Season 2026 UWaterloo Robotics Preliminary Design Review

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1. Introduction

The University of Waterloo Robotics Team (UWRT) is a student-led team of over 30 members from Mechatronics Engineering, Systems Design Engineering, Computer Science, and related programs, with 70% bringing prior robotics experience from FIRST, VEX, and high-school science clubs. The team operates under a three-level organizational structure shown in Figure 1: a Team Lead and Business Lead manage external relations and sponsorships, a Safety Captain ensures regulatory compliance, an Architecture Decision Committee of senior members oversees technical decisions, and general members contribute across mechanical, electrical, firmware, software, and business subteams. To build team capabilities, we implement subteam-specific onboarding training followed by peer-mentoring partnerships between new and senior members. Our outreach efforts include co-hosting local hackathons, participating in regional and national conferences, and engaging with university open-houses and high schools to inspire the next generation of robotics enthusiasts.

2. Administrative Information

2.1. Team Resources

The team operates from a dedicated design bay at the University of Waterloo, equipped with mechanical and hardware prototyping tools. Additional support from university facilities, including the machine shop and paint room, enables complex manufacturing. Funding is sourced from university organizations such as WEEF and EngSoc, along with industry sponsors like Kenesto, QNX, and ProtoSpace Mfg, supporting prototyping, testing, and team operations. A financial statement is detailed in figure 2. This year, our budget is allocated to three main areas: upgrading specific rover functionality such as wheel designs and including an actuated swivel DoFs for improved grip and controls on rocky terrain, exploring development of more bespoke systems like integrated swerve actuators, and maintaining spare components for failures during testing.

2.2. Project Managment Plan

Upon release of the URC 2026 requirements, UWRT's rover development cycle was broken down into three interconnected phases: functional validation, feature integration, and system-level testing. After PDR submission, all subsystems complete independent functional testing to validate core component performance. Prior to the System Acceptance Review, we will develop a minimal viable product demonstrating core system capability across navigation, manipulation, and science tasks. After MVP validation, we will fix stability issues and conduct final system-level testing for competition readiness. The team's project schedule is detailed in the Gantt chart (Figure 3), which specifies responsible subteams, task dependencies, and critical dates. Confluence serves as the primary knowledge management system for technical documentation and meeting minutes.

Integration follows a structured bottom-up approach where subsystems are independently validated before system integration, highlighting modularity in design. System validation occurs through three progressive stages:

Software-in-the-Loop testing using Gazebo simulation for algorithm validation, Hardware-in-the-Loop testing with emulated sensors for system behavior performance, and System-Level testing at the Canadensys lunar facility to evaluate rover performance in competition-realistic environments. Testing schedules for each subsystem are labeled into figure3.

3. Technical Design

3.1. System Overview

As illustrated in Figure 4, our rover is designed with three primary subsystems: a 35kg rocker bogie drivetrain powered by a 48V battery with a modular payload interface for a 6-DoF manipulator with brushless motor-encoder pairs, and a science payload featuring microscope imaging, environmental sensors, and soil sampling capabilities. Most of the rover hardware design is kept from the previous competition cycle, but with a major focus on system robustness and productization.

3.2. Season 2026 Updates

3.2.1. Compute Module

The compute architecture uses a Jetson Orin Nano running ROS2 Humble for high-level autonomy and vision processing (reused from prior seasons), paired with two Raspberry Pi 4B boards running QNX RTOS as new dedicated I/O modules for deterministic sensor preprocessing and motor control. This replaces our previous distributed STM32 network.

3.2.2. Power System

Power distribution architecture remains largely unchanged. We standardized all connection by adopting JST connectors for board-to-board cases, XT connectors for high-current connectors, and RS232 for long-distance signal distribution, eliminating the complexity of our previous mixed-vendor approach.

3.2.3. Communication

Board-to-board communication migrates from UART/I2C to Ethernet with DDS middleware through ROS2. QNX's native IPC mechanism handles intra-board communication on Raspberry Pi boards for high bandwidth, low-latancy sensor messages.

3.2.4. Drivetrain

Our 6 wheeled, differential bar compensated rover-bogie chassis incorporating carbon fiber members and aluminum end joints was reused this competition cycle. System validation shortcomings are addressed with the development of new TPU wheel geometry, modularity of drive servos and active steered drive wheels, allowing for kinematic compensation and improving terrain manuverability and robustness. Motor controllers are upgraded from legacy ODrive to ODrive S1s with better fault handling and GUI support. NAV2 path planning and ROS2control differential drive remain our control stack, with odometry fused from encoders and IMU + GPS through robot_localization to correct drift during autonomous missions.

3.2.5. Arm

The arm mechanical structure and actuators remain unchanged from prior seasons. Hardware simplification this year includes integrating motor controller housings directly onto the arm, eliminating the need for a separate electrical enclosure and reducing wiring complexity. Software focus centers on improving kinematic localization accuracy through better arm integration with the global and local motion planner. We are configuring MoveIt2's hybrid planner to better coordinate arm dynamics. This season, our arm system more focus on the reliability over more advanced functionality.

3.2.6. Science

Figure 5 shows the redesigned science payload architecture, organized into four subsystems: extraction, transport, sampling, and storage. The design emphasizes modularity, robustness, and simplicity for reliable autonomous operation. The sampling module is implemented as a sensor driver to minimize code change in the system.

A. appendix

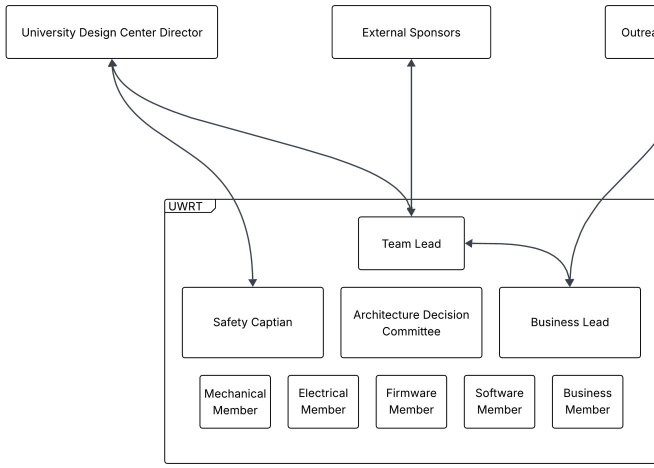

Figure 1. UWRT employs a three-level organizational structure. The Team Lead oversees primary communication with university administrators and sponsors, while the Safety Captain ensures compliance with safety standards. The Business Lead manages outreach initiatives and sponsorship agreements. Senior members form an Architecture Decision Committee that reviews and approves all architectural decisions and purchase requests. The third level consists of general team members across mechanical, electrical, firmware, software, and business disciplines who continuously develop and implement new rover features using state-of-the-art algorithms.

URC PDR Budget

UWRT Actual Income to Date

Name	Description	Balance(USD)
W24 - WEEF Funding	Drivetrain Manufacturing Costs	2840
	PDB & Localization Board Development	710
	Autonomous Driving Sensors	710
	Tools & Space Organization	710
	Total	4970
F24 - WEEF Funding	Project Drivetrain	1065
	Project Arm	1775
	Project Autonomy	659.2847
	Project Science	355
	Bay Safety	123.54
	Total	3854.2847
S25 - WEEF Funding	Manufacturing and Raw Materials	994
	Electrical Manufacturing	355
	Motor Controllers	497
	Compute and Sensors	284
	Bay Improvement	142
	Total	2130
Other	UWaterloo - Giving Day Student Teams Funding	887.5
	UWaterloo - Existing Dean's Funding	3390.96
	QNX by Blackberry - Mission Control Sponsor	3550
	Total	7828.46

UWRT Anticipated Income to Date

Name	Description	Balance(USD)
Other	W25 - WEEF Funding	3391.386
	2025 Dean's Funding	2130
	Total	5521.386

	Total Income	$ 24,304.13
Currency Pair	CAD/USD	0.71
		Date: 2025-12-02

UWRT Project Expenses

Expense Categories	Amount
Drivetrain Subsystem	$ 3,000.00
Arm Subsystem	$ 5,000.00
Rover Communication System	$ 1,500.00
Science Subsytem	$ 2,000.00
Rover Power System	$ 1,000.00
Ground Station	$ 500.00
Transportation and team Merchandise	$ 4,000.00
Total	$ 17,000.00

Figure 2. UWRT Season 2026 Budget: income (left) and expenses by project (right).

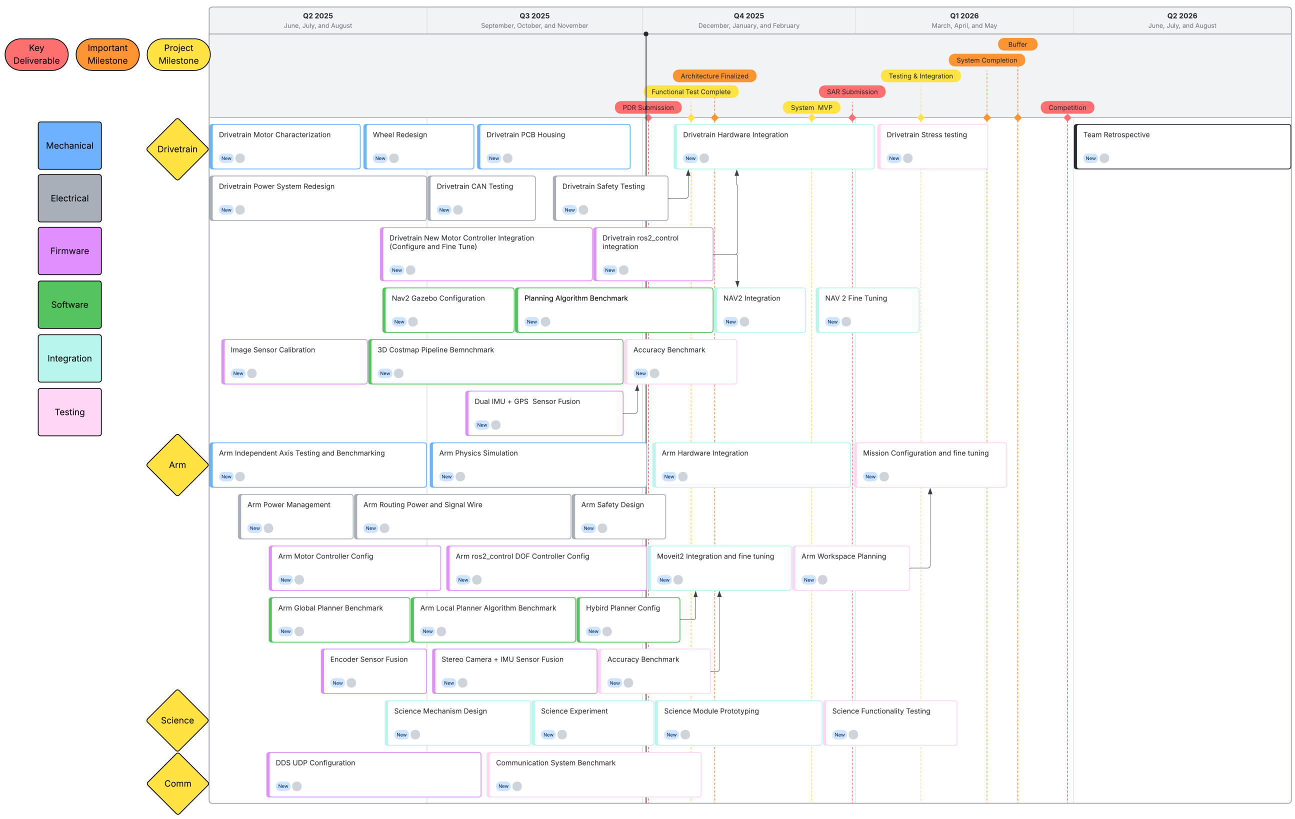

Figure 3. The Gantt chart illustrates the UWRT S26 project timeline and is organized into two sections. The top section displays key project deadlines, color-coded as follows: red indicates URC competition deadlines, orange marks system functionality milestones, and yellow represents project completion deadlines. The bottom section presents the detailed task timeline for each subteam—Mechanical, Electrical, Firmware, Software, Integration, Testing, and specialized subsystems (Drivetrain, Arm, Science, and Communications)—with color-coded task tracking. The team has structured the project around three major milestones. First, the team focuses on validating the functionality of all primary components, including both commercial off-the-shelf and custom-designed parts. Following PDR document submission, the team will lock in the system architecture for the season. The second milestone targets the system's minimal viable product (MVP). Finally, the team will conduct fine-tuning and stress testing to optimize system performance for the University Rover Challenge competition.

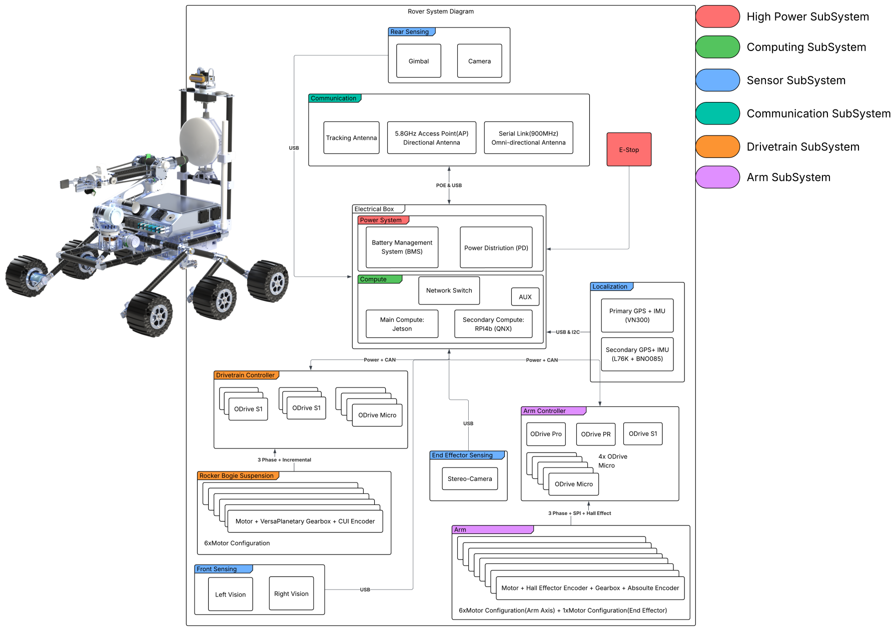

Figure 4. This figure shows the main system diagram for the whole rover system. The center is the Electrical Box containing all the main electronics. BMS is for cell balancing. PD is for over-voltage protection, over-current protection, and state of charge monitoring. Jetson is our main controller solving all the kinematics. Raspberry Pi 4B loaded with QNX serves as an IO expansion board and low-level controller. Communication Module transmits UDP packets and communicates with the ground station. The Rear Sensing Module serves as an overview camera for livestreaming the rover status to the ground station. E-Stop performs the critical safety functionality and cuts the high power rail under emergency. Localization has a dual GPS + IMU configuration providing high accuracy location results after sensor fusion. Front Sensing uses two cameras to perform obstacle avoidance and path planning. Drivetrain and Arm systems are described in their own architecture diagrams.

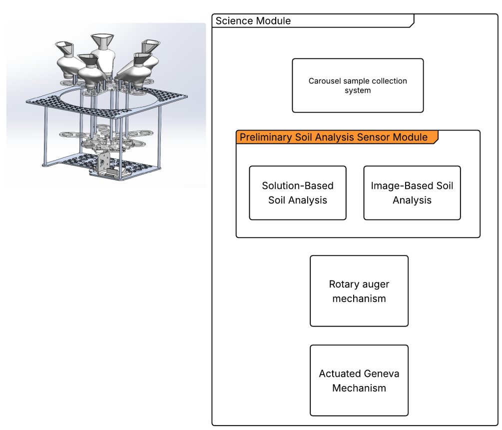

Figure 5. This figure presents the proposed science payload architecture. As the science module development is ongoing, this diagram represents our current preliminary design.