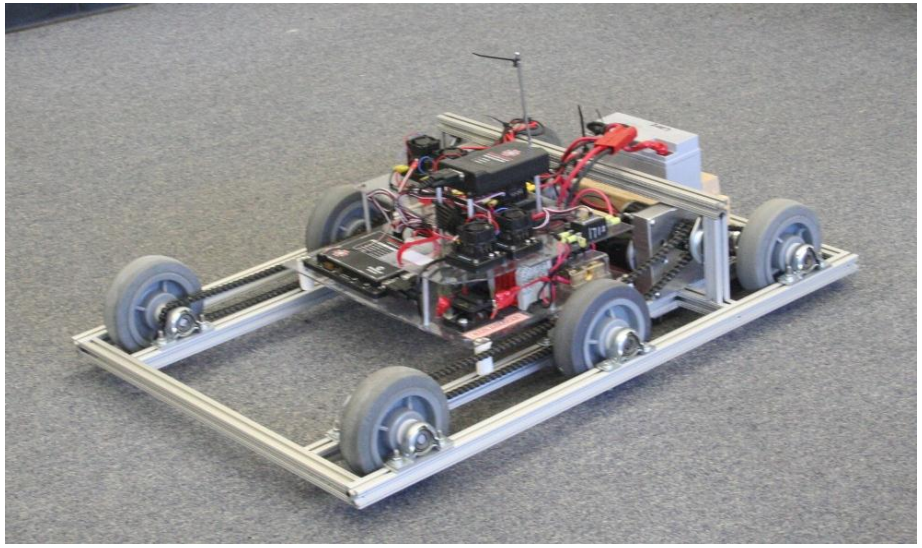
FIRST ROBOTICS DRIVE SYSTEMS

By Andy Baker
President
AndyMark, Inc.

Topics

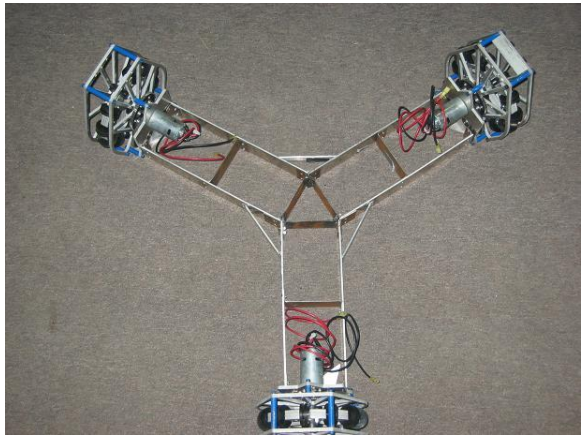
- Importance
- Basics
- Drive Types
- Resources
- Traction
- Mobility
- Speed
- Timing
- Importance



Importance

The best drive train…

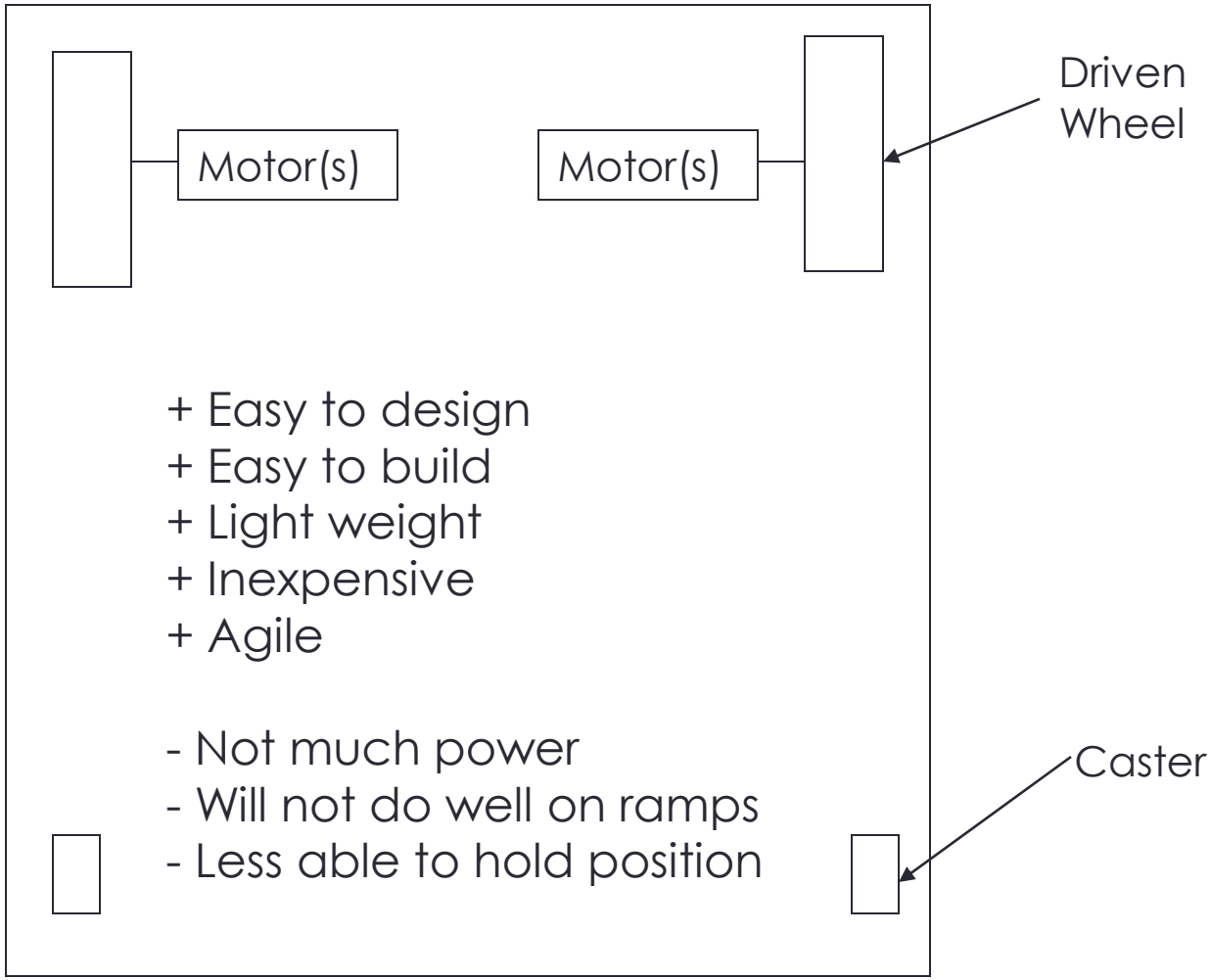
- is more important than anything else on the robot
- meets your strategy goals
- can be built with your resources
- rarely needs maintenance
- can be fixed within 4 minutes
- is more important than anything else on the robot



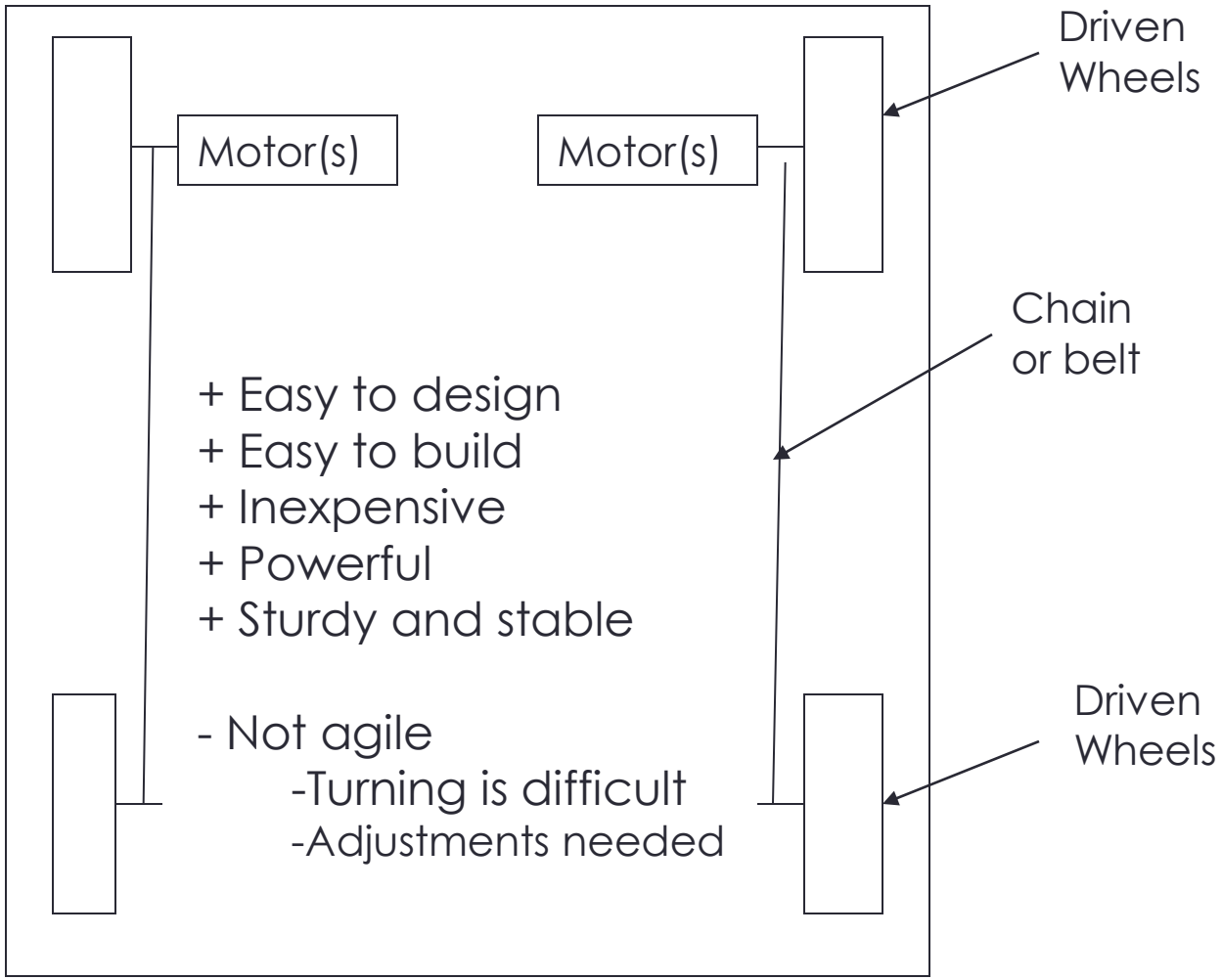
Basics

- Know your resources
- Decide after kickoff:
  - Speed, power, shifting, mobility
- Use most powerful motors on drivetrain
- Don’t drive ½ of your robot… WEIGH IT DOWN!
- Break it early
- Give software team TIME to work
- Give drivers TIME to drive

Drive Types: 2 wheel drive

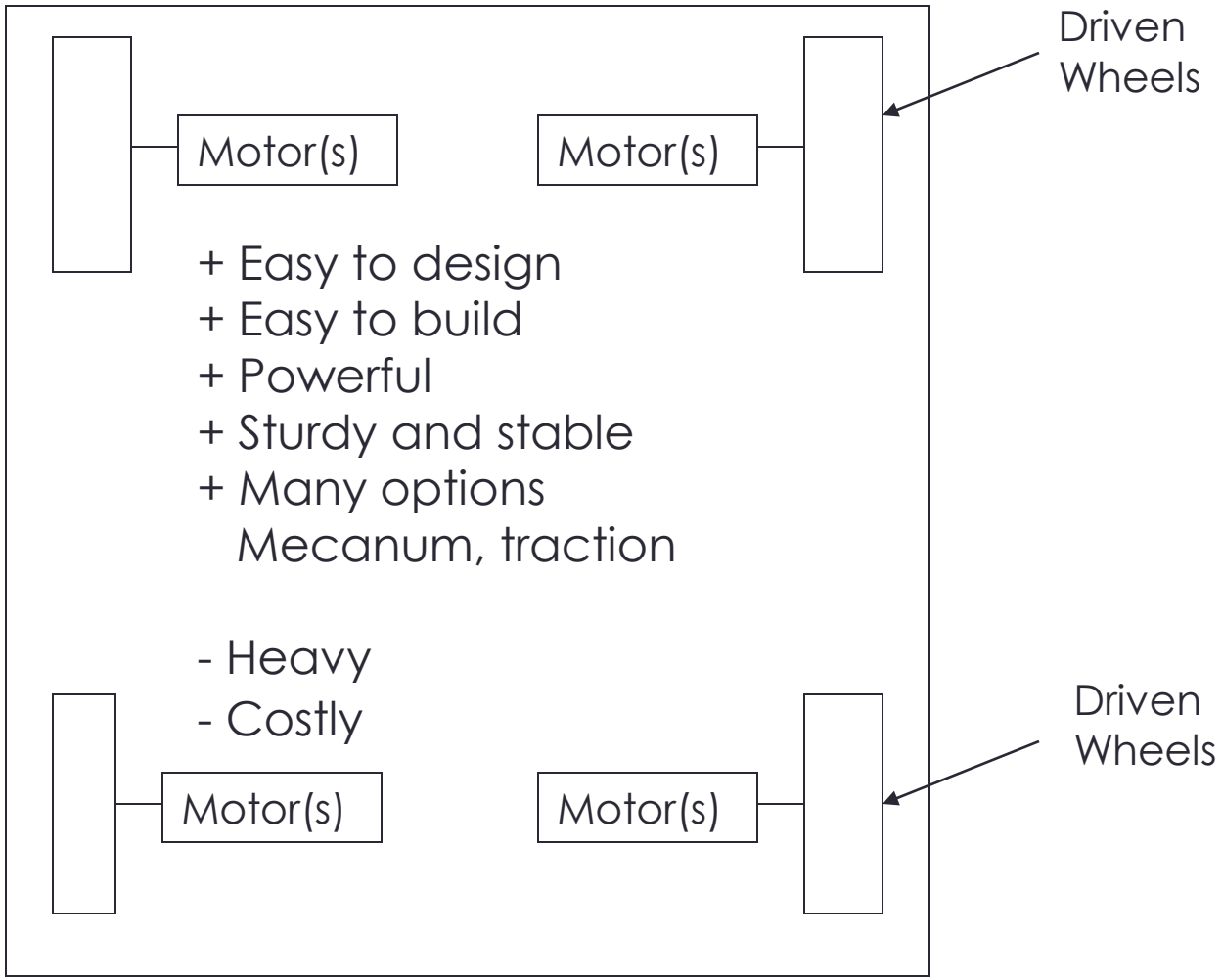


Drive Types:
4 wheel drive, 2 gearboxes



Resource:
Chris Hibner white paper on ChiefDelphi.com
Proves that a wide 4wd drive base can turn easily

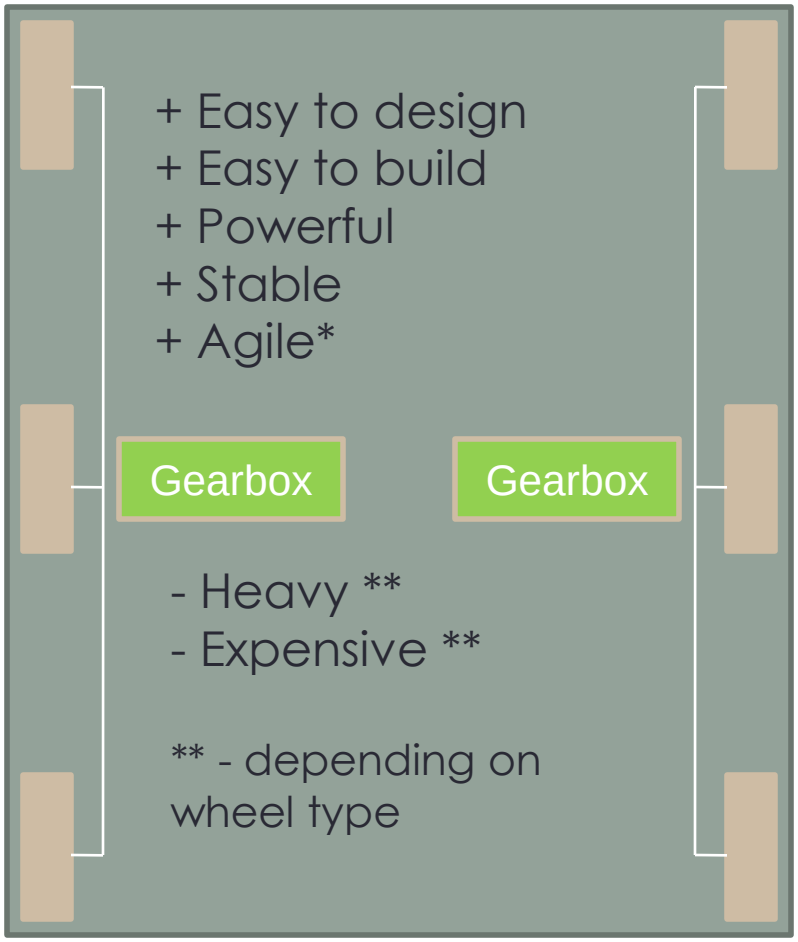
Drive Types:
4 wheel drive, 4 gearboxes



Drive Types:
6 wheel drive, 2 gearboxes

*2 ways to be agile

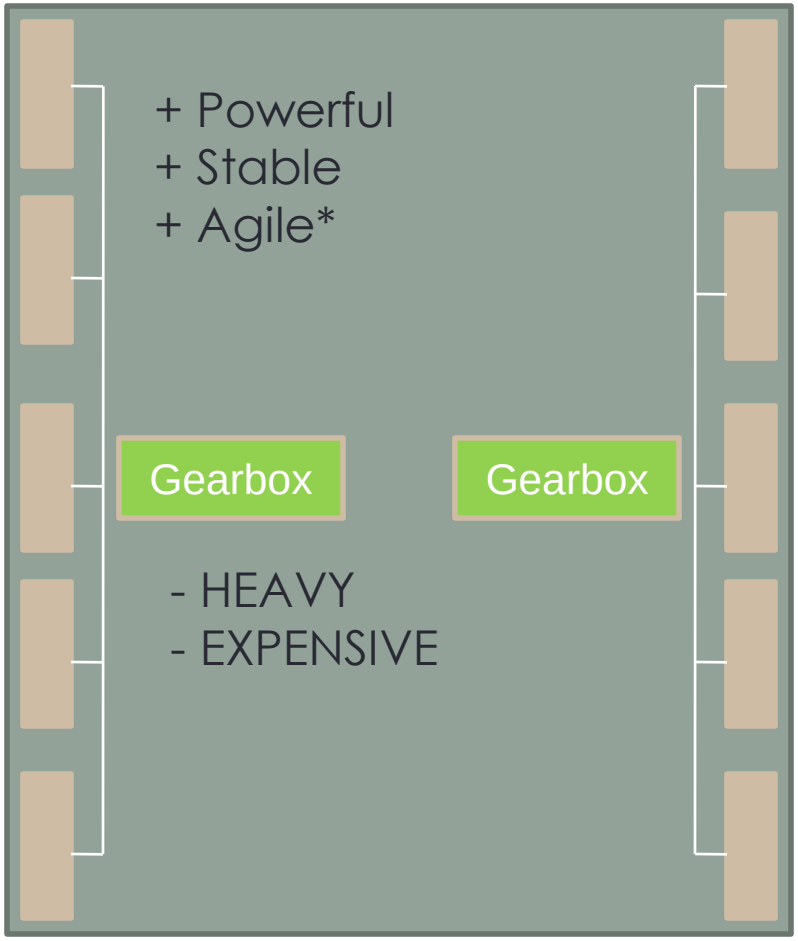
A) Lower contact point on center wheel
B) Omni wheels on front or back or both

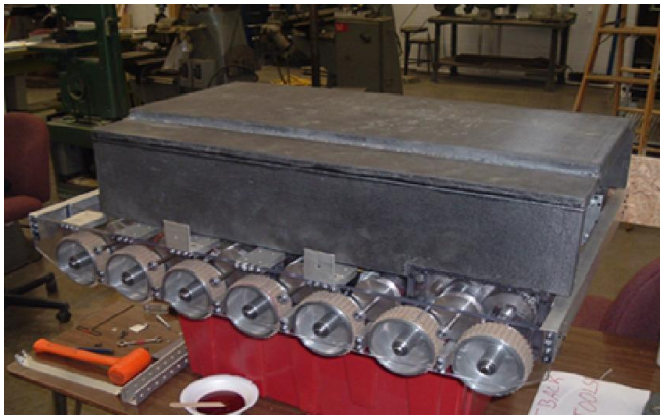


This is the GOLD STANDARD in FRC

+ simple
+ easy
+ fast and powerful
+ agile

Drive Types:
N wheel drive, 2 gearboxes



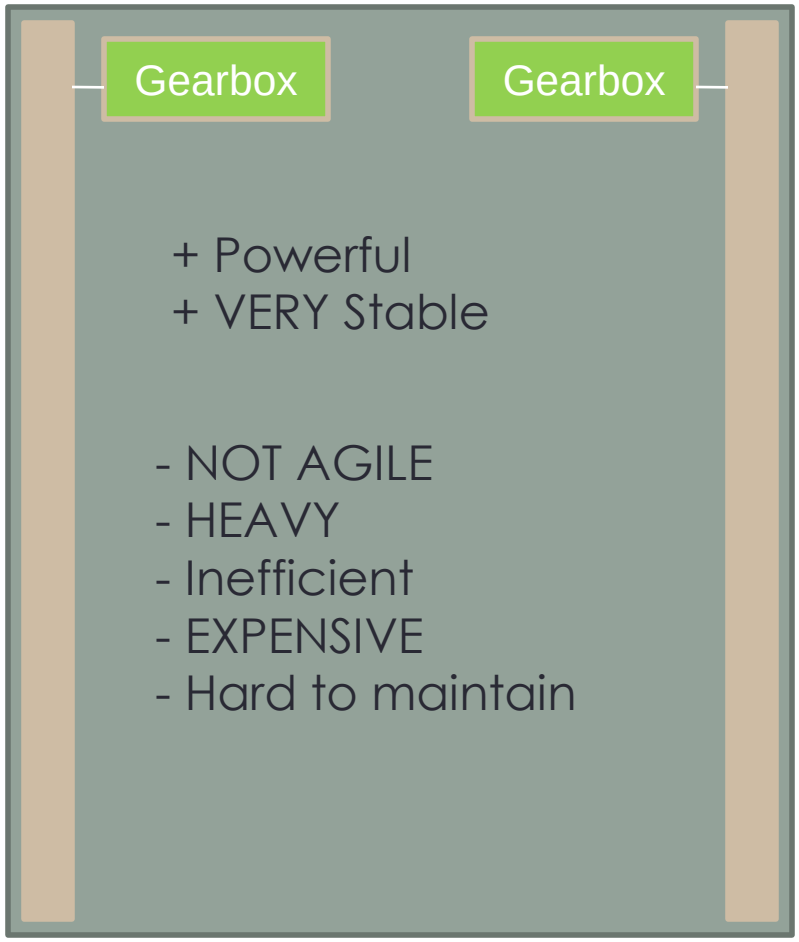


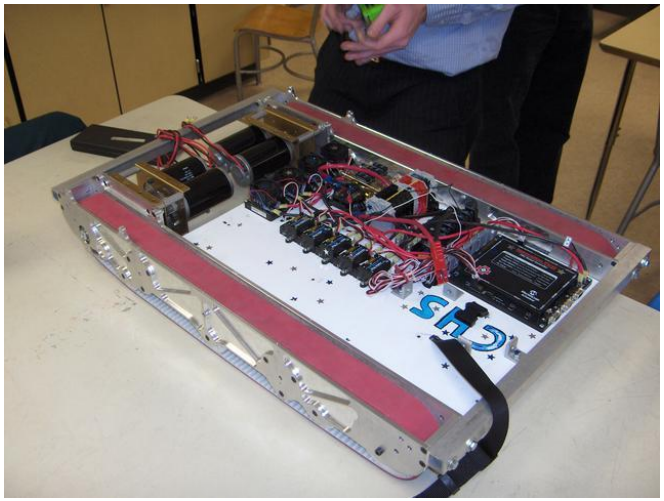
Sole benefit: Ability to go over things

*2 ways to be agile

A) Lower contact point on center wheel
B) Omni wheels on front or back or both

Drive Types:
Tank tread drive, 2 gearboxes





Sole benefit: Ability to go over things

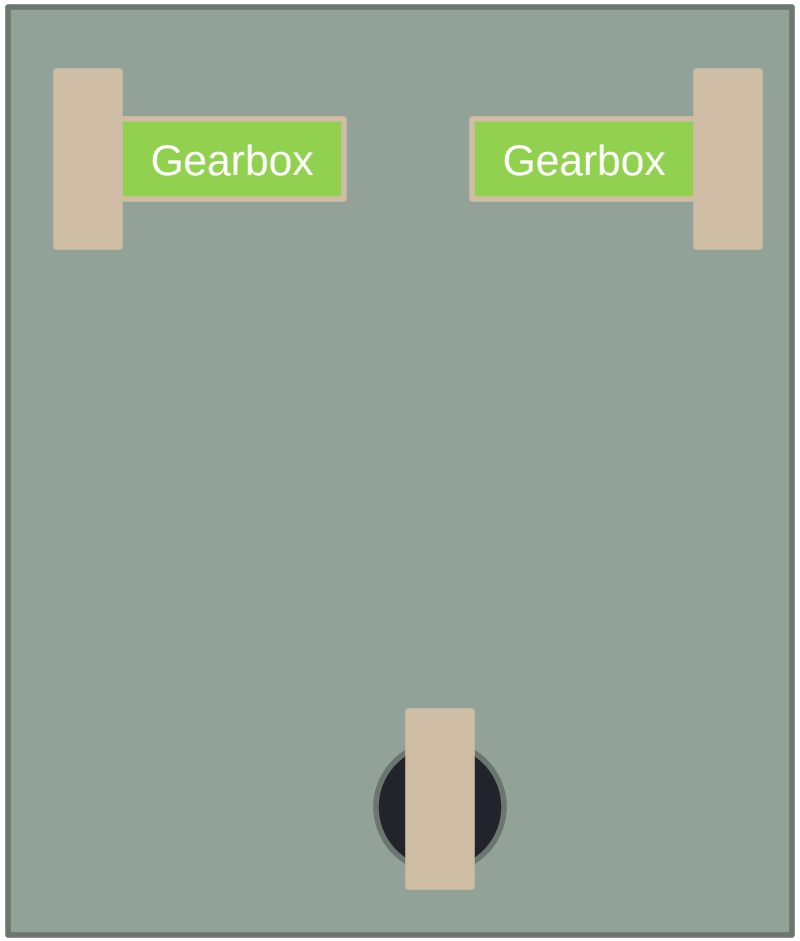
For turning, lower the contact point on center of track wheel

Will NOT push more than a well-controlled 6wd

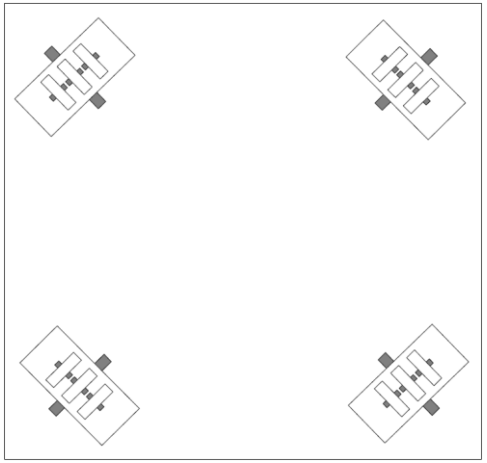
Drive Types: 3 wheel

- Various types
- Lightweight
- Fast
- Non-standard
  - (design intensive)

- Examples:
  - 16 in 2008
  - 67 in 2005



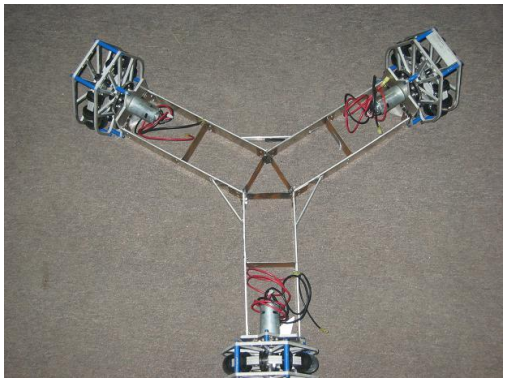
Drive Types: Holonomic - Killough



- 4 wheel drive or 3 wheel drive
- Stephen Killough, 1994

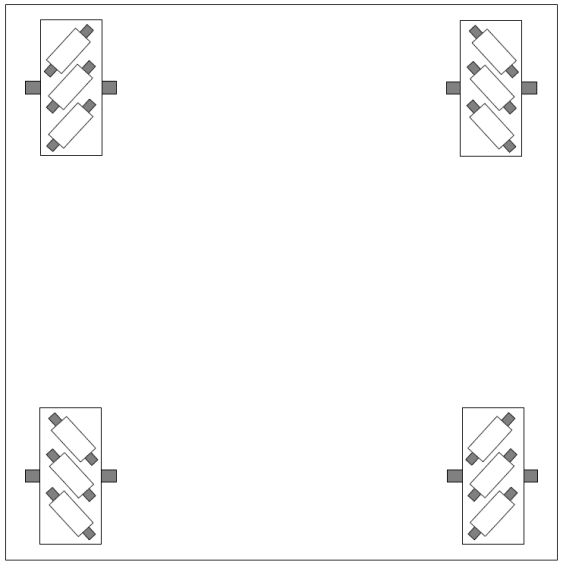
+ Simple Mechanics
+ Immediate Turning
+ Simple Control – 4 wheel independent

- No brake
- Minimal pushing power
- Jittery ride, unless w/ dualies
- Incline difficulty



Drive Types: Mecanum

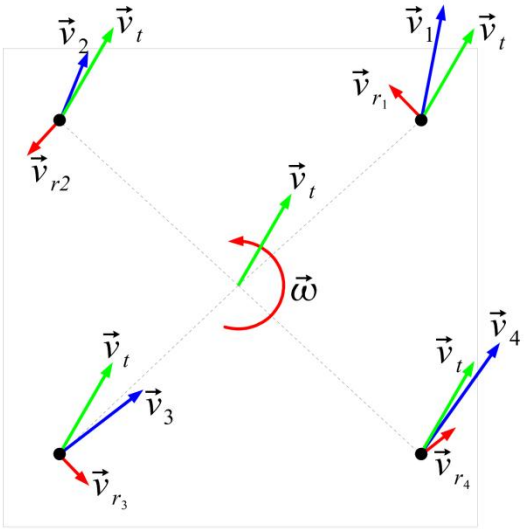
+ Simple mechanisms
+ Immediate turn
+ Simple control – 4 wheel independent
- Minimal brake
- OK pushing power
- Needs a suspension
- Difficulty on inclines

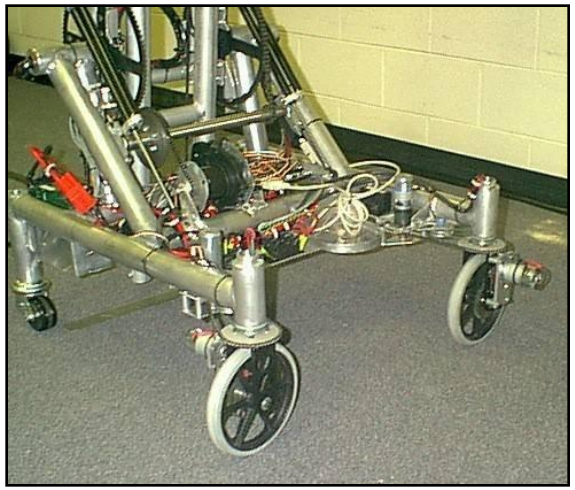


Mecanum wheel chair, team 357

Drive Type:
Swerve or crab steering

- High-traction wheels
- Each wheel rotates to steer
+ No friction losses in wheel-floor interface
+ Ability to push or hold position
+ Simple wheels
- Complex system to control and program
- Mechanical and control issues
- Difficult to drive
- Wheel turning delay
- Omnidirectional drive systems presentation: http://first.wpi.edu/Workshops/2008CON.html





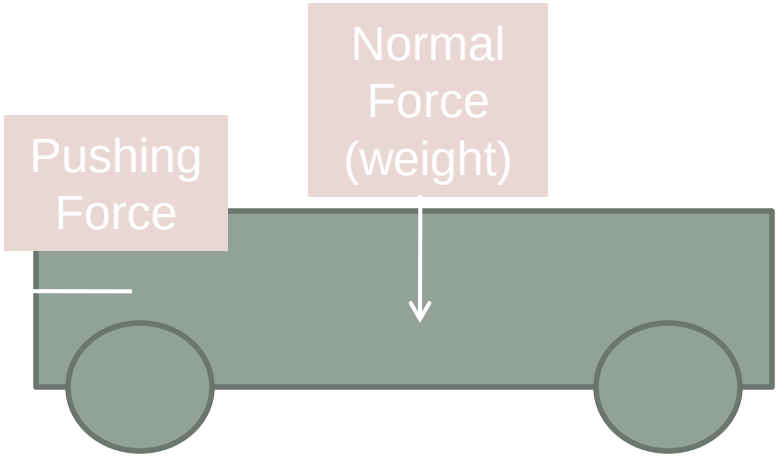
Resources

- Design
  - Difficult: swerve
- Machining
  - Difficult: swerve
  - Moderate: non-kit frame
- Money
  - Kit wheels have been cheap
- Time
  - 6 weeks, long hours, multiple shifts?

Traction

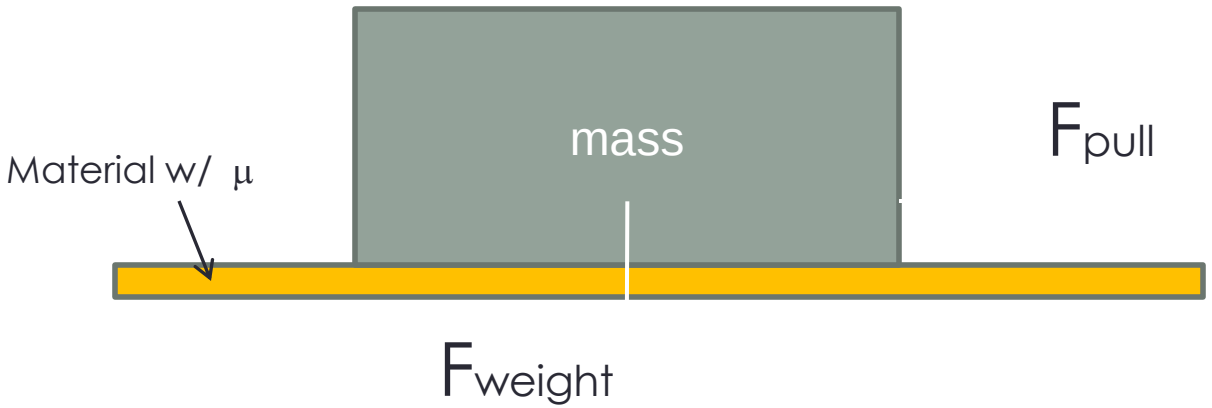
- Static vs Dynamic (←10% lower)
  - Once you slip, you will get pushed
  - Design encoders into your system
  - Dynamic breaking & traction control
- Pushing force = Weight * μ
  - μ = friction coefficient

Static friction coefficients
μ = 0.1 = caster (free spinning)
μ = 0.3 = hard plastic
μ = 0.8 = smooth rubber, 80A durometer
μ = 1.0 = sticky rubber, 70A durometer
μ = 1.1 = conveyor treads



More on Traction

- You can determine μ



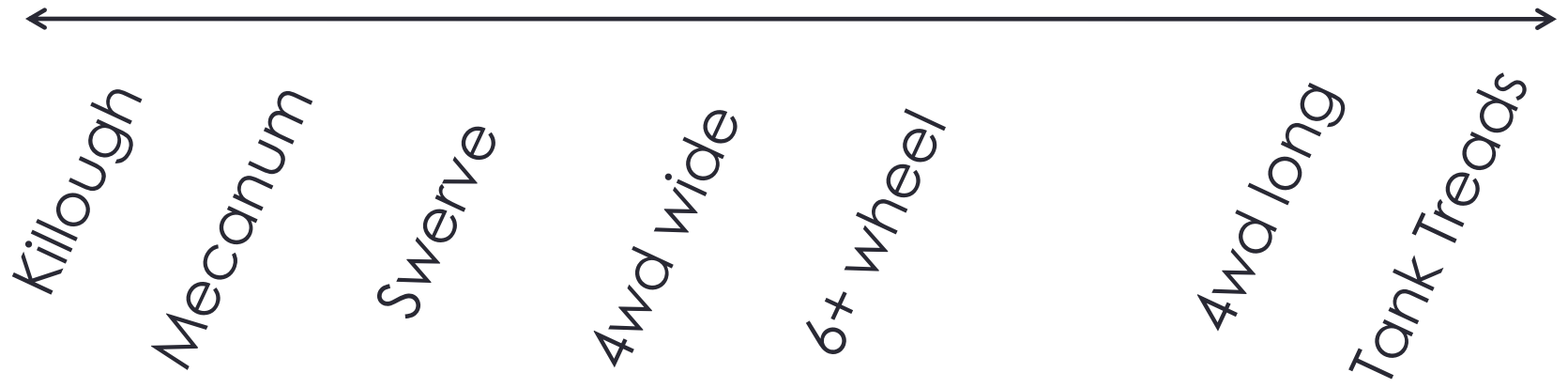
$$\mu = F_{pull} / F_{weight}$$

Mobility

- Move +/- 1 foot in any direction in under 1 second
- Generally speaking, the more mobile your robot is, the less it can resist a push

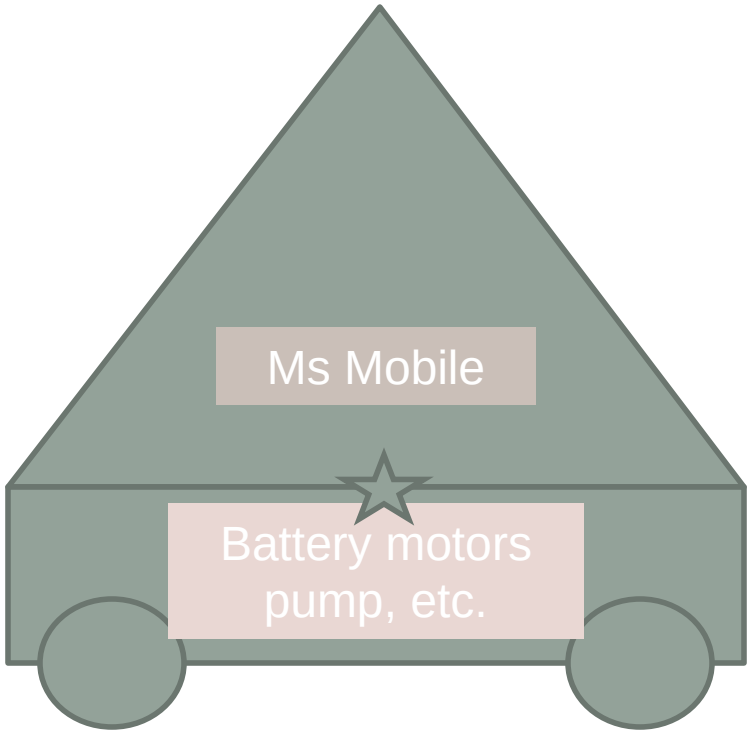
More mobile

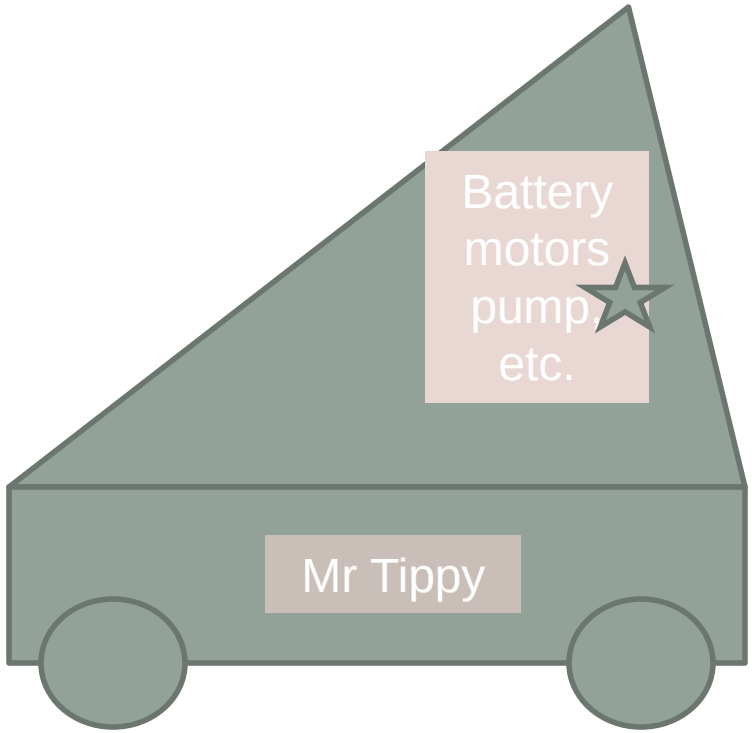
less mobile



Center of gravity (Cg)

- Robot mass is represented at one point
- Mobility increases when Cg is low and centered
- High parts = light weight
- Low parts = heavy (within reason





Speed

- Game dependent, however… this increases every year
- 2008 max: 20 ft/sec
- Controllable top speed: 15 ft/sec
- Average 1-speed rate: 9 ft/sec
- Good pushing speed: 5 ft/sec

Worksheet example

Timing

- Get something driving early
  - End of week 2
  - Practice for operators
  - Lessons learned for electrical
  - Strategy lessons
- Continuously improve
  - Good enough is not good enough
- Finish final drivetrain by week 4

Importance

- Boat anchor = any heavy mass that does not move
- A non-reliable or non-repairable drive base will turn your robot into a boat anchor

- Good drive bases win consistently
- Reliable drive bases win awards
- Well-controlled, robust drive bases win Championships

More info

- Ken Patton and Paul Copioli
  - Robot Drive System Fundamentals
  - http://first.wpi.edu/Images/CMS/First/2007CON_Drive_Systems_Copioli.pdf
- Ian Mackenzie and Andy Baker
  - Omni Directional drive trains
  - http://first.wpi.edu/Workshops/2008CON.htm