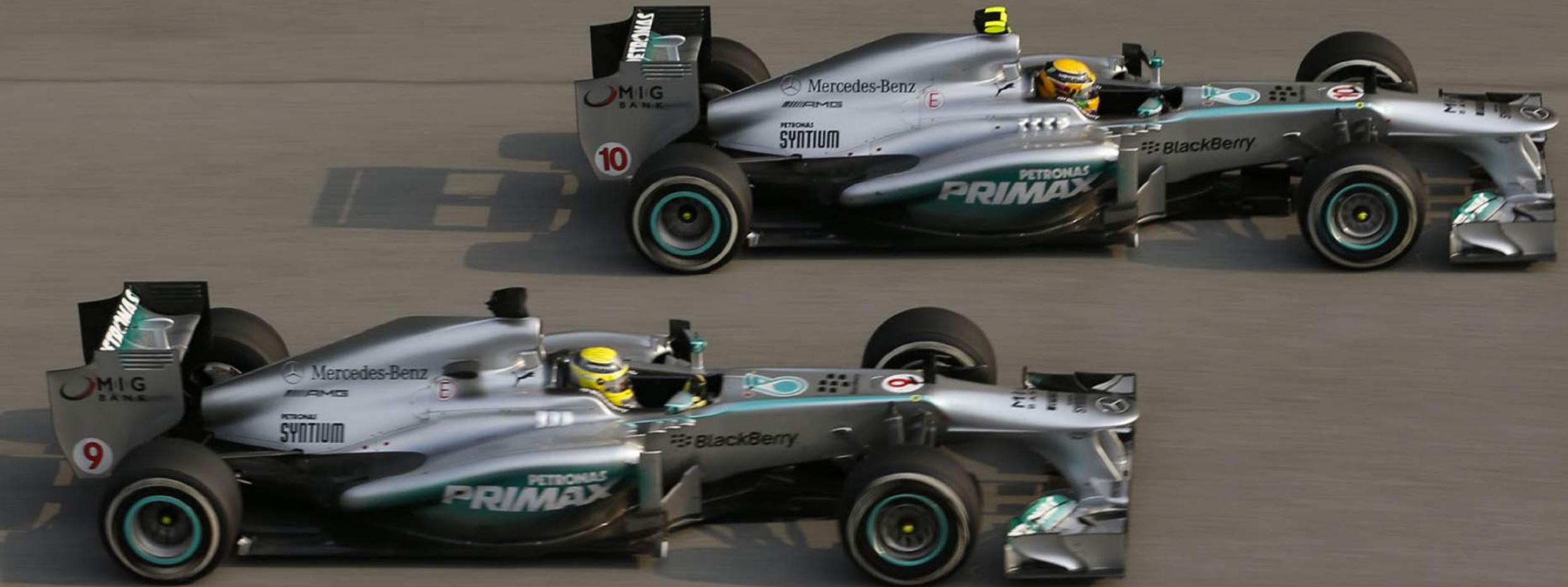
20  
TURNS

3.4  
MILES

LAPS

**Practice Session 3:**  
**Race | Time trials | Head-to-head racing**

All teams have similar cars, with the same sensors



# Battle of algorithms





# Racing is all about team work





Control and Navigation

Mapping and Localization

Perception and Sensing Engineer

Future racing teams will look like this

# Work in Teams from now onwards..

- 7 total teams
- 4 members per team
- You select the teams..

The screenshot shows a social media interface with a pinned post at the top. The pinned post is titled "F1/10 Team Signup" and contains a note from "Instr" dated 2/26/19. The note explains that users can sign up for teams of 4 from a pool of 7 teams. Below this, there are other posts: one about TA office hours (1/28/19), a private search for teammates (1/11/19), and another pinned post about the signup deadline (1/11/19). The main content area displays the "F1/10 Team Signup" note again, providing more details about the signup process and equipment provided.

New Post Search or add a post... stop following

PINNED

Instr F1/10 Team Signup 2/26/19  
Hello all, Use this sheet to signup for teams of 4. There are a total of 7 teams you can choose from. Each team will b

Instr TA Office Hours & Location 1/28/19  
I will be holding office hours on Mondays & Wednesdays from 10:00am - 11:00am. - Varundev #pin

Private Search for Teammates! 1/11/19

LAST WEEK

Instr F1/10 Team Signup Deadline... Fri  
All, Use this link to signup for teams if you have not already done so. If not, you will be assigned to teams at rando 1

note

## F1/10 Team Signup

Hello all,

Use this [sheet](#) to signup for teams of 4. There are a total of 7 teams you can choose from.

Each team will be given an F1/10 racing platform next week along with all the necessary equipment to keep the cars in running condition for the rest of the semester.

Do not take the team names too seriously; every car has similar performance (this is a battle of algorithms after all).

- Varundev

#pin

labs

# 7 teams



ASTON MARTIN



WILLIAMS  
MARTINI  
RACING



Sauber F1® Team

# Work in Teams from now onwards..

UVA F1/10 (Spring 2019)						
Vehicle Number	Color Code	Team Name	Member 1	Member 2	Member 3	Member 4
1		Scuderia Ferrari	Austin Sullivan	Andrew Lewis	Sandesh Banskota	Clayton Smith
2		McLaren Racing	Elmo Alexander	Andrew Smith	Adam Chang	James Mekavibul
3		Red Bull Racing	Rahul Tuladhar	Johnny Wong	Christopher Geier	Alex Liang
4		Mercedes Petronas	Bryan Rombach	Josie Li	Michael Benos	William Tonks
5		Renault Sport	Nova Zhang	Lauren Phan	Sarah Smith	Kacey Price
6		Williams Martini	Mert Karakas	Derin Serbetcioglu	Nate Olsen	Scott Miller
7		Sauber Racing	Erin Joost	Hamza Kakeh	Keerthi Radhakrishnan	Cherokee Toole

# 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)

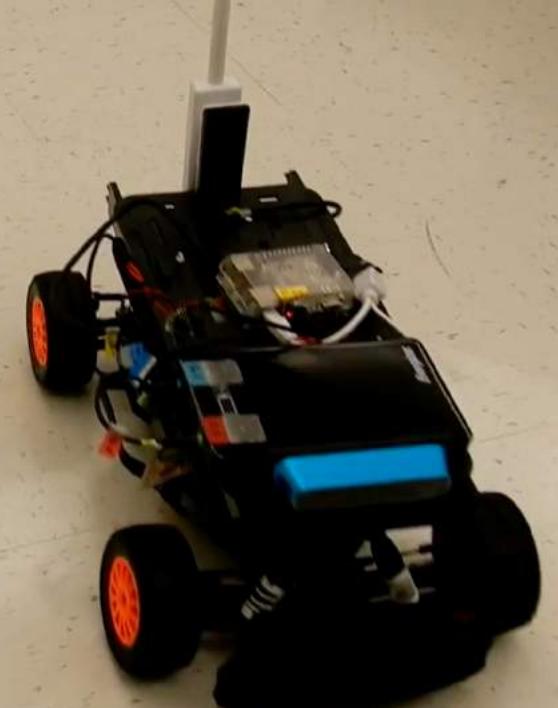
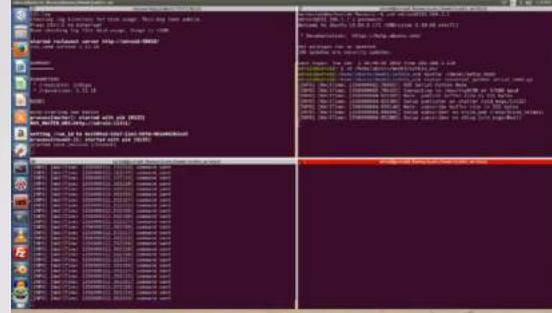
[Teams](#)[Home](#)[Logistics](#)[Syllabus](#)[Resources](#)A collage of images illustrating the F1/10 Autonomous Racing project. It includes a 3D model of a race track, a person in a racing seat with a steering wheel, a close-up of a racing car's mechanical components, and a group photo of the team members standing behind their cars.

**F1/10 Autonomous Racing**

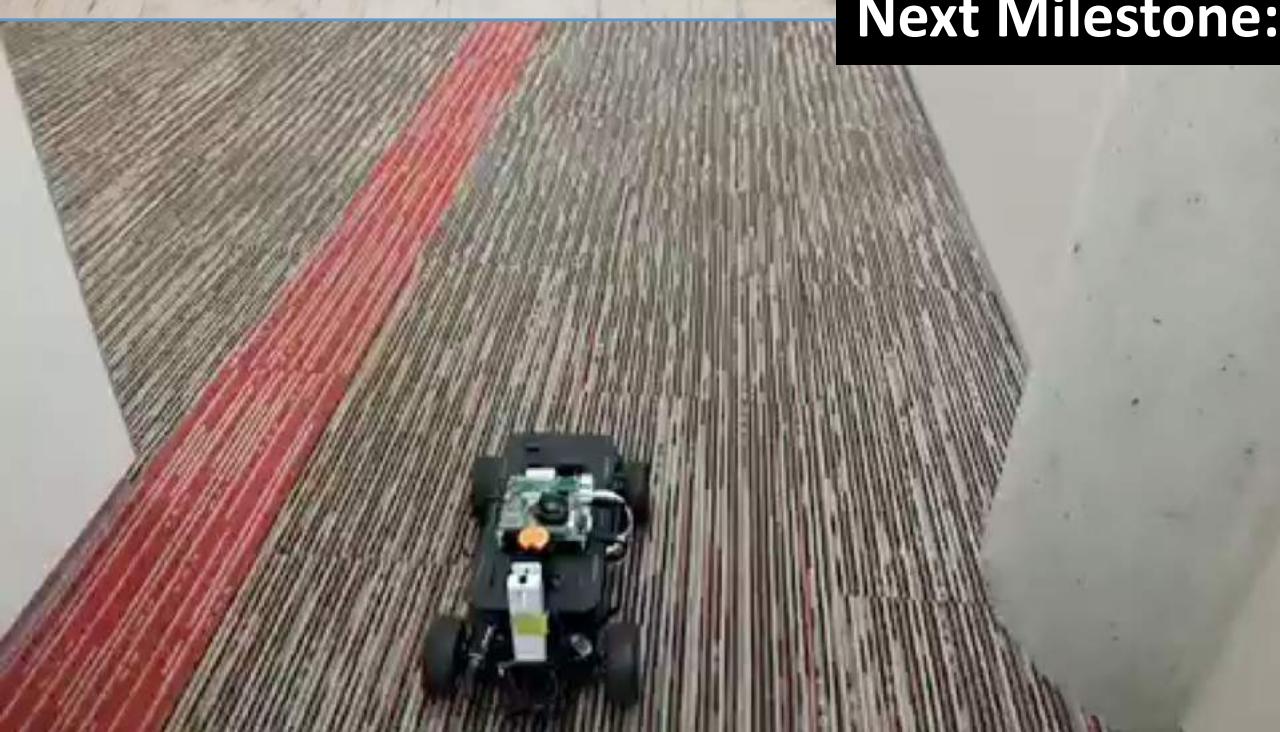
Build. Drive. Race!  
Perception. Planning. Control

1/10 the scale. 10 times the fun!

[GET STARTED](#)



Next Milestone: F1/10 TeleOperation

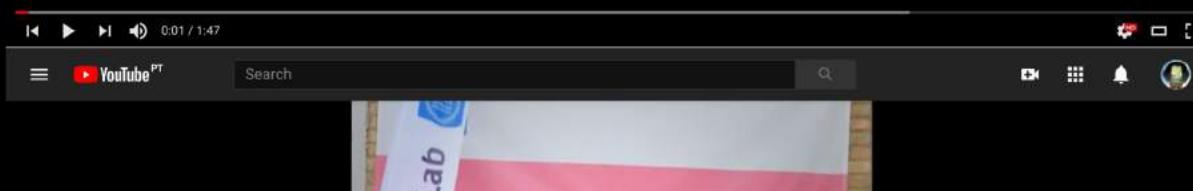


A screenshot of the YouTube PT interface showing the UConn logo.

A screenshot of the YouTube PT interface showing a presentation slide with the text "ŘEŘICHA".

# UCONN

UNIVERSITY OF CONNECTICUT  
RACING HUSKIES



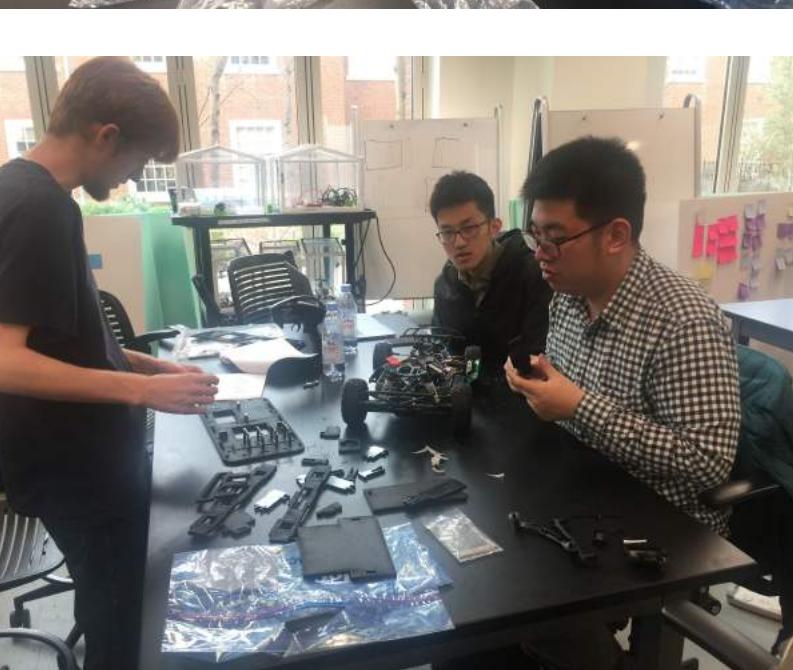
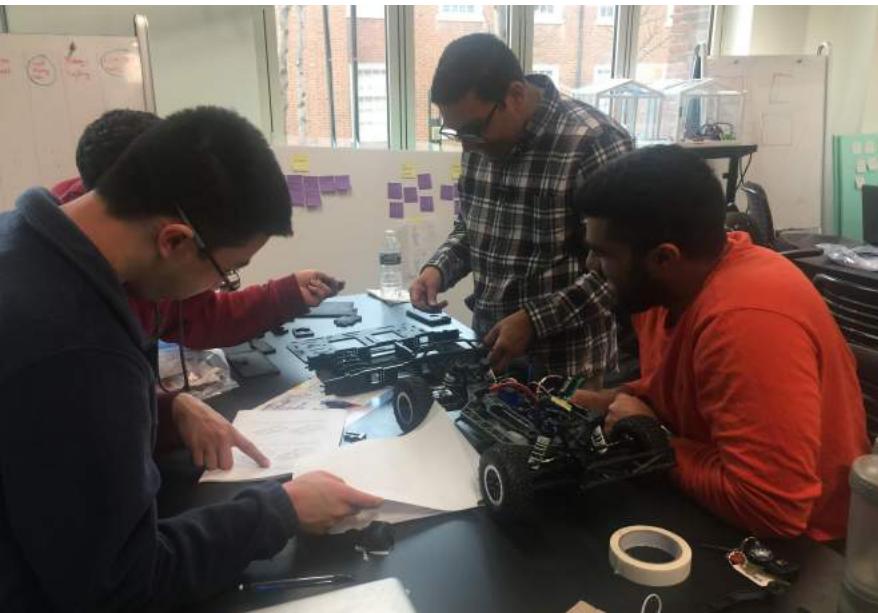
A YouTube video player showing the title "F1/10 Meet the teams". The video frame shows two people sitting at a desk with a car model in the background.

A YouTube video player showing the title "Our Team". The video frame shows a grid of four people's faces. Below the video, there are descriptions of the team members:

- Kilho, Lee: Ph.D Candidate @KAIST, Car assembly&prototype
- Jaeyoung, Ahn: Master's student @KAIST, Driving algorithm
- Minsu, Kim: Associate Professor @KAIST, Advisor
- Insik, Shin: Master's student @KAIST, Mapping/planning

Build.

# A racing car is never a finished product , its always a prototype.



Similar dynamics, different parameters

# **TRAXXAS XO-1      vs      Tesla Model S**



# Sensor Integration



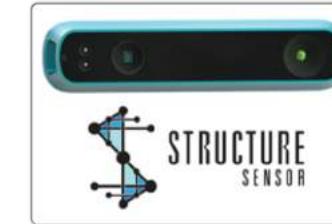
LiDAR



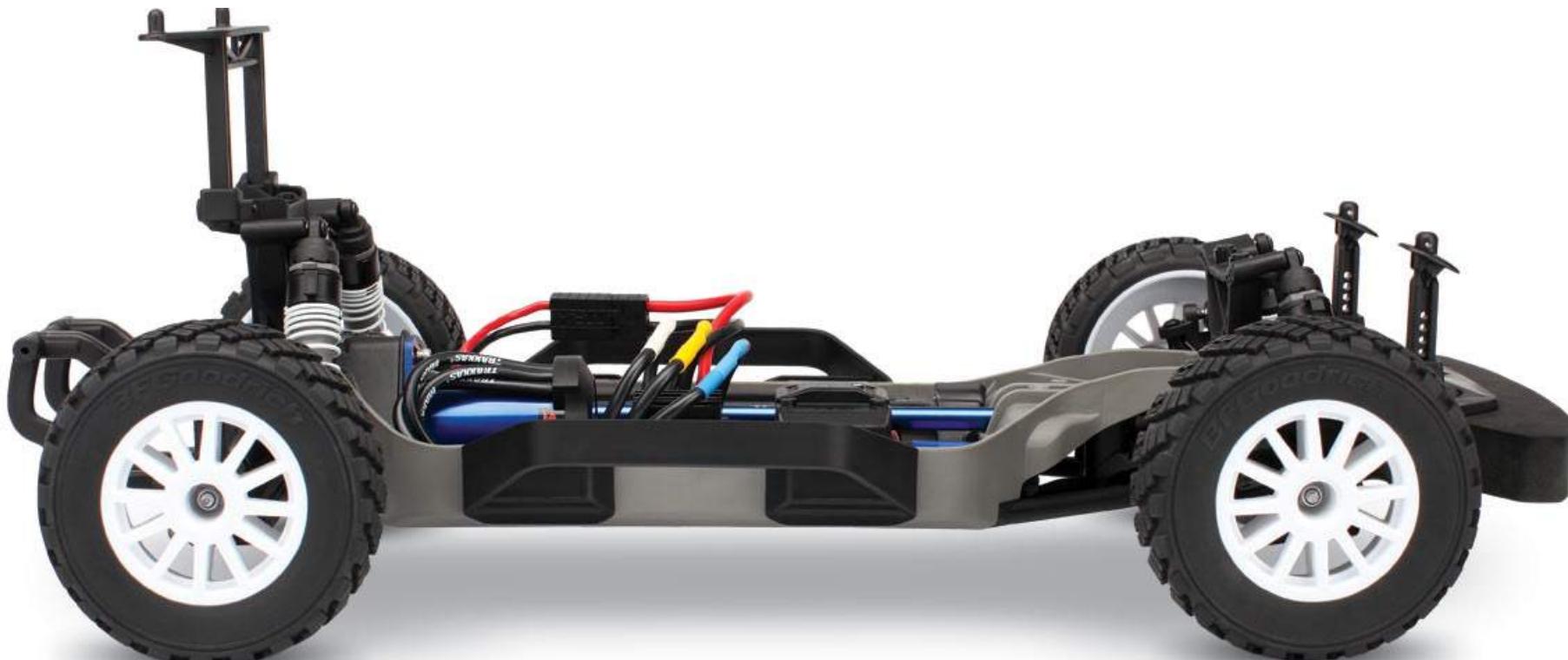
Camera



IMU



IR Depth Cameras



# Sensor Integration



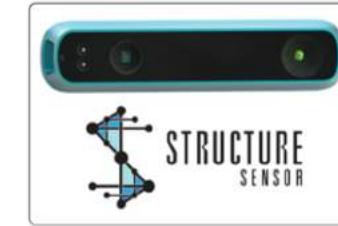
LiDAR



Camera



IMU



IR Depth Cameras



Wi-fi Telemetry



Onboard Computer

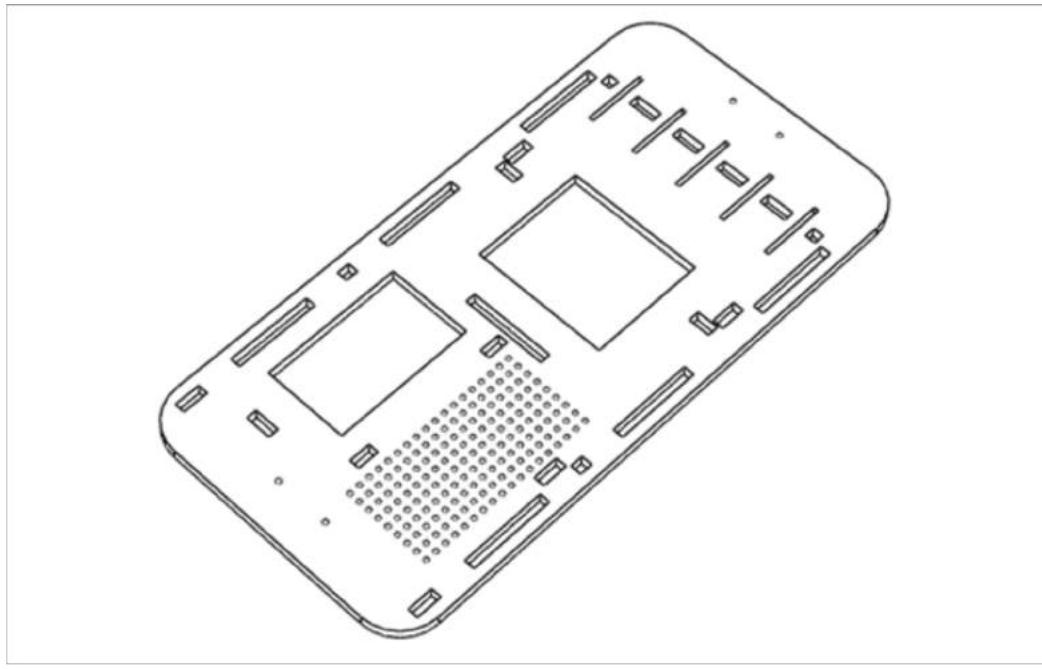
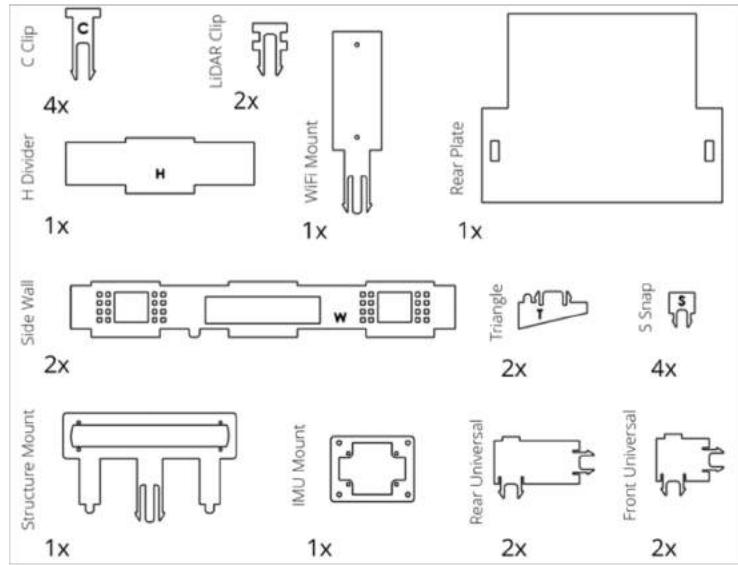
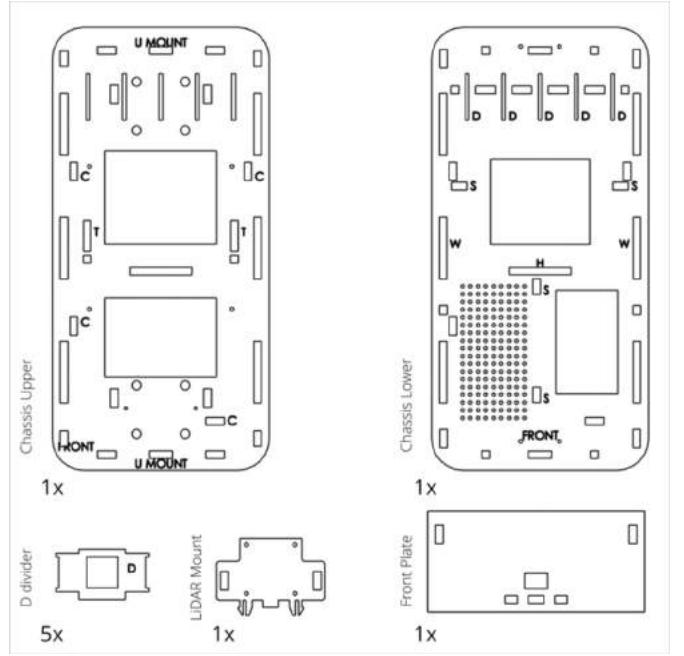


Motor  
Controller



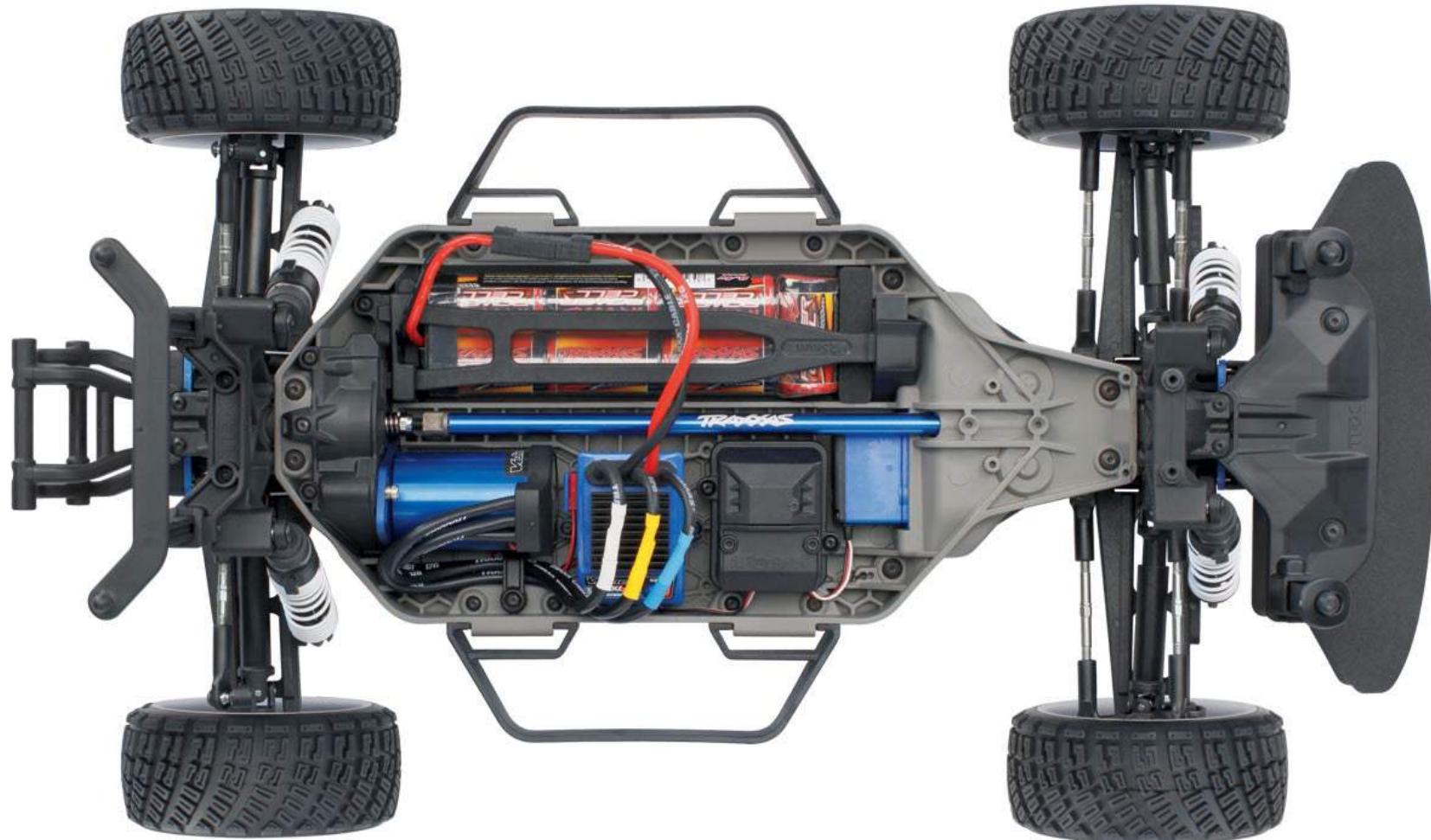
Battery

# With simple IKEA style build instructions

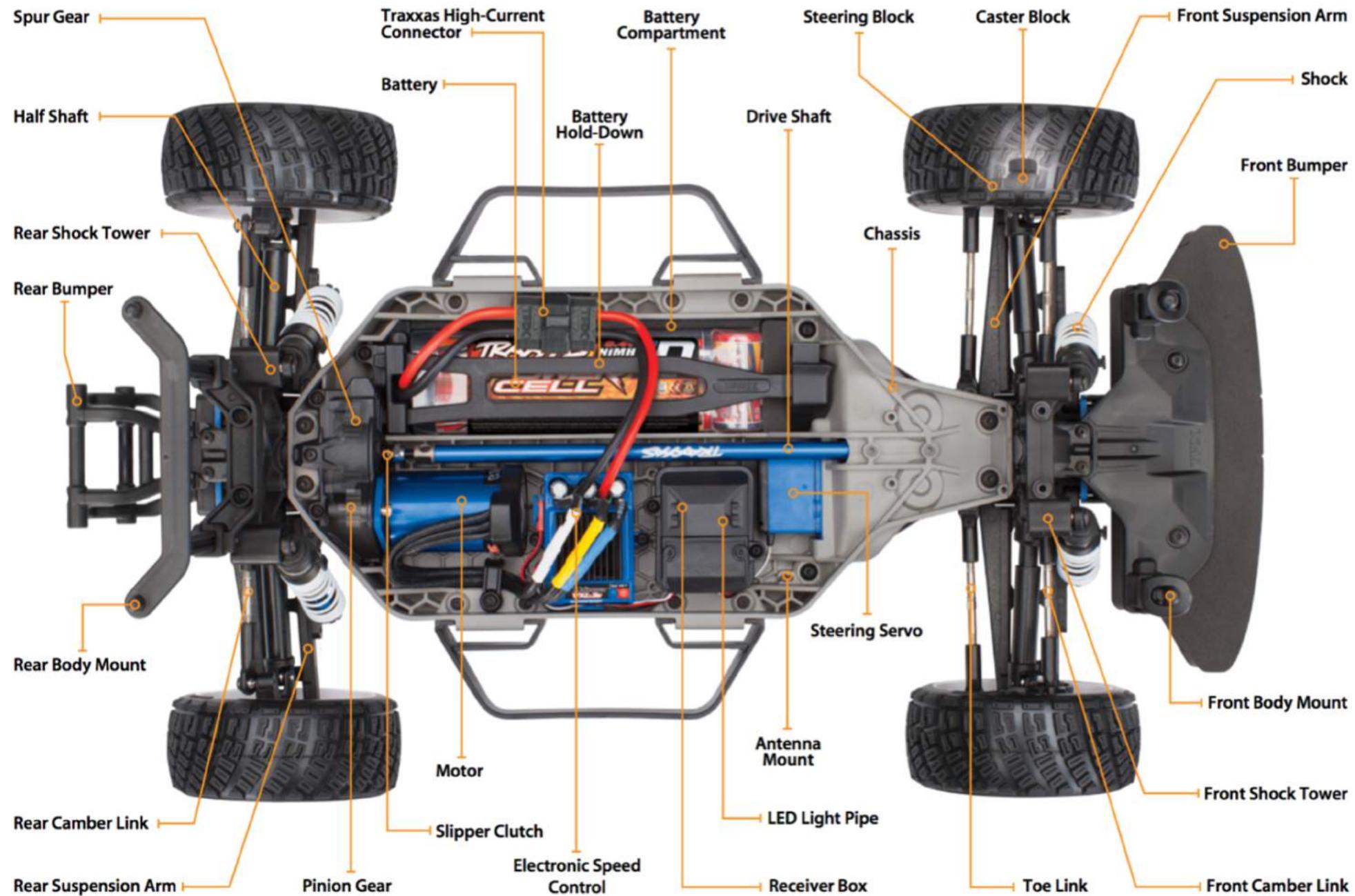


# F1/10 Race Car Assembly [Time Lapse]

# Traxxas 1/10 scale RC race car

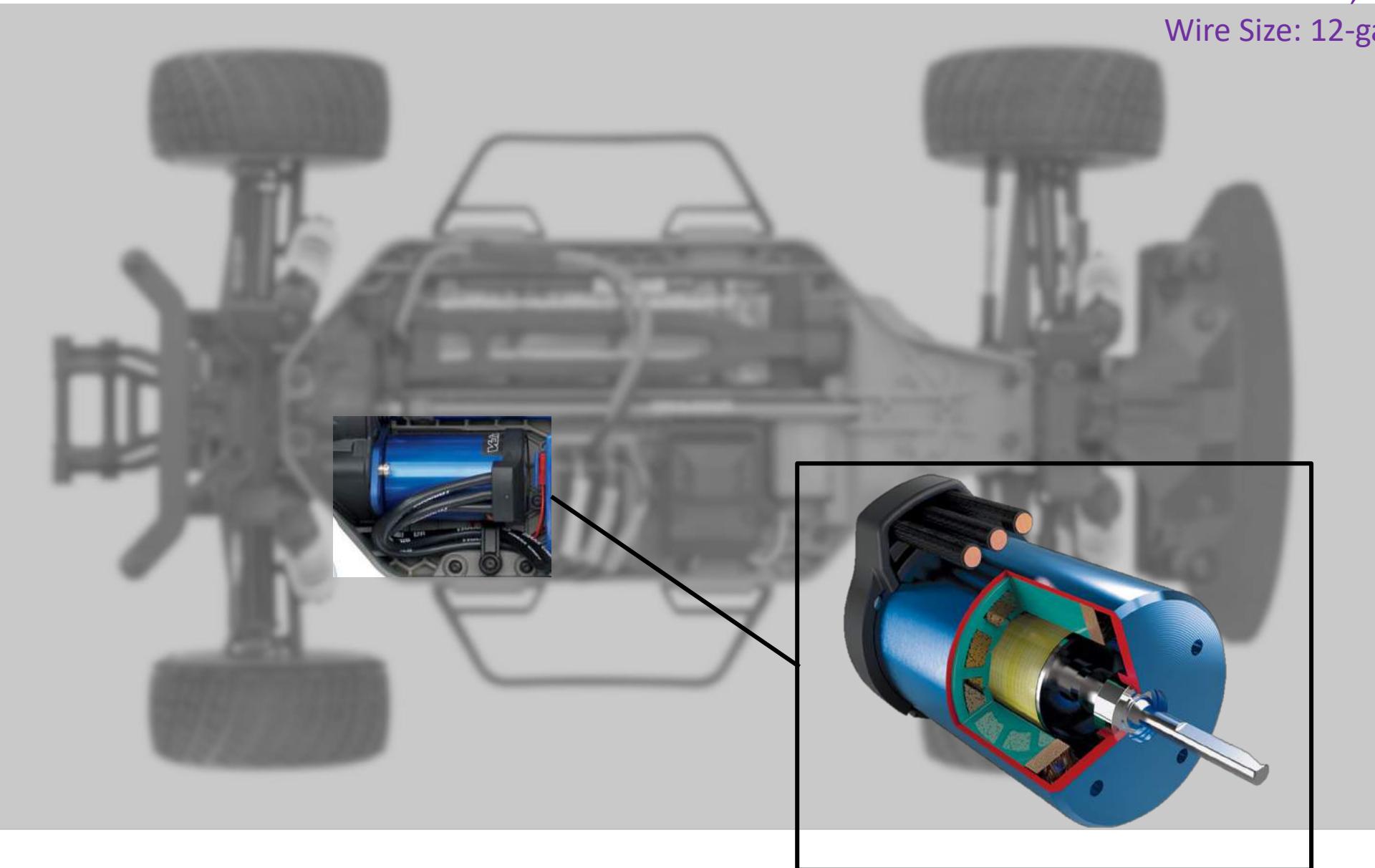


# Traxxas 1/10 scale RC race car

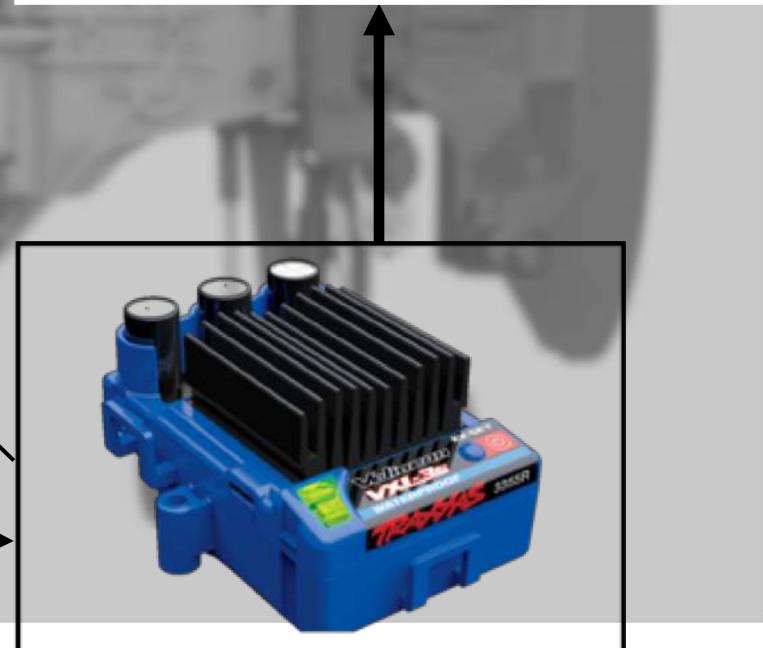
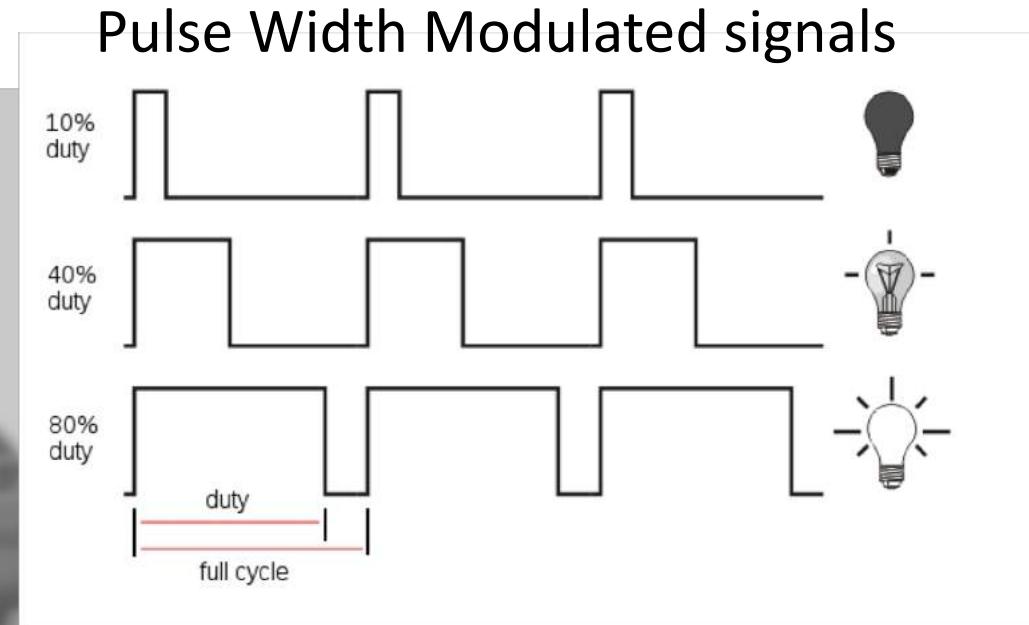
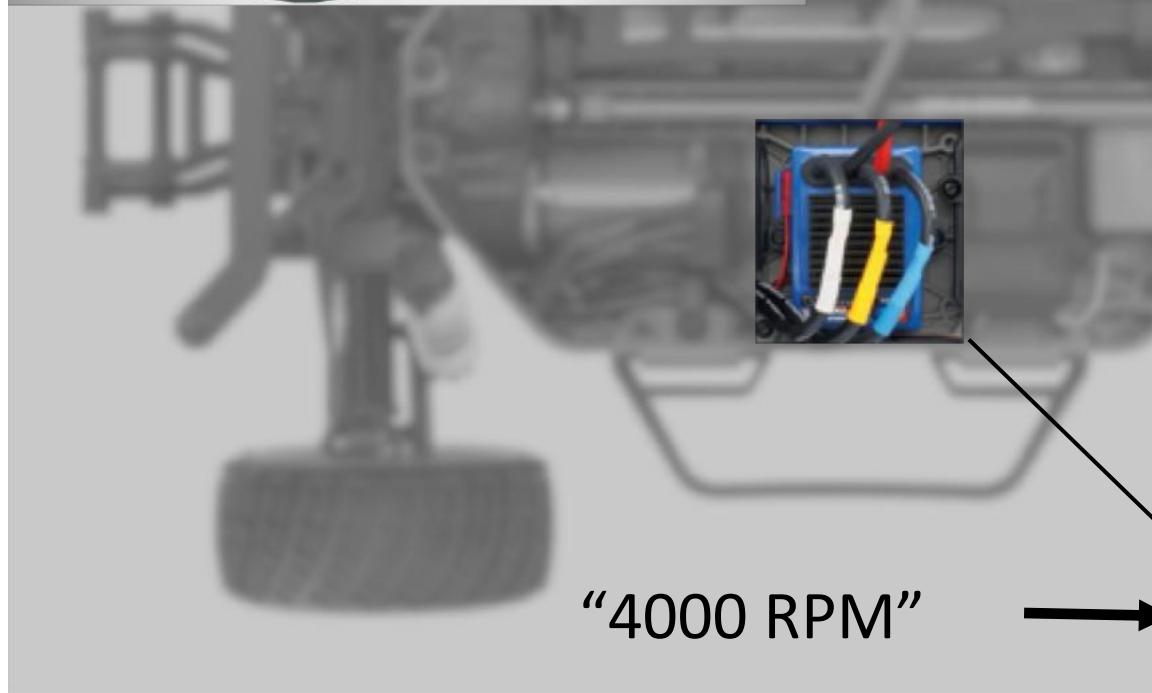


# Brushless DC motor

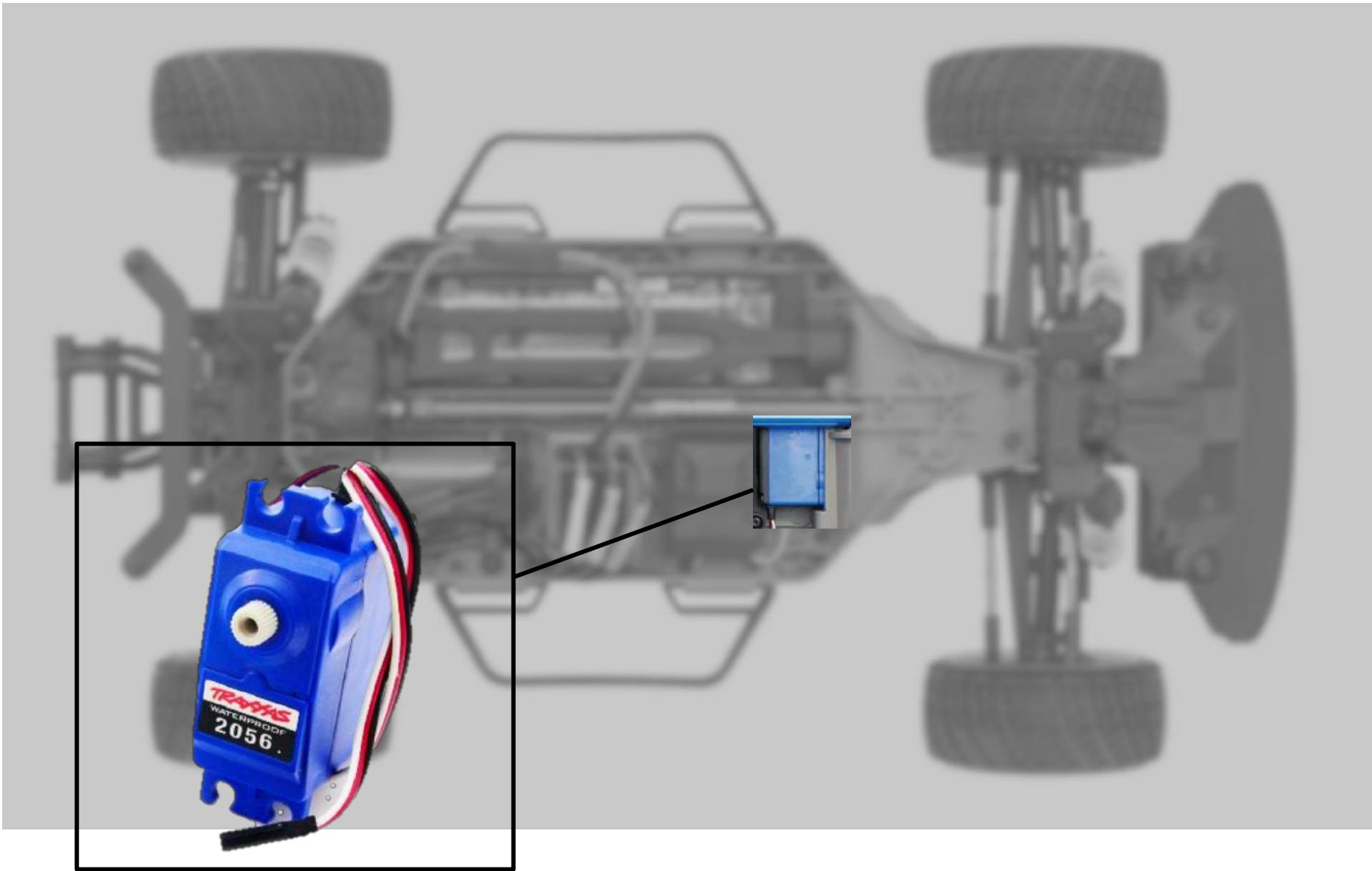
Velineon 3500 Brushless Motor  
RPM/volt: 3500  
Max RPM: 50,000.  
Wire Size: 12-gauge



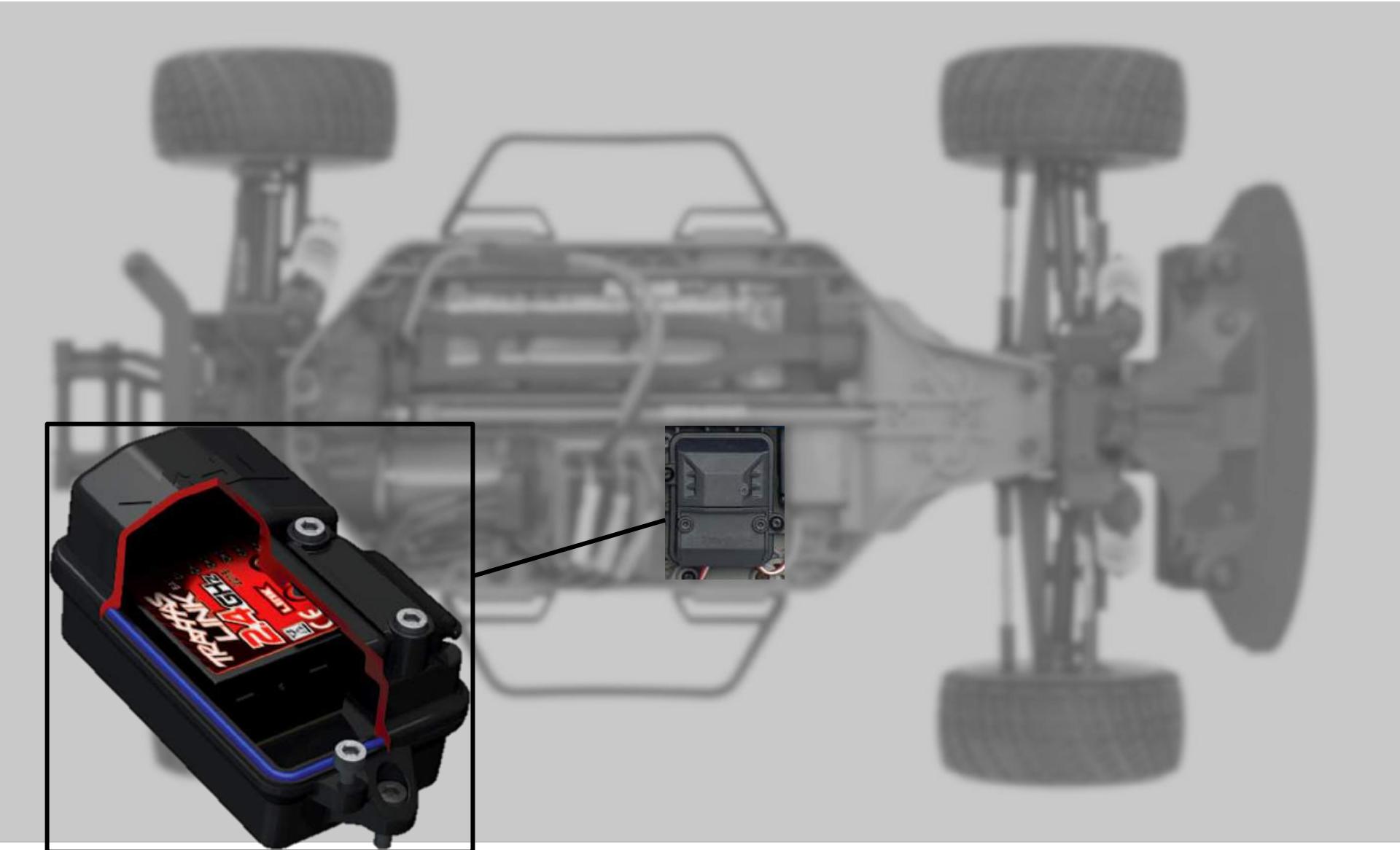
# Electronic Speed Control (ESC)



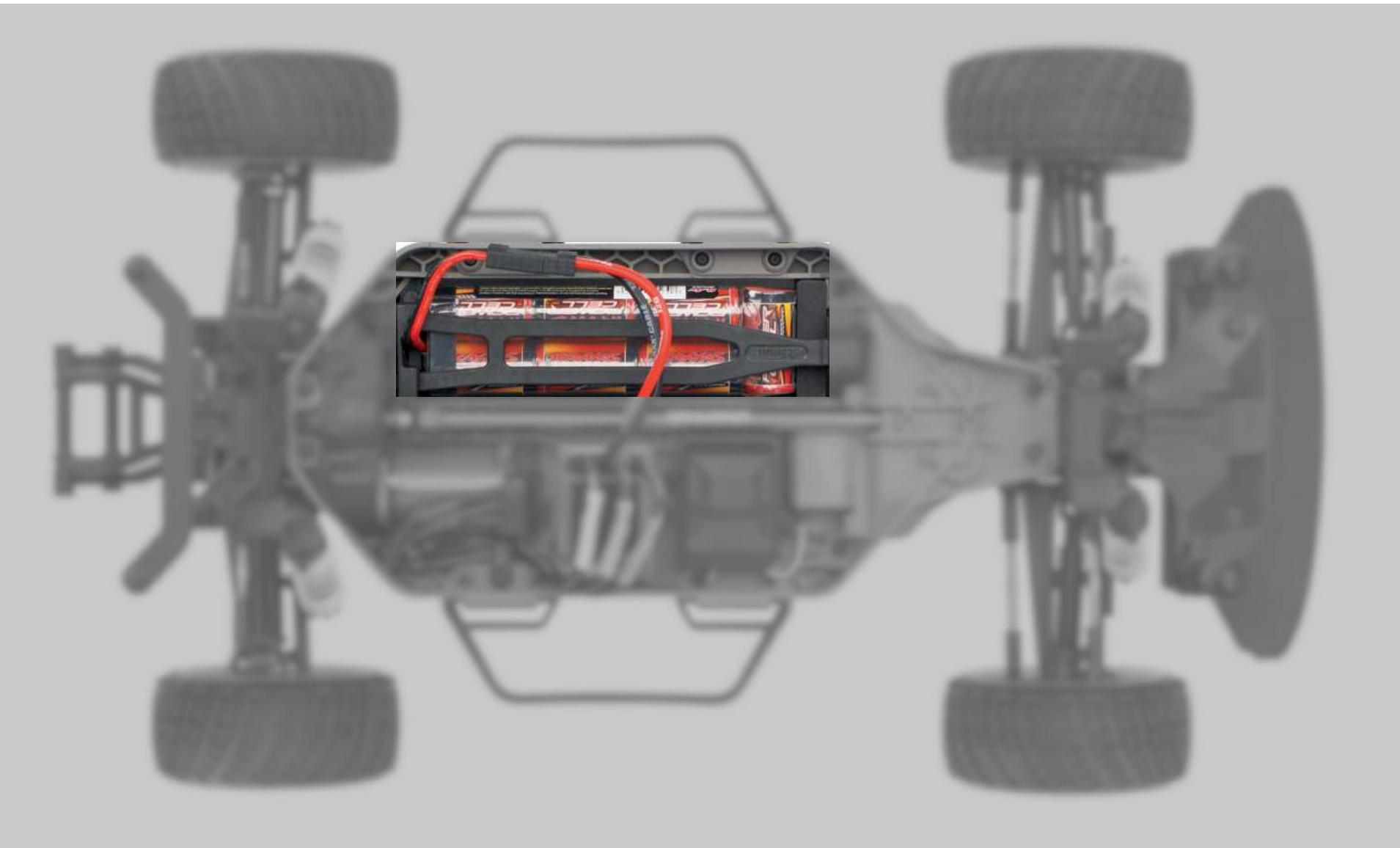
# Servo motor for steering



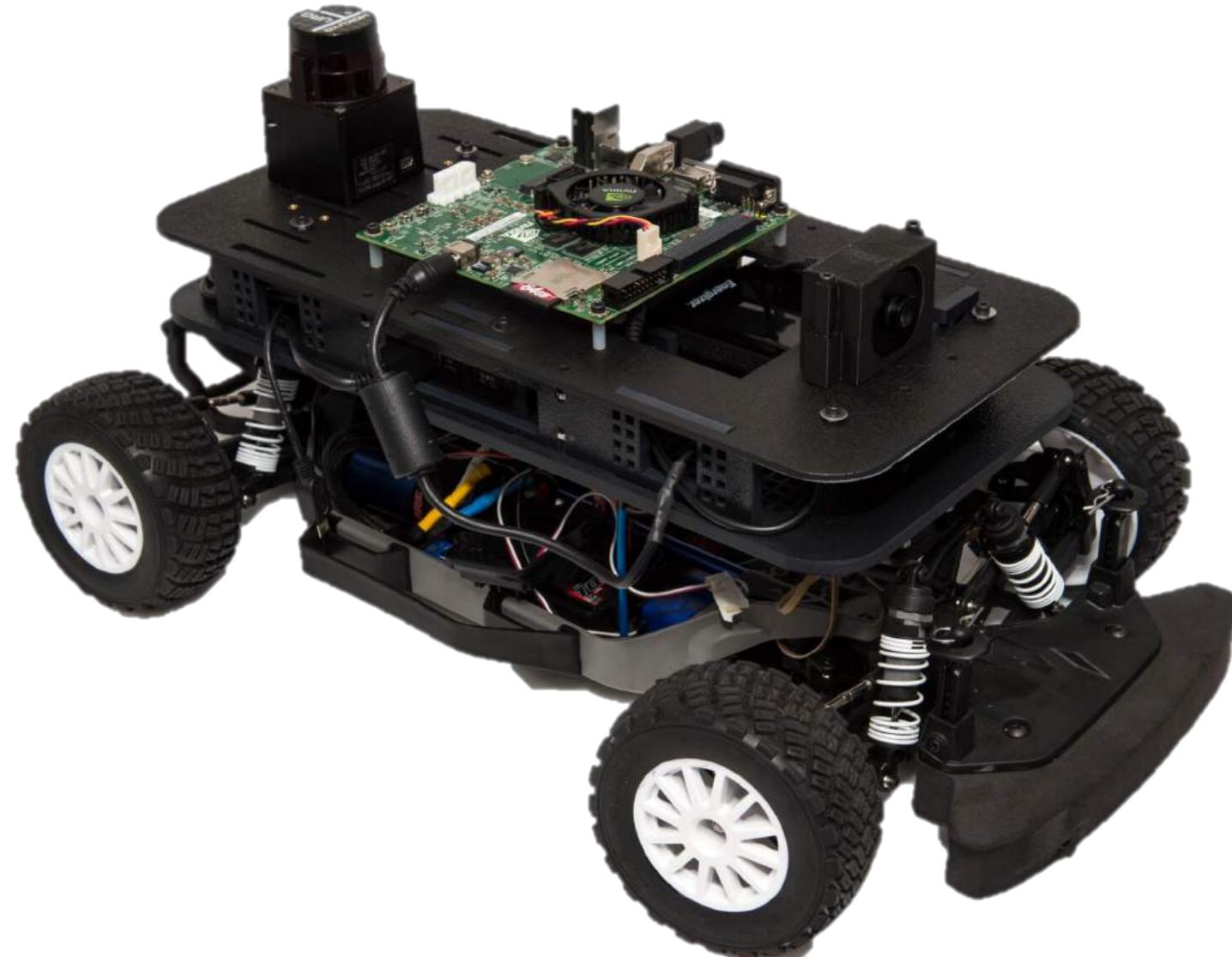
# Radio receiver



# Battery pack

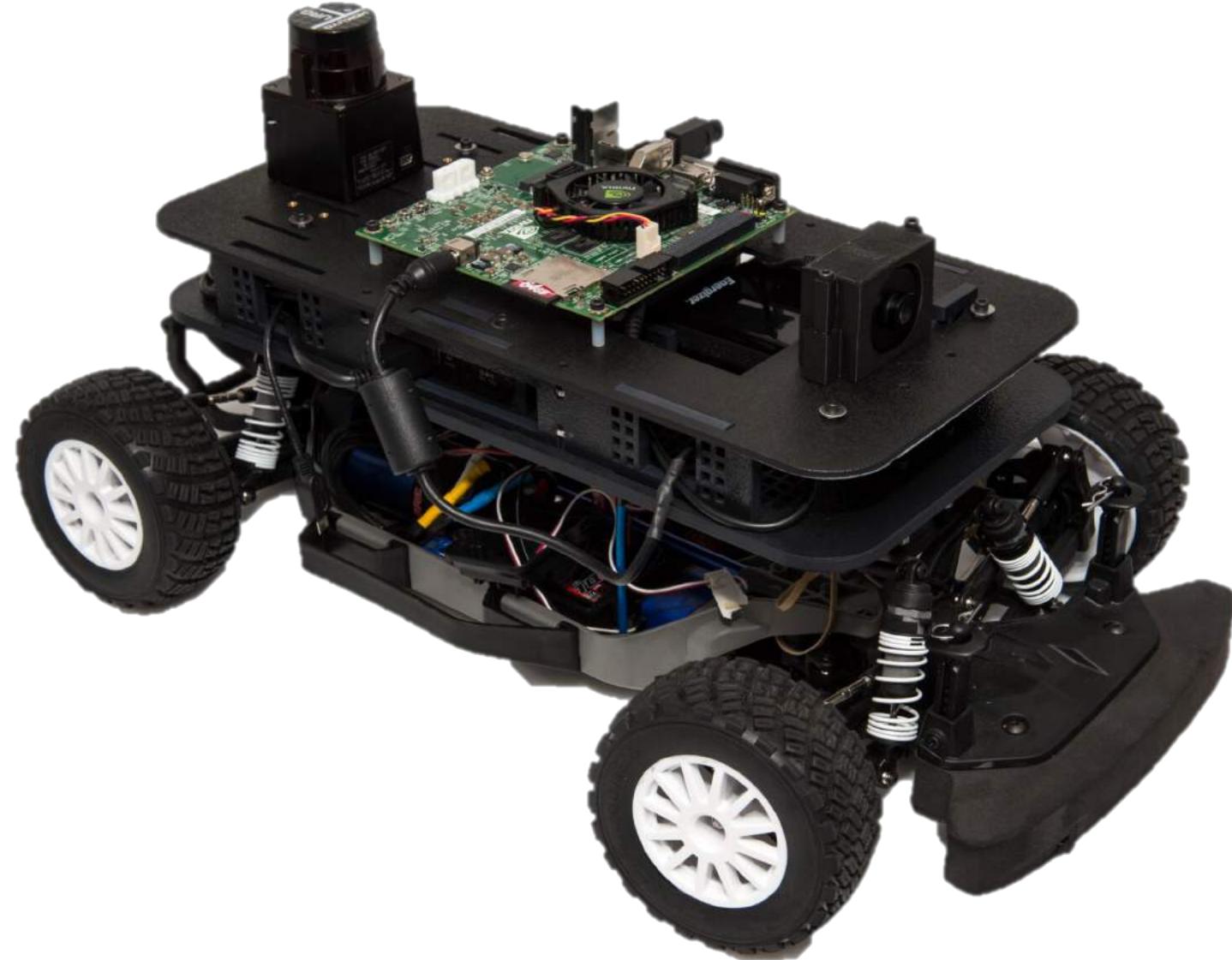


# On-board computer



Nvidia Jetson TK1  
256 CUDA cores  
8GB memory  
ARM Quad-core  
Denver dual-core

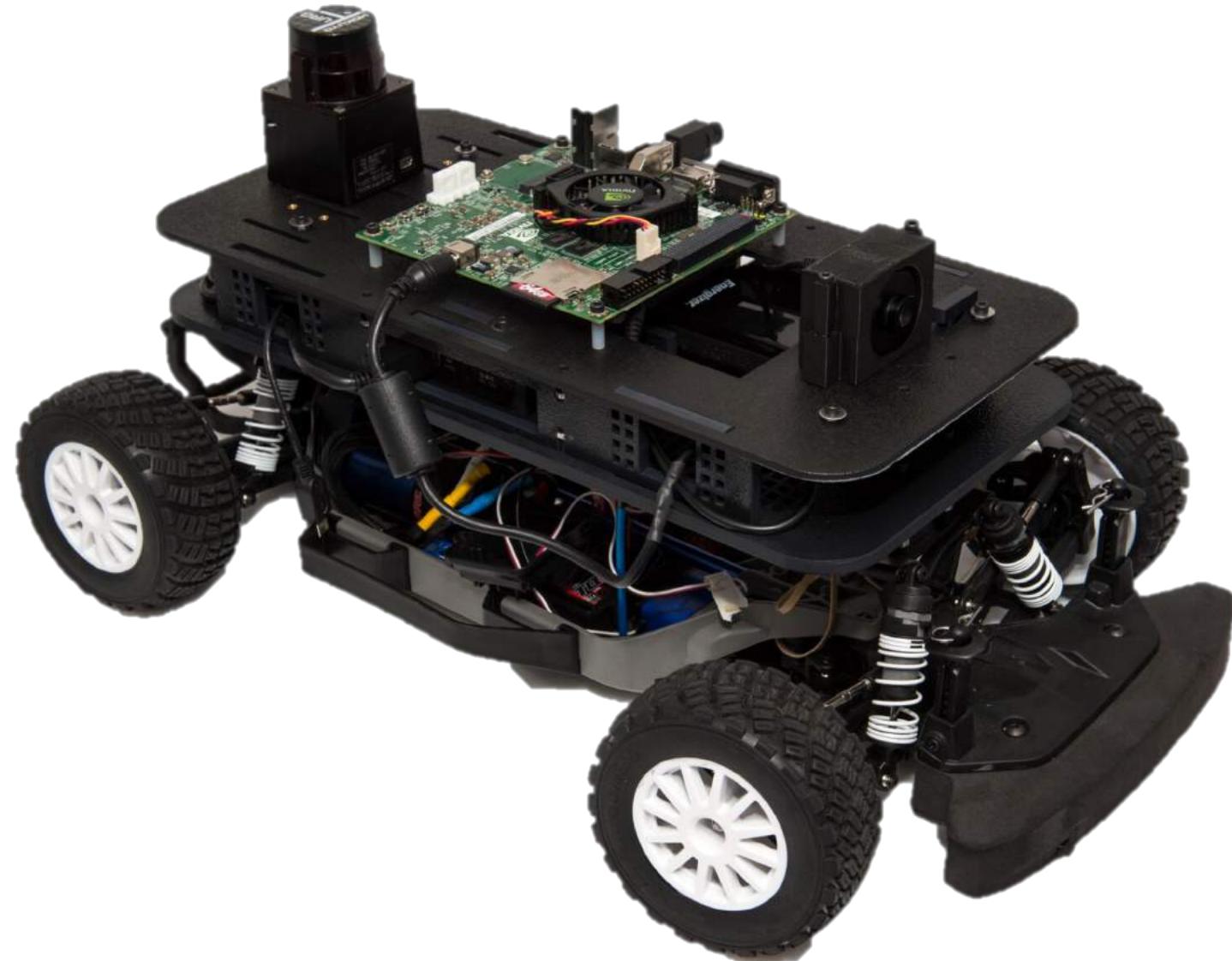
# Sensors



LiDAR  
Hokuyo 4LX



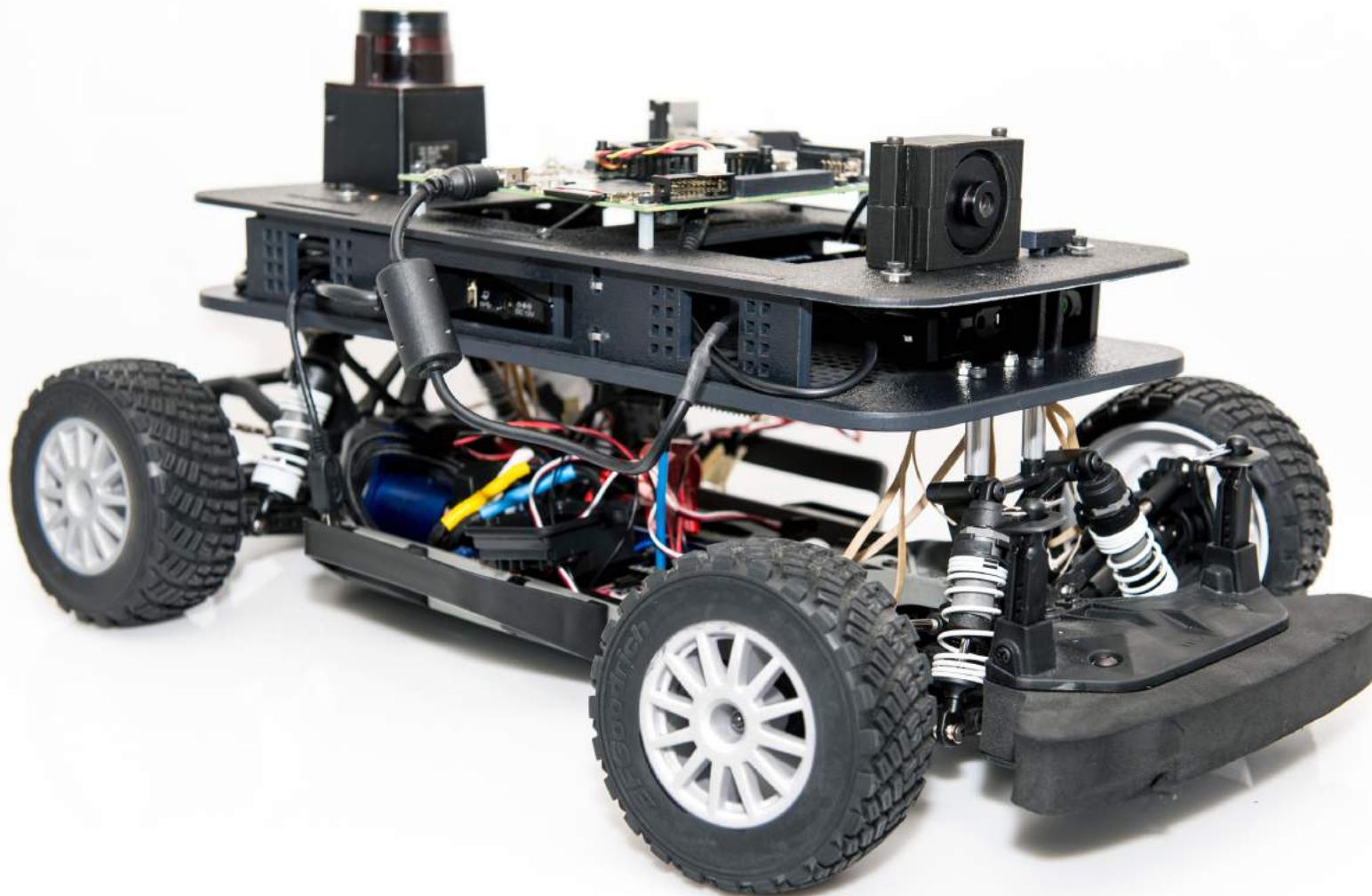
# Communication



Wifi telemetry

Ubiquiti Pico Station  
100+ Mbps

Acts as an access point  
Each car has its own  
Wifi network



MOVE  
FAST AND  
BREAK  
THINGS

Expectation



Use caution at all times



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

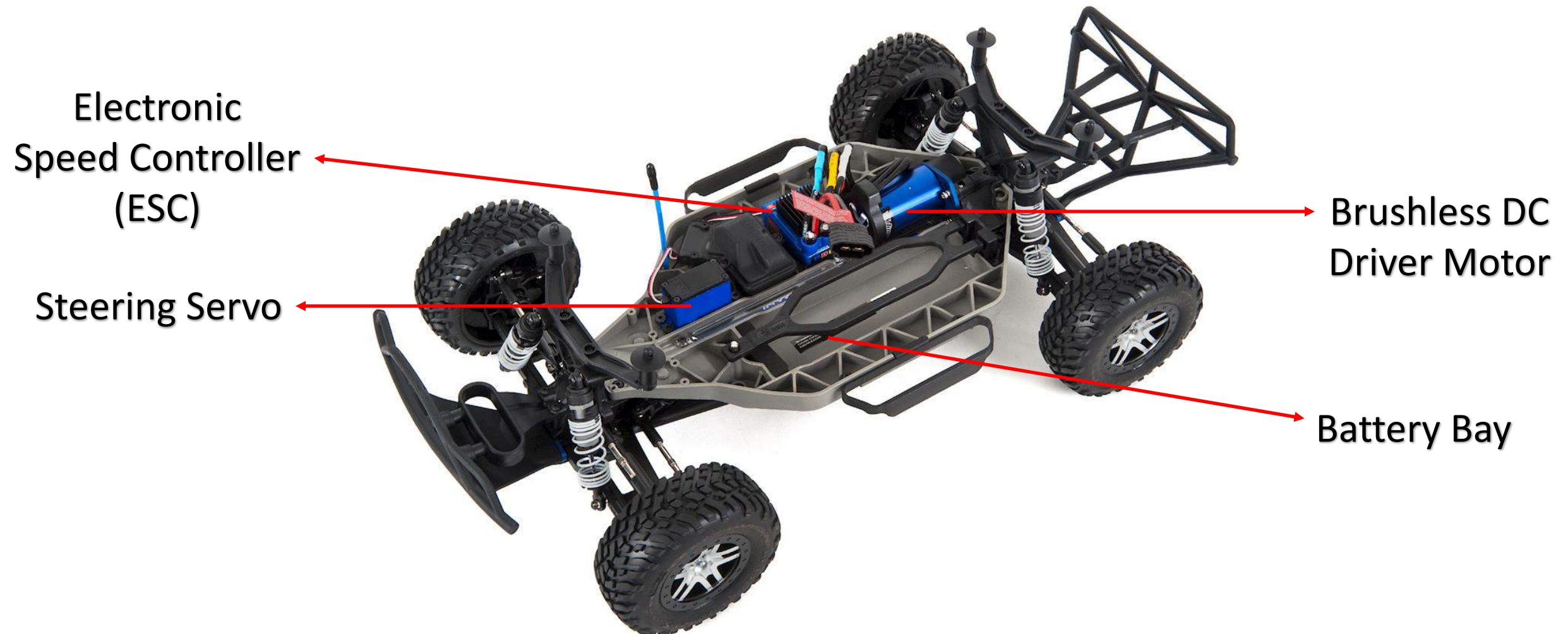
Pay special attention to the handling of Li ion high current batteries

When in doubt; ask the instructor

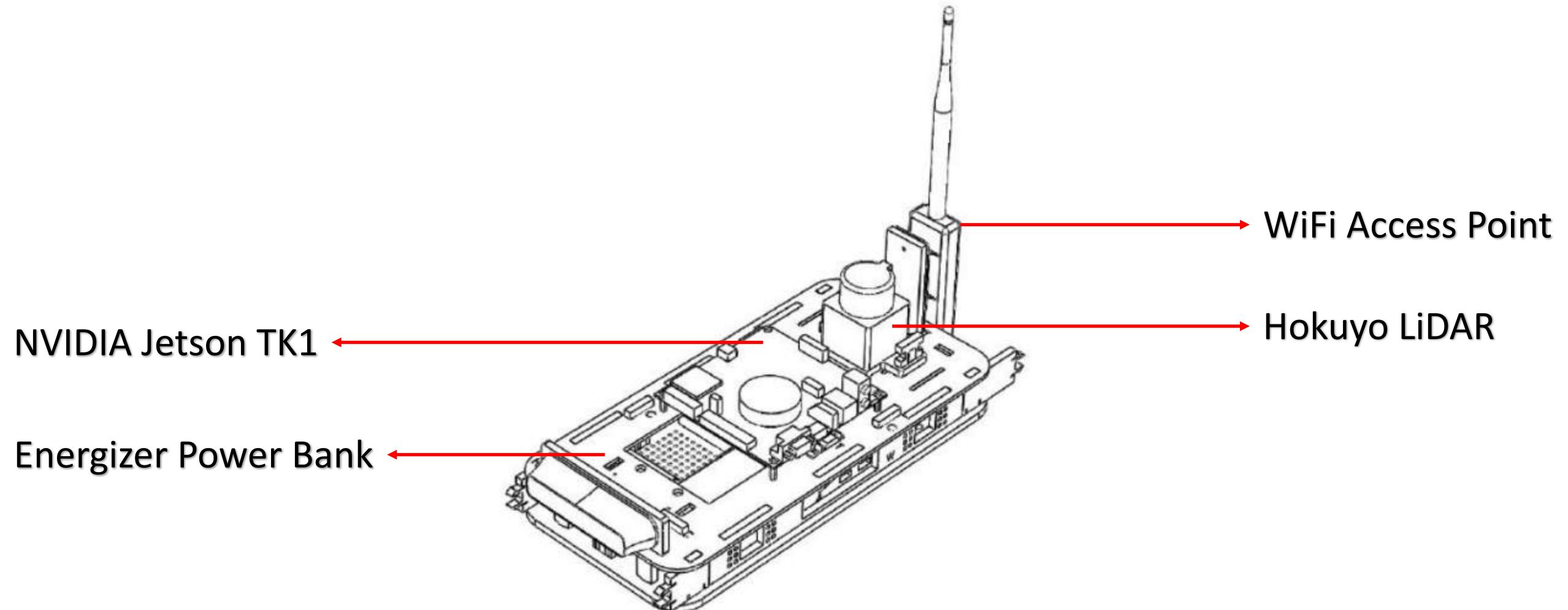
Reality



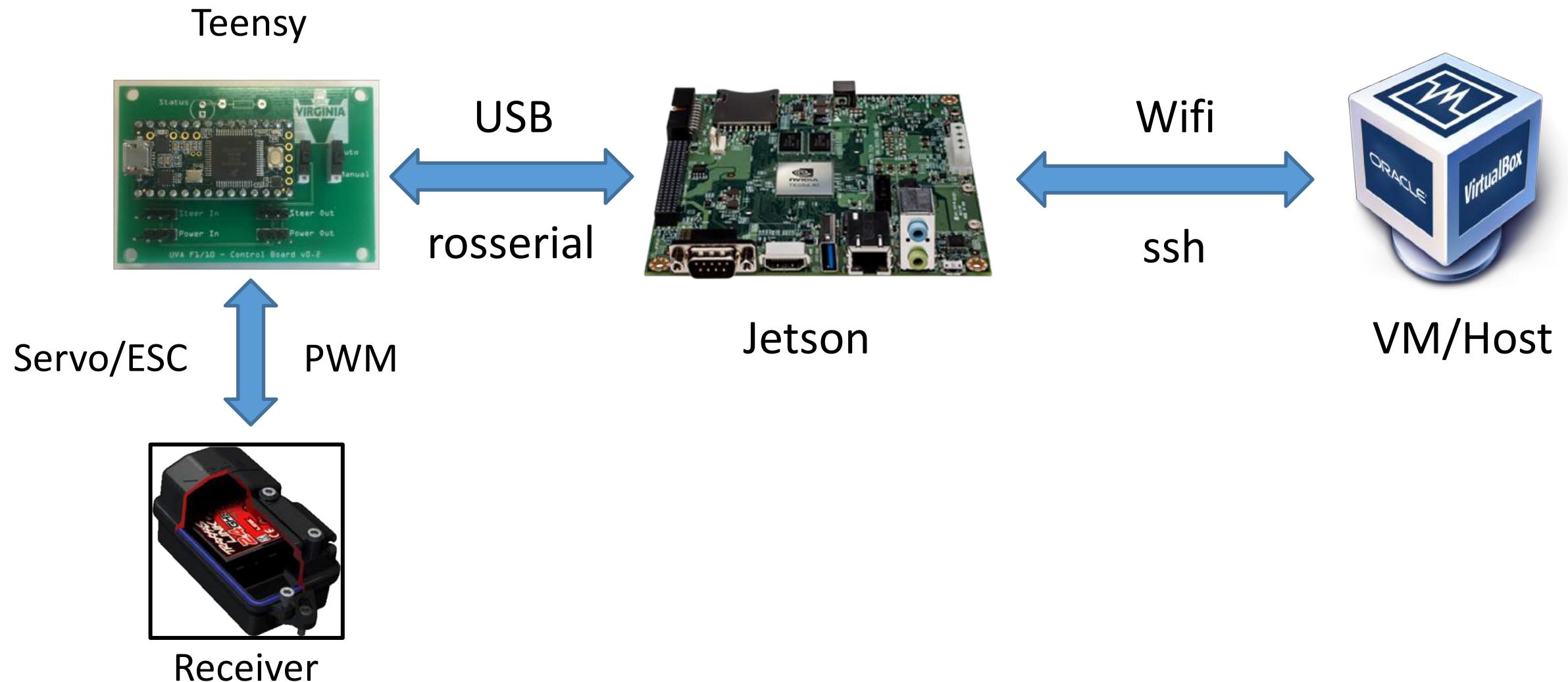
# The F1/10 Platform (Chassis)



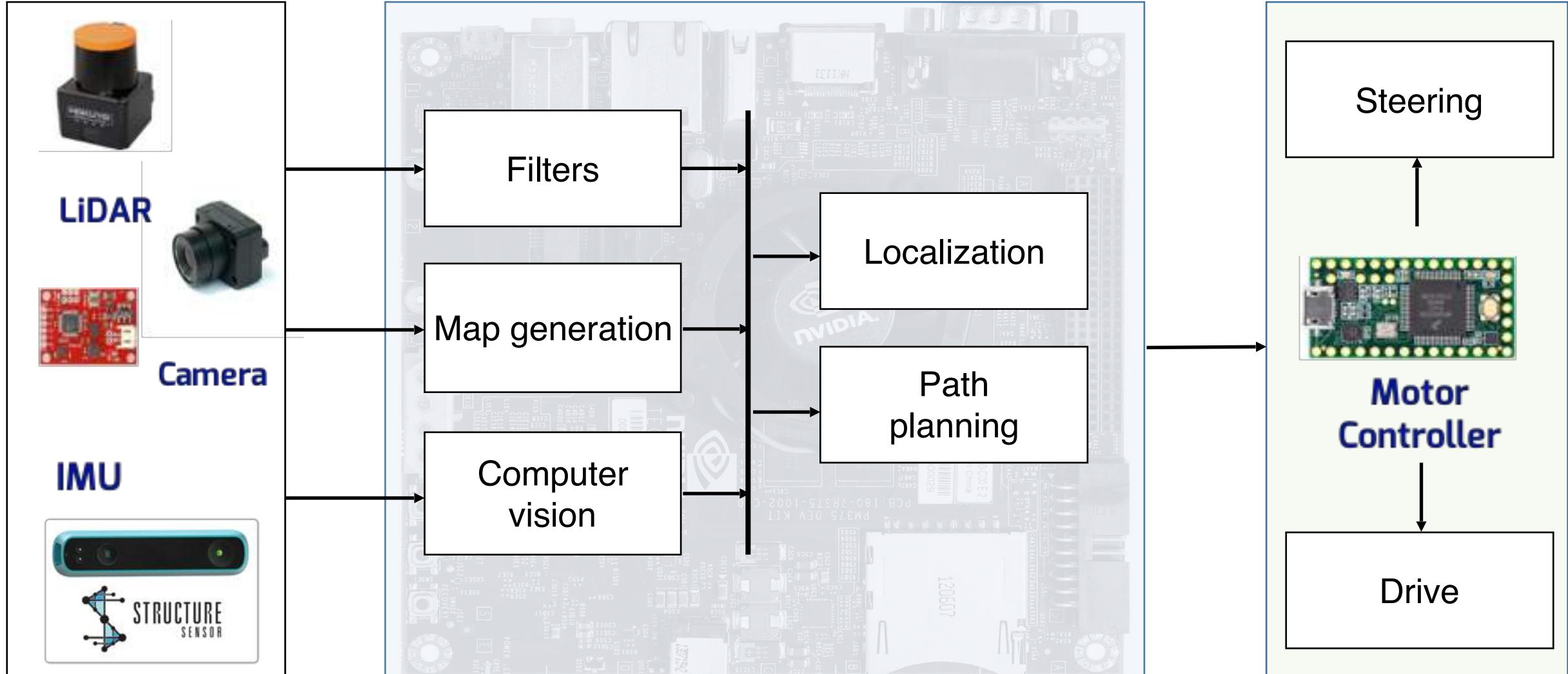
# The F1/10 Platform (Top Plate)



# Compute Connection Diagram



# System Architecture

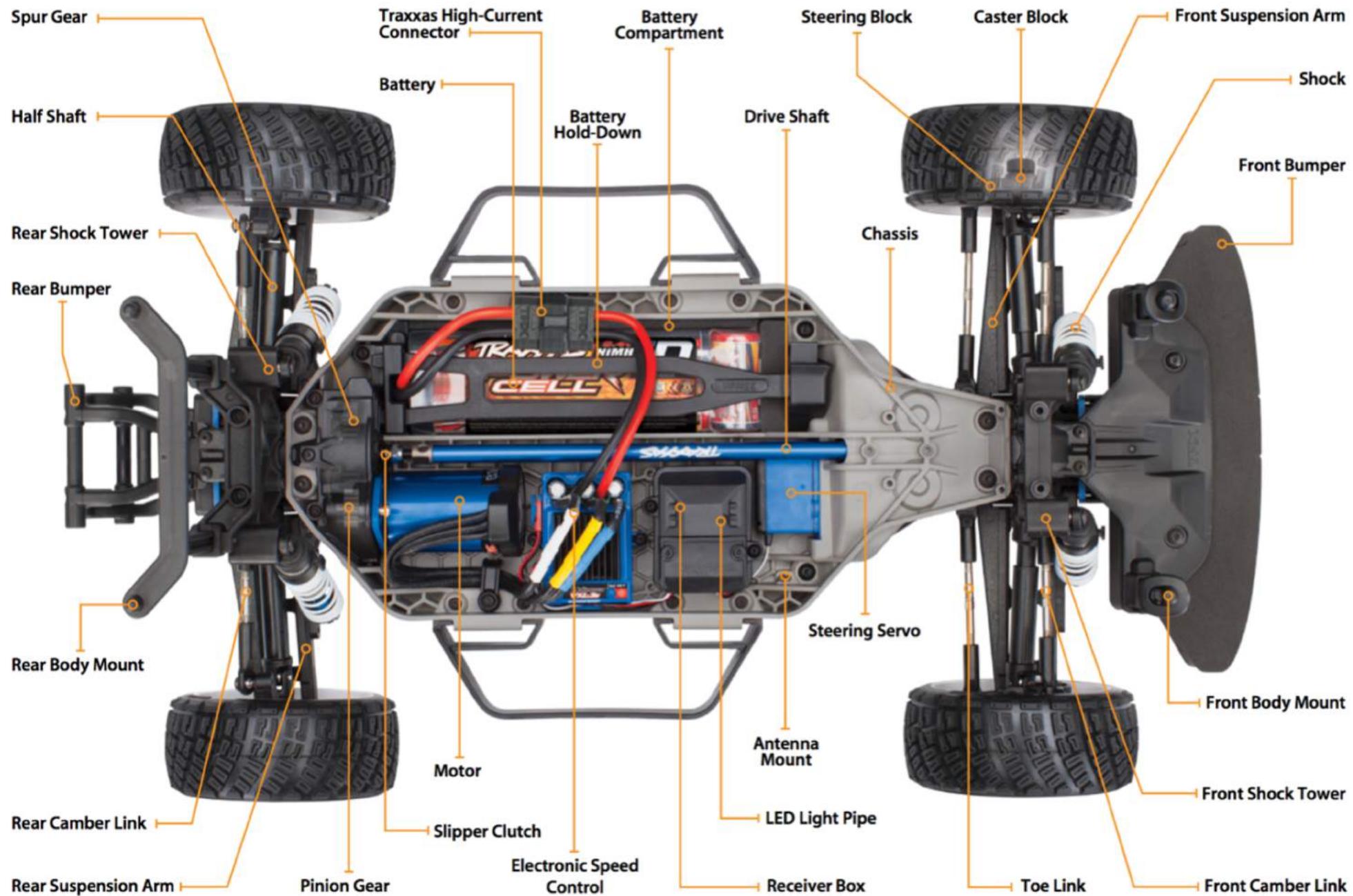


Perception

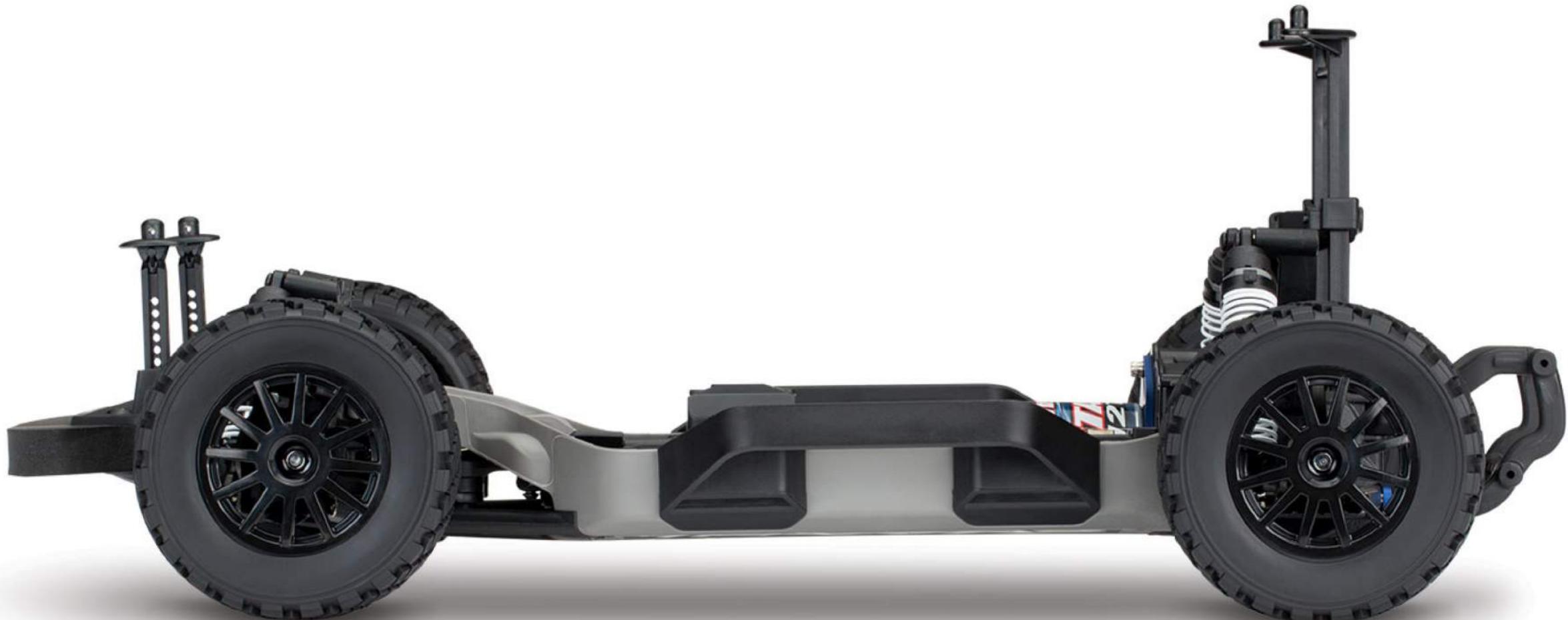
Planning

Control

# Traxxas 1/10 scale RC race car

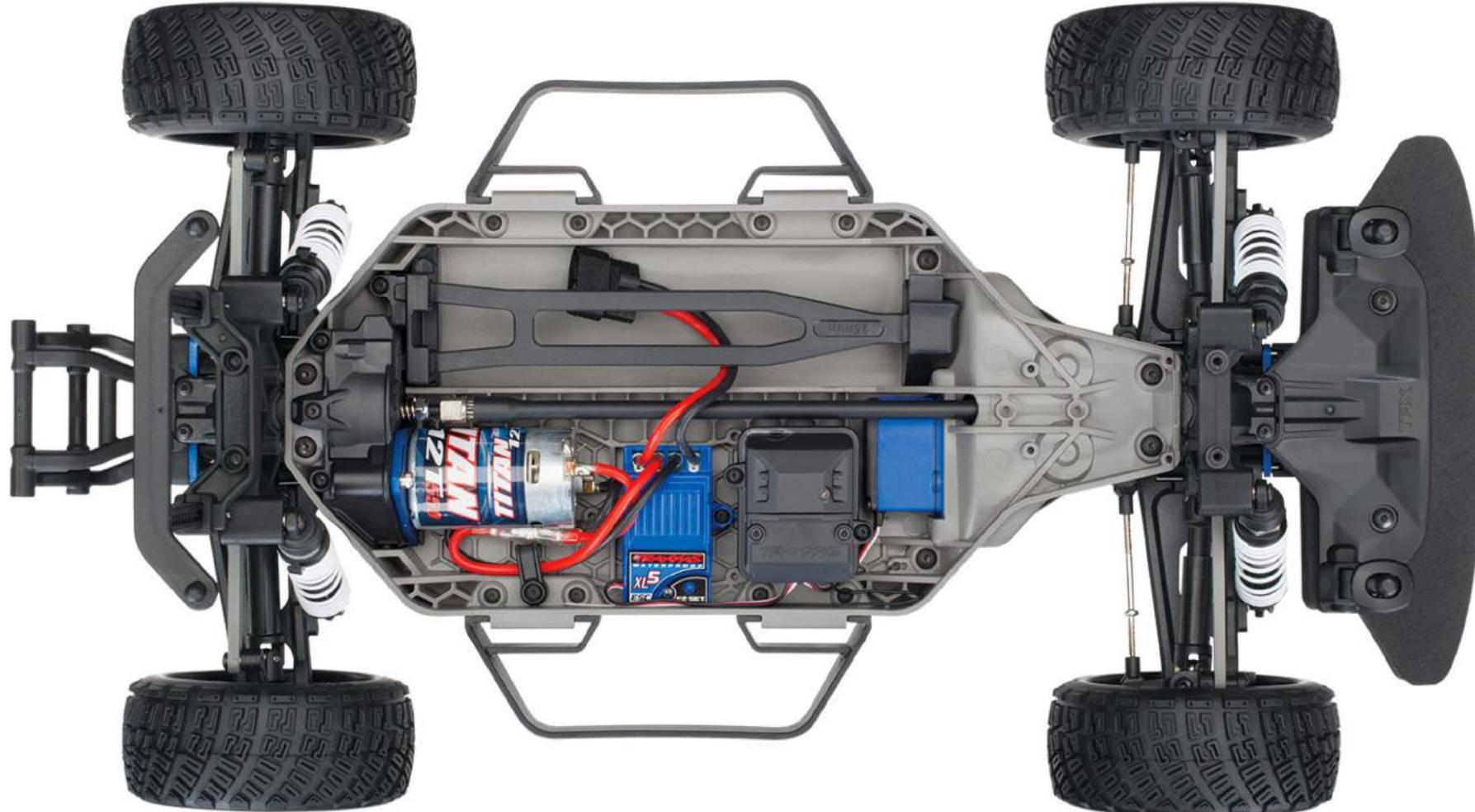


# Low center of gravity



# Perfect weight bias

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

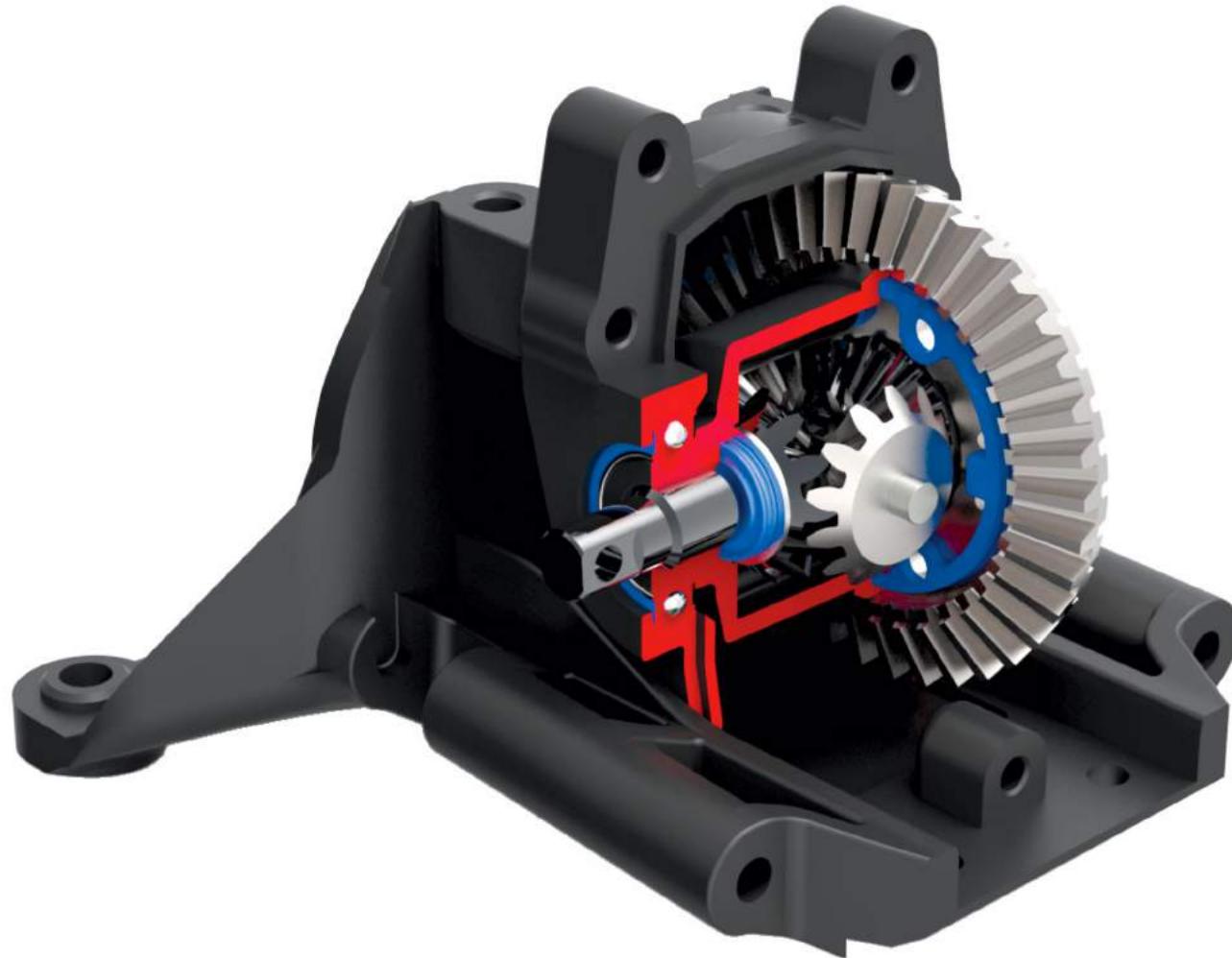


# **Oil filled Shocks**

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



# Differential



# Drive shaft

telescoping, universal-joint driveshaft



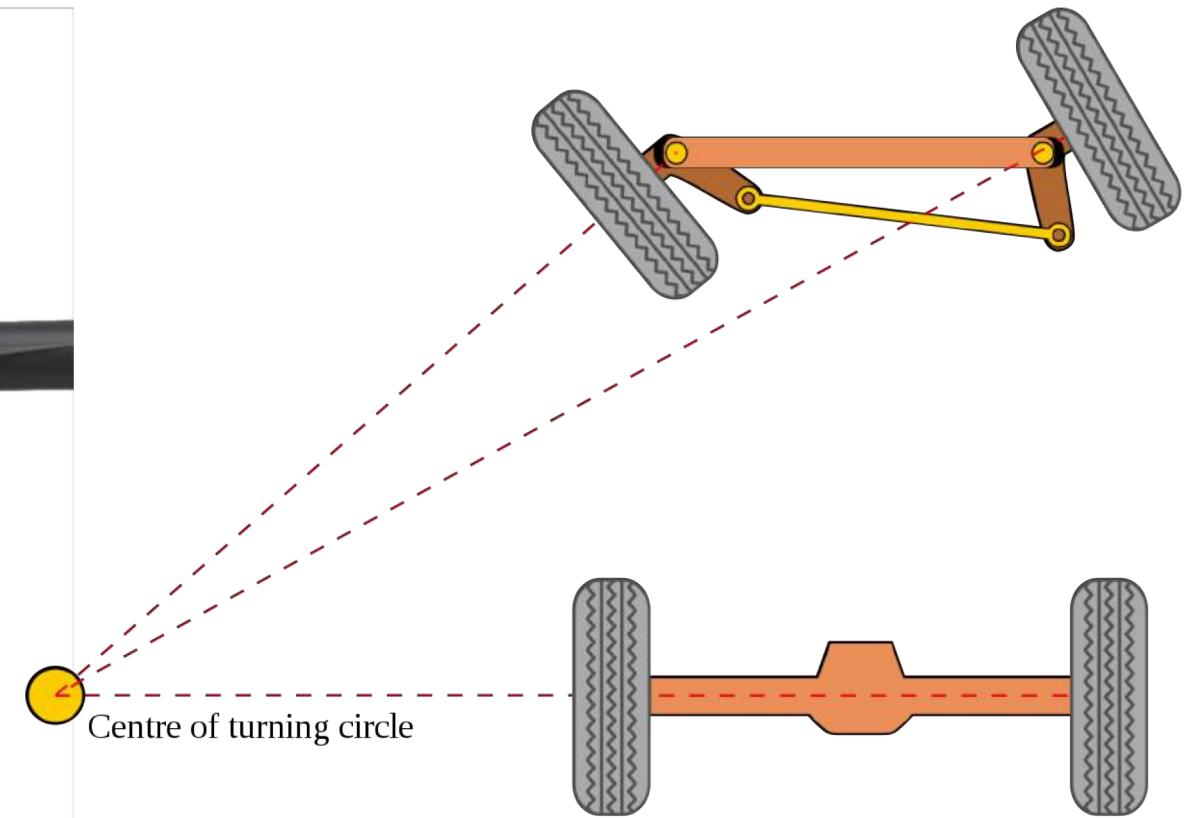
# Long travel suspension



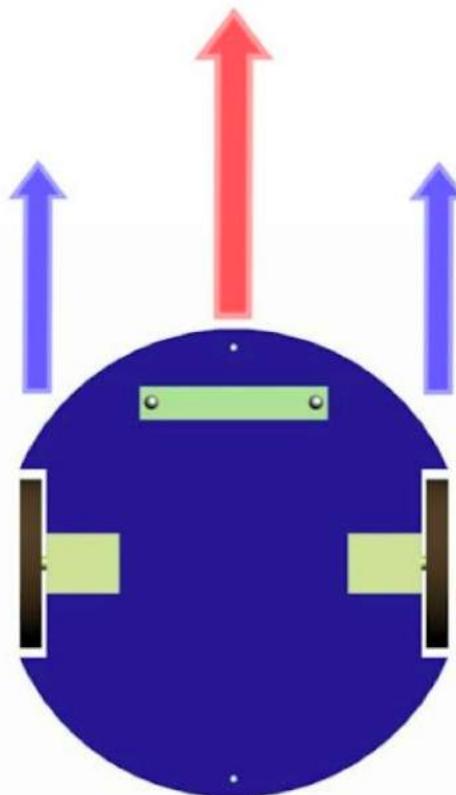
# Long travel suspension



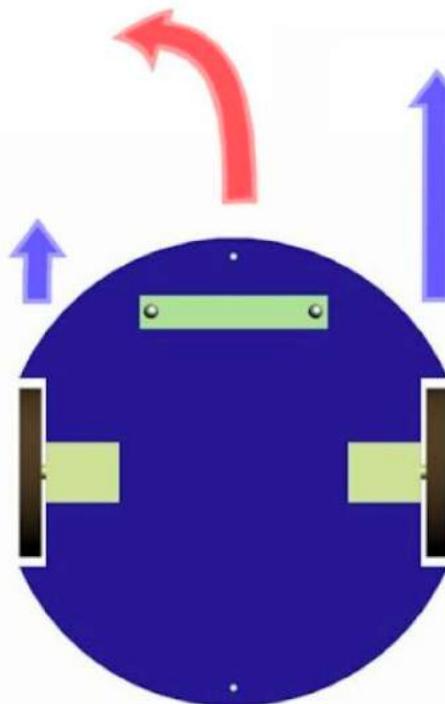
# Ackerman steering



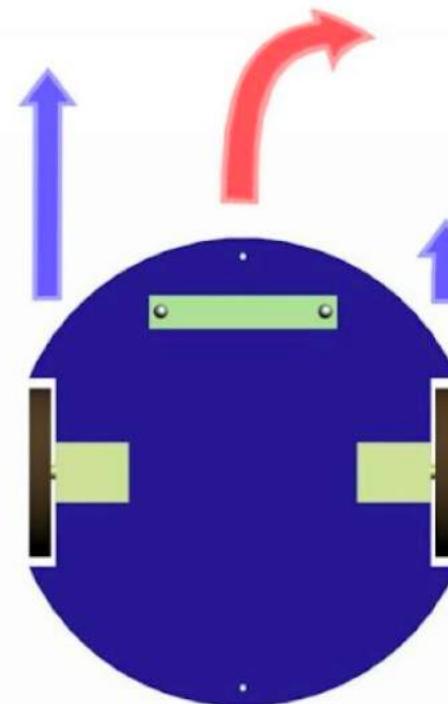
As opposed to differential drive robots..



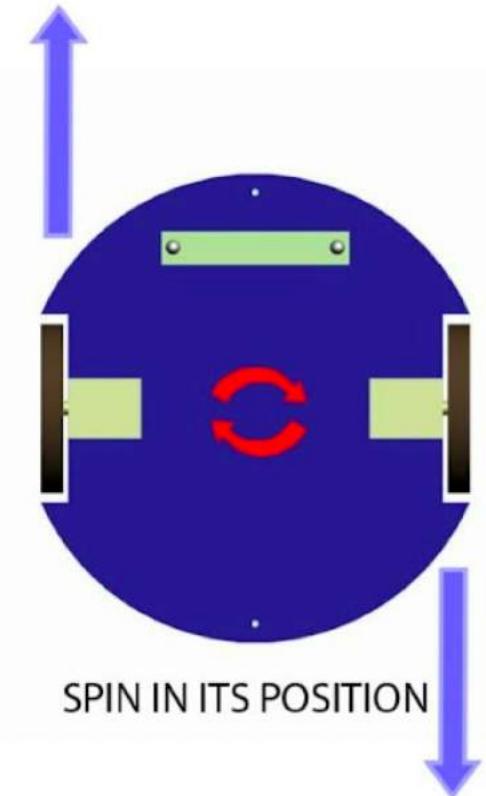
STRAIGHT



TURN LEFT



TURN RIGHT



SPIN IN ITS POSITION

# Race inspired tires and wheels



# Drive modes

Three drive profiles

- Sport Mode - forward / brake / reverse
- Race Mode - forward / brake
- Training Mode™ - 50% forward / brake / 50% reverse

We will start here.. seriously...start here.. why you ask..

You will find out at  
the end of the  
lecture

# Complete battery pack

Practice LiPo safety !





## WARNING! CAUTION! DANGER!

**FIRE HAZARD!** Your model is able to use LiPo batteries. Charging and discharging batteries has the potential for fire, explosion, serious injury, and property damage if not performed per the instructions. Before use, read and follow all manufacturer's instructions, warnings, and precautions. In addition, Lithium Polymer (LiPo) batteries pose a SEVERE risk of fire if not properly handled per the instructions and require special care and handling procedures for long life and safe operation. LiPo batteries are intended only for advanced users that are educated on the risks associated with LiPo battery use. Traxxas does not recommend that anyone under the age of 14 use or handle LiPo battery packs without the supervision of a knowledgeable and responsible adult. Dispose of used batteries according to the instructions.

### Important Warnings for users of Lithium Polymer (LiPo) batteries:

- LiPo batteries have a minimum safe discharge voltage threshold that should not be exceeded. The electronic speed control is equipped with built-in Low-Voltage Detection that alerts the driver when LiPo batteries have reached their minimum voltage (discharge) threshold. It is the driver's responsibility to stop immediately to prevent the battery pack from being discharged below its safe minimum threshold.
- Low-Voltage Detection is just one part of a comprehensive plan for safe LiPo battery use. It is critical to follow all instructions for safe and proper charging, use, and storage of LiPo batteries. Make sure you understand how to use your LiPo batteries. If you have questions about LiPo battery usage, please consult with your local hobby dealer or contact the battery manufacturer. As a reminder, all batteries should be recycled at the end of their useful life.
- ONLY use a Lithium Polymer (LiPo) balance charger with a balance adapter port to charge LiPo batteries. Never use NiMH or NiCad-type chargers or charge modes to charge LiPo batteries. DO NOT charge with a NiMH-only charger. The use of a NiMH or NiCad charger or charge mode will damage the batteries and may cause fire and personal injury.
- NEVER charge LiPo battery packs in series or parallel. Charging packs in series or parallel may result in improper charger cell recognition and an improper charging rate that may lead to overcharging, cell imbalance, cell damage, and fire.

- ALWAYS inspect your LiPo batteries carefully before charging. Look for any loose leads or connectors, damaged wire insulation, damaged cell packaging, impact damage, fluid leaks, swelling (a sign of internal damage), cell deformity, missing labels, or any other damage or irregularity. If any of these conditions are observed, do not charge or use the battery pack. Follow the disposal instructions included with your battery to properly and safely dispose of the battery.

- DO NOT store or charge LiPo batteries with or around other batteries or battery packs of any type, including other LiPos.
- Store and transport your battery pack(s) in a cool dry place. DO NOT store in direct sunlight. DO NOT allow the storage temperature to exceed 140°F or 60°C, such as in the trunk of a car, or the cells may be damaged and create a fire risk.
- DO NOT disassemble LiPo batteries or cells.
- DO NOT attempt to build your own LiPo battery pack from loose cells.

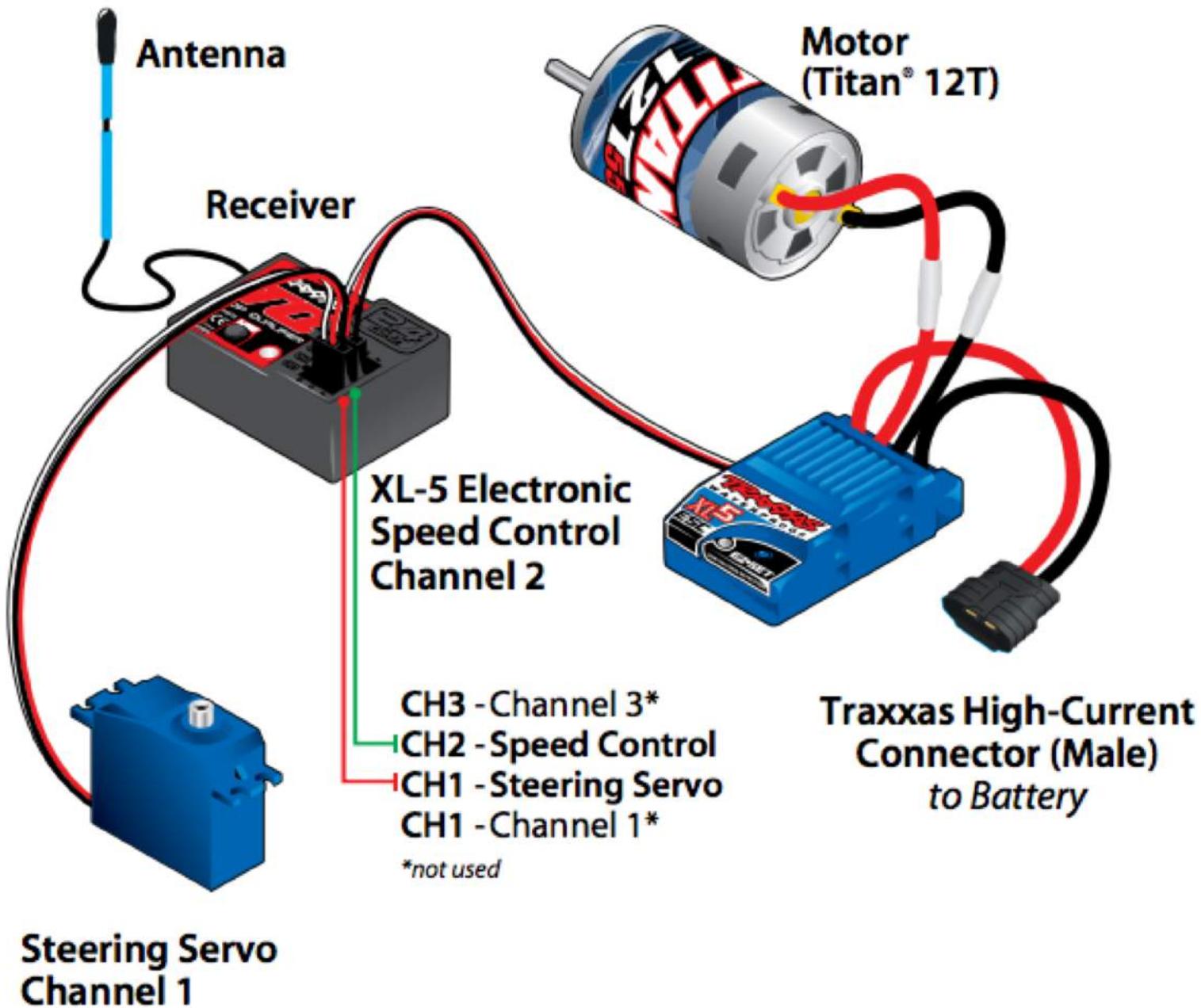
### Charging and handling precautions for all battery types:

- BEFORE you charge, ALWAYS confirm that the charger settings exactly match the type (chemistry), specification, and configuration of the battery to be charged.
- DO NOT attempt to charge non-rechargeable batteries (explosion hazard), batteries that have an internal charge circuit or a protection circuit, batteries that have been altered from original manufacturer configuration, or batteries that have missing or unreadable labels, preventing you from properly identifying the battery type and specifications.
- DO NOT exceed the maximum manufacturer recommended charge rate.
- DO NOT let any exposed battery contacts or wires touch each other. This will cause the battery to short circuit and create the risk of fire.
- While charging or discharging, ALWAYS place the battery (all types of batteries) in a fire retardant/fire proof container and on a non-flammable surface such as concrete.
- DO NOT charge batteries inside of an automobile. DO NOT charge batteries while driving in an automobile.
- NEVER charge batteries on wood, cloth, carpet, or on any other flammable material.



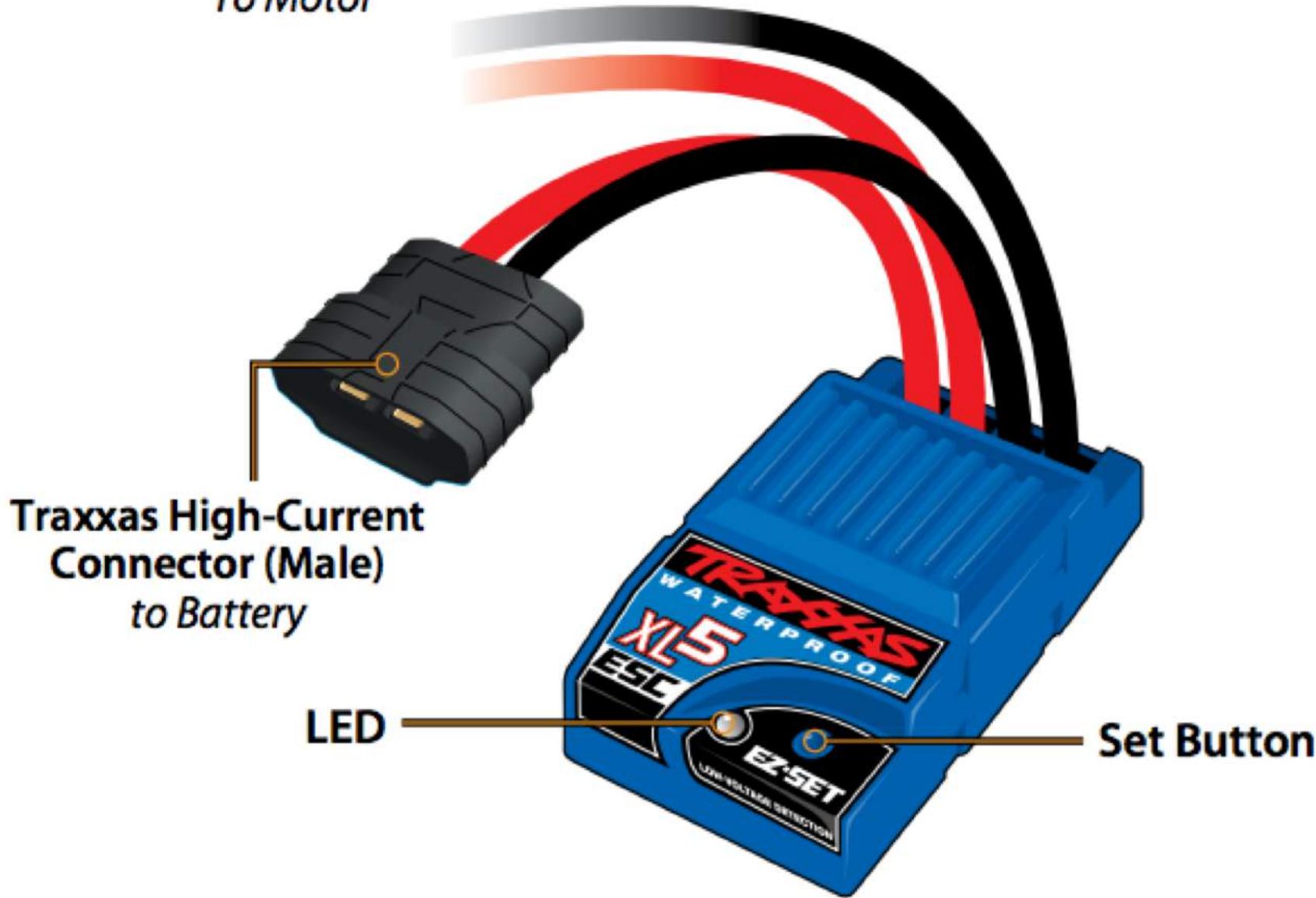
## Practice LiPo safety !

## MODEL WIRING DIAGRAM

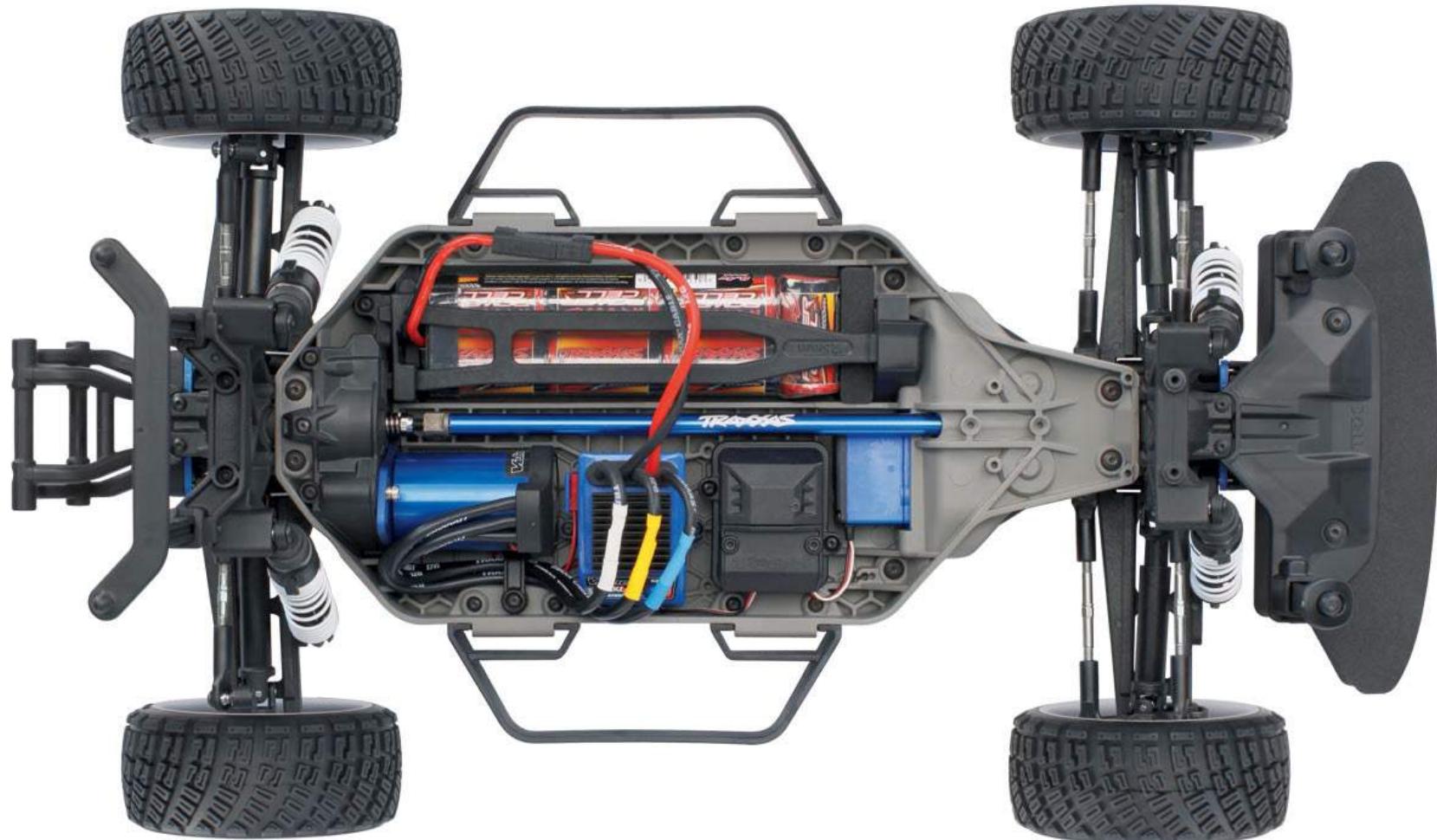
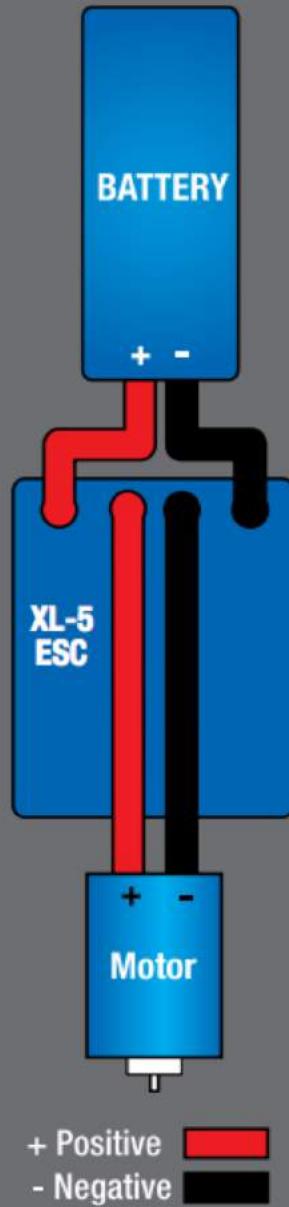


## XL-5 ELECTRONIC SPEED CONTROL

*To Motor*



## XL-5 Wiring Diagram



## RADIO SYSTEM CONTROLS



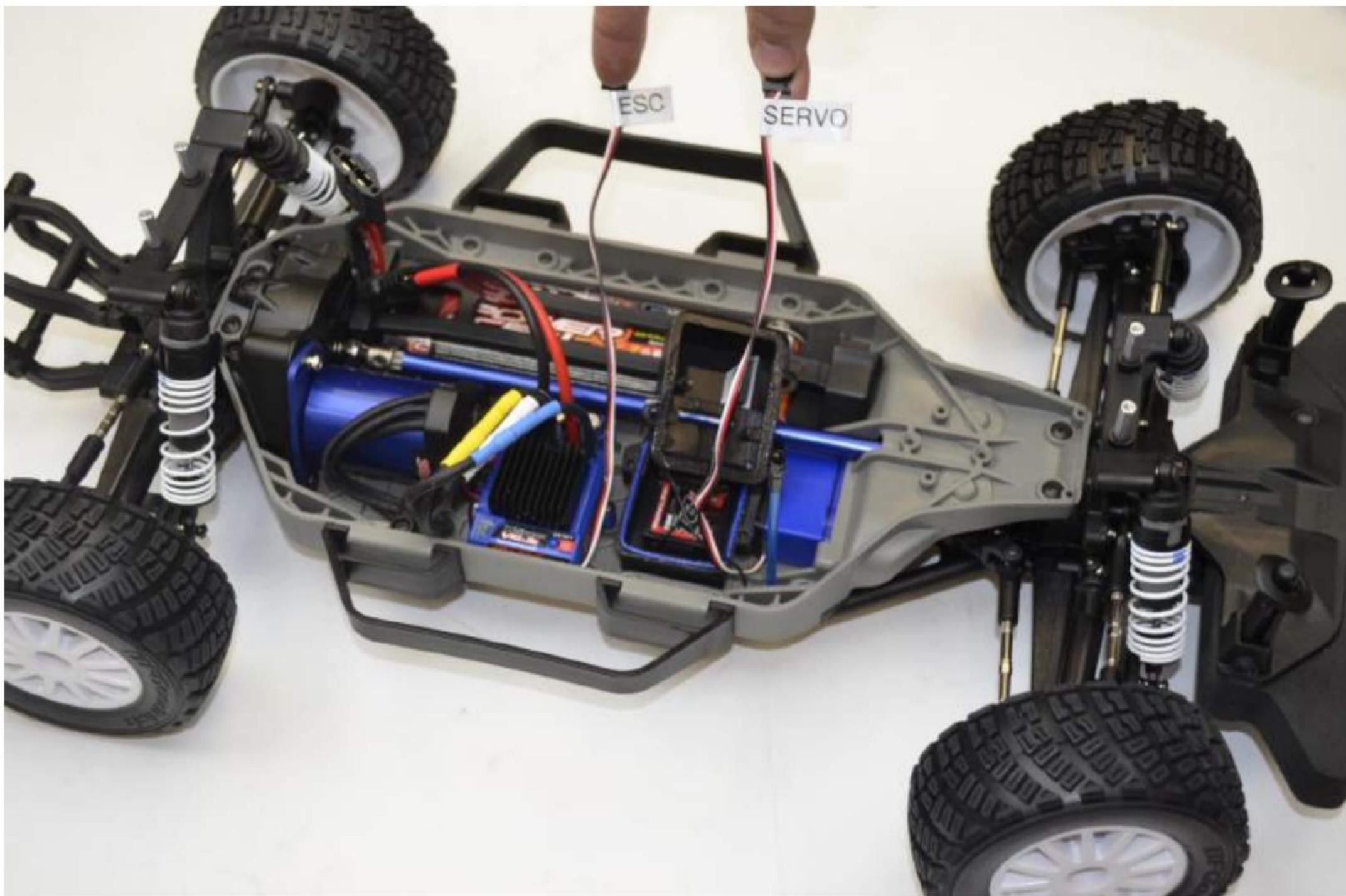
## RADIO SYSTEM RULES

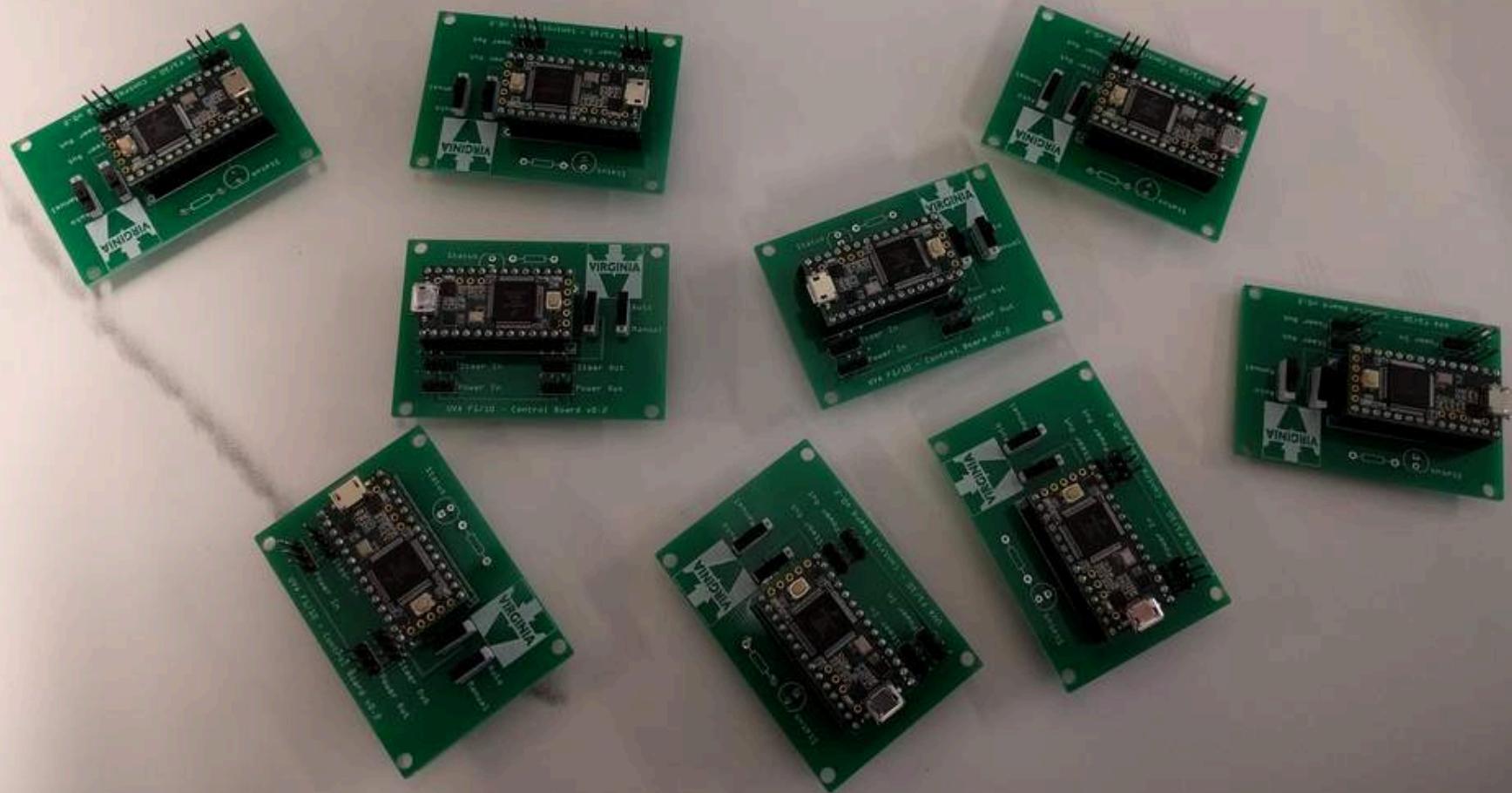
- Always turn your transmitter on first and off last. This procedure will help to prevent your model from receiving stray signals from another transmitter, or other source, and running out of control. Your model has electronic fail-safes to prevent this type of malfunction, but the first, best defense against a runaway model is to always turn the transmitter on first and off last.

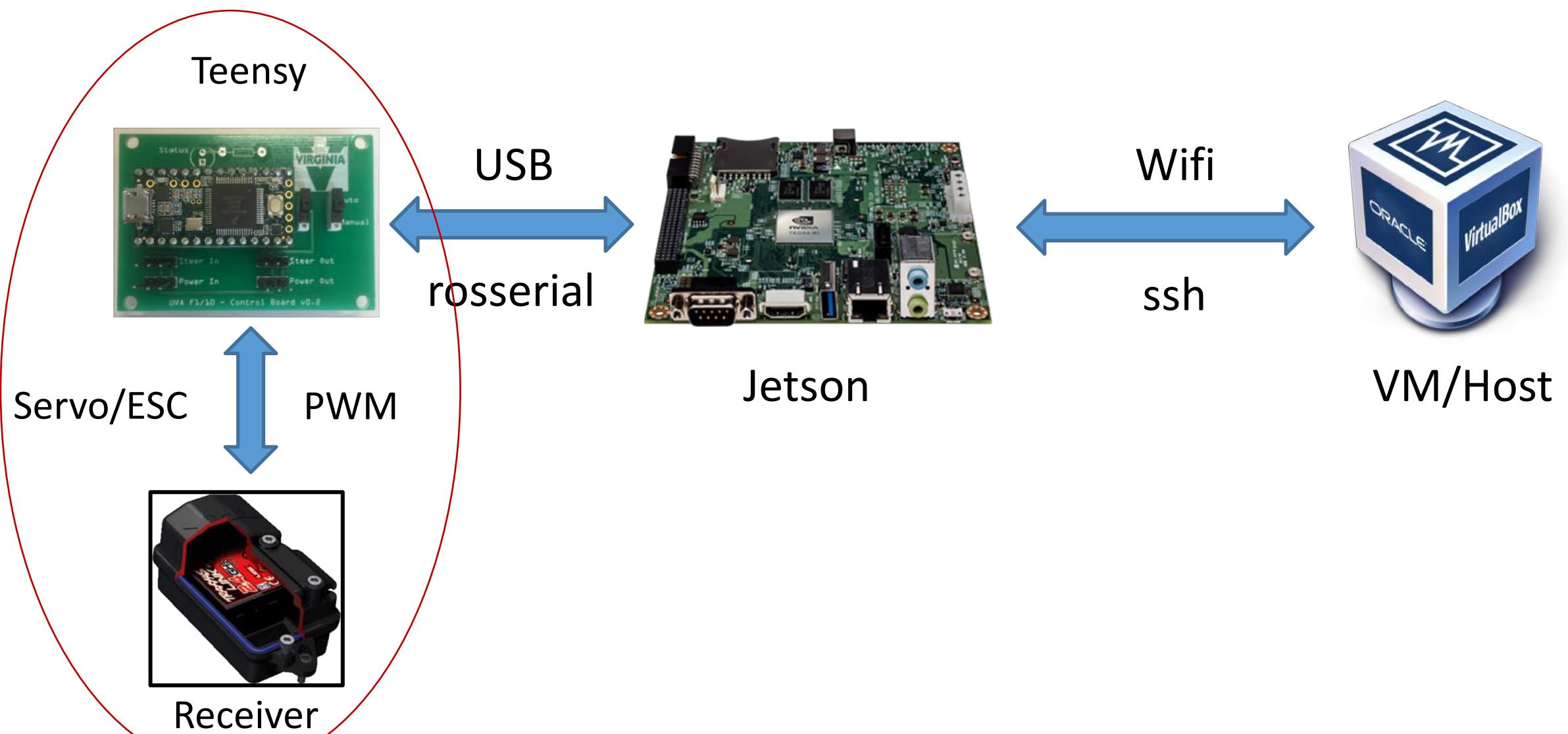
### RADIO SYSTEM CONTROLS

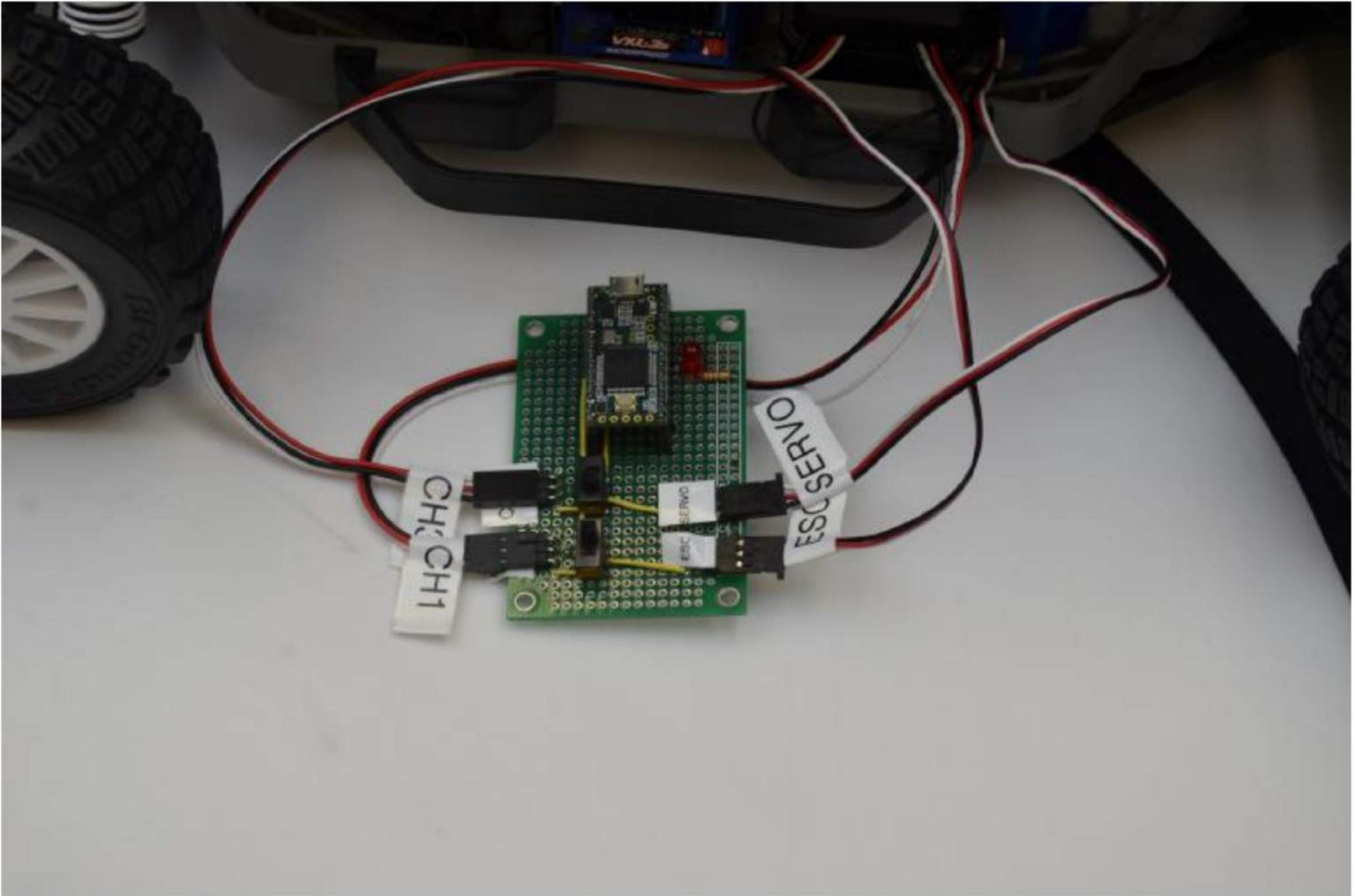


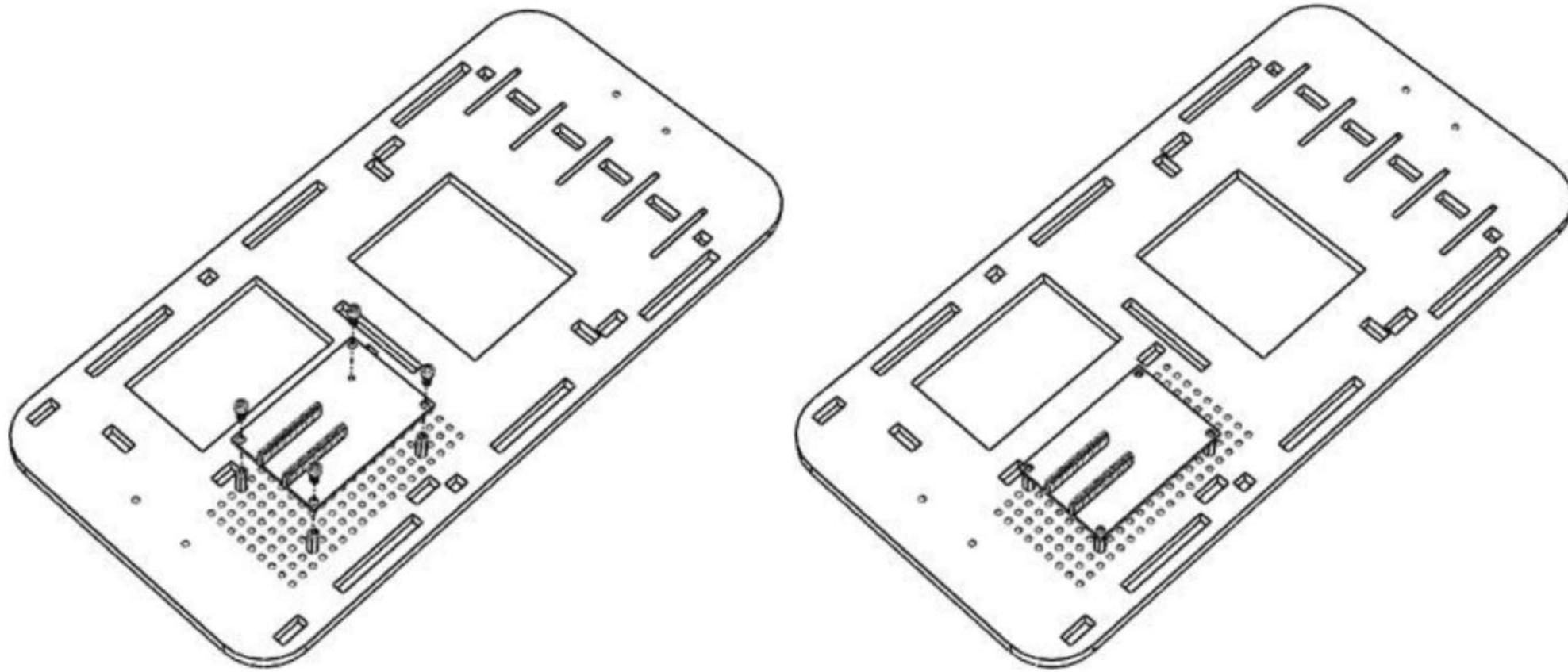
- Always use new or freshly charged batteries for the radio system. Weak batteries will limit the radio signal between the receiver and the transmitter. Loss of the radio signal can cause you to lose control of your model.







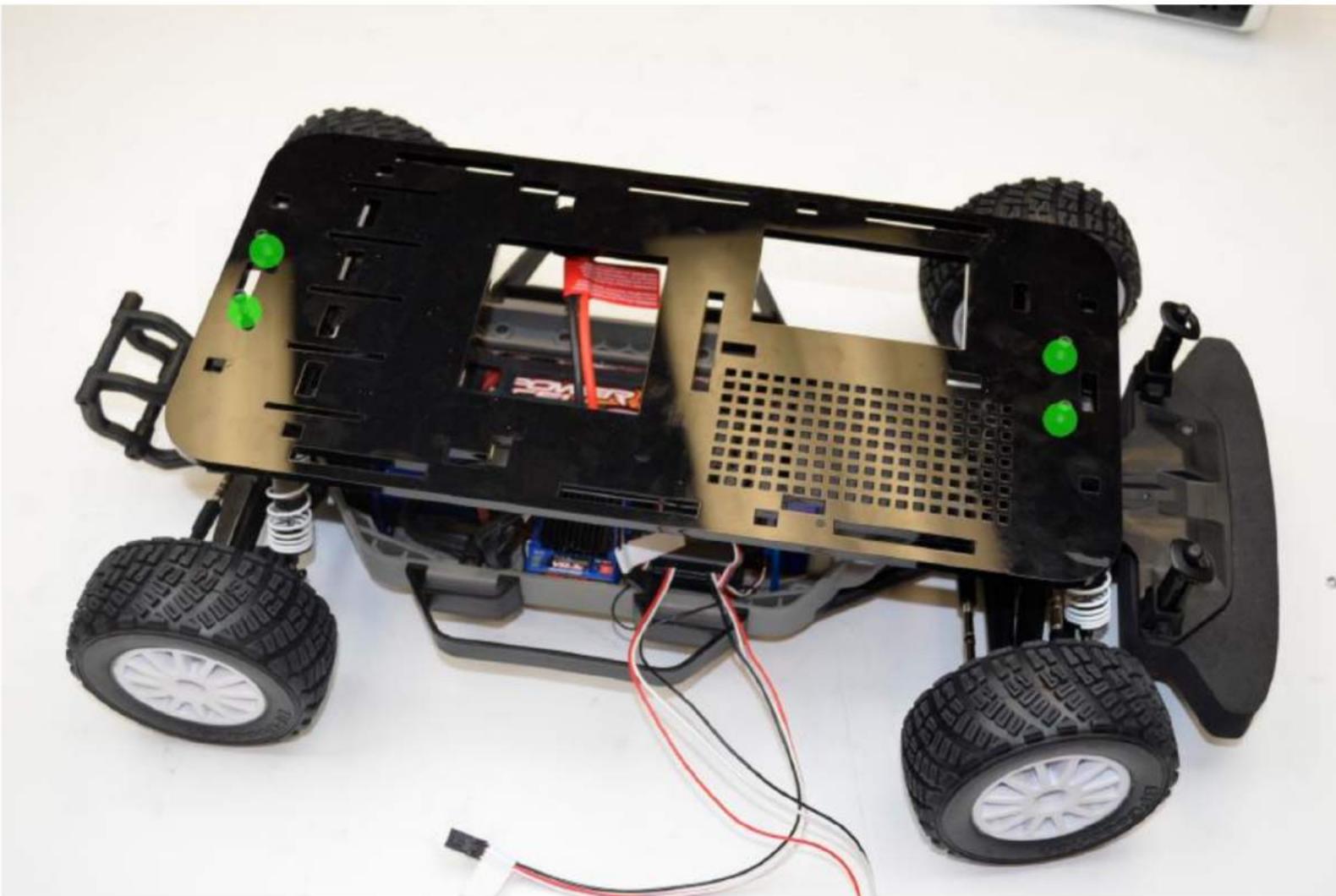




Step 2: With the ***Chassis Base*** front facing towards you, and the bottom facing up, mount the ***Teensy*** board to the ***Chassis Base*** with to the corresponding holes as shown. Use two M3 screws to secure the board threading them into the ***Chassis*** (no nut is required).

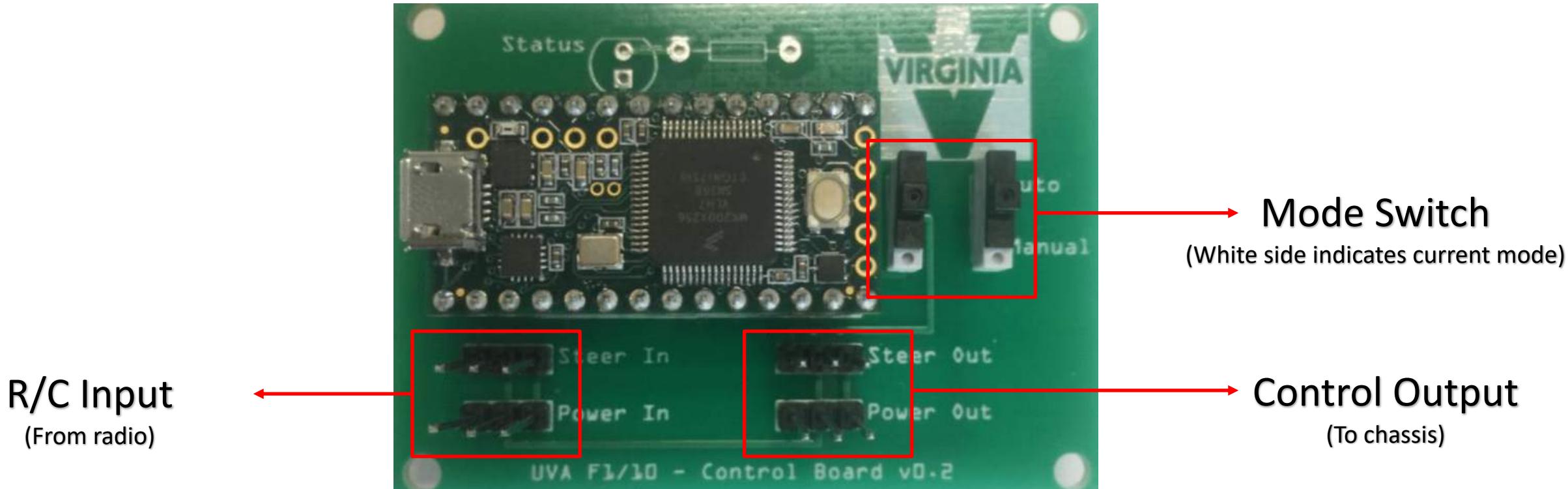
## Mounting the Chassis

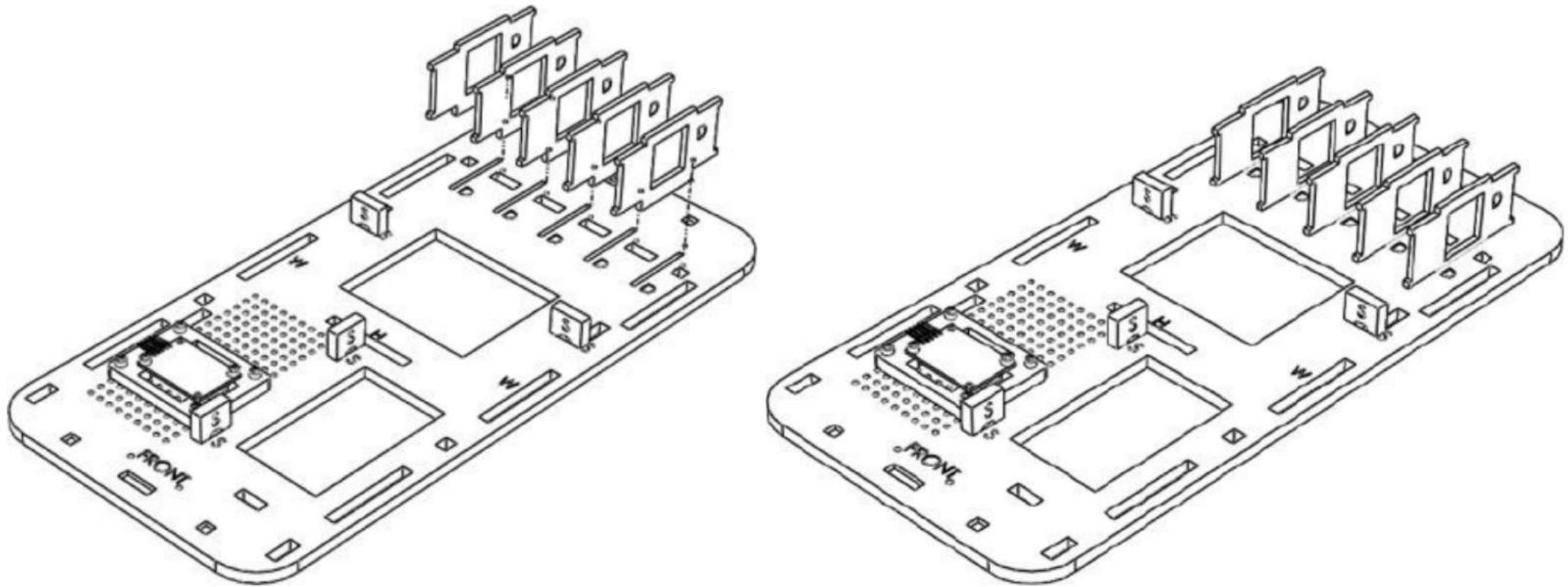
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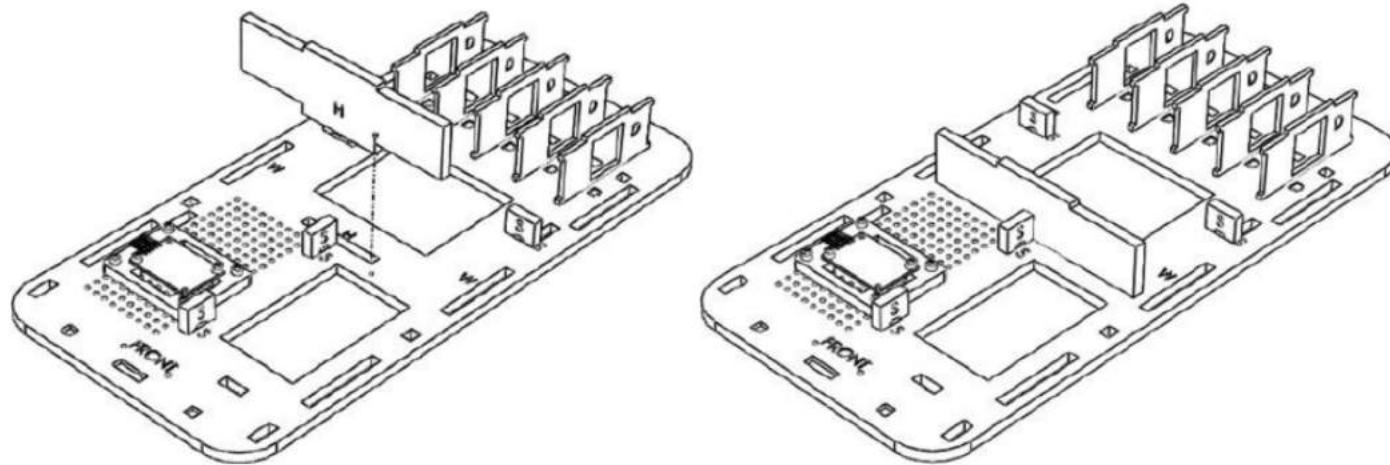
Step 3: Mount the **Chassis Base** to car with the "front" text facing up and forward. Use 4 M3 screws to mount the chassis to the 4 stand offs previously installed.

# Teensy Controller

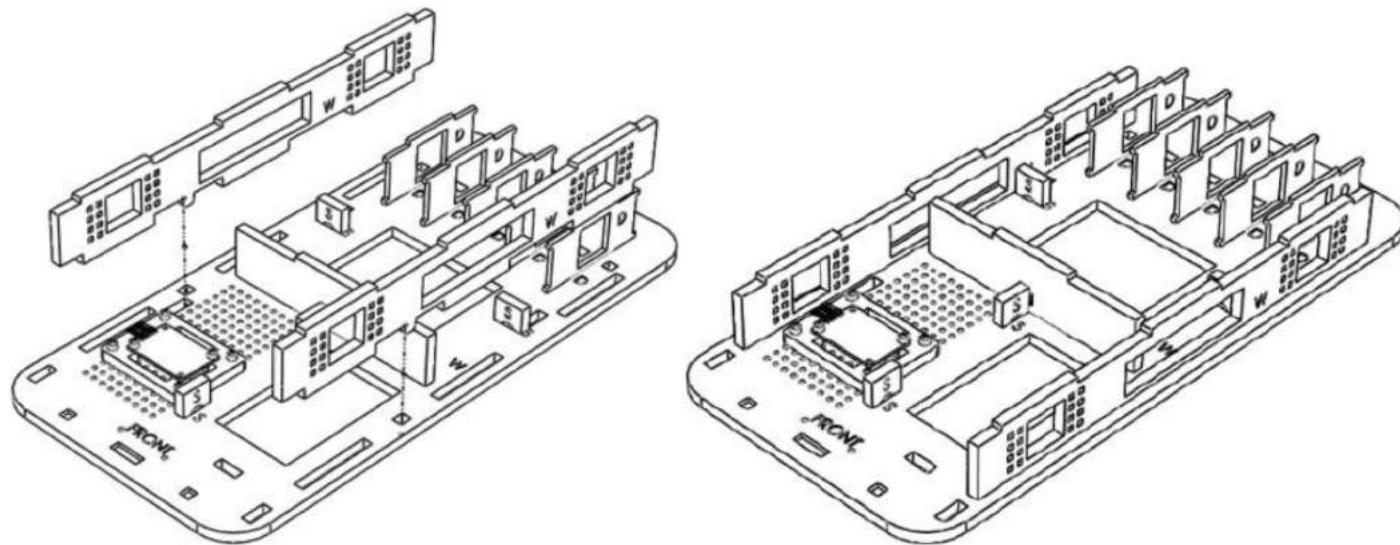


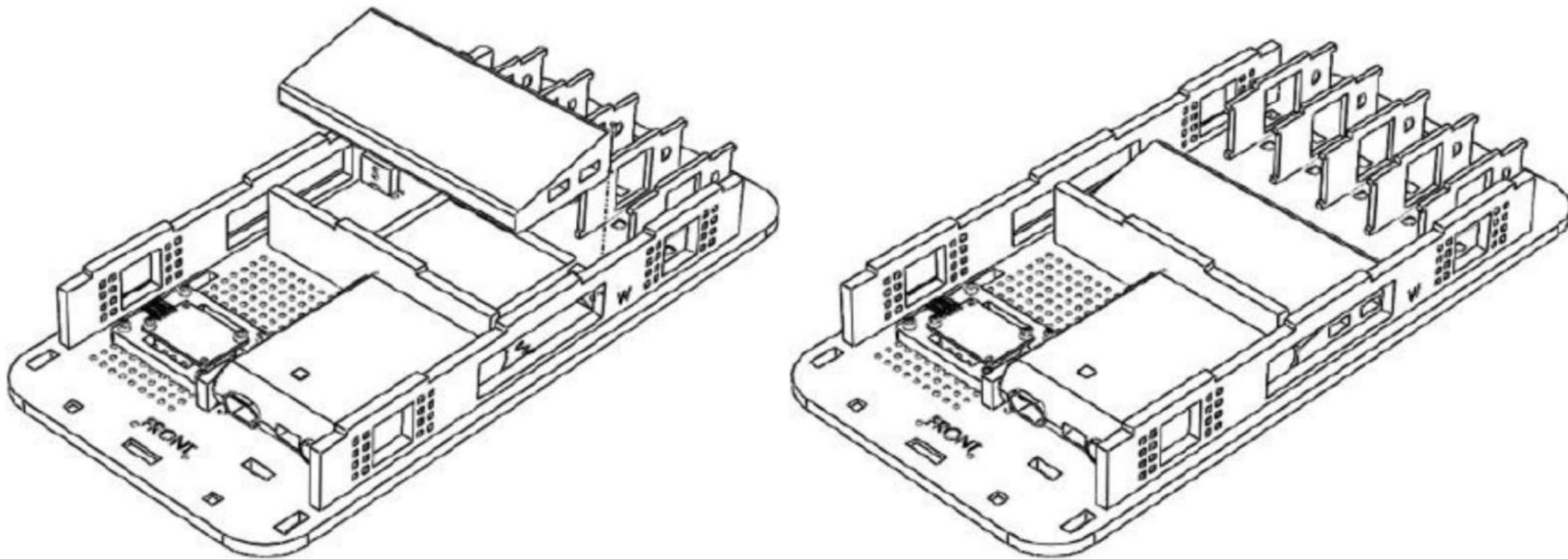


Step 2: One at a time press in all the *D Dividers* (5 total) in the slots on the back end of the *Chassis*. Assure they are pressed fully into their slots.

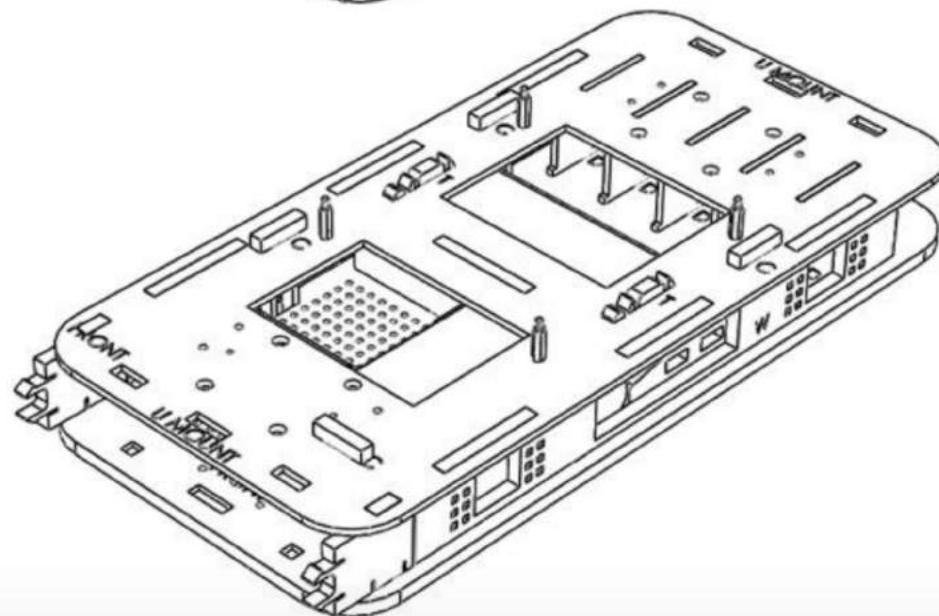
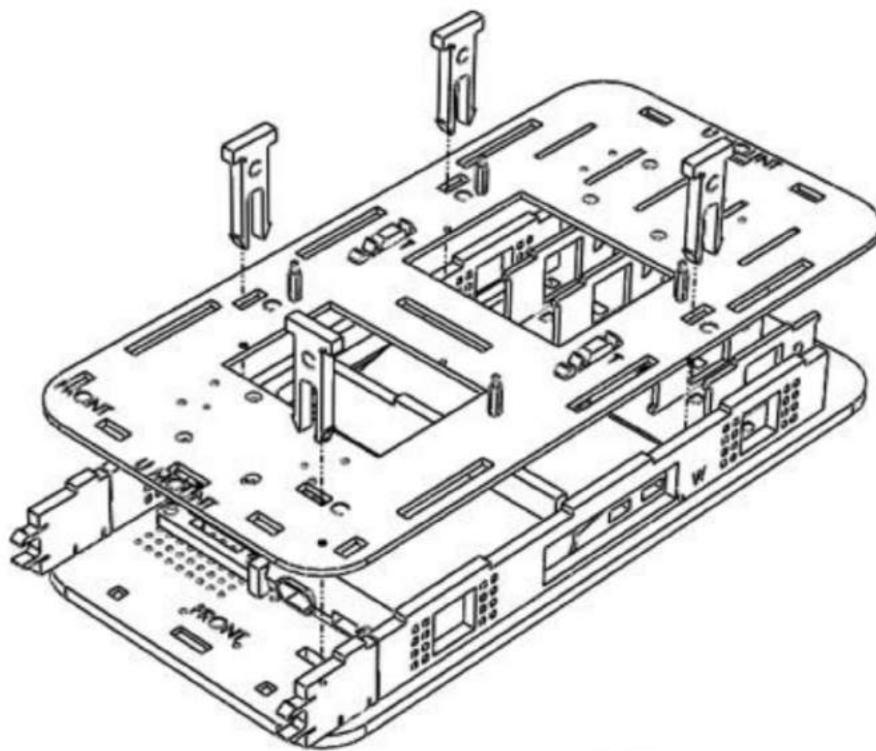


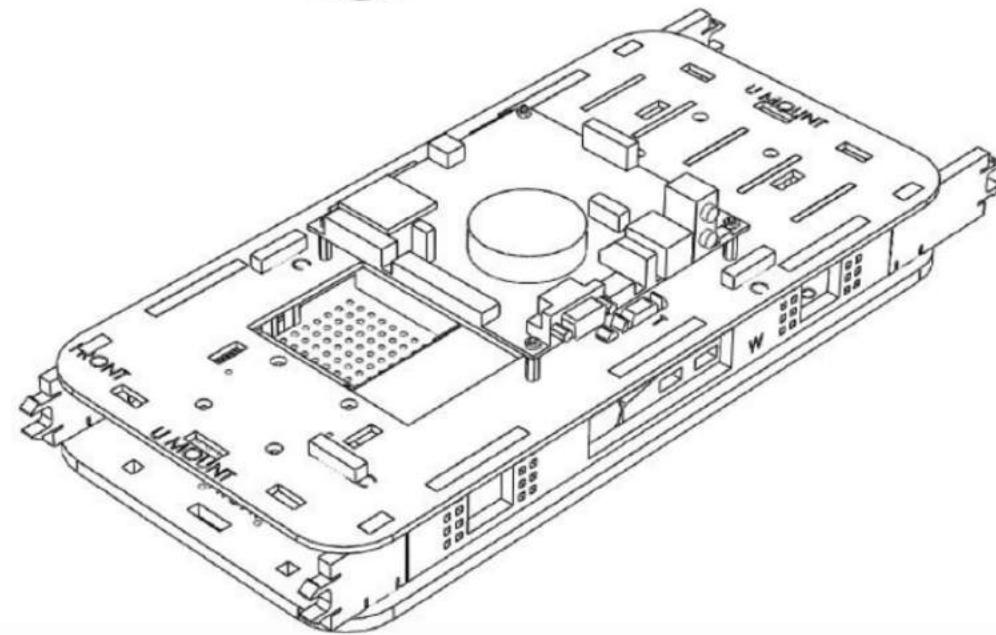
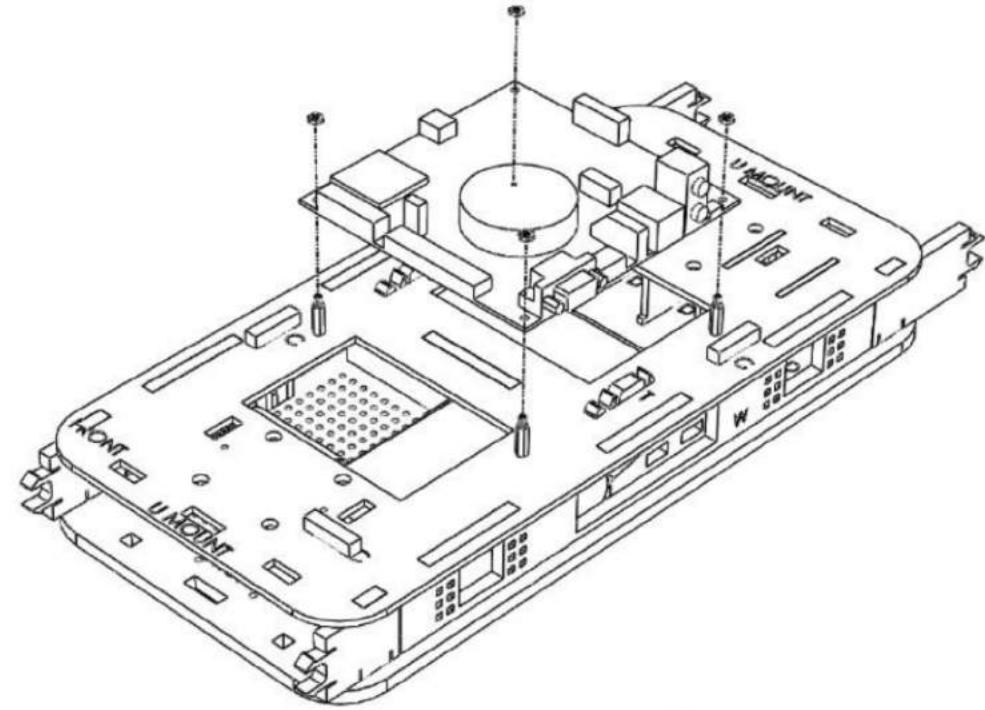
Step 3: Insert the *H Divider* into the corresponding H slot on the middle of the *Chassis*.

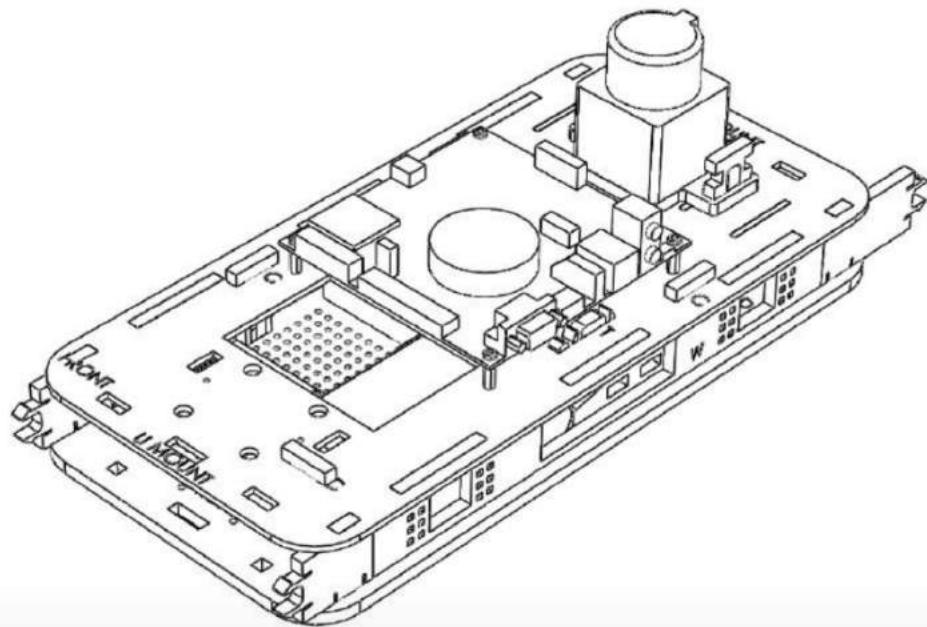
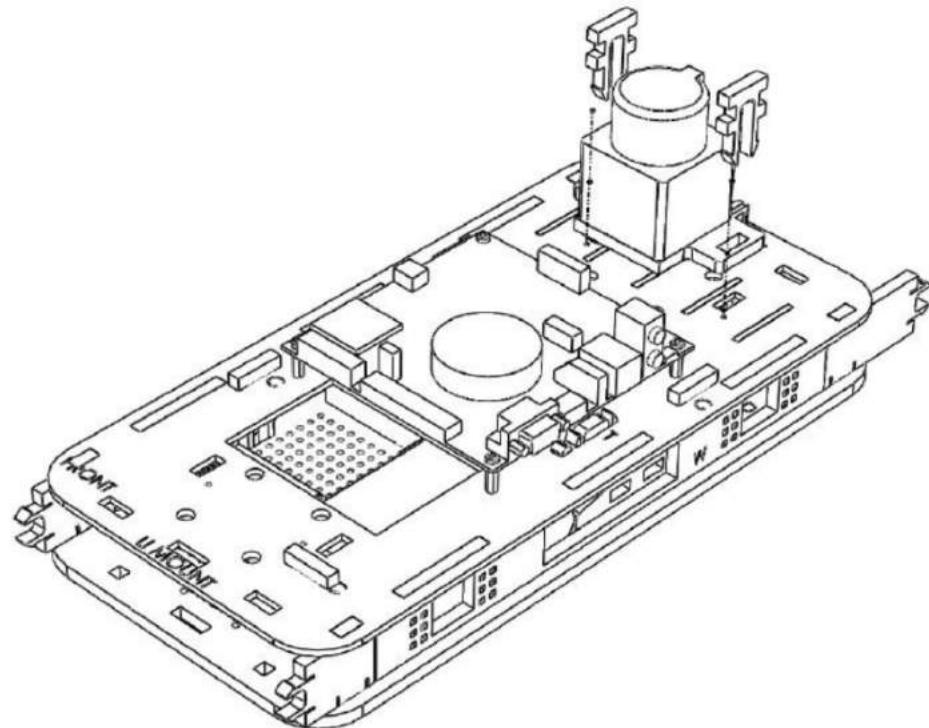


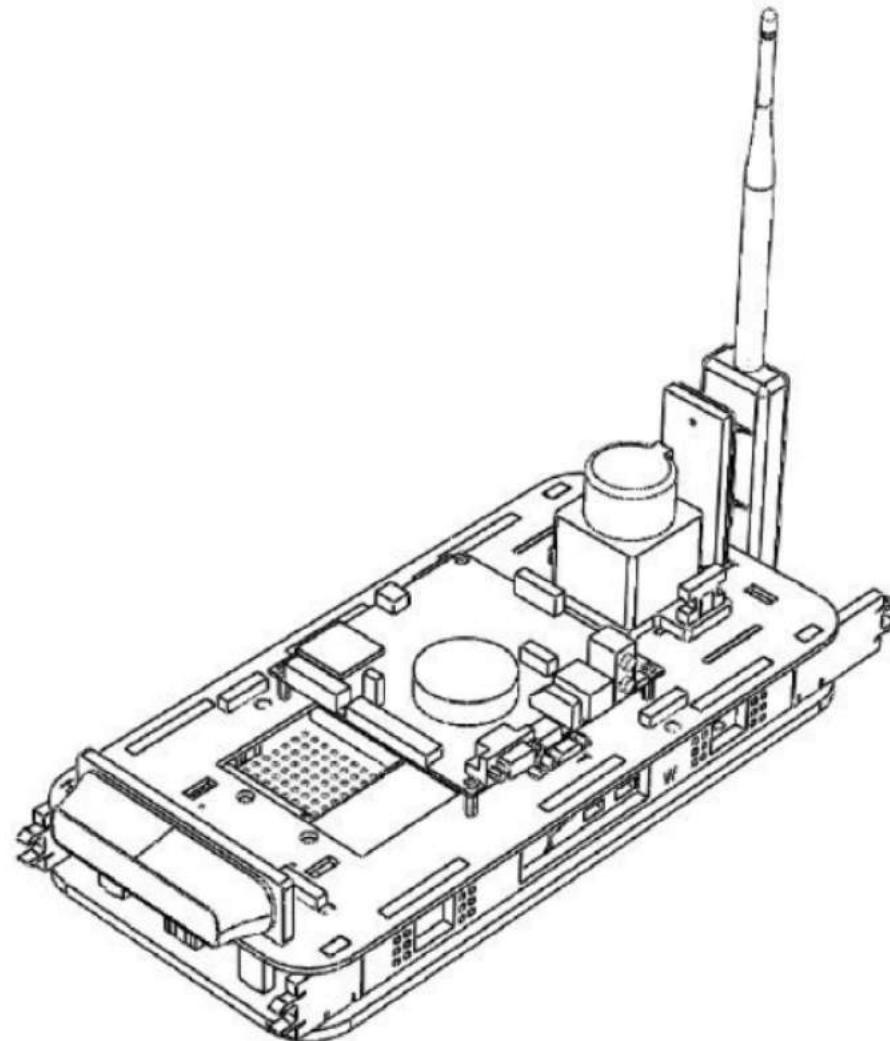
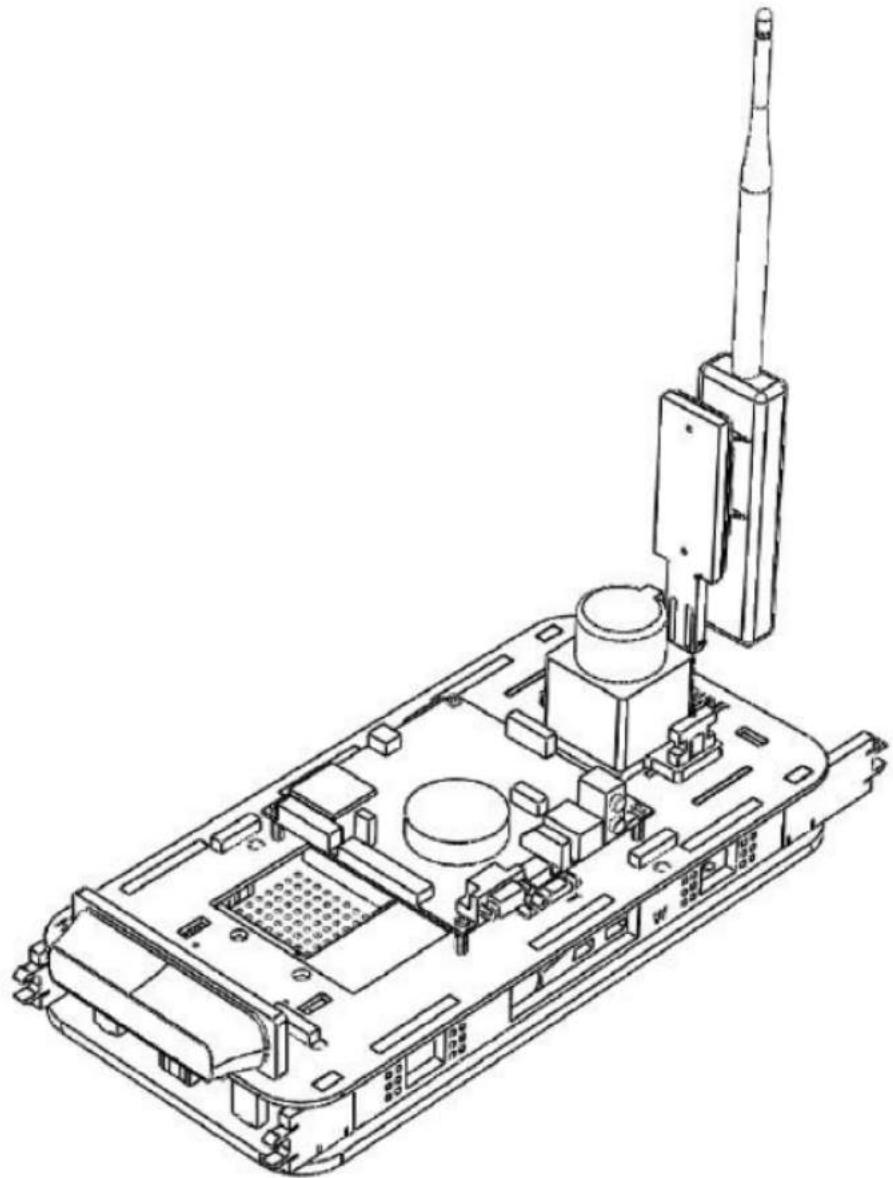


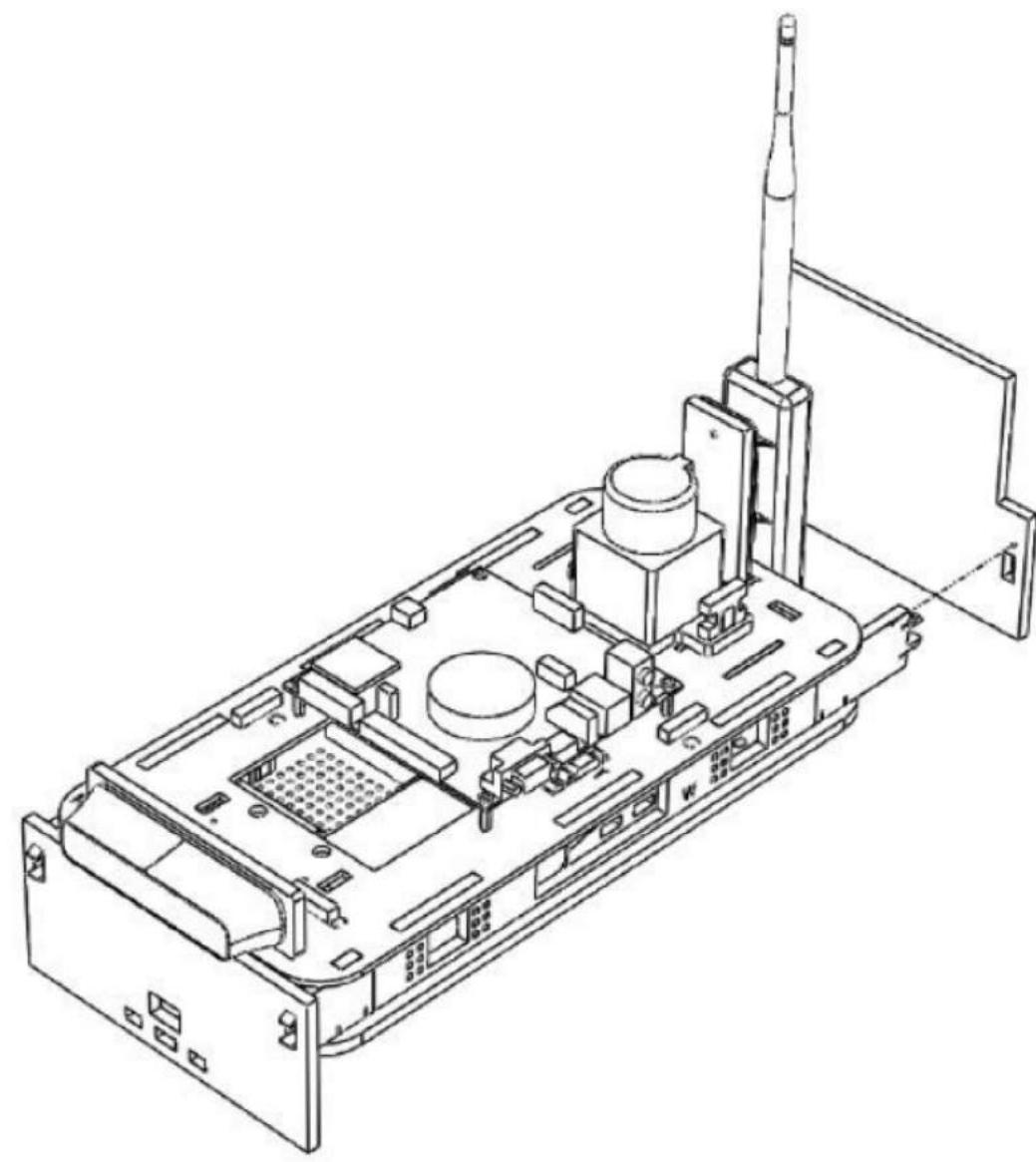
Step 6: Insert the ***USB Hub*** in the USB hub location so that the USB ports are facing the back and the Amazon logo is on the lower right corner.







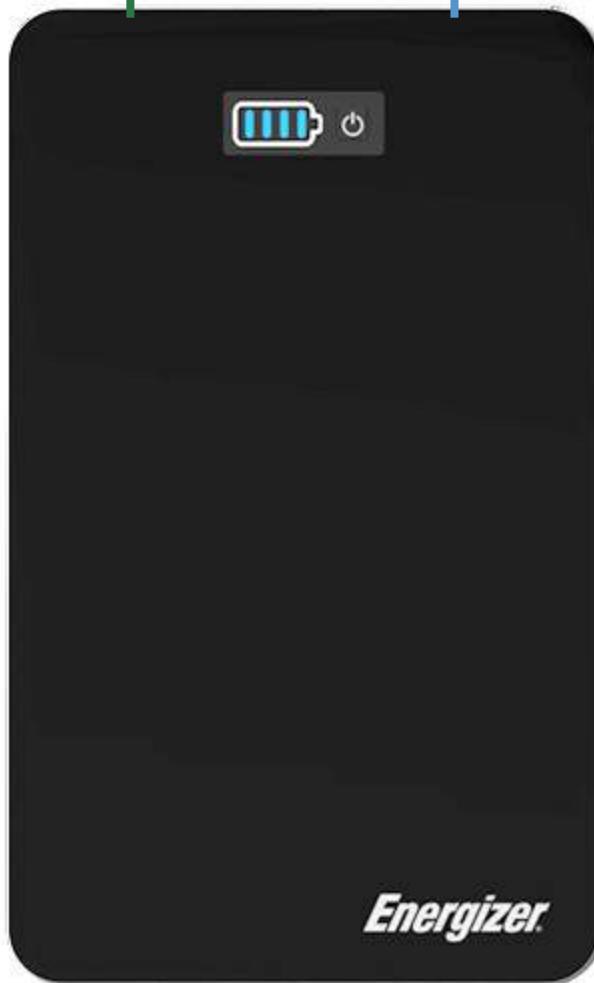




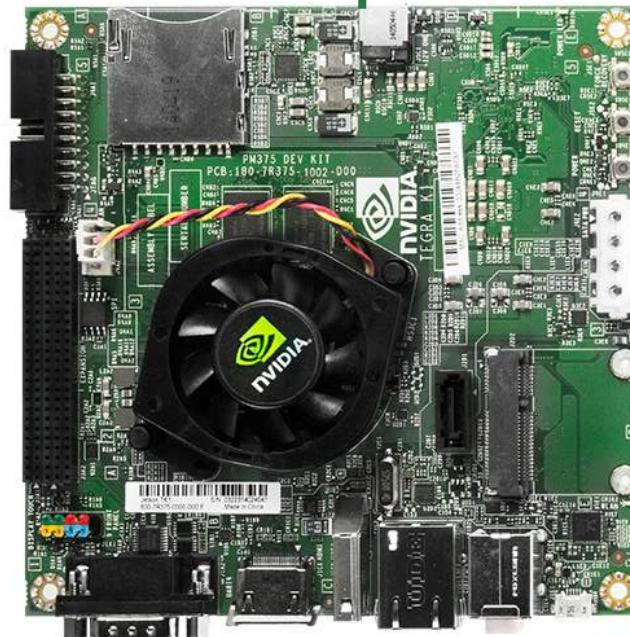
# Power Connections

Green connects to green Jetson

(TK1) 12V



Blue connects to Wifi Station



Power Bank

Jetson TK1

Ubiquiti Pico Station

F1/10 autonomous car cost : \$2,700

Cheap.Fast.Reliable

[Pick 2]

