Drivetrain Selection

Purpose of a Drivetrain

- Move around field
  - Typically 27' x 54' carpeted surface
- Push/Pull Objects and Robots
- Climb up ramps or over/around obstacles
- Most important sub-system, without mobility it is nearly impossible to score or prevent points
- Must be durable and reliable to be successful
- Speed, Pushing Force, and Agility important abilities

Types of Wheels

- "Traction" Wheels
  - Standard wheels with varying amounts of traction, strength & weight
    - Kit of Parts (KOP)
    - AndyMark (AM) or VEX Pro
    - Pneumatic
    - Slick
    - Custom

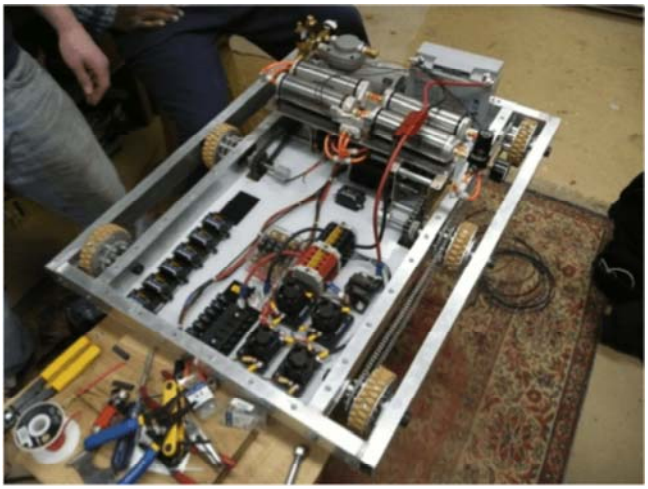
- Omni
  - Rollers are attached to the circumference, perpendicular to the axis of rotation of the wheel
  - Allows for omni directional motion

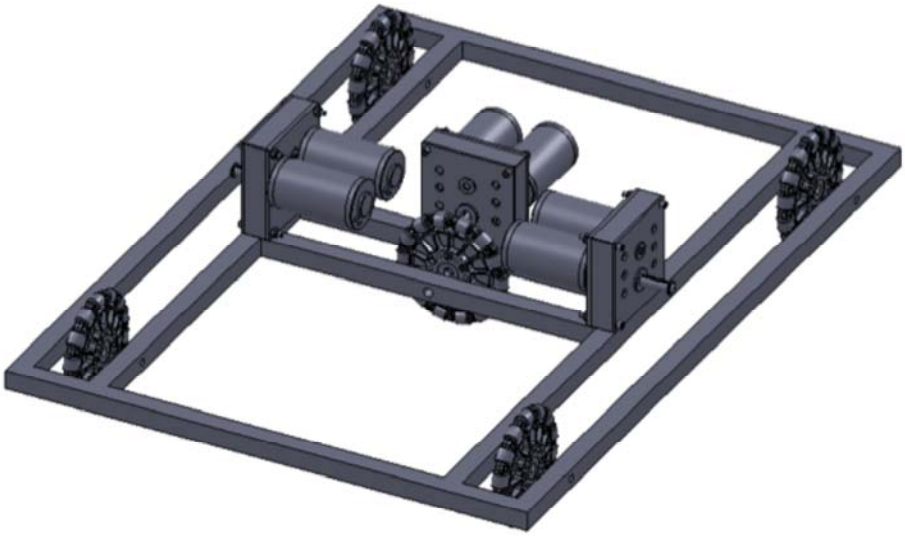
- Mecanum

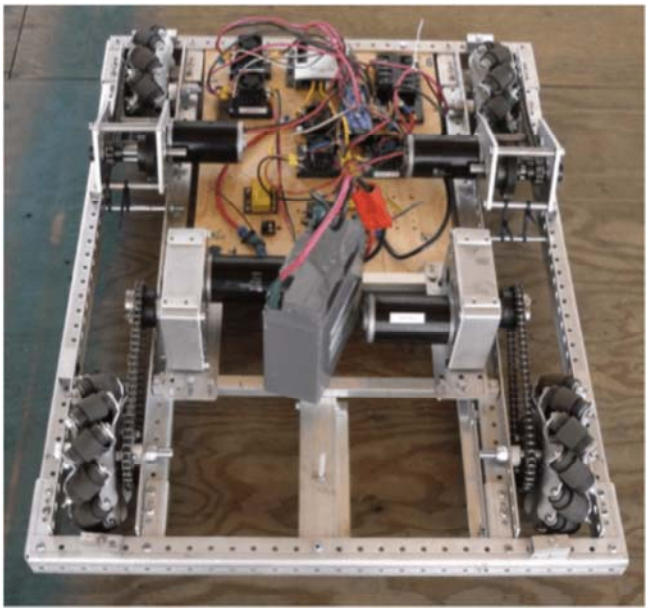
- Rollers are attached to the circumference, on a 45 degree angle to the axis of rotation of the wheel
- Allows for omni directional motion

Types of Drivetrains

- Tank
- Swerve
- Slide
- Mecanum
- Holonomic

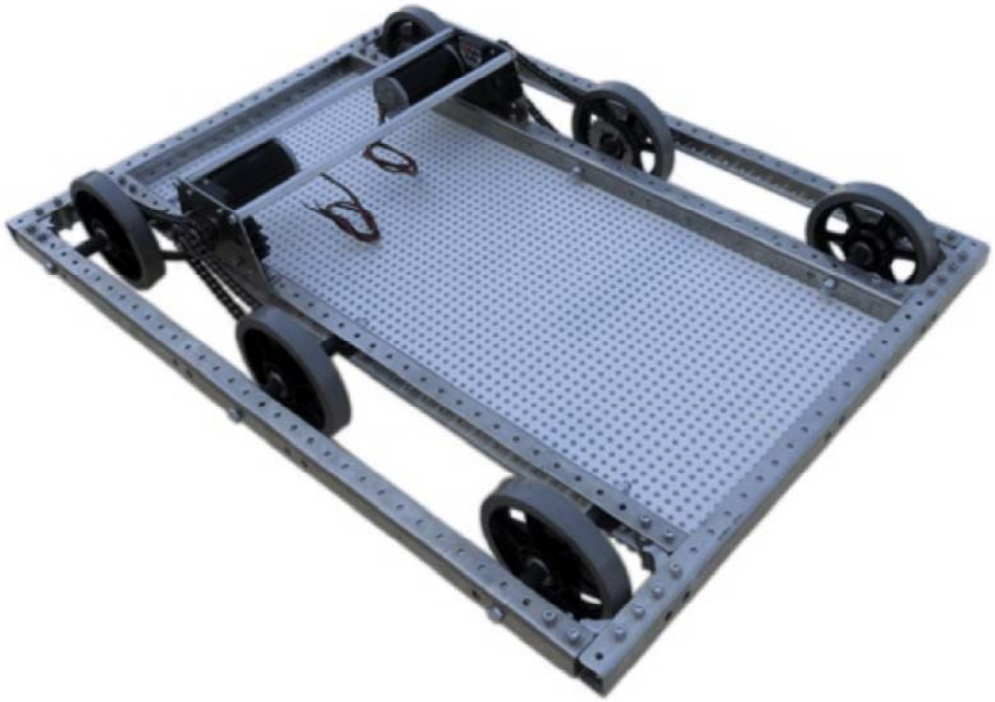






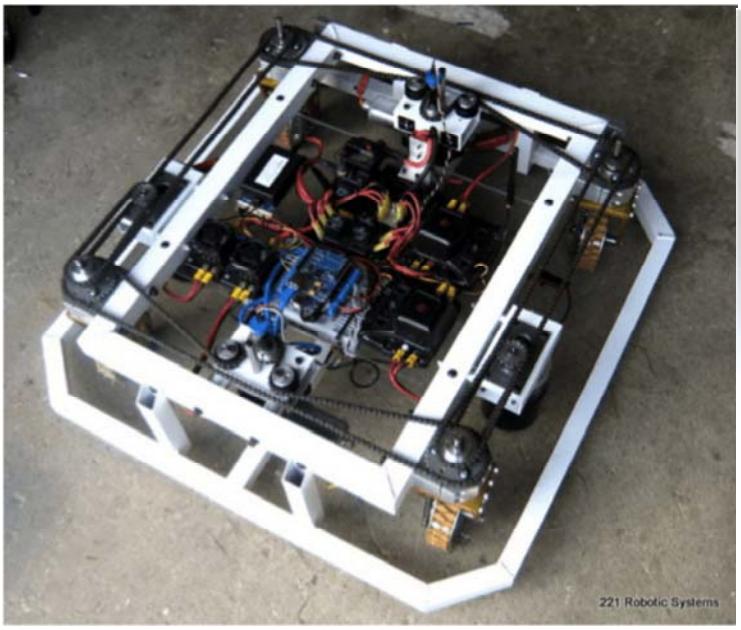
Types of Drivetrains: Tank

- Left and right wheel(s) are driven independently
- Typically in sets of two (1-4 sets is common, sometimes higher)
  - Strengths
  - Simple & cheap to design, build, and program
  - Easy to drive
  - Potential for high speed and/or pushing force
- Weaknesses
  - Slightly less agile than other drivetrains



Types of Drivetrains: Swerve/Crab

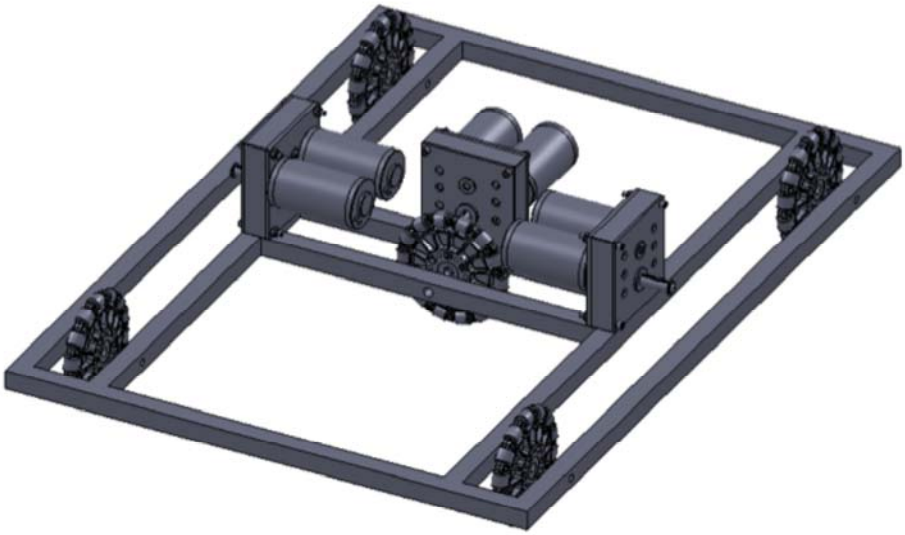
- Wheels modules rotate on the vertical axis to control direction
- Typically 4 traction wheels
- Strengths
  - Potential for high speed and/or pushing force
  - Agile
- Weaknesses
  - Very complex and expensive to design, build and program
  - Extra motors required to be able to rotate robot frame



Types of Drivetrains: Slide

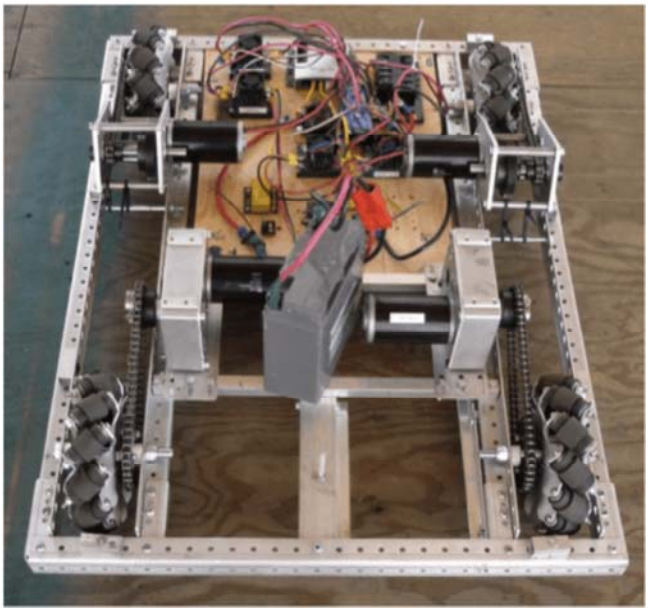
- Similar layout to tank drive, with an extra wheel(s) perpendicular to the rest

- Must use all omni wheels
- Strengths
  - Fairly easy and cheap to design, build, and program
  - Agile
- Weaknesses
  - No potential for high pushing force
  - Extra wheel(s)/motor(s)/gearbox(es) required to allow robot translate sideways



Types of Drivetrains: Mecanum

- Similar layout to tank drive, but each wheel must be driven independently
- Must use 4 mecanum wheels
- Strengths
  - Fairly easy to design & build
  - Agile
- Weaknesses
  - No potential for high pushing force
  - Challenging to program and learn to drive well
  - Requires extra gearboxes
  - Wheels are expensive



Types of Drivetrains: Holonomic

- 4 omni wheels positioned on 45 deg angle in the corners of the frame
- Each wheel must be driven independently
- Strengths
  - Agile
- Weaknesses
  - No potential for high pushing force
  - Very challenging to program and learn to drive well
  - Requires extra gearboxes

Compare Drivetrains

- Choosing the right drivetrain is critical to the success of an FRC robot
- Several drivetrains to choose from
  - Each one has its own strengths and weaknesses
- Important to **quantitatively** evaluate all options to ensure optimal solution is chosen
  - Best method to do this is a "Weighted Objectives Table"

Drivetrain Attributes

- Agility
  - Ability to translate in the x and y axis as well as rotate about the z axis simultaneously
- Strength

    - Push robots and/or game pieces
    - Resist defense from all sides of the drivetrain
- Number of Motors
    - Number of motors allowed on an FRC robot is limited
    - Most drivetrains use 4 CIM motors to power wheels
    - Additional motors to rotate wheel modules or translate sideways may take away from motors for other robot functions
- Programming
    - Ideally does not require sensor feedback (eg. wheel module angle)
    - Ideally does not require advanced algorithm to calculate individual wheel speed/power
- Ease to Drive
- Intuitive to control so little practice is required to be competitive
- Just because some drivetrains have the ability to move sideways doesn't mean the driver will use the ability
    - Often drivers end up turning the robot because it is more natural or going sideways feels (or actually is) slower
- Traverse Obstacles
    - The ability of a drivetrain to traverse ramps, bumps or steps
- Design
    - This is a very general heading. Sub headings grouped as there is a strong relationship between them
        - Cost
        - Ease to design (select components and choose dimensions)
        - Ease to manufacture
        - Ease to assemble
        - Ease to maintain/repair
        - Weight

Weighted Objectives Tables

- Give each attribute of each drivetrain a relative score between 1 and 5
- Weights are dependant on
    - Strategic analysis of the game (priority list)
    - Teams resources

	Weight	**Tank**	**Swerve**	**Slide**	**Mecan**	**Holo**
Agility	?	3	5	5	5	5
Strength	?	4	5	1	1	1
Motors	?	5	1	3	5	5
Program	?	5	1	4	3	2
Drive	?	5	3	3	2	1
Traverse	?	5	4	4	3	1
Design	?	5	1	4	4	3

- Agility, Strength & Ability to traverse obstacles
    - Relative to #1 priory, reliability
        - 0 = not important or required
        - 10 = equally as important as reliability
- Number of Motors
    - Depends on complexity of other robot features and ability to design with all motors
        - 0 = no other features/very strong ability to design with all motors
        - 10 = very complex/little ability to design with other motors
- Programming
    - Depends on strength of programming team (# of students/mentors, experience, ect)
- Ease to Drive
    - Depends on amount of available practice

        - 0 = have a full practice field and practice robot with committed drivers that train every day
        - 10 = no practice field/robot, no time in build season to practice
- Design
    - How many students/mentors do you have?
    - How much experience do you have?
    - What tools are available to you (hand tools < bandsaw < mill)?
    - How many hours are your shop facilities available/will you use them?
    - How much money do you have?
    - Drivetrains with a low design score require significant resources to design a reliably
        - 0 = lots of experience, students, mentors, tools, money
        - 0 = The desired drivetrain has been used in a previous season or prototyped in the off season
        - 10 = No experience, few students, mentors, tools, money

Typical Weights for a Rookie or Low Resource Team

- 5 - Agility
- 5 - Strength
- 5 - Number of Motors
- 10 - Programming
- 10 - Ease to Drive
- 0 - Traverse Obstacles
- 10 - Design

- Resources are low, so it is more important to build a simple drivetrain that is easy to program and learn how to drive to ensure reliability.
- The performance of the drivetrain (agility & strength) are not as important as reliability
- The number of motors is not as important because additional features should be very basic and require few (or no) motors

Rookie/low Resource Team Weighted Table

- Rookie/low resource team weighted table
- Tank drivetrain much higher score than others
- Slide drive second best

	Weight	**Tank**	**Swerve**	**Slide**	**Mecan**	**Holo**
Agility	5	3 (15)	5 (25)	5 (25)	5 (25)	5 (25)
Strength	5	4 (20)	5 (25)	1 (5)	1 (5)	1 (5)
Motors	5	5 (25)	1 (5)	3 (15)	5 (25)	5 (25)
Program	10	5 (50)	1 (10)	4 (40)	3 (30)	2 (20)
Drive	10	5 (50)	3 (30)	3 (30)	2 (20)	1 (10)
Traverse	0	5 (0)	4 (0)	4 (0)	3 (0)	1 (0)
Design	10	5 (50)	1 (10)	4 (40)	4 (40)	3 (30)
Total	225	93% (210)	47% (105)	69% (155)	64% (145)	51% (115)

Comparison of weighted tables for different resource teams

	Rookie	Average	Strong
Agility	5	8	10
Strength	5	8	10
Motors	5	6	5
Program	10	7	3
Drive	10	7	3
Traverse	0	0	0
Design	10	7	3

	Tank	Swerve	Slide	Mecan	Holo
Rookie	93%	47%	69%	64%	51%
Average	89%	56%	67%	66%	56%
Strong	82%	71%	64%	66%	61%

When to choose a swerve drive

- Strength & Agility equally as important as reliability
- Lots of students/mentors
- Access to advanced tooling
- Large budget
- Team has strong ability to use other motors for robot function
- Team has practice field and practice robot
- Team has used a swerve in a previous season, or prototyped one in the off season

	Swerve
Agility	10
Strength	10
Motors	2
Program	2
Drive	2
Traverse	0
Design	2

	Tank	**Swerve**	**Slide**	**Mecan**	**Holo**
Swerve	79%	80%	63%	63%	59%

When to choose a slide drive

- Agility equally as important as reliability
- Strength is not required (game has no interaction with opponents)
- Team has practice field and practice robot
- Team has used a slide in a previous season, or prototyped one in the off season
- Lots of students/mentors
- Team has strong ability to use other motors for robot function

	Slide
Agility	10
Strength	0
Motors	1
Program	3
Drive	1
Traverse	0
Design	3

	Tank	**Swerve**	**Slide**	**Mecan**	**Holo**
Slide	78%	67%	89%	87%	79%

When to choose a mecanum drive

- Agility equally as important as reliability
- Strength is not required (game has no interaction with opponents)
- Team has practice field and practice robot

- Team has used a mecanum in a previous season, or prototyped one in the off season
- Strong programing ability
- Lots of students/mentors

	Mecan
Agility	10
Strength	0
Motors	5
Program	2
Drive	2
Traverse	0
Design	3

	Tank	**Swerve**	**Slide**	**Mecan**	**Holo**
Mecan	82%	60%	83%	88%	82%

Designing a Tank Drivetrain

- At this point we have concluded Tank-Style Drivetrain is *usually* the best option for all teams, regardless of the game or the teams resources
- Why don't all teams use Tank-Style Drivetrains?
  - Some (few) teams have **a lot** of resources
  - Trying new things to learn new skills/gain new experiences
    - Understanding this choice will make them less competitive
  - Improper strategic analysis of the game and evaluation of team resources
  - Improper analysis of strengths and weakness of various drivetrains
    - Omni directional drivetrains have a significant "cool factor" that distract teams