Critical Design Review

STORM

TEAM 2729

CHEROKEE HIGH SCHOOL

LENAPE HIGH SCHOOL

LENAPE

LOCKHEED MARTIN

Agenda

- Introduction & Strategy — **Josh Berkowitz**
- Robot Design
  - Mechanical
    - Chassis & Drive Train
    - Kicker System
    - Hanging System
  - Electrical
  - Software
- Program Management & Support Functions
- Summary

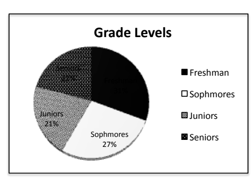
THE STORM ROBOTICS TEAM, FRC 2729

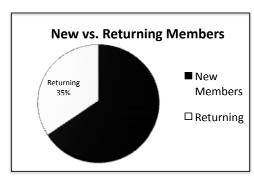
Introduction

THE STORM ROBOTICS TEAM, FRC 2729

Team Biography

- Team is composed of students from both Lenape & Cherokee High Schools
- Base of operation is Lenape High School
- 91 Student Members





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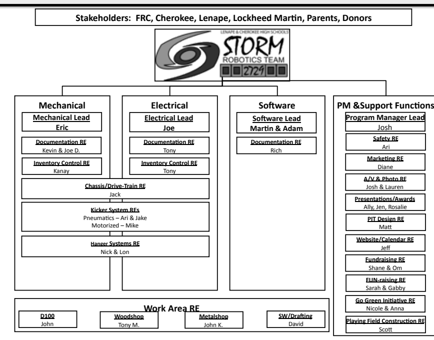
Team History

- Our Team was established in 2009 – (2nd year)
- LMCO sponsorship start in 2009 – (2nd year)
- 2009 Season Competitions:
  - Washington and Philadelphia Regional Events
  - Atlanta World Championships
- 2009 Off-Season Events
  - Duel on the Delaware – Salem County College
  - Ramp Riot - Wissahickon High School
- Awards:
  - Won Highest Rookie Seed Award in Galileo Division at Atlanta World Championship
  - Won Highest Rookie Seed Award at Philadelphia Regional Event
  - Won Rookie All-Star at both Washington & Philadelphia Regional Events
- Gracious Professionalism (this Season)
  - Thanks to Red Devils and Iron Devils for loaning us air cylinders
  - Held Skype conference with RV Red Devils to discuss idea of pre-loading air cylinders and share kicker prototype

Team Org Chart



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Team Advisors and Mentors

- Faculty Advisors
  - Nathan Knauss
  - James Hessler
  - James Scott
  - Scott Harris
- Mentors
  - Matthew Smith (ATLP)
  - Vitaliy Aynbinder (ATLP)
  - William McCorkle (ATLP)
  - Leslie Hurff
  - Burt Hurff
  - Maurice Grontkowski
  - Edward Cohen

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Competitions & Award Plans

BREAKAWAY

Competitions:

- Orlando Regional Competition
  - March 11, 12, and 13
- Philadelphia Regional Competition
  - March 25, 26, and 27
- Atlanta World Championships
  - April 15, 16, and 17

Awards:

- What awards are we applying for?
  - Chairman's Award
  - Woodie Flowers Award
  - Website Award
  - Entrepreneurship Award

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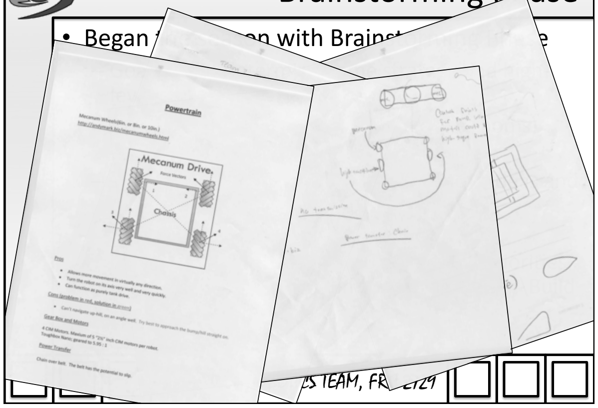
Brainstorming Phase

- Began t… on with Brainst… e



Priorities

- Team Priorities (based on vote during Brainstorming)

1. Agility (Maneuverability) 2. Bump 3. Kicking 4. Hang	**Demand** (critical to the project, MUST be included)
5. Speed 6. Push the ball 7. Camera Targeting	**Preferred** (important, but the project won't fail without it))
8. Flipping ourselves 9. Tunnel 10. Suspending Others	**Wish** (not that important, but it would be nice if it is possible)

Agenda

- Introduction & Strategy
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    - Chassis & Drive Train — **Jack Kolodziej, Kevin Eckenhoff, Eric Van Emburgh**
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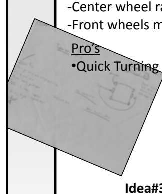
Drive Train Ideas

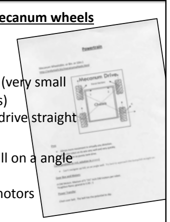
Idea#1 - Hybrid Wheel Design (6-wheel)
-Back wheels are rough tops
-Center wheel raised 1 inch
-Front wheels mecanum wheels



Pro's
•Quick Turning

Con's
•Low traction to get over bump
•No experience with omni wheels.

Idea#2 – 4x Mecanum wheels

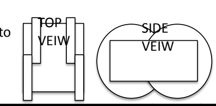


Pro's
• Strafing
•Easy turning (very small turning radius)
• Still able to drive straight

Con's
• Cant go uphill on a angle (bump)
• Requires 4 motors

Idea#3 - "GIANT wheels"

The idea for the big wheels was to prevent flipping going over the bumps. And if we do flip we will still be able to drive.



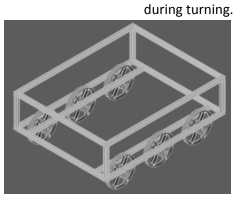
Drive Train Ideas

Idea#4 - 6 wheel center wheel raised.

The center wheels are for bump stability, so we do not bottom out when going over the bump. We did not want the center wheel to be raised 1/2" or to touch before the bump for turning friction.

Idea#5 - 6 wheel center wheel lowered.

The center wheel is still for bump stability, but the center wheel is lowered 1/8" for a smaller turning radius and more maneuverability. Now the center wheel acts as a "pivot" during turning.



Frame Construction

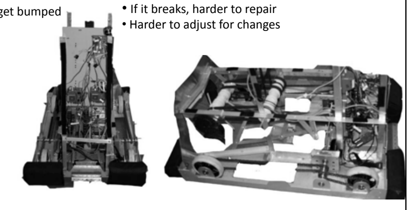
Approach #1 - Aluminum sheet chassis

Pros:

- More precise
- Fabricated to our needs
- Doesn't shift if we get bumped
- More rigid design
- One time assembly

Cons:

- One time assembly (wrong size then problems occur)
- If it breaks, harder to repair
- Harder to adjust for changes



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Frame Construction

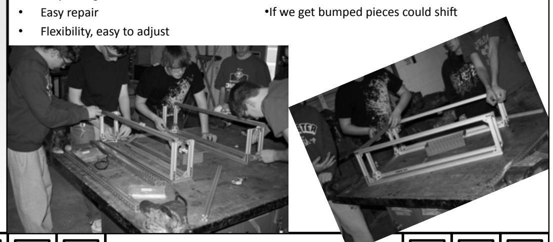
Approach #2 - T-slot chassis

Pros:

- Easy changes
- Easy repair
- Flexibility, easy to adjust

Cons:

- Doesn't look as nice
- If we get bumped pieces could shift



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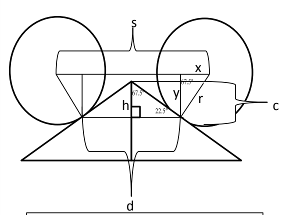
Supporting Analysis

Bump Traversal Analysis:



$$\tan(22.5) = \frac{h}{d/2}$$
$$d = \frac{2h}{\tan 22.5}$$
$$s = d + 2x$$
$$x = r\cos(67.5)$$
$$s = \frac{2h}{\tan(22.5)} + 2r\cos(67.5)$$
$$h = \frac{s\tan(22.5)}{2} - r\cos(67.5)\tan(22.5)$$
$$c = h + r - y$$
$$y = r\sin(67.5)$$
$$c = h + r - r\sin(67.5)$$
$$c = \frac{s\tan(22.5)}{2} - r\cos(67.5)\tan(22.5) + r - r\sin(67.5)$$
$$c = \frac{s\tan(22.5)}{2} - r(\cos(67.5)\tan(22.5) - 1 + \sin(67.5))$$

Resulting equation defines the undercarriage height to traverse bump

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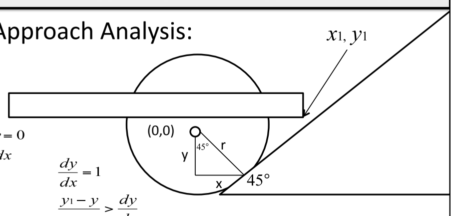
Supporting Analysis

Bump Approach Analysis:



$$x^2 + y^2 = r^2$$
$$2xdx + 2ydy = 0$$
$$2ydy = -2xdx$$
$$\frac{dy}{dx} = \frac{-2x}{2y}$$
$$\frac{dy}{dx} = \frac{-x}{y}$$
$$x = r\sin(45°)$$
$$y = -r\cos(45°)$$
$$\frac{dy}{dx} = \frac{-r\sin(45°)}{-r\cos(45°)}$$

$$\frac{dy}{dx} = 1$$
$$\frac{y_1 - y}{x_1 - x} > \frac{dy}{dx}$$
$$y_1 + r\cos(45°) > x_1 - r\sin(45°)$$
$$y_1 > x_1 - r(\cos(45°) + \sin(45°))$$
$$y_1 > x_1 - r\sqrt{2}$$

Resulting equation defines the chassis overhang (relative to axle) given a chassis height

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Supporting Analysis Results

- Using these calculations, we found that with 12.25" axle spacing and 8" diameter wheels, our chassis should be at least 2.21" off of the ground. This was raised to 3.5" for margin.
- Using this height, we found that the chassis can extend 9.15" from the axle of the wheel. We used this knowledge to decide on extending it 6".

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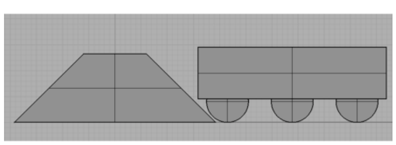
Bump Traversal Model

A animation put together by our CAD design team, to show clearance over the bump.



Note: Undercarriage height is exaggerated for this example

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Chassis Demo

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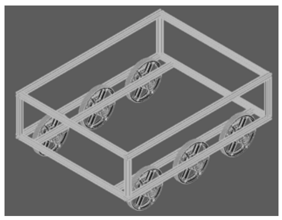
Final Chassis Design

•Chassis configuration allows for maneuverability, high traction, low CG, and ability to traverse field bump

•Dimension Limits – 38”x28”x60”
•Weight Limit – 120lbs

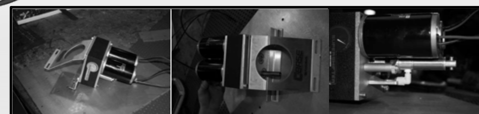
•Wheels: 6 wheel rough tops
•Frame: T-slot
•Center wheel: lowered 1/ 8”
•Frame height: Low
•Frame size: Longer than wider
•Center of gravity: low for stability

•Note: Front of frame to be modified to accommodate kicker system



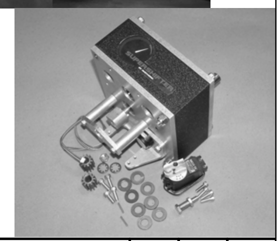
Path Forward … combination of “best of” ideas and backed up with analysis and prototyping

Drive Train



The transmission we chose is a two-speed shift-on-the-fly gearbox (Super Shifter)
- Incorporates pneumatic-powered shifting
- Low gear = 24:1 ratio
- High gear = 9:1 ratio

We choose to go with a two speed transmission to have best of both worlds …
Torque and Speed



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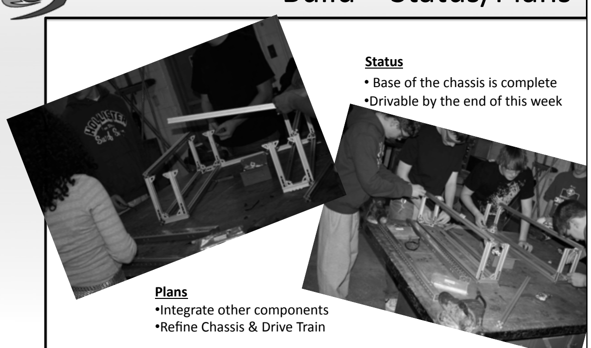
Build – Status/Plans



Status
• Base of the chassis is complete
•Drivable by the end of this week

Plans
•Integrate other components
•Refine Chassis & Drive Train

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Agenda

- Introduction & Strategy
- Robot Design
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    - Chassis & Drive Train
    - Kicker System **Mike Britland, Ari Bross, Jake Ellis**
    - Hanging System
  - Electrical
  - Software
- Program Management & Support Functions
- Summary

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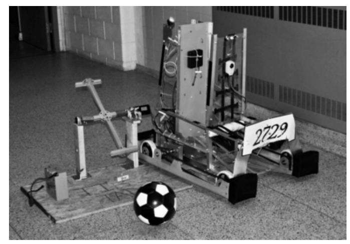
Ideas

- Ideas Considered
  - Pneumatic Kicker
    - Uses pneumatic cylinder to kick ball
  - Spinning Kicker
    - Uses spinning arm to kick ball

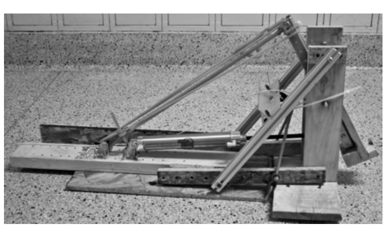
Spinning Kicker

- T-slot frame
- Spinning T-slot arms
- Direct drive from CIM Motor
- Constantly spinning
- Has to spin back up to speed after kicking ball



Pneumatic Kicker

- Pneumatic Air Cylinder
- Pivoting Kicking Arm
- Surgical tubing for added power



Kicker Prototype Demo

Kicker Pros/Cons

	Pneumatic	Motorized
Accuracy	More Accurate	Random hits
Rate of Fire	8 Per Minute	20+ Per Minute
Distance	12-18 Feet	6-10 Feet
Safety	Stored Potential Energy	Unstable
Prior Knowledge	No Prior Experience	Used Last Year
Space Constraints	Less Space Required	More Space Required
Current Drain	11 Amps	20-30 Amps
Complexity	More Fail Points	Basic Setup
Team Decision	X	

Pneumatic Kicker was selected as path forward

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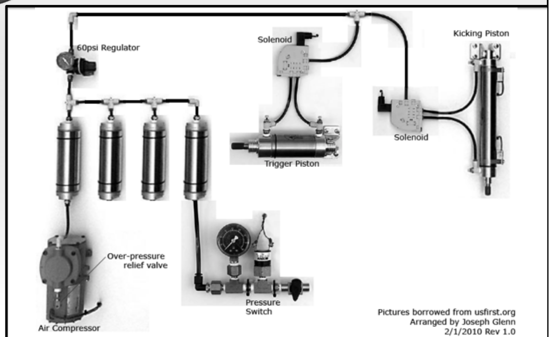
Pneumatic Kicker-Cont.



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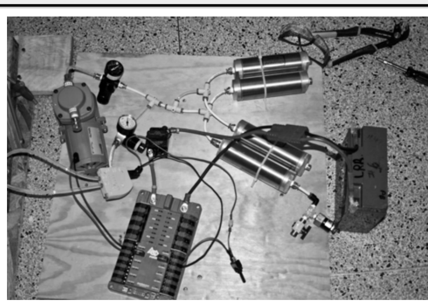
Pneumatic Kicker-Cont.



Pneumatics Test Bed

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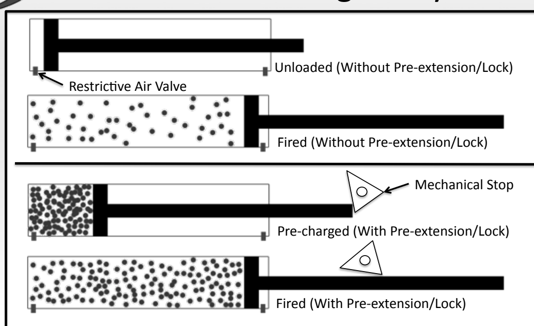
Pre-loading Air Cylinder



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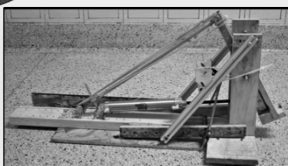
Pneumatic Kicker-Cont.



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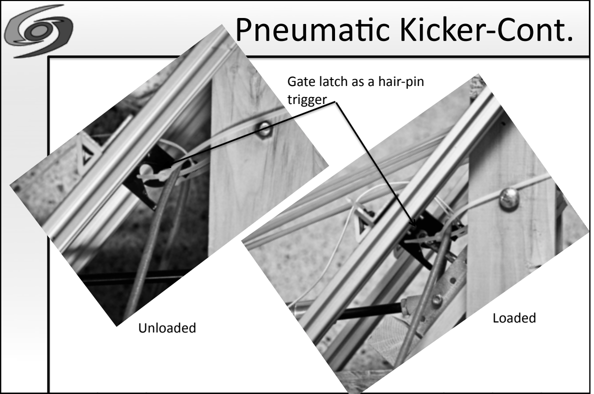
Pneumatic Kicker-Cont.



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Pneumatic Kicker-Cont.

- Tension in surgical tubing acts like a compound bow
  - Tension lessens when arm locks in
- Cylinder is pre-extended by 3 inches to allow for a stronger punch
- Cylinder- 1.5” bore, 8” stroke
- Operating pressure- 60 PSI

- Kicker is pre-fired but held back by a modified gate latch
- This method allows for a quicker, more powerful burst of air
- This method bypasses flow restrictions of tubing and connectors
- Secondary, smaller cylinder used to release “hair-pin trigger”

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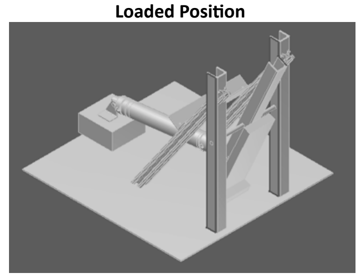
CAD Drawings

Loaded Position



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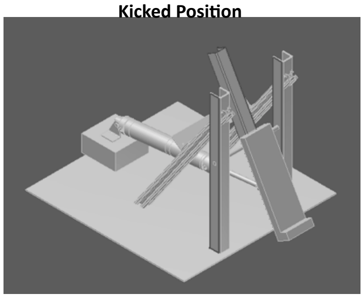
CAD Drawings

Kicked Position



Build - Current

- Demonstrated kicking capabilities
- Design and test phase finished
- Preparing to construct out of metal
- Awaiting working chassis for final mounting and placement

Future Plans

- Ball "magnet"
  - Keeps ball in place prior to kick
- Refine pneumatic board layout
- Optimize kicking performance
  - Parallel solenoids for higher volume release
  - Piston angle
  - Increase tension in surgical tubing

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    - Hanging System **Nick Colucci**
  - Electrical
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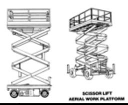
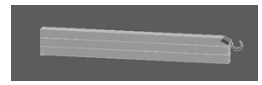
Ideas

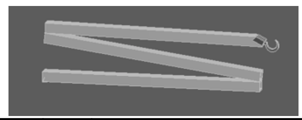
	Scissor Lift	Retractable Arm	Telescopic Arm
Pros	•Simple Design	•Easy to build •Light	•Not Bulky
Cons	•Heavy •Difficult to Build	•Less Stable Selected as Path Forward	•Difficult to build •Expensive •Not Reliable
			

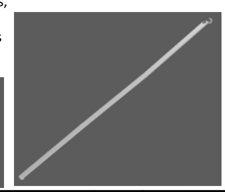
Prototypes & CAD

- Prototypes & CAD



•A wire that runs through three aluminum tubes, attached to each other by hinges, is pulled by a winch system that straightens the tubing. This is used to place a hook on the tower.





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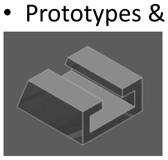
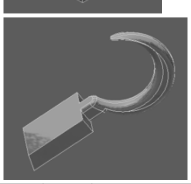
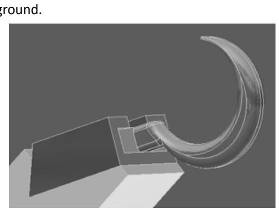
Prototypes & CAD

- Prototypes & CAD Continued



•The arm then retracts and the hook detaches from the rubber housing holding it in place and is left on the tower. The hook is then pulled by another winch, thus lifting the robot off the ground.





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Build – Status/Plans

- Build Status
  - – Initial Hanging arm prototype in process
- Build Plans (next 2 weeks)
  - – Finalize Hanging Prototype
    - Test
    - Building winch setup
  - – Final Build & Integrate with robot

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  - Electrical **Joe Glenn**
  - Software
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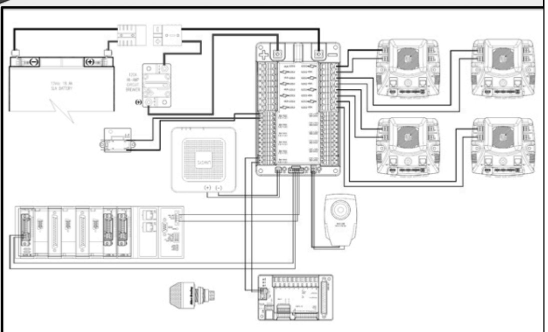
Electrical

- Goal is to support the Electrical and Pneumatic requirements of robot components:
  - Drive Train
  - Kicker System
  - Hanging System
  - Misc.

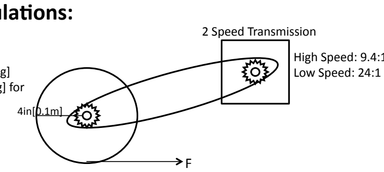
Power Distribution Diagram



Supporting Analysis

Torque Calculations:

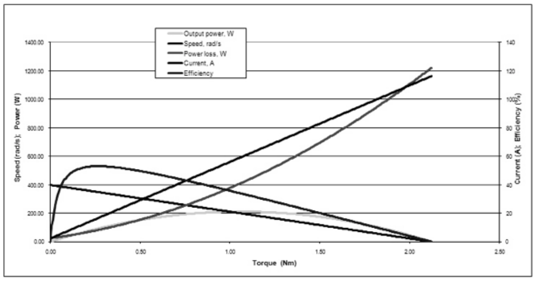
Robot Mass: 150lbs [68.04kg] (120lb[54.43kg] maximum, 30lb[13.61kg] for battery and bumpers)



$$Force = mass \times acceleration$$
$$Force = 150lb[68.04kg] \times 6.56 ft/s^2[2m/s^2]$$
$$Force = 984 ft/lbs[136.08N]$$
$$Torque = F_1 r_1$$
$$Torque_{required} = 984 ft/lbs[136.08N] \times 4in[0.1m] = 13.6$$
$$Torque_{motor} = .45Nm \times 4 \times 9.4 = 16.92Nm$$
$$Torque_{motor} > Torque_{required}$$
$$\therefore Safe$$

Required Torque determined to be safe and in-range

Motor Curves



Motor Curves used to evaluate Performance under various conditions

Peukert's Law and Robot Amperage

Components of Significant Current Draw	
CIM Motor x 4	27A x 4 average = 108A
Pneumatic Pump	10A
Total:	118A

Peukert's Law: $T = \frac{C}{I^n}$

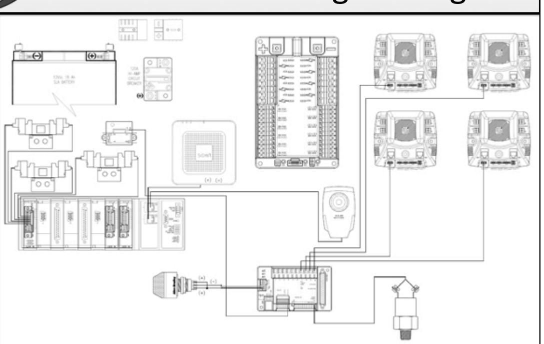
What Peukert states is that the amount of time a battery with last is equal to the battery's theoretical capacity(our batteries are rated for 18Ah) divided by the current draw to the power of Peukert's number.

$T = \frac{18\text{Ah}}{118\text{A}^{1.1}}$

T = 5.7 Minutes

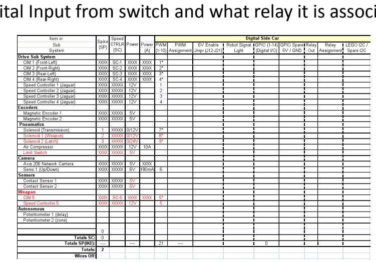
118Ah Is the maximum current our robot will ever draw. What this equation tells us is that the battery could sustain our maximum current draw for over two times the match duration.

Signal Diagram



Electrical Wiring Diagram

- Master Electrical Wiring Sheet
  - Shows relationship between all electrical components
  - Ex: Digital Input from switch and what relay it is associated with



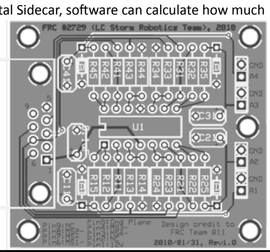
Motor Current Sensing Circuit

Process:

- Utilizing knowledge of the resistance of the breakers allows us to monitor how much the voltage drops per amp of current.
- By amplifying the voltage drop, we are able to get a reading.
- By feeding the data lines into the Digital Sidecar, software can calculate how much current the motors are drawing.

Possibilities:

- Allows software to monitor how much current the motors on the robot draw.
- By monitoring this current draw, software can implement measures to prevent the motors from drawing too much current and tripping breakers.



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Build – Status/Plans

- Build Status
  - Initial wiring backplane and motor support
- Build Plans (next 2 weeks)
  - Finalize Electrical and Pneumatic systems
  - Support integration of components (Kicker & Hanger)
  - Final Wiring Diagrams & Documentation

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Agenda

- Introduction & Strategy
- Robot Design
  - Mechanical
    - Chassis & Drive Train
    - Kicker System
    - Hanging System
  - Electrical
  - Software **Martin Borstad, Adam Seeman**
- Program Management & Support Functions
- Summary

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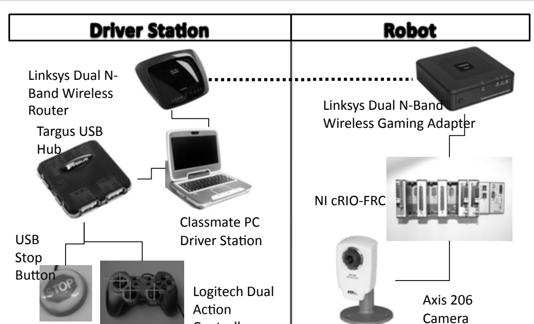
Network Infrastructure



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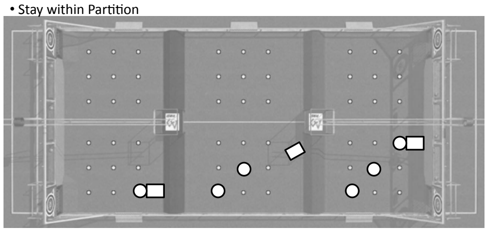
Modes of Operation

Goals of Autonomous
- Detect Target
- Calculate Distance Moved
- Register Robot-Ball Contact
- Variable Delay
- Stay within Partition

Goals of Teleoperated
- Driver Assistance in Shooting
- Intuitive Controls
- Traction Control
- Automatic Gear Shifting



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Systems of the Robot: Navigation

- Steering
  - Tank Drive
  - Two 2-speed transmission (possibly automatic)
- Controlling
  - Gamepad: Logitech Dual Action Gamepad
- Positioning
  - Encoders
    - Calculate Distance and Speed
    - Calibrate motors in tank drive
  - Gyros
    - Calculate Angle relative to ground

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Systems of the Robot: Kicker

- Detecting Ball / Ball Possession
  - Limit Switch to detect contact with ball and provide indication to operator
- Maintaining Control of the Ball
  - Motors/wheels that keep the ball in possession without picking it up
- Kicking
  - Automatically Preload Piston
  - Fire Piston using button on controller
  - Use Limit Switches to prevent Piston from overextending

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Systems of the Robot: Vision

- Tracking Target
  - Camera Image on Dashboard
  - Indicator when Robot is on Target
  - Default Targeting Algorithm used to pull data
  - Auto tracking and firing during autonomous

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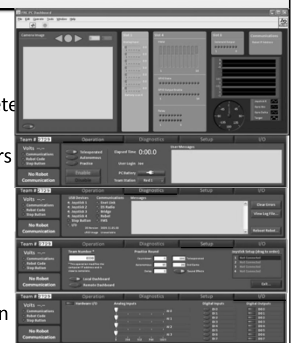
Systems of the Robot: Hanger

- Hanging Robot
  - Use driver station to control hook delivery mechanism
  - Control winch motor to lift robot off ground

Dashboard

- Indicators
  - Ball in Possession
  - Target Aligned
  - Piston Preload Complete
  - Gear Position
  - Velocity to switch Gears
- Pit Controls
  - Motion
  - Kick
  - Hang
  - Winch
  - Emergency Stop Button



Software Demo

Future Developments

- Parallel Java development
  - Preparation for Next Year
- Team Scouting Database
  - Offensive/Defensive Ability
  - Over or Under Hump
  - Kicking Distance/Accuracy
  - Hanging Ability

Agenda

- Introduction & Strategy
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Adam Seeman, Josh Berkowitz

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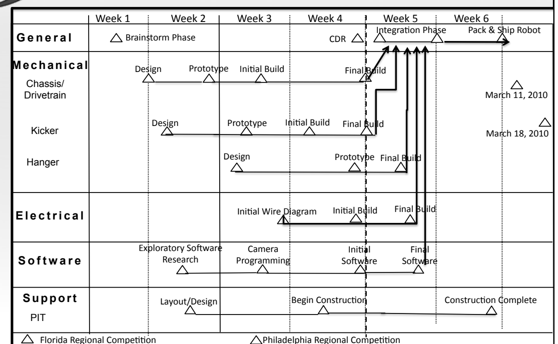
Team Schedule



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Budget

	Budget	Spent to Date
Drive train	$1400	$1300
Structural Materials	$600	$450
Pneumatics	$250	$200
Electronics	$150	$50
Spare parts	$250	$0
Pit	$250	$0
Field Construction	$100	$50
Total	$3000	$2000

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Marketing

Giveaways for Competitions

- Buttons
- Alliance Flags
- Flyers
  - Tri-fold Brochures

Team Uniforms

- Redesigned team shirts
- Team Sweatshirts

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Going Green

This year we are making a large effort to go green by:

- Collecting bottle caps to reuse for artwork in the PIT
- Conserving energy in an efficient manner by using lights, computers, and tools only when necessary
- Recycling all scrap metal and wood.
- Building a robot to use as a mobile recycling bin
- Exploring Solar Panel uses (ex: charging robot batteries)
- Educating other teams on going green at Robotics Competitions

Storm's Website

Team2729.org

Thank You to the Following:

LOCKHEED MARTIN

LENAPE RHS DISTRICT

SCHOTT solar

Morris Energy Group

DR PEPPER SNAPPLE GROUP

Merchant & Evans, Inc.	Runway Cafe
Victor DeLuca	Buzz Cortese
Steve's Auto Body	Barretta Tile and Stone, Inc

Conclusion

- Design Nearing Completion
  - Chassis Prototype Complete
  - Kicker and Hanger Prototypes complete
- Build In-Progress
  - Chassis & Drive-Train nearing completion
  - Component Integration beginning next week
  - Initial SW Delivery next week

On Plan to Complete Robot for Testing Phase and Delivery (Feb 23rd)

Questions

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Closing Montage

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