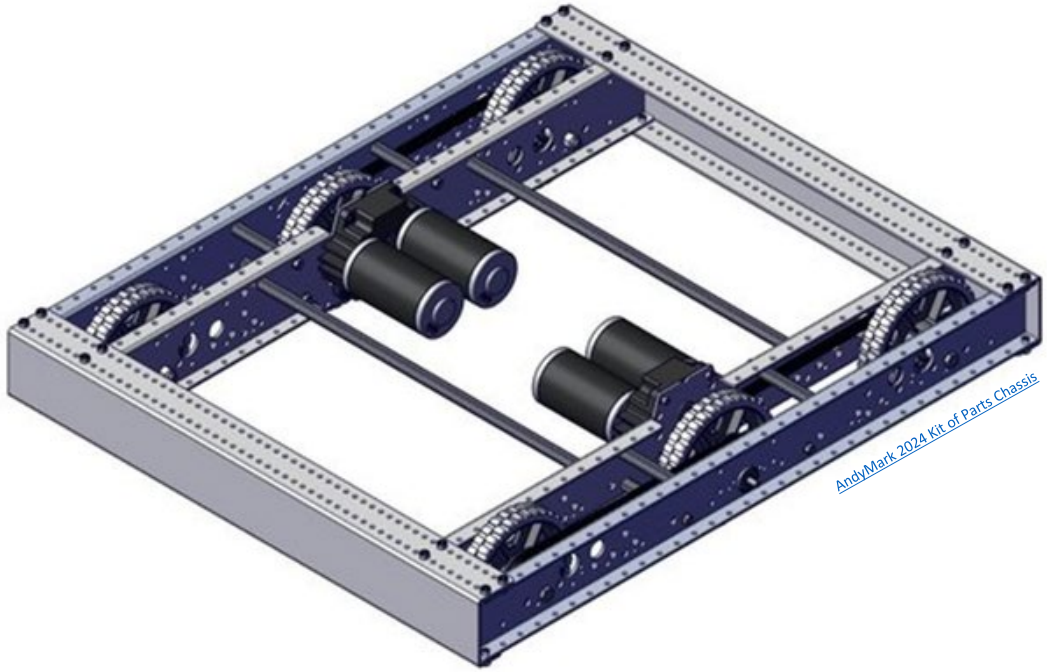
Module 2: How Do *FIRST*® Robotics Competition Robots Work?

ROBOT CHASSIS AND DRIVETRAIN

The **robot chassis** is the structural component of a robot that provides a foundation for the robot's drivetrain and other mechanisms. When you design a robot chassis, it is important to ask several questions:

- What size will the **frame** be?
- How will the **bumpers** and other robot components attach to the frame?
- Which **drivetrain** will the robot have?
- Will electronics be located in a **belly pan** or elsewhere?



AndyMark 2024 Kit of Parts Chassis

The **frame** is a critical part of your robot structure. Important parts of the robot will attach to the frame, so it must be **strong and robust**.

Parts of the Frame

- **Drive Rails** – The sides of the robot where the drive wheels and gearboxes are located.
- **Cross Members or Ladder Bars** – Usually 2x1 aluminum box tube that connect to the drive rails at the front and back of the robot.

Frame Size and Shape

- Frames can be different shapes and sizes; however, the frame perimeter often has a maximum size. Make sure to check your season's Game Manual for season-specific details.

Frame Tips and Tricks

- Use 1/8"-thick box tube for durability.
- Smaller robots are more maneuverable but make packaging mechanisms and electronics more challenging.
- A robot will not pass inspection if it exceeds the frame perimeter size in the Game Manual.

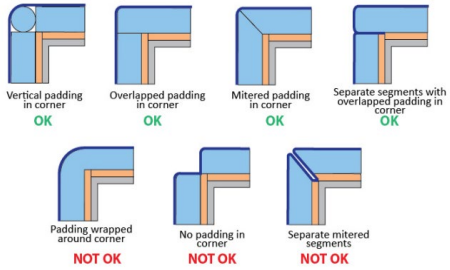
Frame Materials and Resources

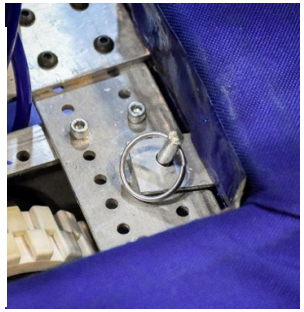
- **Aluminum Box Tube** examples include:
  - REV MAXTube
  - ThriftyBot
  - West Coast Products
- **Sheet Metal** examples include:
  - AndyMark Drive Base
  - Custom fabricated frames

Bumpers protect the frame perimeter and feature the team's number on all sides of the robot. Teams will need **blue bumpers** and **red bumpers**. Check each season's Game Manual for details.

Bumper Basics

- Bumpers absorb shock from collisions with field elements and other robots.
- Bumpers consist of a shock-absorbing material (such as foam) as well as a rigid backing (such as plywood) that are then wrapped in durable cloth.
- If your bumpers come off during a match, your robot will be disabled immediately for safety reasons.
- See the *FIRST* Robotics Competition Bumper Guide for the most up-to-date information.





Bumper Tips and Tricks

- Don't wait until the last minute to construct bumpers. Poorly constructed bumpers can cost a team matches and create headaches during competition.
- Make your bumpers sturdy, durable, and easy to remove and reattach.
- During matches, bumpers must be firmly attached to the frame, typically with brackets, in at least two spots per side.
- Numbers are often applied before the fabric is put on the bumpers, which takes planning and precision.

Bumper Materials and Resources

The *FIRST* Robotics Competition Bumper Guide is an excellent resource with links for materials and steps for construction.

One type of *FIRST* Robotics Competition **drivetrain** is **tank drive**, which involves traction wheels powered by a single gearbox connected on each side by chains located inside or outside of the box tube.

Types of Tank Drives

- **West Coast Drive** – Has cantilevered wheels that stick out from the frame rather than be contained within it.
- **4-Wheel Drive, 6-Wheel Drive,** or **8-Wheel Drive**

Tank Drive Advantages

- Simple to build and program
- Good pushing power and traction
- Generally easy to maintain

Tank Drive Weaknesses

- Can't drive sideways (strafe).
- Turning issues (skid steer) can cause too much friction and brownouts if not built properly.

Design Fixes to Skid Steer Issues

- **Drop Center** – Center wheel(s) are slightly lower (1/16"–3/16") to make turning easier.
- **Omni Wheels** – Omni wheels can be used at the front and/or back to help with turning.

Tank Drive Materials and Resources

- **Tank Drive Kit** examples include:
  - AndyMark 2024 Kit of Parts Chassis
  - AndyMark West Coast Drive Kit
- **WPILib** includes tutorials for programming.
- Wheels are offered by many vendors, such as:
  - WestCoast Products
  - REV ION
  - AndyMark

Another type of *FIRST* Robotics Competition **drivetrain** is **holonomic drive**, which enables omnidirectional driving including spin, strafe, and diagonal driving. **Swerve drive** is a popular holonomic drivetrain.

Types of Holonomic Drives

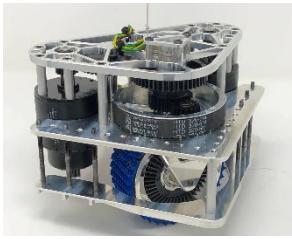
- **Swerve Drive** – Allows for an optimal combination of speed, pushing power, and maneuverability and is quickly becoming a gold standard for drivetrains.
- **Mecanum/Omni Drive** – Maneuverable but lacks pushing power compared to tank and swerve drives.

Swerve Drive Advantages

- Excellent maneuverability and speed
- Good pushing power
- A variety of Commercial Off-the-Shelf (COTS) swerve modules and products available

Swerve Drive Weaknesses

- Expensive and complex to assemble.
- Heavier than most tank drives.
- Each wheel requires two motors, which can drain a battery faster.
- Can be challenging to code, but code libraries are available.



Swerve Drive Examples and Resources

- **COTS Swerve Drive Modules** examples include:
  - REV Robotics
  - West Coast Products
  - AndyMark
  - ThriftyBot

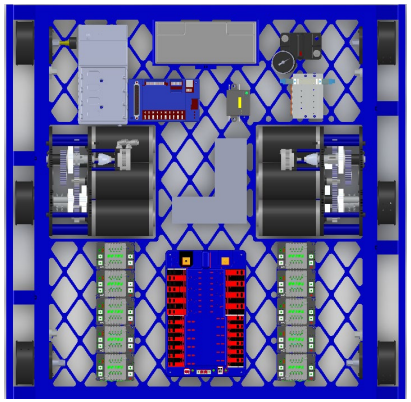
Some teams use a **belly pan** at the bottom of the robot, which connects the drive rails and ladder bars. A **belly pan** can be used as a spot to mount the electronics, battery, compressor, and other robot mechanisms.

Belly Pan Advantages

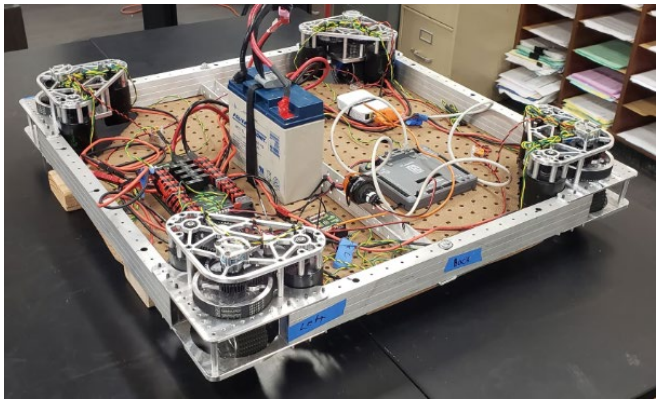
- Provides needed structural support to the robot frame. Robots without a belly pan often need cross supports for the frame.
- Commonly made of 1/4"–1/2“ plywood, 1/16"–1/8" aluminum, or 1/8" perforated polycarbonate.
- Provides a mounting location for electronics and other components.

Belly Pan Weaknesses

- Adds weight to a robot.
- Can make some electronics difficult to access, depending on the design of the robot and its mechanisms.
- Be cautious if attaching a belly pan to tank drive rails that have a chain-in-tube drivetrain. Rivets could hit and damage the chain inside the box tube.



FRC Team 254 West Coast Drive with Belly Pan



FRC Dark Matter 2643 Swerve Drive with Belly Pan

Belly Pan Examples and Resources

- **COTS Materials** examples include:
  - AndyMark Perforated Polycarbonate Sheet
  - Aluminum perforated sheet
  - Plastics, plywood, or sheet metal can be purchased at many hardware stores and other suppliers.