Drivetrains

Team 1732

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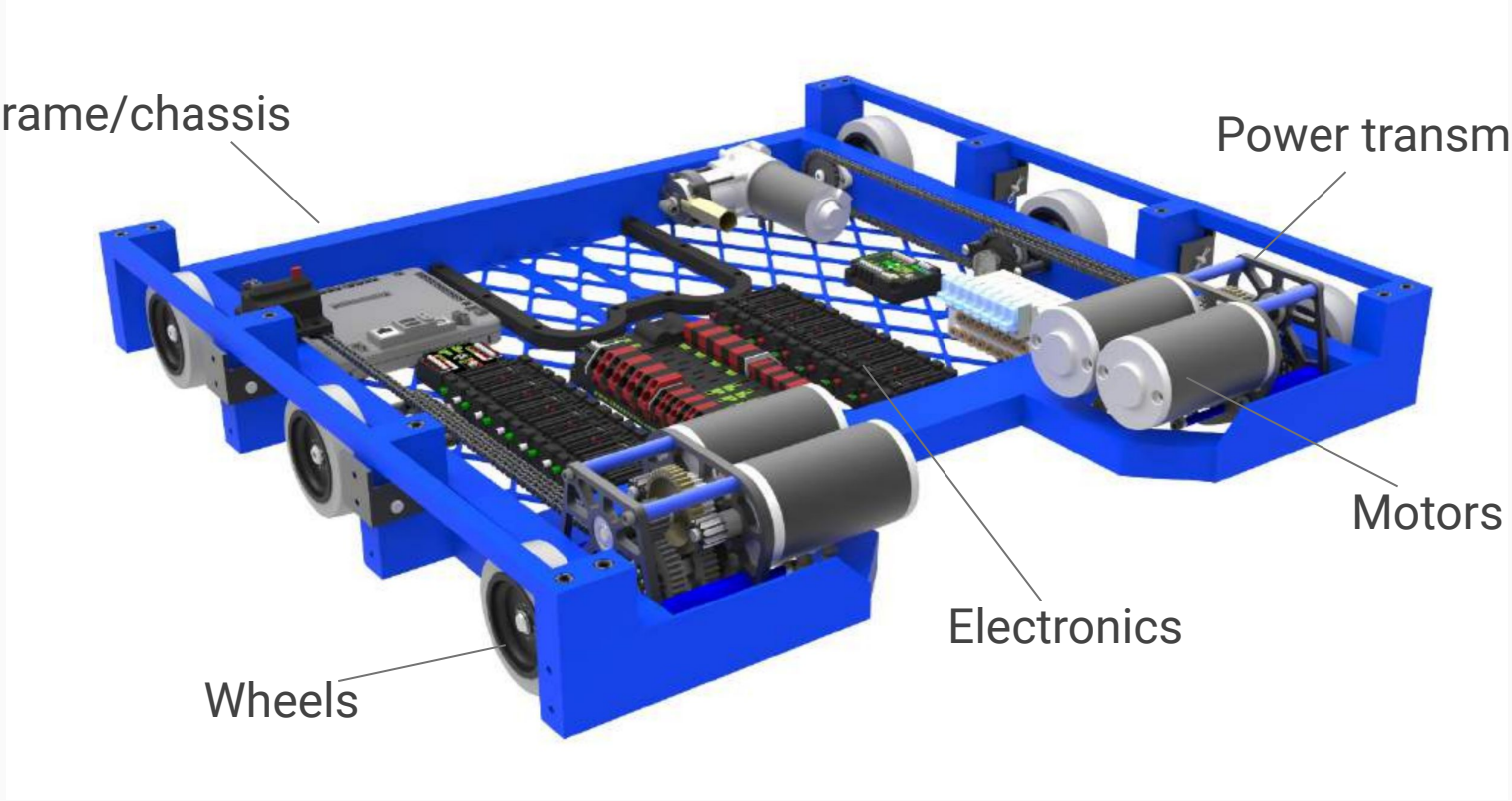
Agenda

- Overview
- Wheels
- Drivetrain types
- Drivetrain selection
- Frame types
- Gearboxes
- Motors + Electronics
- Driver stations
- CAD

Importance of a Drivetrain

- The **most** important part of a robot
- Move around the field
  - Can rarely score without a working drivetrain
  - At the very least, you can play defense
- Must be durable and reliable
- Can be optimized for speed, pushing force, and/or agility

Parts of a Drivetrain



Wheels

Traction Wheels

Wheel	Durability	Tread	Comment
Colson **Performa**	High	Medium grip, reliable traction	Dead simple, almost indestructible
Andymark **HiGrip**	Medium	Several hardnesses available, soft grips better but wears faster	*Kit of Parts* wheel, cheap and reliable, can break spokes
WCP **Pneumatic Wheel**	High	Medium/High	Expensive, can have long lead times
VexPro **Traction Wheel**	Medium	Several treads and tires available. Treads are high maintenance to attach and fix.	Modular, adjustable

VexPro - Colson Performa

Andymark - HiGrip

Westcoast Products - Pneumatic Wheel

VexPro - Traction Wheel

Roller Wheels

- Omni
  - Rollers attached perpendicular to direction of rotation
  - Allow for sideways movement

VexPro - Omni Wheel

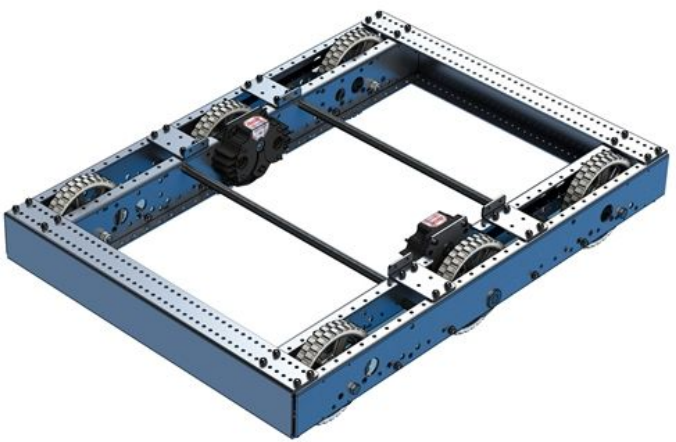
- Mecanum
  - Rollers attached at 45 degree angle to axis of rotation
  - Allow for omni directional movement

Andymark - MK Mecanum Wheel

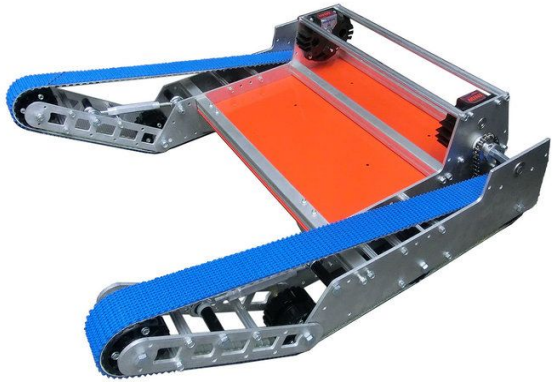
Drivetrain Types

Types: Tank Drive

- Wheels on one side are tied together
  - “Skid steer”, friction while turning
- Strengths
  - Can be the easiest to design and build
  - Potential for high pushing power and/or speed
  - Configurable
    - Center-drop to limit turning scrub
    - “Flat” with corner omnis to limit rocking and offer consistent turning
    - 2+2= Tractions and Omnis
    - Tank treads
- Weaknesses
  - Slightly less agile than other drivetrains



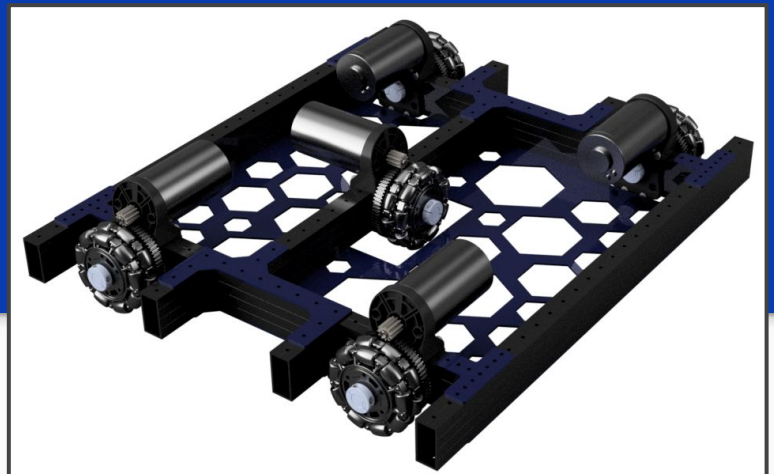
Andymark - AM14U chassis (Kitbot)



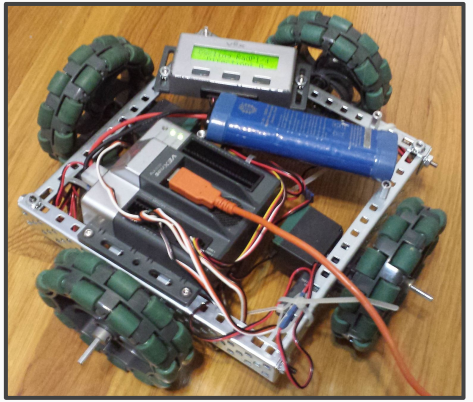
Andymark - Rhino Track Drive

Types: Omni-directional

- H-Drive
  - Allows strafing without losses
  - Less powerful strafing
  - More complex
- Holonomic / X - Drive
  - 4 omni wheels at angles to corners
  - Lossy in all directions
  - Susceptible to defense



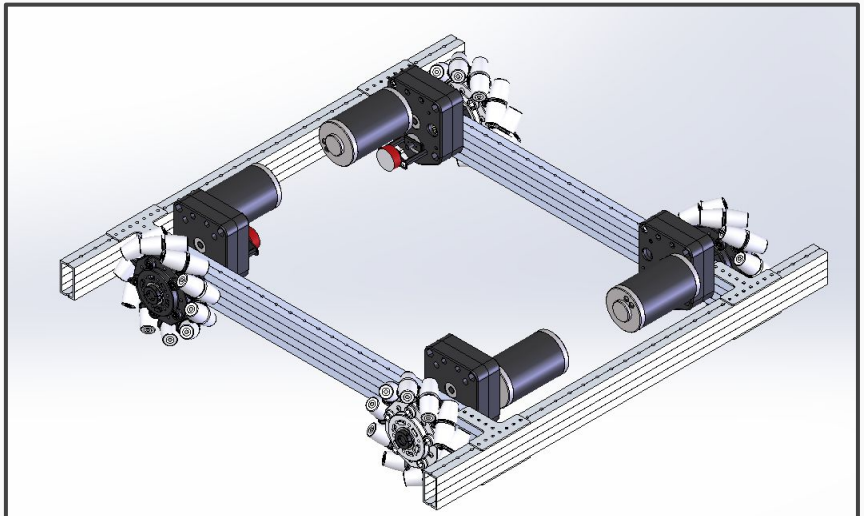
Team 5725 - H-drive



Holonomic / X - Drive

Types: Mecanum

- Wheel force vectors point at 45° angle
- Pros
  - Allows strafing, turning, full omni-directional motion
  - Fairly easy to design and build
- Cons
  - Wheels “fight” and create some losses
  - Low pushing force
  - Rollers make it susceptible to defense
  - Difficult to drive well
  - Wheels are expensive

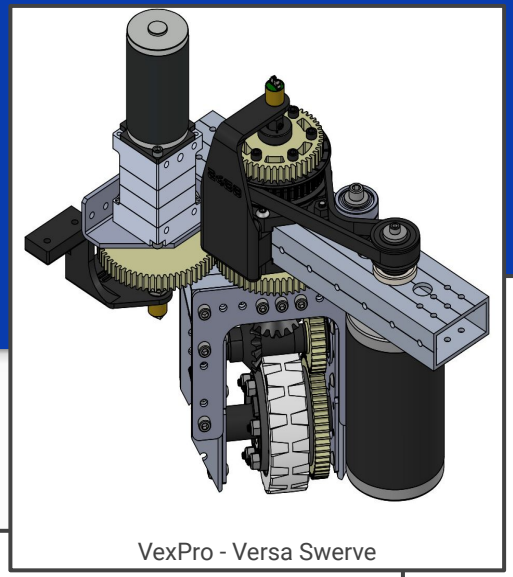


VexPro - Mecanum Wheel Drive

Types: Swerve

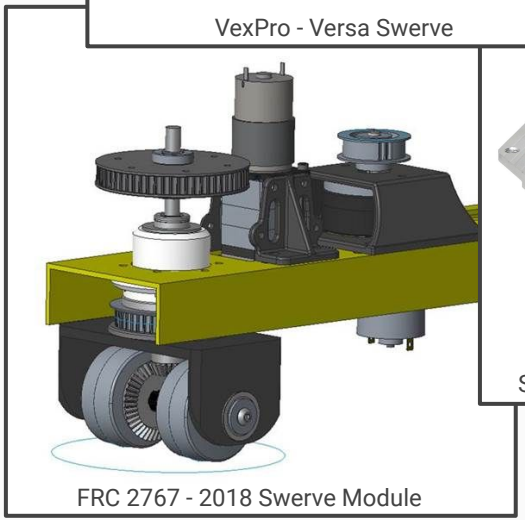
- Uses a motor to drive and a motor to steer module
- Mechanically complicated
- Very difficult to design, build, and master
- Very difficult to program
- Very difficult to drive effectively
- The best maneuverability
- Expect to spend several years revising designs before seeing on-field payoff

- High risk, high reward



VexPro - Versa Swerve

Swerve Drive Specialties - Mk1 Module



FRC 2767 - 2018 Swerve Module

Selecting your drivetrain

Pick Attributes

- Agility
  - Able to move and rotate
- Strength
  - Push robots, play and resist defense
- Speed
  - Traverse the field quickly
- Programming
  - Difficulty to write and tune code
- Ease of driving
  - Intuitive control
- Cross obstacles
  - Ability to overcome field terrain
- Design
  - Cost
    - Gearboxes, wheels, frame, etc
  - Ease to design
    - What are your capabilities?
  - Manufacturing
    - Can you build it in-house? Will sponsors make some parts? Lead times?
  - Assembly
    - Time taken, difficulty
  - Weight
    - Robot weight is capped, what do you want to spend on the drivetrain?
  - Repairing

Comparison table

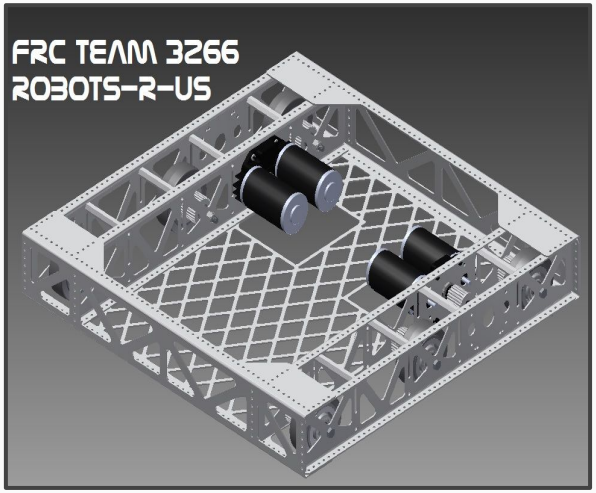
- Score the different options
- Consider using a 1-5 or 1/3/9 system
- Weight the attributes based on important to the game, from your team strategy
- Fill in the white sections per your team's abilities

	Weight	Tank	Omni	Mecanum	Swerve
Agility	9	3 (27)	9 (81)	3 (27)	9 (81)
Strength	3	9 (27)	1 (3)	3 (9)	9 (27)
Speed	9	9 (81)	3 (27)	3 (27)	3 (27)
Prog	3	9 (27)	3 (9)	3 (9)	1 (3)
Drive	3	9 (27)	3 (9)	3 (9)	1 (3)
Terrain	1	9 (9)	3 (3)	1 (1)	3 (3)
Design	1	9 (9)	3 (3)	3 (3)	1 (1)
Sum		207	135	85	145

Frame types

Chassis Construction Overview

Sheets

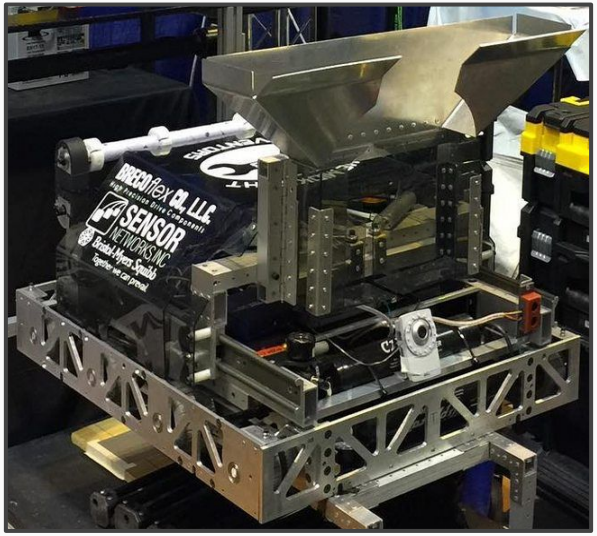


FRC 3266- 2013 Offseason Robot

Tubes

FRC 314- 2011 Robot

Plates



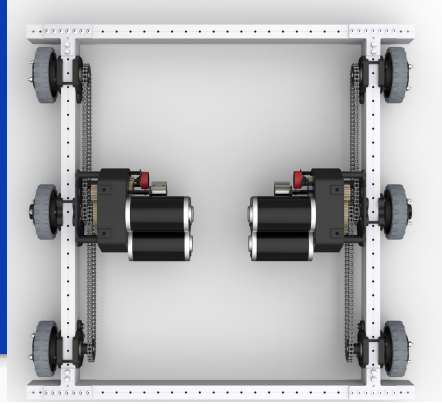
FRC 1923 - 2017 Robot

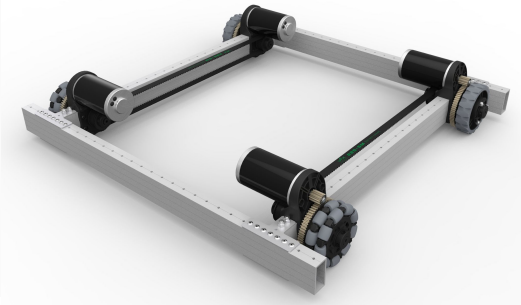
Kitbot

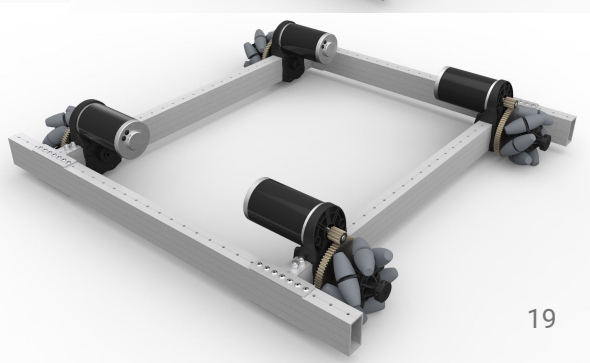
- AndyMark AM14U
- Default drivetrain, comes in Kit of Parts (KoP)
- Configurable
  - Long/Square/Short
    - depends on robot mechanism needs, like a wide intake or a long drivetrain to make a tall robot less tippy
- Upgrade to 2 CIMs each side (4 total)

Versachassis System

- VexPro
- Very customizable
- Can be as simple or as complicated as you want
- Allows drivetrains in almost any configuration







Gearboxes

Gearboxes - COTS

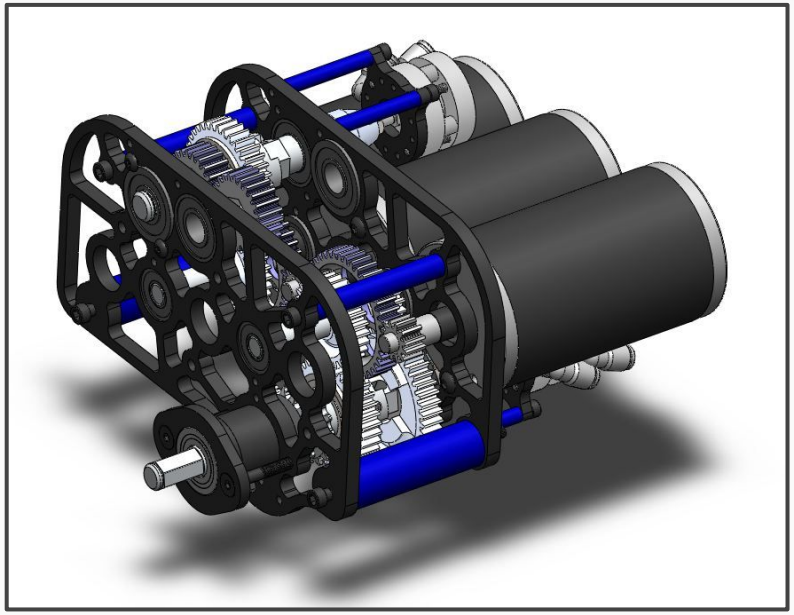
- COTS (Commercial Off The Shelf)
  - VexPro
    - 2/3-CIM ballshifter
    - 2 CIM Single Speed Dingle Reduction
    - Single Speed Single Reduction (SSSR)
  - Andymark
    - Toughbox Mini (KoP)
    - EVO Slim
      - Options for Cim or 775 mounting pattern
  - West Coast Products
    - 3 CIM single speed





Gearboxes - Custom

- Allows full customization
  - Exact speed
  - Shifting vs single speed
  - Form factor
  - Special features like a power-take-off (PTO)
  - Typically cheaper than COTS
- Unless you know exactly what you're doing and already have made these, don't do it during a build season. Try it in the off-season.
  - There are so many COTS options. Do you think you can do better than them?



Team 254 - 2013 Gearbox

Motors + Electronics

JVN Calculator

1-Speed Drivetrain

	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)	Speed Loss Constant	Drivetrain Efficiency
CIM	5310	2.43	133	2.7	81%	90%

# Gearboxes in Drivetrain	# Motors per Gearbox	Total Weight (lbs)	Weight on Driven Wheels	Wheel Dia. (in)	Wheel Coeff
2	2	154	100%	4	1.3

Driving Gear	Driven Gear
12	40
14	40
15	22
1	1

Drivetrain Free-Speed	Drivetrain Adjusted Speed	Pushing Match Current per Motor
6.63 ft/s	5.37 ft/s	50.94 Amps
13.97 : 1	<-- Overall Gear Ratio	

- Calculate motor needs
- Compare gearing options
- Useful for drivetrains, and any motor mechanism

Motor Characteristics

Motor	Free Speed (RPM)	Max Power (W)	Stall Torque (N·m)	Stall Current (A)	Weight (lb)	
NEO *brushless*	5676	406	2.60	105	0.94	
CIM *brushed*	5330	337	2.41	131	2.80	
Mini CIM *brushed*	5840	215	1.41	89	2.16	
775Pro *brushed*	18730	347	0.71	134	0.80	

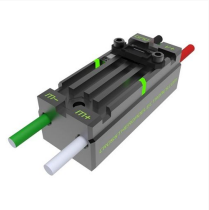
Via motors.vex.com and *revrobotics.com*

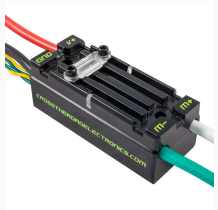
Motor Trade-offs

- CIM / MiniCIM drivetrains are tried and true
  - 4 or 6 motor configurations of each are very good drivetrains
  - Dead simple, hard to break
  - Sealed motors deal well with heat dissipation
- 775Pro drivetrains have high risk but possible rewards
  - 6 or 8 motor
  - Light weight
  - Risk of burning out motors without current limiting/ramping
  - If you don't already know how to do it and what to do, don't. Use CIMs.
- NEO drivetrains
  - 4 or 6 motor
  - Lightest weight
  - Highest power density
  - Limited testing time (introduced in 2019 season)
  - Seem like THE way to go for drivetrains, moving forward

Drivetrain Electronics - Components

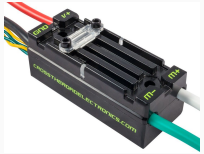
- Critical Components
  - Motors
  - Motor Controllers
  - Power Distribution Panel (PDP)
  - RoboRio
- Auxiliary Components
  - 120 Amp Main Breaker
  - Robot Battery
  - OpenMesh Radio





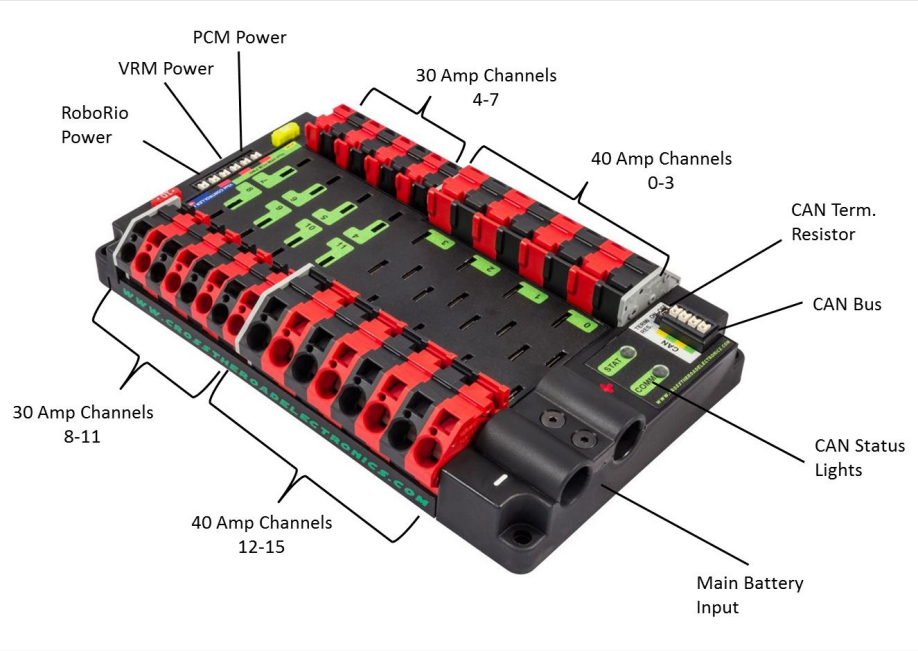
Motor Controllers

- Drivetrain motor controllers connect to 40A slots on the Power Distribution Panel
- Communication Options
  - CAN
    - Daisy-chained network, simplifies wiring but creates single point of failure
  - PWM
    - Single cables to each controller, requires many wires (usually a mess)
- Spark MAX required for NEO brushless motors

Name	Comms	Feedback	Cost	
Spark	PWM	Forward/ Reverse Limit Switch	$40	
Victor SPX	PWM/CAN	None	$50	
Talon SRX	PWM/CAN	F/R Limit Switch Encoders Potentiometer	$90	
Spark MAX	PWM/CAN /USB	F/R Limit Switch Encoders Potentiometer	$75	

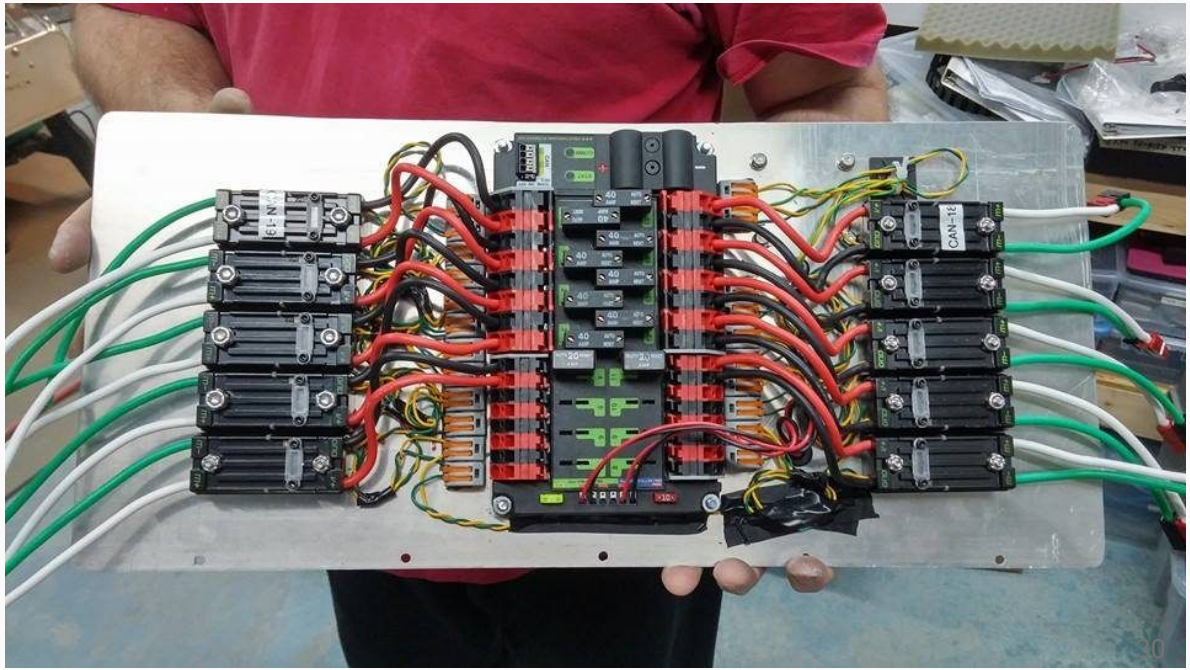
Power Distribution Panel

- Power Distribution Panel - AM-2856
  - Connects battery power and ***distributes*** it to other systems on the robot
  - Motor controllers should be connected to the 40A slots
  - Smaller motors connect to the 30A slots
- PDP can support connecting 15 devices, but only a maximum of 6 CIM Motors
  - Teams need to be mindful of the amount of current the total number of motors will draw to avoid brownouts



Examples - Wiring Best Practices

https://www.chiefdelphi.com/forums/showthread.php?p=1440512



https://www.chiefdelphi.com/forums/showpost.php?p=1444876&postcount=11

Driver Stations

Driver Stations

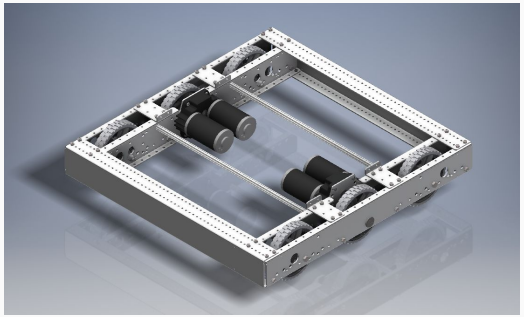
- Simple & intuitive
  - Don’t confuse your drivers!
- Traditional driver stations have two positions: Driver & Operator
  - Allow driver to focus on driving and minimal functions
- Inputs depend on personal preference
- Easy to transport
  - Small stations can fit in a briefcase
  - Large stations can have a shelf on the robot cart, or wheels
- Reconfigurable
  - Allow the driver to move for a better field view

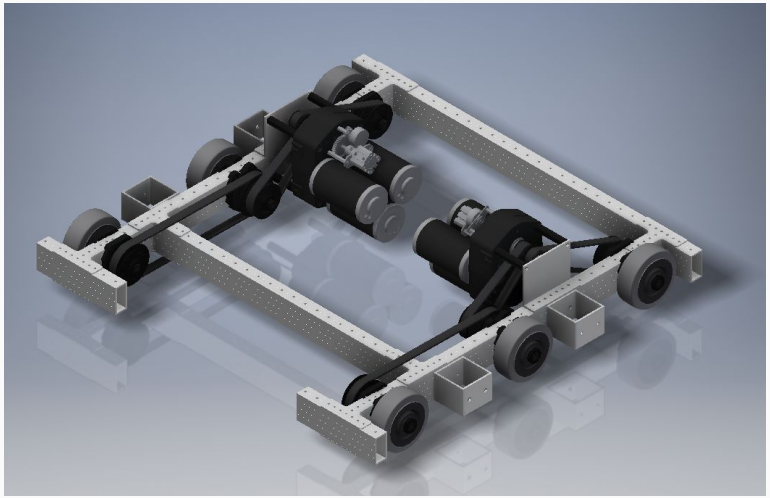
Driver Station - Control Types

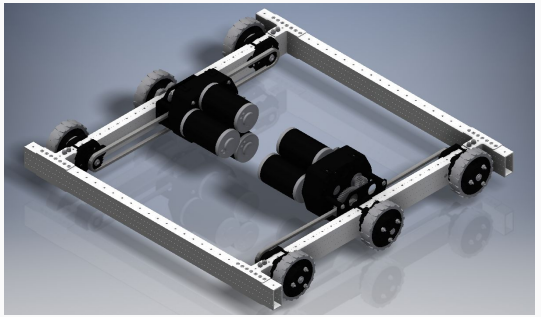
- Joysticks
  - Tank drive maps well to joysticks
    - Allows fine control over turning and positioning, but worse control for driving straight at varying speeds
  - Joystick buttons can map to robot functions
- Gamepad
  - Allow for mapping several functions to one controller
  - Mappings can easily change to match personal preference
  - Very familiar, but possibly less intuitive and less fine control
- Arcade buttons
  - Specific mapping of a control to a single button
  - Typically a custom button panel, takes time, know-how
  - More user friendly for quick learning and customized layouts

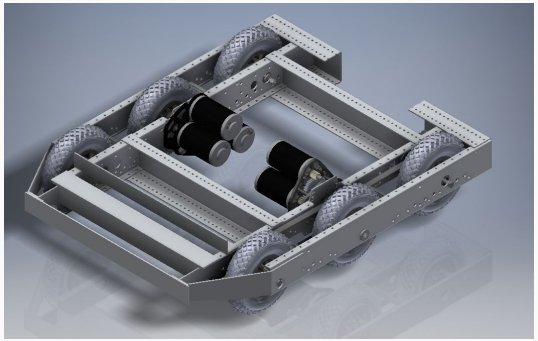
CAD

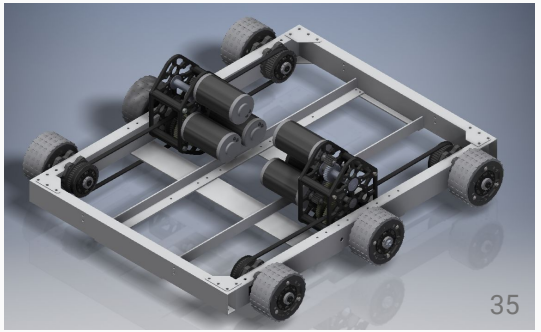
CAD











Questions?

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