WILDCAT ROBOTICS

Kansas State University

"Umbrella"

STORM 2026 — Power Flash
Design Report

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Name	Role
Jack Lilley	Team Captain / Mechanical
Reid Ellis	CAD & Programming
Paris Burghouts	Electrical
Ethan Hartshorn	Programmer / Electrical
Dr. William Hageman	Faculty Advisor

1. Team and Robot Overview

1.1 Introduction

Wildcat Robotics represents Kansas State University in the 2026 STORM (Student Tele-Operated Robotics Mission) competition. The team presents Umbrella, a teleoperated ground robot designed to compete in the Power Flash challenge.

Wildcat Robotics is composed of students from Kansas State University, organized into three focused sub-teams covering mechanical design, electrical systems, and software development.

1.2 Team Organization

The team is structured into three sub-teams; Mechanical, Electrical, and Software. Sub-team leads coordinate with Team Captain Jack Lilley to ensure alignment across the robot's design and build phases.

Captain	Software	Mechanical	Electrical
Jack Lilley	Ethan Hartshorn	Reid Ellis	Paris Burghouts

1.3 Robot Overview

Umbrella is a mecanum-wheeled ground robot built around an elevator assembly. The elevator carries both the battery intake mechanism and a climbing hook, allowing the robot to efficiently score batteries during the match and execute a Utility Line climb at the end. The robot is designed to be mechanically simple, electrically reliable, and straightforward to operate under the blind teleoperation conditions imposed by the competition.

1.4 Design Process

The team's design process consisted of four main sections; concept development, simple dynamic analysis, CAD, and production.

Concept development was done mainly on whiteboards and iPads, where score values and rules were broken down and understood, and critical design constraints were decided.

Simple dynamic analysis involved calculations of robot and game piece momentum, rotational inertia of game pieces, time analysis of mechanical components such as the elevator, and torque calculations for motor power.

The design and CAD phase was instrumental in utilizing the information and ideas gathered during the previous phases to visualize mechanisms. OnShape was used to create dimensions sketches that were able to visualize how the robot would interact with field elements and game pieces with different arm or elevator geometries.

Production involved the creation of rapid prototypes, and ultimately competition ready machined parts. Our rapid prototyping took advantage of laser cutting and 3D printing technology to greatly reduce the cost and time required to produce functional tests pieces. Prototypes of the intake, which took advantage of laser cutting, which would take hours to 3d print, took only 2 minutes to cut out.

2. Mechanical Design

2.1 Overview

Umbrella's mechanical design is centered on three systems: a mecanum drivetrain for omnidirectional movement, an elevator-mounted intake arm for battery collection and deposition, and a hook-and-elevator climbing mechanism for ascending the Utility Line.

2.2 Drivetrain

The drivetrain uses four mecanum wheels, each independently driven, arranged in the standard X-configuration. Mecanum drive was chosen specifically for its ability to strafe the robot laterally without rotating, which is critical for aligning the robot precisely with Battery Bank slots during the Teleop period at an acceptable speed with rotational considerations.

Each wheel is driven by a dedicated motor controlled through a Cytron MDD10A controller. The wheels have rollers at a 45° angle to the rest of the wheel. This creates a force parallel to the orientation of the wheel. By combining these forces, the robot can move in any direction, as well as turn by varying the motor speeds and directions.

2.3 Battery Intake and Placement

Battery collection is handled by a roller intake mounted on a rotating arm at the top of the elevator assembly. The arm pivot is offset so that one side of the robot can be used for scoring on the further, high scoring area, and the other side could be used to score on the closer, lower scoring area, without requiring extension of the arm. The arm angles the rollers downward toward the field surface, allowing the robot to drive toward a loose battery and draw it into the robot's possession using friction rollers. Once a battery is captured, the arm repositions to align for insertion into a Battery Bank slot.

2.4 Elevator Assembly

A two stage elevator provides vertical travel for both the intake arm and the climbing hook. The elevator uses a linear stage with guided rails and is driven by 2 dedicated motor. The elevator serves two distinct purposes during a match: raising and lowering the intake arm to the appropriate height for battery slot engagement and elevating the climbing hook above the Utility Line bar prior to latching.

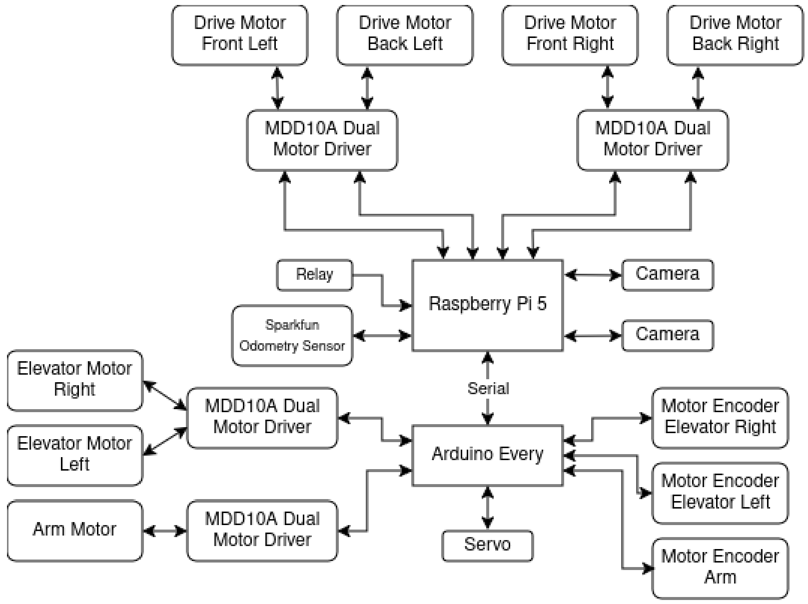
2.5 Climbing Mechanism

Umbrella climbs the 1" square aluminum Utility Line tube using a basic hook-and-latch mechanism mounted on the elevator. To initiate a climb, the elevator raises the hook above the height of the Utility Line, the robot drives forward to position the hook over the bar, and the elevator then drives downward, causing the hook to engage and latch onto the tube. Further elevator retraction lifts the robot off the field floor.

3. Electrical Design

3.1 Overview

Umbrella's electrical system is built around a Raspberry Pi 5 as the primary compute platform. MDD10A motor controllers manage all drive and mechanism motors. The system operates from a 12V NiMH battery with regulated lower-voltage rails for logic and sensors.



3.2 Power Distribution

The main 12V NiMH battery supplies power to the MDD10A motor controllers and to a set of DC-DC converters providing regulated 5V rails for the Raspberry Pi 5 and associated peripherals. All power connections are fused or otherwise protected at the distribution point. The NiMH chemistry was selected for its robustness, safety in a lab environment, and compatibility with standard charging infrastructure.

There is another module for the grid that distributes appropriate power to two wires that contact the charging pad utilizing a potentiometer varied by a calibrated servo.

3.3 Compute and Control

The Raspberry Pi 5 serves as the primary onboard computer, running the robot's control software, processing sensor data, and managing network communication with the operator. Cytron MDD10A motor controllers receive PWM and DIR commands from the Raspberry Pi and drive the four mecanum wheel motors, the elevator motor, and the intake roller motors.

3.4 Sensors

The robot incorporates the following sensors to support the operator and autonomous functionality:

- Cameras: Two cameras to provide a video feed for the driver and to position the robot automatically based on AprilTags.
- Optical Odometry Sensor: The optical sensor measures a gyroscope and movement relative to the field to update the robots odometry position.
- Motor Encoders: The GoBuilda motors contain a built-in encoder to track motor position. This information is used to set the arm and elevator to set positions.

4. Safety and Reliability

4.1 Electrical Safety

- All power connections are fused at the main distribution point to protect against short circuits.

- The NiMH battery chemistry eliminates thermal runaway risk present in some LiPo configurations.

4.2 Software Safety

- Control messages and hardware signals are zeroed immediately when no input is received, preventing runaway motion.
- The autonomous routine includes encoder-based position bounds checking to prevent the robot from leaving the field boundary unexpectedly.

4.3 Mechanical Reliability

- Critical structural components and the hook mechanism are 3D printed from durable materials and designed with replaceable spares prepared for competition day.
- The elevator assembly includes hard stops at both travel limits to prevent over-extension.

5. Software Design

5.1 Overview

Umbrella's software is written entirely in Python and is divided into two components: Robot Software running on the Raspberry Pi 5 onboard the robot, and Operator Software running on the operator's computer in the Operation Center.

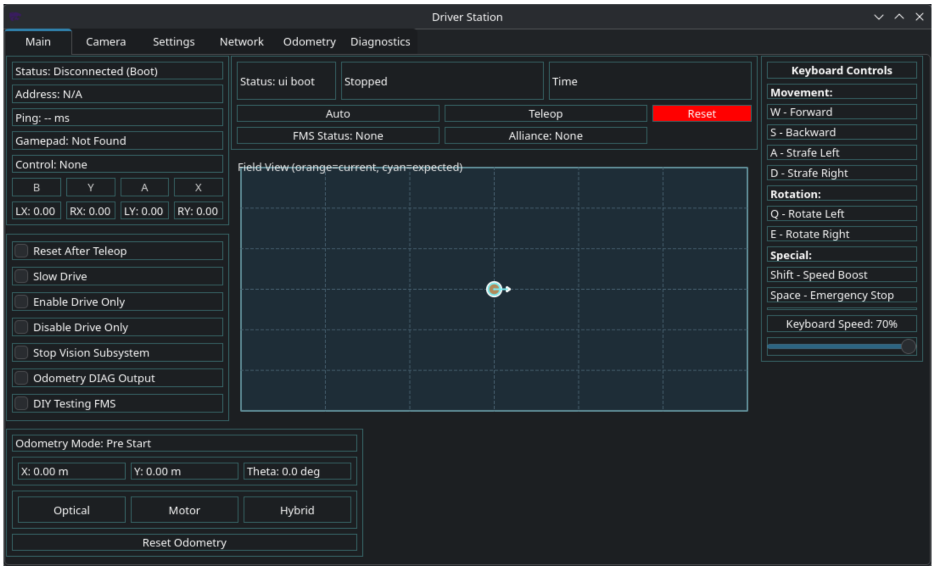
5.2 Robot Software

The Robot Software runs on the Raspberry Pi 5 and interfaces with an Arduino Every to perform different functions. The software maintains a constant connection to the driver station software when on the same network. It also handles the data packets coming from the driver station software to perform different functions. It also handles data from sensors, sending that data back to the driver station software, and running local functions. Our software also runs an OpenCV thread to give out relative position to the AprilTags across the field, letting us automatically align with the field elements.

5.3 Autonomous Routine

During the 30-second Autonomous period, the robot executes a pre-programmed routine to drive toward the nearest Battery Bank assigned to the team, using apriltag detection to help guide the robot into place. The intake arm deposits the preloaded battery into the Bank slot. The robot then drives to completely exit the Team Zone.

5.4 Operator Software



The operator software lets the driver see different info the robot transmits back such as its odometry position, encoder positions, camera feeds, and diagnostic data. This also allows us to let us send data and control the robot's different functions like driving via controller or enabling the autonomous/teleop modes.

6. Bill of Materials

Item	Unit Cost (USD)	Qty	Total Cost (USD)
Raspberry Pi 5	$73.99	1	$73.99
Raspberry Pi 4 (backup)	$64.98	1	$64.98
Cytron MDD10A Motor Controllers	$23.48	4	$93.92
Mecanum Wheels + Motors	$TBD	4	$TBD
NiMH 12V Battery	$TBD	1	$TBD
Elevator Linear Stage / Rails	$TBD	1	$TBD
Intake Roller Motors	$TBD	TBD	$TBD
Hook / Latch Hardware	$TBD	1	$TBD
Odometry Module	$86.40	1	$86.40
Camera Module	$25.99	2	$51.98
Structural / Frame Materials	$TBD	—	$TBD
Fasteners and Misc Hardware	$TBD	—	$TBD
3D Printing Filament	$TBD	—	$TBD
Total			**$TBD**

Note: Team members' personally owned tools and lab equipment available through Kansas State University are not included in the cost. 3D printing costs reflect material only.