Making Things Move

Oklahoma Robotics Summit
OSU Campus
September 15, 2007

Story, with complete prejudice and bias, told by:
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Power Plants for FIRST Robots

- Electric Motors
- Pneumatics

2007 Electric Motors

• (2-4) CIM Motors	5,000 rpm
• (1-2) CIM "Mini-bike" Motors	2,300 rpm
• (2) F-P 'Barbie Car' Motors (6V motors!)	19,000 rpm
– With plastic gearbox	100 rpm
• (2) BaneBots Motors	16,500 rpm
– With various bolt-on transmissions	135 - 4,200 rpm
• (2) Keyang Window Motors	100 rpm
• (1) Denso Window Motor	100 rpm
• (2) Globe Motors	100 rpm
• (1) Mabuchi Motor	---------

Motor Selection

Most teams:

- Use 2 or 4 CIM motors for their drive train
- Use 5-8 motors total
- Don’t use the Mabuchi motor at all
- Don’t ever let the F-P 6-volt motors stall *(poof!)*
- Never let the Globe motor shaft be overhung

Pneumatics

- Must use kit compressor
- 60 psig max to cylinders
- Maximum of 2 storage tanks
- ¾”, 1”, and 2” cylinders
  - Any number allowed
  - Cylinders must be from the Parker-Hannifan order form or identical
- Valves 1-way or 2-way
- Challenging to control cylinder stroke between full open and full close

Drive Train Priorities

1. Reliability
   - No breakdowns

   Minimum for good team

2. Maneuverability
   - Position accurately to pick-up scoring pieces

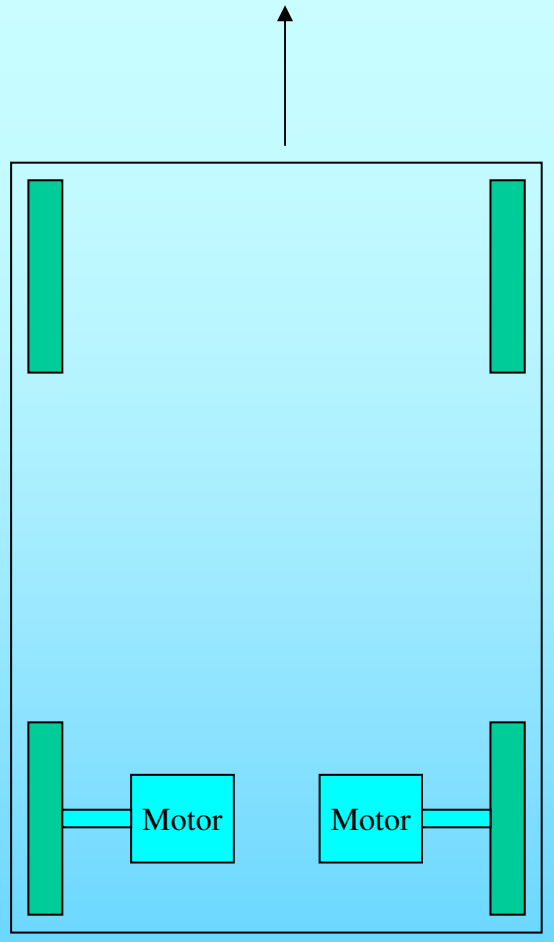
   Separates high/low scorers

3. Shifting Power
   - Low gear for pushing

   Premium teams – <u>if</u> you maintain reliability

Basic Design

- 1 motor left
- 1 motor right
- Joystick control
  - x-y consideration
- Front wheels turn free (or coasters)



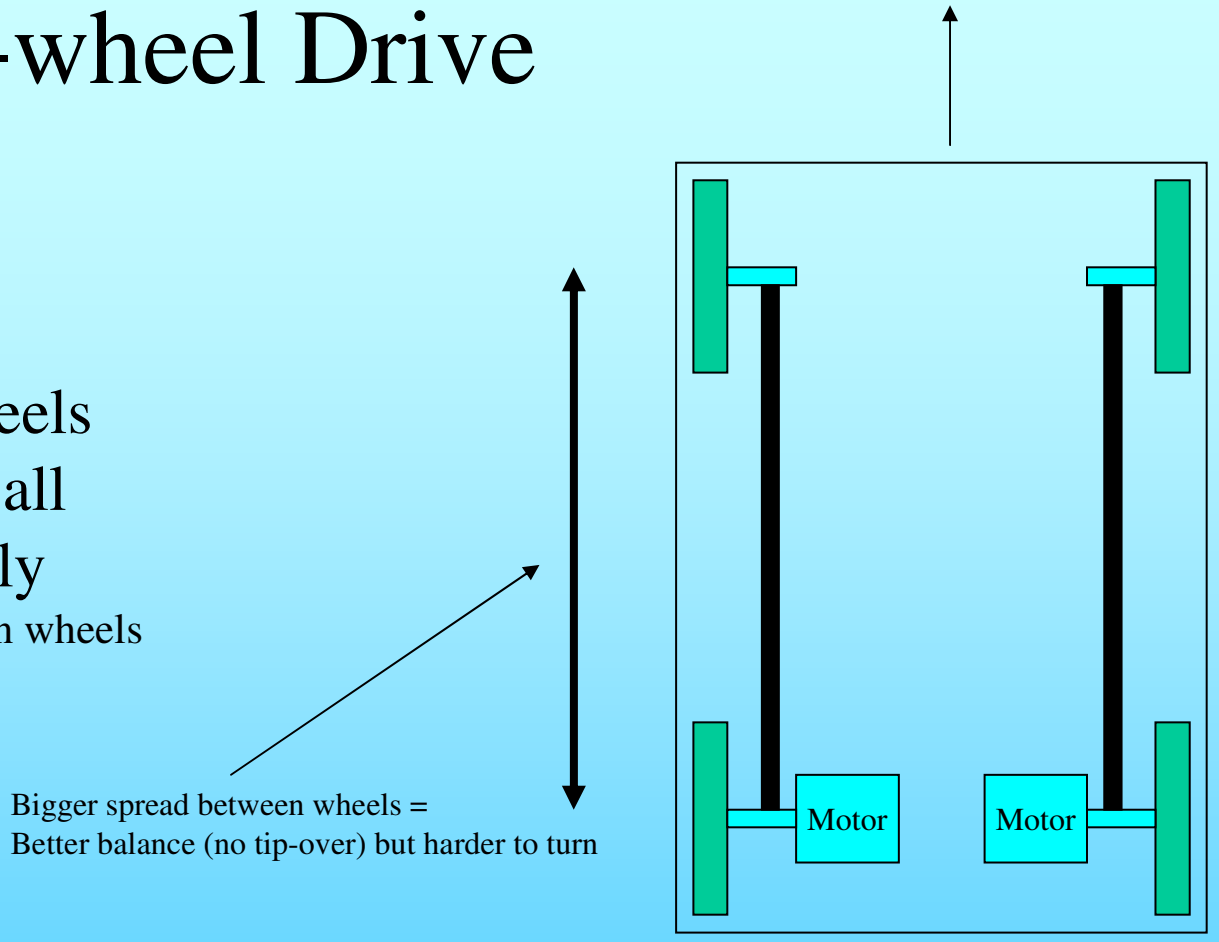
Top View

Pro: Easy, dependable, zero-turning radius

Con: Low traction, hard to position accurately

4-wheel Drive

- Add chain from back-to-front wheels
- Few teams power all 4 wheels separately
  (wastes 2 motors – more on wheels spinning later)



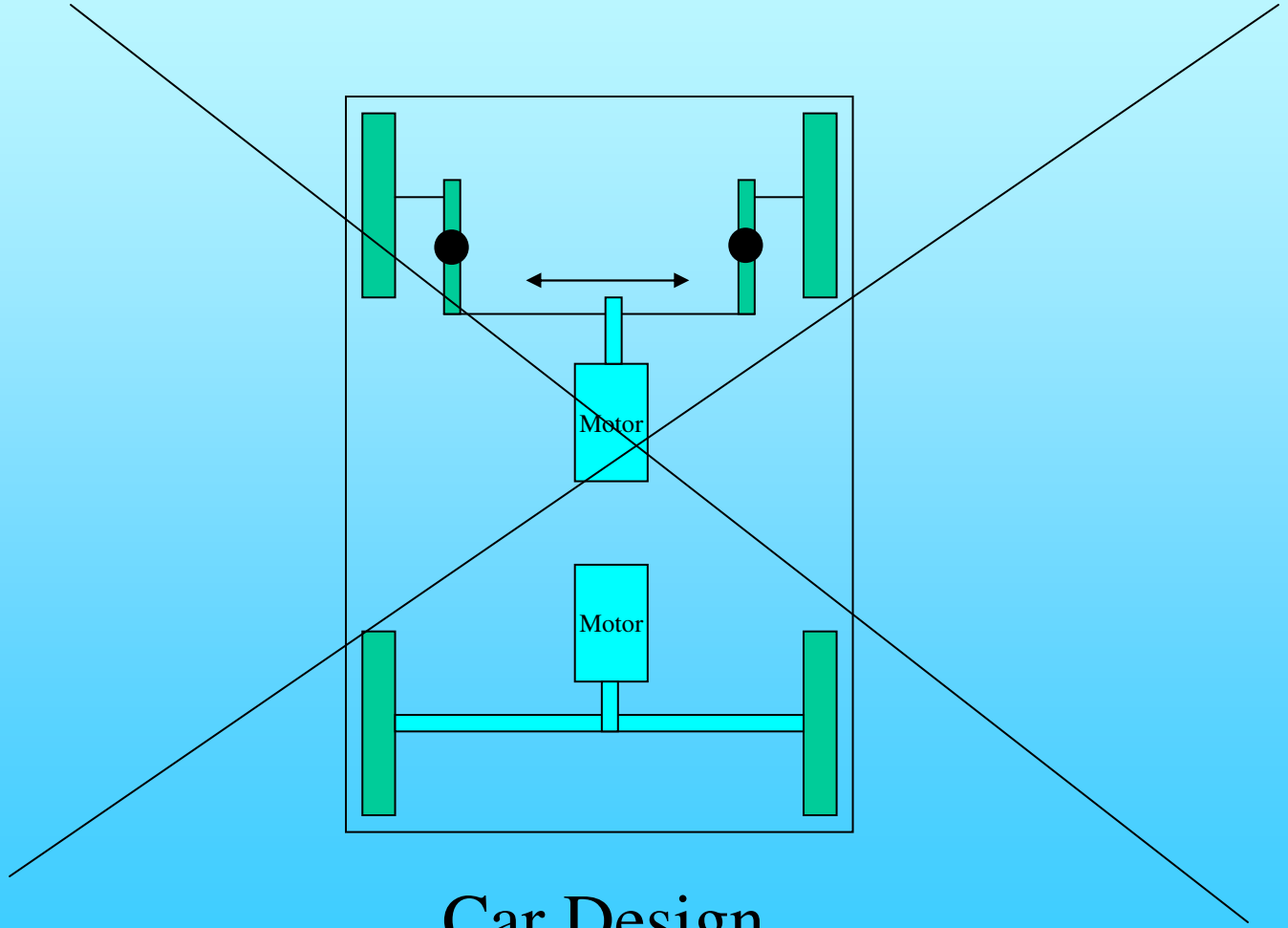
Top View

Pro: Better traction, more accurate positioning

Con: Harder to turn, especially under load

Nobody Does a Car Design

Big turning radius = poor maneuverability



Car Design

Robot Speed

1. Figure how fast you want to go across a 50-ft arena

   Usually in 5-7 seconds, or 7-10 ft/sec

2. Based on your wheel size, calculate your max rpm

   Example:

   8” wheel = 2 ft/revolution
   To go 10 ft/sec you need 5 revolutions/sec
   5 revolutions/sec = 300 rpm

3. Gear your motor to 300 rpm

   Sprockets/chains easy but heavy;
   Spur gears lighter but require precise machining

To Get Speed You Want:

- Chain sprocket reduction(s)
- Spur gear reduction(s)
- Worm gear reduction(s)
- Dewalt purchased gear reduction (3-speed)
- Other purchased gear reductions (home-made or commercially available)

Wheels

Considerations:

- Traction is most important
  - Arena is carpeted with industrial carpet
  - Too much traction and you won't turn well
  - Too little traction and you'll get pushed around
- Pick the wheel that gives you the most traction but still allows you to turn reasonably smooth
  - Do tests during the build season; use similar carpet to their arena
  - What works best when your robot weighs 60 lbs isn't the same at 130 lbs
  - If an overhung arm picks up something heavy, you might not turn well
  - Innovation First, Inc. has interesting wheels for sale (ifirobotics)
- Omni-wheels!?
  - Not as bumpy as you think
  - But you can get pushed sideways easier
  - Can be purchased!

Power vs. Speed vs. Traction

Points to remember:

1. It does you little good to have lots of motor power once the wheels start spinning
2. On anything but 2-wheel drive with front coasters, good pushing traction will always be penalized to some degree by problems turning; the wheels have to 'slip' when turning
3. Nobody's robot gets into a pushing match while turning; it's always front or back pushing
4. Nothing solves the power/speed/traction combination better than a shifting transmission

Tricks of the Trade

1. ¼” chain is fine and saves weight

2. You can program a ‘slow’ speed on a joystick button
   - Hold the trigger down for ½ power, for example
   - Can help immensely in accurate positioning

3. Robot ‘coast’ vs. hard stop
   - Jumper wire on speed controller

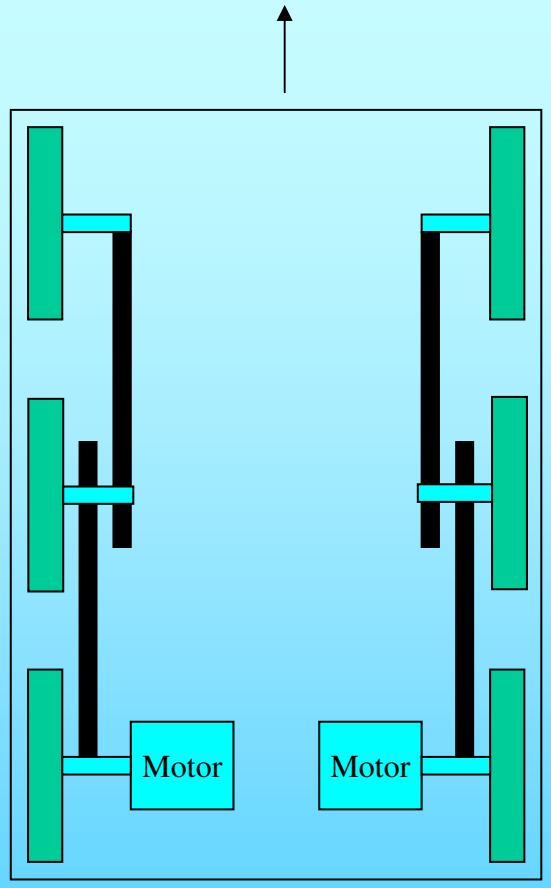
4. Robust enough to last 20 hrs
   - Not 2000 hrs
   - Not 0.2 hrs

5. Leave enough time to train your driver(s)
   - Finishing early to accomplish this is easier said than done

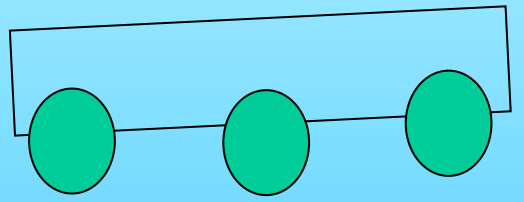
Advanced – Making Things Move

4/6 wheel Drive, Center Wheels

- Chain 3 wheels together on each side
- 'Drop' center wheel ~3/16" so only 4 wheels contact ground



Top View



Side View

Pro: Easier turning than 4 wheels on corners

Con: Extra weight, robot 'rocking'

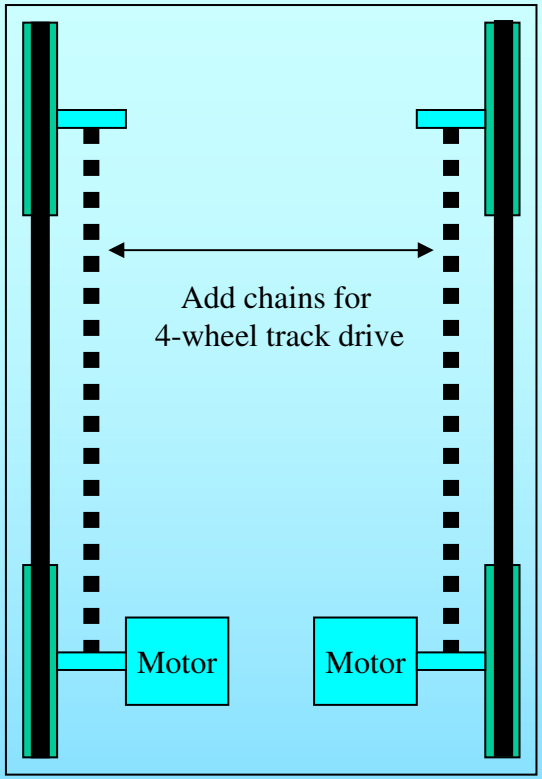
Track Drives

Really just 2 or 4-wheel drive with a belt around the wheels

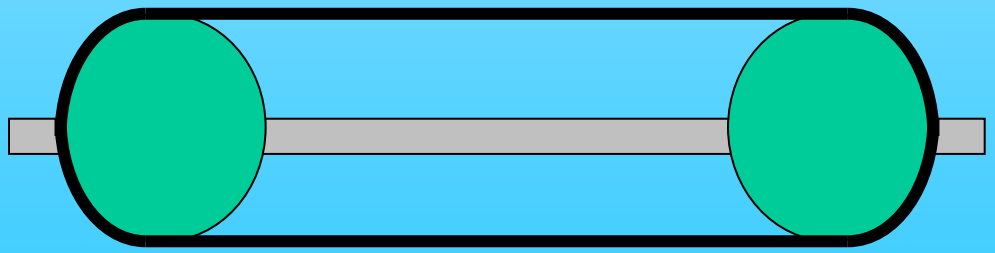
Pro: More traction if you can force the track down on the floor (idler gears); cool-looking;

Con: Hard to turn; tremendous forces trying to push the track off the gears when you turn

We gave up on this drive after one bad year; the chains kept coming off when turning



Top View

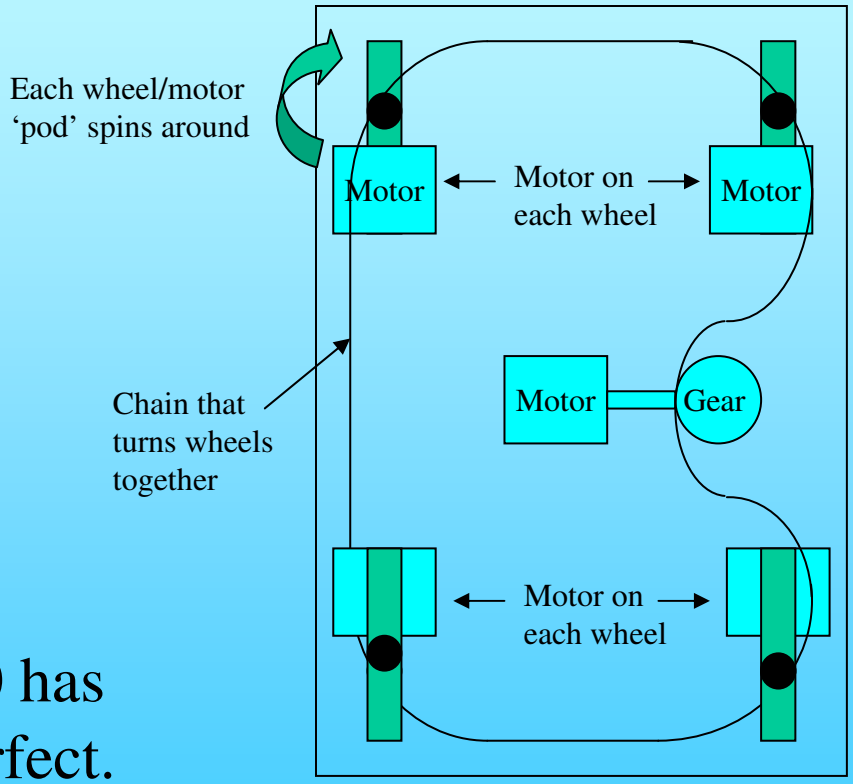


Side View

Swerve Drive

Omnibot or Swerve Drive

4 wheel pods, independently powered, that turn in unison on a common chain; robot frame doesn't turn – the wheels do; advanced teams only; <u>the ultimate in maneuverability</u>



Talk to Ron Markum! Team 1750 has a great one – took two years to perfect.

Omni-Wheels

- Omni-wheels!?
  - Not as bumpy as you think
  - Can be purchased!
  - But you can get pushed sideways easier

6” or 8” wheels, $45/ea,
www.andymark.biz

4” wheels, $56/ea,
www.superdroidrobots.com

4” wheels, $21/ea,
www.robotobjects.com

Shifting Transmissions

- Most teams purchase Dewalt 3-speed drill motor transmissions or gearboxes w/ servo mounts from AndyMark.biz
  - Dewalt design posted on Chief Delphi site for CIM motor mounting; takes some machining
  - Can buy off-the-shelf from AndyMark

- Some teams use spur gears and slide the shafts; some problems shifting at speed

- Some intriguing shift-on-the-fly designs
  - We spin three different gear sets and 'catch' the one we want by sliding a shaft, making metal balls slide into the recesses of the gears

- Low gear a lot more important than high
  - High only good for brief 'race' to scoring object or scoring zone

Remember: Reliability is #1 priority!!

Shifting Transmissions

My observed order of winners in pushing wars:

1. Lowest gear
2. Tie - Best traction
   - Biggest motors
3. Lowest center of gravity

Avoiding Back-driving of Motors

- Consider spring shocks or counter-weights
- Many chain sprockets are better than a few
- Worm gears are wonderful to prevent this but have their limits
- Make sure you get the added help from the speed controller brake!
- Use friction washers or create friction somehow

Good Web Sites

- Motor info, tips on building, website links – GREAT INFO – www.usfirst.org, First Robotics Competition, Documents & Updates - Competition Manual, Section 8 - "Related Documents and Resources", then "FIRST Guidelines, Tips, and Practices".
- Electronics/wheels/other: www.ifirobotics.com
- Banebots + CIM Motors: www.banebots.com
  - Note: Banebots supplies motors w/ encoders mounted and calibrated!
- Good Gearboxes/Shifters/Wheels: www.andymark.biz
- Dewalt 3-speed Transmission Motor Mounts: www.chiefdelphi.com/media/papers/1592, click on 'download file' under "Nothing But Dewalts" (.pdf file)

Show-and-tell examples