THE WAR. LORDS

2485

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Part of Team 2485's mission statement is to "develop real world experience and leadership skills by building high functioning competitive robots." We aspire to a high level of technical accomplishment every season, and our robot for the 2020 season is no exception.

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The drivetrain is designed for high torque and to optimize acceleration over a 10 to 15 foot sprint distance with a design goal of reliability and maintainability.

DESIGN OVERVIEW

The drivetrain utilizes a West Coast Drive using Size 35 chain for reliability and WCP bearing blocks with cam tensioners for maintainability. The West Coast Drive offers sufficient maneuverability as overly precise alignment of the robot is not required due to design choices including the use of a motorized turret for the shooter, motorized pitch actuation for the shooter, a wide mecanum intake, and using Limelight feedback for control. This is the team's first year using brushless motors after testing them in the off-season. The drivetrain includes 6 inch diameter wheels to clear obstacles. The team evaluated pneumatic wheels but selected rigid wheels for stability of the shooting platform while shooting from long range.

DESIGN DETAILS

- 6 wheel West Coast Drive
- 6" Colson wheels with .094" center wheel drop
- 1/8" wall 22 inch x 32 inch drivetrain frame (118" frame perimeter 27" x 32")
- Battery in the front (opposite the intake) to help move the center of gravity forward
- 9 inch bumper cut out for power cell path, only allows one power cell to enter the robot at a time



DRIVETRAIN



duce the weight of the design.

DESIGN DETAILS

- reduction
- Provides similar power to the 4 775pro gearboxes the team used in previous years with less weight and fewer PDP slots
- Geared for low-end torgue to maximize acceleration
- Optimized for a 10' to 15' sprint distance
- US Digital Optical encoder on the center wheel drive shaft records wheel rotation for autonomous driving after backlash of the gear train

CALCULATIONS

	1-Spe	eed Drivetrain								
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			Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)		Speed Loss Constant	Drivetrain Efficiency	
		Neo 🖕	5676	2.6	105	1.8		81%	90%	
		# Gearboxes in Drivetrain	# Motors per Gearbox		Total Weight (lbs)	Weight on Driven Wheels		Wheel Dia. (in)	Wheel Coeff	
		2	3		154	100%		6	1.1	
		Driving Gear	Driven Gear		Drivetrain Free-Speed	Drivetrain Adjusted Speed		"Pushing" Current Draw per Motor		
		20	80		14.86 ft/s	12.04 ft/s		44.01 Amps		
		20	50		10.00 : 1	< Overall Gea	Gear Ratio			
		1	1							
		1	1							

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Artemis's drivetrain includes two custom gearboxes to optimize the gear ratios, and to re-

• 3 NEO motors per side geared to deliver 14.81 ft/s with a 10:1 gear

The intake is designed to allow the driver to rapidly pick up power cells from the widest possible acquisition area behind the robot and automatically serialize them for easy handling once within the robot.

DESIGN OVERVIEW

The intake pivots down from the robot's starting configuration and uses a compact design to conserve space, to minimize the rotational inertia and to be less susceptible to damage. A polycarbonate bar further protects the intake from damage in collisions and serves as a stiffener.

DESIGN DETAILS

- Intake is actuated by a Bosch seat motor. This motor provides certain advantages
- High reduction through a worm drive ensures it not backdrive, allowing us to stop at any angle and turn off the motor
- Torque is more than sufficient to lift our intake.
- Part of the decision to eliminate the need for a pneumatic system
- 2" diameter vectored wheels (mecanum wheels)
- 2" diameter Omni wheels
- 2" wide polyurethane flat belt

POSITIONING

- Located on the rear side of the robot so that most cycles do not require turning the robot around
- Wide intake to capture power cells from anywhere along the width of the robot
- Power cells are centered along the bumpers

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MECANUM INTERNISTING

MECANUM NTAKE

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POWER CELL INDEXING

- These mecanum wheels are used at both left and right ends of the intake for their ability to center the power cell before it enters the robot so that a separate indexing mechanism was not required
- In the center of the intake, omni wheels pull the power cells into the bumper cutout in a single-file linearized fashion

POWER CELL COMPRESSION

- es and an incremental encoder

POWER TRANSMISSION

- Connection of the motor to the intake assembly is described below:
- A ¹/₂" hex shaft is driven by a hex coupler attached to a custom steel shaft on the Bosch seat motor
- The hex shaft is connected to the intake through hex-broached blocks held in 1" square tubing.
- A 2 inch wide polyurethane flat belt on the inboard end of the intake transfers power cells into the magazine
- The inboard roller is a dead axle and thus rides on bushings so that it can be on the intake pivot shaft
- 3D printed 31t double-wide dead axle GT2 pulley transfers torque between lower magazine stage and the intake

• The intake position is designed for 1 inch compression of power cells with the carpet, but by using a motor to control this pivoting location, the compression can be adjusted by adjusting the positioning of existing limit switches. • Controls of the intake pivoting deployment include up and down limit switch-

The magazine is designed to hold up to 5 power cells in an orderly, evenly spaced path despite asynchronous intaking of power cells from the field.

DESIGN DETAILS

The design was selected to hold the power cells in an efficient arrangement while preventing jamming due to power cell to power cell or power cell to stationary wall interaction.

- Holds five power cells in an orderly path
- Top stage is driven by a NEO with a 1.33:1 belt reduction
- Bottom stage is drive by a NEO with a 2.5:1 belt reduction
- Utilizes retroreflective beam break sensors
- Feeds all 5 power cells into the shooter in approximately 5 seconds.

ZONING

- Indexes power cells to maintain separation between power cells
- Uses a two zone system with feedback from beam break optical sensors to coordinate motion between zones, indexing the second zone only when a power cell reaches the end of the first zone, to stack power cells in close proximity to each other and allow indexing in single power cell increments.
- Lower zone drives intake through GT2 timing belts and runs while intaking.
- Drive of the lower zone is combined with the intake through a dead axle.
- While intaking, the upper stage only runs when a power cell is detected in the lower stage

OTHER DECISIONS

- Polycarbonate side panels retain power cells and also keep retroreflective beam break sensors in alignment, 2" polyurethane flat belting move power cells throughout the magazine,
- Belts on both sides prevent the power cells from rotating prevents power cells from jamming due to touching while rolling, wider 2 inch belting used to prevent power cells from escaping past the belt

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VER CELL AGAZINE



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The shooter allows the driver to rapidly fire accurate and consistent shots from nearly anywhere on the field, including a close range shot from the initiation line and a long range shot behind the color wheel.

DESIGN OVERVIEW

To accomplish this we utilize a motorized turret (yaw) and motorized hood (pitch). Together with a Limelight camera on the turret, the algorithm calculates the turret and hood angle as well as the flywheel speed for the optimum shot. This algorithm is active during both teleop and auto. Achieving a wide control of pitch in a turret based double flywheel shooter was a design challenge. The design utilizes nesting rollers to maintain power cell control over a wide pitch control range from 7 to 45 degrees.

DESIGN DETAILS

- Double flywheel selected over a single flywheel
- We determined that the exit velocity of a double flywheel is predictable and double that of a single flywheel shooter for a given RPM. This should more easily enable long range shots.
- 4 inch 60A neoprene Fairlane wheels spin between 2000 to 5000 RPM to launch power cells at a max velocity of 90 feet/second
- The center of the wheels are located ³/₄ inches below the center of the power cell to give the shot backspin. This is adjustable by changing spacers.
- Each side is driven with a NEO. A 1:2 speed increase allows for a max speed of 11,350 RPM. Velocity headroom allows for faster shot recovery
- Internal NEO encoder is utilized for velocity control
- 3D printed rollers and GT2 timing belts guide power cells into the shooter

ANGLE ADJUSTMENT

- Pitch angle of the shot is adjusted by a ¼-20 leadscrew
- Driven by a NEO 550 with a 5:1 belt reduction
- Yaw rotation angle is adjusted by a 775Pro motor driving a COTS Armabot Turret240
- Limelight vision camera is utilized to auto align to the high goal vision target
- IGUS cable track allows for 340 deg rotation of the turret
- Dead spot is on the back right
- Cable track spring loaded using a retractable tensioner cable with a modified assembly to allow the Kit of Parts chain to work in a "reverse bend radius" mode to allow rotary motion in a confined space.

LEADSCREW TRANSMISSION CALCULATION

- ACME ¼-20 thread lead screw
- Pitch between threads P = 0.05 inch
- Pitch diameter D= 0.225 inch (from Nook, ~halfway between major and minor diameter)
- Timing belt ratio = 60T / 12T = 5X
- Axial motion = P / 5 = 0.01 inch per rotation of the NEO 550 motor, or 1.8 inch/sec at the motor free speed
- Stall torque of the NEO 550 motor is 0.97Nm = 8.58 in-lb, consider the belt ratio of 5:1 = 42.9 in-lb
- Lead screw ratio = (pi x 0.225) / 0.05 inch = 14.1
- Using a friction coefficient of 0.3 for the steel to Delrin interface, the calculated force at stall torque is 484 lbs, which is 40X greater than the 12 lb weight of the shooter and above the buckling limit of the leadscrew. Driving this small load, we do not demand high torque of the NEO 550 motor and can operate it near its free speed



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DESIGN OVERVIEW

The climber uses three telescoping square tubes to reach a hook to a maximum height of 75 inches. The assembly is powered by a single motor driving a winch drum. Constant force springs allow the telescoping tubes to extend. A hook that flips up via a torsion spring acts as a fourth stage of the extension. Climbing load is taken by the hook, rope, lower pulleys and winch. The telescoping tubes do not bear the climbing load (load is limited by the springs), but the tube arrangement does prevent hook rotation in yaw to stabilize the climb against rocking or spinning.

DESIGN DETAILS

- lowering the climber hook
- reduction

- Top stage is .0625" wall 0.75" x 0.75" polycarbonate tubing
- Allows for easy driver alignment
- Middle stage: .125" wall 1.5" x 1.5" aluminum tubing
- Bottom stage: .0625" wall 2" x 2" aluminum tubing

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• 1.25" OD 1/16" wall aluminum tube spools the 5/64" HTS 75 Dyneema rope

• Driven by a 775pro with a 70:1 VersaPlanetary with a ratchet stage to prevent backdriving and controlled using an SRX Mag Encoder stage • #25 chain links VersaPlanetary output to winch shaft with a 1.125:1 chain

• Rotation initially unspools the line, after which rotation in the same direction spools the line back in on the opposite wind direction on the drum. • During unspooling, constant force springs lift two telescoping stages.

• Collisions with climbing rung cause deflection instead of breaking the bot

THE HOOK

- Hook is machined aluminum, with a pivot axis near its base
- Rubber tape prevents the hook from sliding on the bar
- The hook springs up using a torsion spring.
- Before the endgame, it is restrained by a vertical post attached to the second stage that passes through a hole in the hook.
- When the 3rd stage raises relative to the 2nd stage, the hook is pulled out of the post allowing the hook to spring up.
- The hook then acts as a fourth stage for the purposes of climber vertical reach.

ROPE MANAGEMENT

- Rope is guided from the hook down through a pair of 16mm cheek pulleys to keep it well managed on the winch.
- Top end of the rope is tied to the clevis assembly connected to the hook. The connection is below the pivot axis so the rope does not interfere with the rotation of the hook
- Rope passes through the center of the telescoping tube assembly
- The rope then is turned horizontally by a guide pulley below the attachment point of the climber mast assembly.
- A second pulley turns the rope vertically to reach the drum of the winch.
- Rope is tied to the winch drum
- Attachment point to winch drum is horizontally offset from the pulley allowing for a significant fleet angle to encourage clean rope winding

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CLABING MECHANISM



SOFTWARE

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VISION

A Limelight camera at the front of our turret tracks the high vision target. This allows us to automatically align the turret, determine angles and speed for our shots, and score quickly and with minimal effort from the drivers.

TURRET ALIGN

We run a simple proportional controller using the Limelight's x angle from the target in order to quickly align the turret. In the turret's default state, it constantly tracks the target using feedback from the Limelight, and if the Limelight does not view the target, it uses gyroscope feedback to stay approximately locked on to the target. The drivers can also control the target relative to the field, again using gyroscope feedback.

AUTOSHOOT

Using the Limelight's y angle from the target, and taking into account gravity, lift, and drag, we calculate an RPM and angle to set our shooter at. The entrance angle (to the port) we use to calculate the shooter values can be set manually by the drivers to adjust the arc of the shot.

POWER CELL INDEXING

Dynamic indexing logic using input from IR sensors along the magazine determines how many balls are within the robot at all times. This allows consistent intake of balls with minimal driver input, and sets up efficient, consistent, and well-spaced shooting.

AUTONOMOUS ROUTINES

Autonomous routines are dynamically selected via the Shuffleboard interface.

PATH GENERATION

Vision allows us to localize the robot relative to the power port. Using this data, we create hermite splines to generate paths that efficiently get us to our target.

PATH FOLLOWING

A Ramsete controller ensures we track the path we generate consistently and accurately.



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