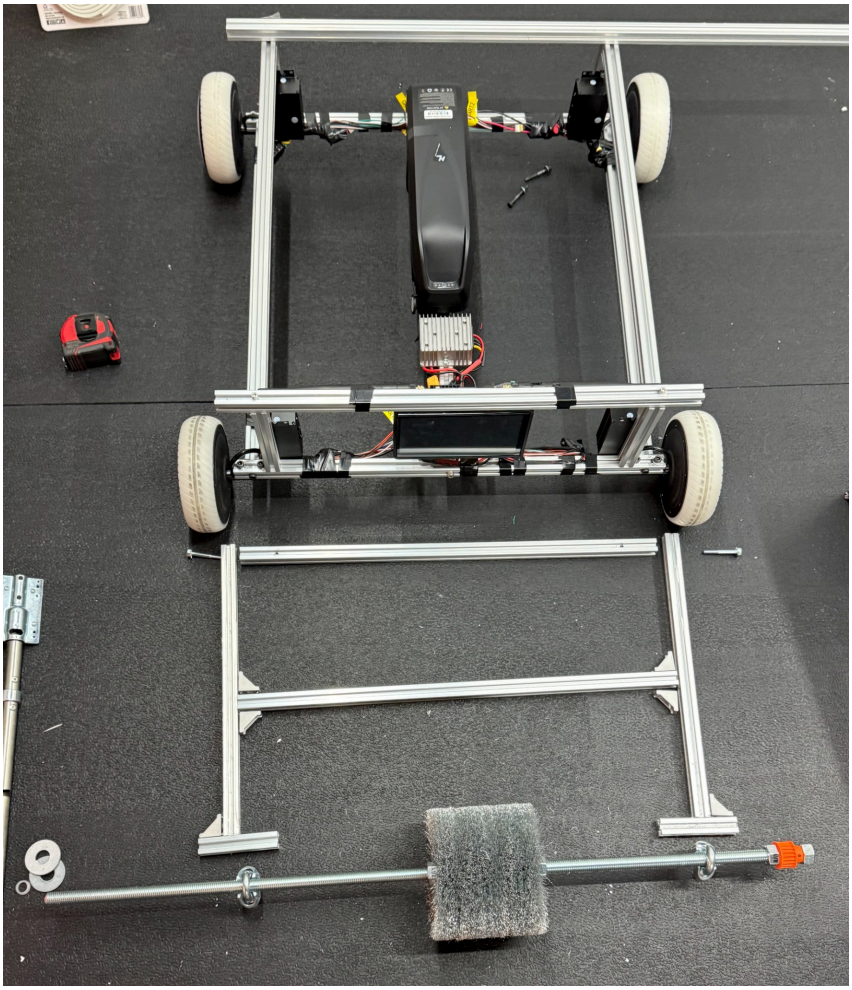
Technical Manual

BVR0

Base Vectoring Rover



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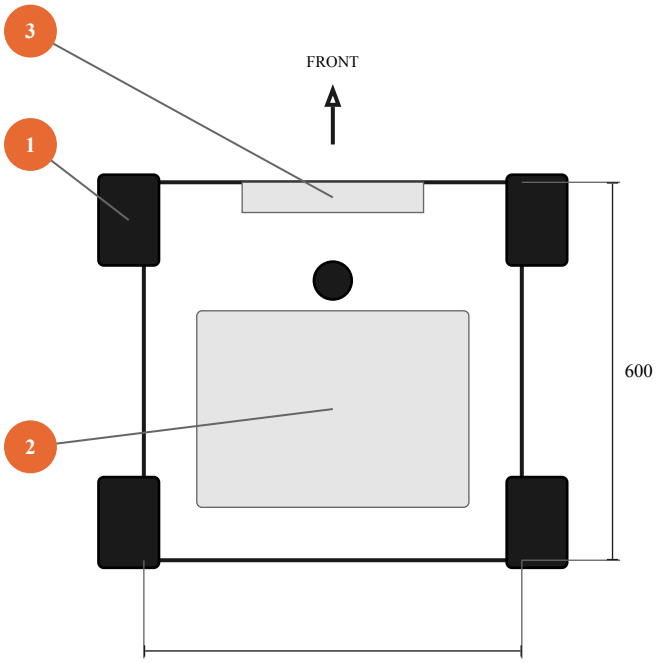
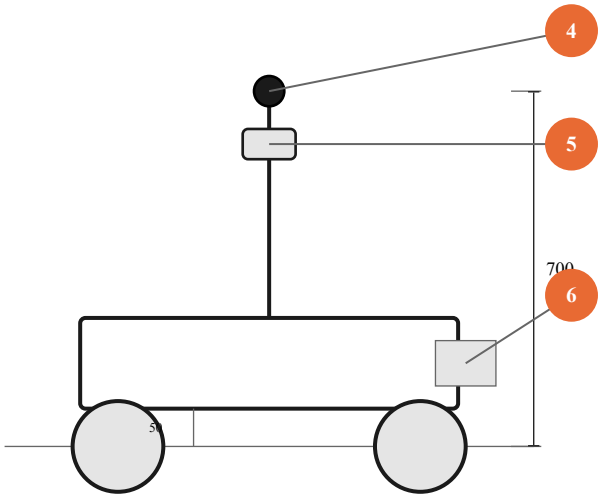
Contents

1 Overview



TOP VIEW



SIDE VIEW

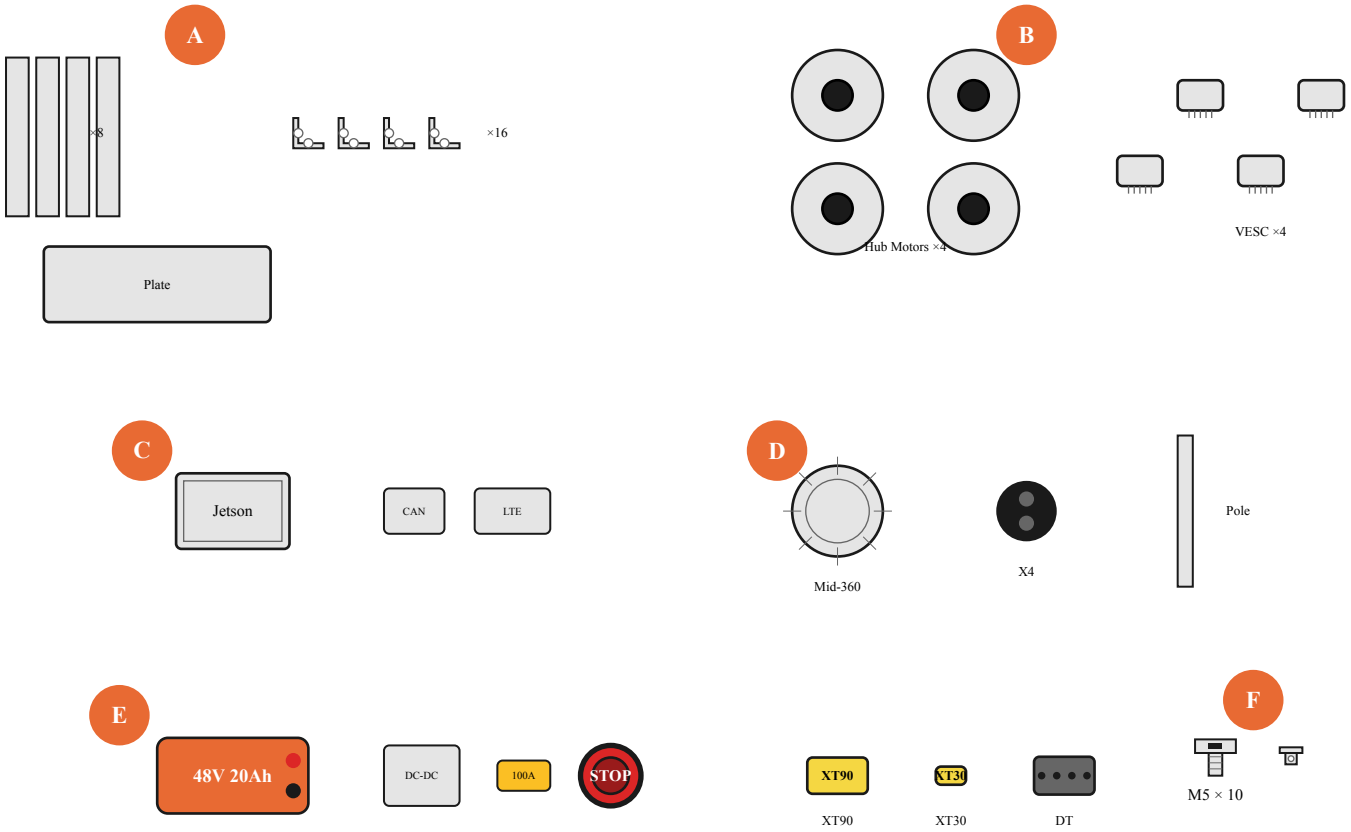
Components

1. Hub motor wheels (×4) — 350W each
2. Electronics bay — Jetson, VESCs, power
3. Tool mount — quick-attach interface
4. 360° camera — Insta360 X4
5. LiDAR — Livox Mid-360
6. Tool attachment point

Specifications

Dimensions	600 × 600 × 700 mm
Weight	30 kg with battery
Battery	48V 20Ah (960 Wh)
Motors	4× 350W hub motors
Speed	1.0–2.5 m/s
Runtime	4 hours
Temp range	−20°C to +40°C

2 Bill of Materials



Parts Key

A	Chassis: extrusions, brackets, plate	$150
B	Drivetrain: motors, VESCs, mounts	$800
C	Electronics: Jetson, CAN, LTE	$900
D	Perception: LiDAR, camera, pole	$1,800
E	Power: battery, DC-DC, fuse, E-stop	$400
F	Hardware: bolts, T-nuts, wire, connectors	$100

Cost Summary

Chassis	$150
Drivetrain	$800
Electronics	$900
Perception	$1,800
Power	$400
Hardware/Wiring	$100
Total	**$4,150**

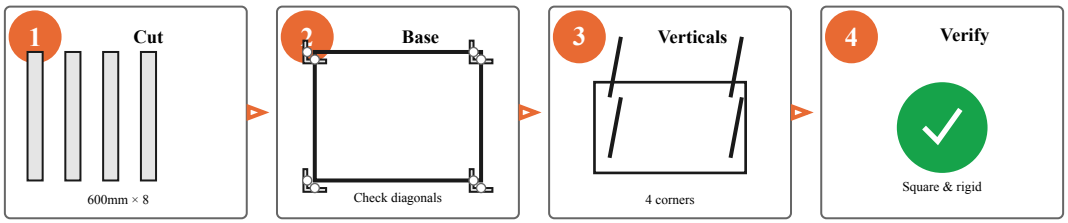
All parts commercially available. Custom fab limited to plate cutting.

3 Assembly

Required Tools

Hex Keys	Screwdriver	Wrenches	Multimeter	Torque
2.5, 3, 4, 5mm	Phillips 2	8, 10, 13mm	V / Ω / Cont.	All M5 bolts

3.1 Phase 1: Chassis Frame



3.2 Phase 2: Motor Mounting

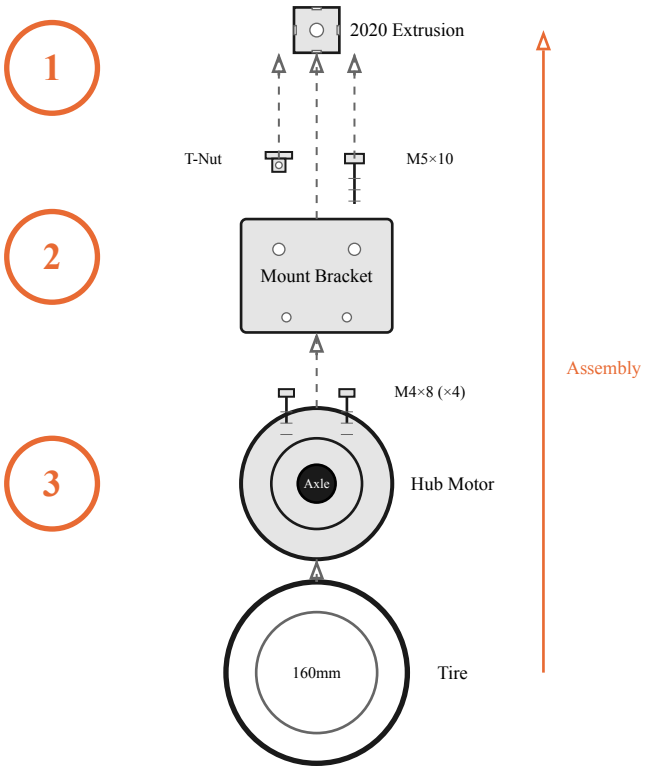


Figure 5: Exploded view: (1) Insert T-nuts into extrusion, (2) Bolt bracket to frame, (3) Attach motor and tire

3.3 Phase 3: Electronics Mounting

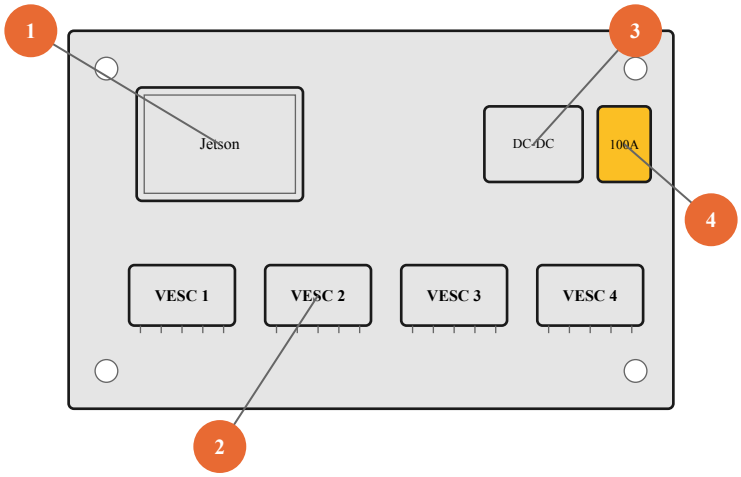


Figure 6: Electronics plate: (1) Jetson Orin NX, (2) VESC motor controllers, (3) DC-DC converter, (4) Main fuse

3.4 Phase 4: Wiring

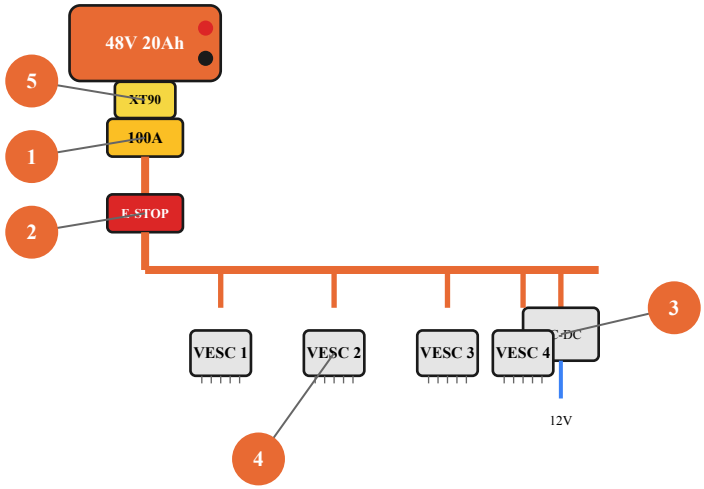


Figure 7: Power distribution: (1) Main fuse, (2) E-Stop relay, (3) DC-DC converter, (4) VESCs, (5) XT90 disconnect

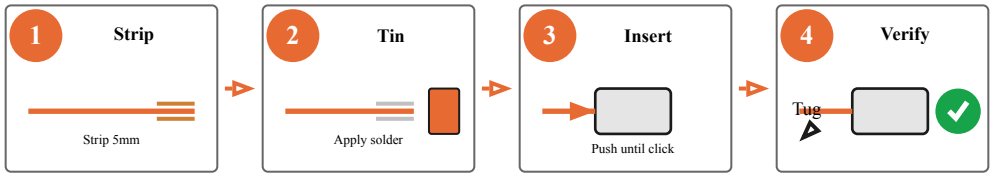
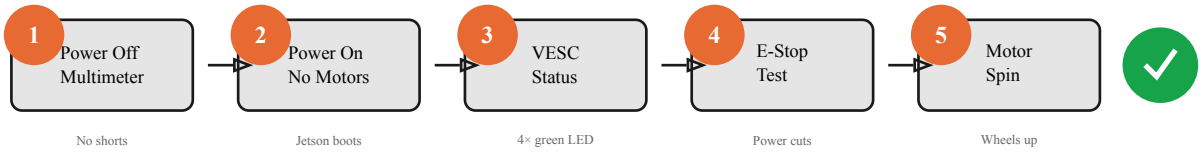


Figure 8: CAN wiring sequence: (1) Strip 5mm insulation, (2) Tin exposed wire, (3) Insert into JST connector, (4) Verify with gentle tug test

3.5 Phase 5: Testing



Quality Checklist

- [ ] All bolts torqued to 4 Nm
- [ ] No exposed wiring
- [ ] CAN bus termination verified
- [ ] E-Stop cuts power in 100ms
- [ ] All wheels spin freely
- [ ] Battery secure
- [ ] All connectors clicked
- [ ] Thermal management OK

4 Electrical System

The electrical system distributes power from the 48V battery to motors and electronics. This section details the power topology, CAN bus network, and connector pinouts.

4.1 Power Distribution

Power flows from the battery through a single 100A fuse, then splits to three subsystems: motor controllers (VESCs), emergency stop circuit, and DC-DC converter. The E-Stop relay can cut power to the VESCs while leaving the Jetson powered for diagnostics.

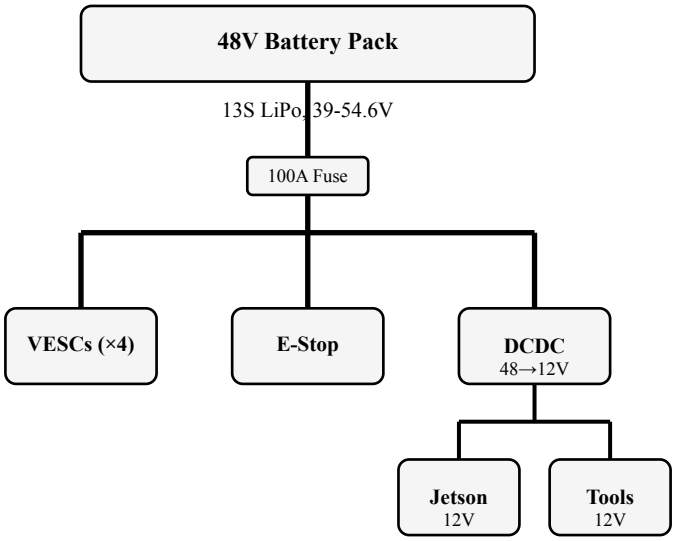


Figure 10: Power distribution from 48V battery to all subsystems

4.2 Main Components

Each component in the power system serves a specific protective or conversion function.

Component	Specification
Battery	13S4P Li-ion, 48V 20Ah with BMS
Main Fuse	100A ANL at battery positive
E-Stop	Normally closed contactor, cuts 48V to VESCs
DCDC	48V→12V, 20A for Jetson + accessories
VESCs	4× VESC 6, 60A continuous each

4.3 CAN Bus Topology

The CAN bus connects all motor controllers and the tool interface in a daisy chain. Each end of the bus requires a 120Ω termination resistor to prevent signal reflections.

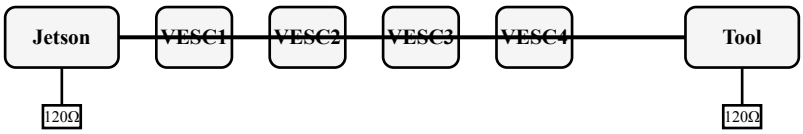


Figure 11: CAN bus daisy chain with 120Ω termination at each end

The CAN bus operates at 500 kbps using twisted pair wiring (CANH and CANL). Termination resistors are essential: without them, signal reflections cause communication errors.

4.4 Connectors

Standardized connectors enable quick assembly and field replacement.

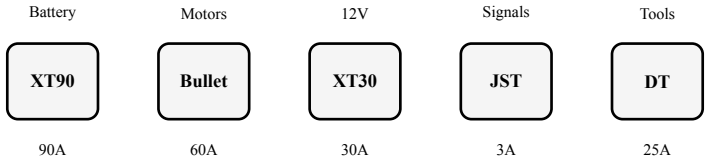


Figure 12: Connector types used throughout the rover

Connector	Use
XT90	Main battery power (90A rated)
5.5mm bullet	Motor phase wires (60A rated)
XT30	12V accessories (30A rated)
JST-XH	Sensors and buttons (signal level)
Deutsch DT06-6S	Tool interface (weatherproof)

4.5 VESC Configuration

Each VESC requires configuration via the VESC Tool software before first use. The CAN ID must be unique for each motor controller.

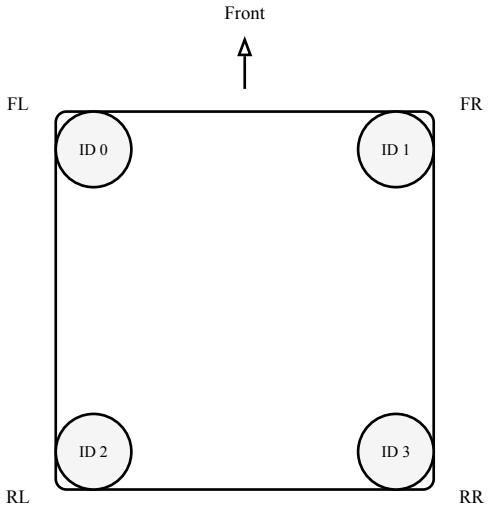


Figure 13: CAN ID assignment by wheel position

Setting	Value
Controller ID	0-3 (unique per VESC)
CAN Mode	VESC
CAN Baud Rate	CAN_500K
Send CAN Status	Enabled
CAN Status Rate	50 Hz

5 Operation

Operating the BVR0 requires completing startup procedures, understanding teleoperation controls, and following shutdown protocols. This section covers each phase of operation.

5.1 Startup Procedure

Startup follows a consistent sequence that verifies system health before enabling motor control.

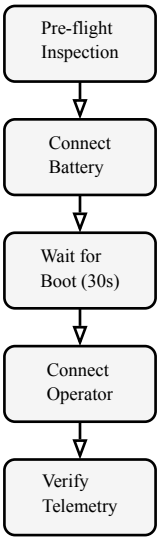


Figure 14: Startup sequence from inspection to operation

Pre-flight check: Before connecting power, verify the battery is charged (>40V), the E-Stop is not engaged, wheels are clear of obstructions, and the LTE antenna is connected.

Power on: Connect the battery via the XT90 connector. The Jetson will boot automatically, which takes approximately 30 seconds. The onboard display will show the dashboard when ready.

Connect operator station: Open the operator interface in a web browser and navigate to the rover's IP address. Verify the video feed is active and telemetry readings are nominal before commanding movement.

5.2 Teleoperation

The operator controls the rover through a web interface that displays video, telemetry, and control inputs.

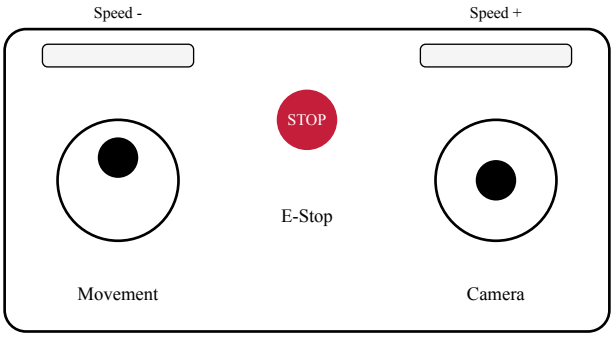


Figure 15: Gamepad control layout for teleoperation

The rover accepts input from keyboard (WASD), gamepad, or touchscreen. Movement commands map the left stick to forward/backward and rotation. The right stick pans the 360° camera view. Speed is adjusted with bumpers or scroll wheel.

5.2.1 Control Modes

Three control modes provide different levels of automation.

Mode	Description
Direct	1:1 joystick to motor control, no assistance
Assisted	Obstacle avoidance prevents collisions
Waypoint	Autonomous path following between points

5.3 Shutdown Procedure

Proper shutdown protects the electronics and battery.

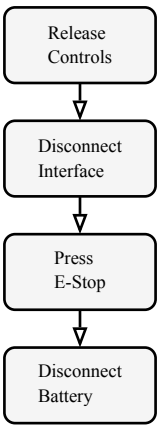


Figure 16: Shutdown sequence

Release all controls so the rover comes to a stop. Disconnect from the operator interface. Press the physical E-Stop button. Finally, disconnect the battery using the XT90 connector and store the rover in a dry location.

5.4 Tool Attachment

Tools connect via a quick-release mechanical mount and a Deutsch DT electrical connector.

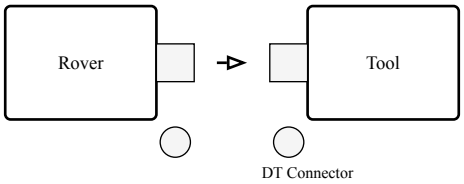


Figure 17: Tool attachment via quick-release mount and DT connector

Power off the rover before attaching tools. Align the tool mount with the front bracket and engage the quick-release latch. Connect the Deutsch DT connector for power and CAN communication. Power on and verify the tool appears in the dashboard.

6 Safety

The BVR0 is a powered machine capable of causing injury. This section covers safety protocols, hazard awareness, and emergency procedures.

> ⚠ **DANGER** This is a heavy, powered machine. It can cause serious injury if mishandled. Always maintain situational awareness when operating.

6.1 Hazard Awareness

Understanding potential hazards enables safe operation.

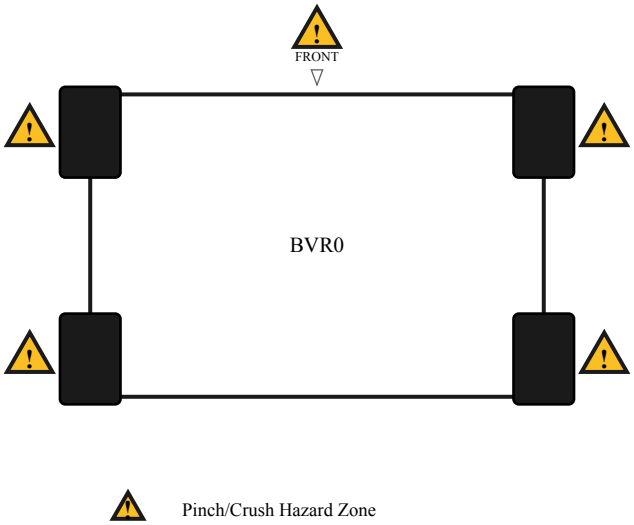


Figure 18: Hazard zones: wheel areas and tool mount require clearance during operation

Keep hands and feet clear of wheels and moving parts at all times. The hub motors can generate significant torque instantly. Never reach under the rover while it is powered.

6.2 Battery Safety

Lithium-ion batteries require careful handling to prevent fire or explosion.

> ⚠ **WARNING** Lithium-ion batteries can catch fire if damaged, overcharged, or short-circuited. Handle with care.

Figure 19: Battery handling requirements

Store batteries at room temperature (15-25°C). Never charge batteries unattended. Inspect for physical damage before each use. Do not expose to water or extreme temperatures. Use only the provided charger. Dispose of damaged batteries through proper recycling channels.

6.3 Emergency Stop

Multiple E-Stop mechanisms provide redundant safety.

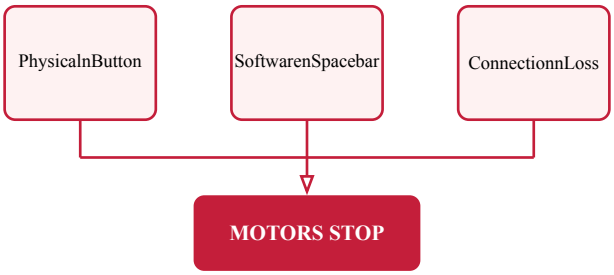


Figure 20: Three independent paths to emergency stop

The physical E-Stop button on the rover chassis immediately cuts power to all motors. The software E-Stop (spacebar in operator interface) sends a stop command over the network. If the network connection is lost for more than 2 seconds, the rover automatically stops.

> **i NOTE** To reset after E-Stop: identify and resolve the cause, twist or pull the physical button to release, reconnect the operator interface, and confirm the rover is ready in the dashboard.

6.4 Operating Conditions

Environmental limits ensure safe operation.

Condition	Limit
Temperature	−20°C to 40°C
Precipitation	Light rain/snow only
Wind	< 40 km/h
Visibility	Operator must see rover or camera feed

Do not operate on slopes exceeding 15%. Do not operate in standing water deeper than 50mm. Always maintain a clear line of sight or reliable video feed.

7 Maintenance

Regular maintenance ensures reliable operation and extends the life of components. This section covers inspection schedules, maintenance procedures, and troubleshooting.

7.1 Regular Inspection

Perform these checks before each operation.

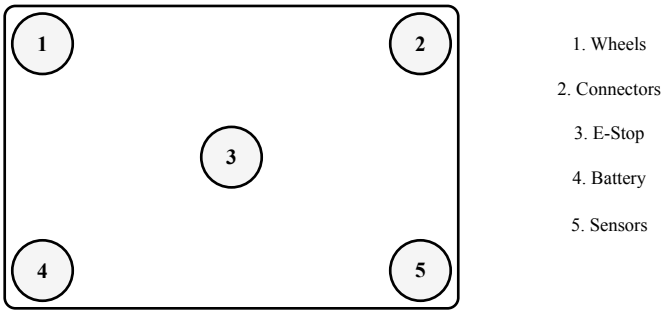


Figure 21: Pre-operation inspection points

- [ ] Battery voltage > 40V
- [ ] No visible damage to chassis or wheels
- [ ] All connectors secure
- [ ] Wheels spin freely
- [ ] E-Stop button functions
- [ ] Sensors clean and unobstructed

7.2 Periodic Maintenance

Scheduled maintenance prevents failures and catches wear before it becomes critical.

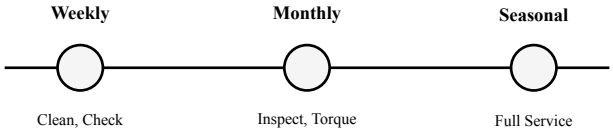


Figure 22: Maintenance schedule intervals

Weekly: Clean debris from wheels and chassis. Wipe camera lenses. Check CAN bus connections. Verify LTE signal strength at operating locations.

Monthly: Inspect wiring for chafing or wear. Check bolt torque on motor mounts. Clean battery contacts. Update firmware if available.

Seasonal: Perform full electrical inspection. Check bearings on hub motors. Replace worn cables or connectors. Calibrate sensors if needed.

7.3 Storage

Proper storage protects the battery and electronics during periods of non-use.

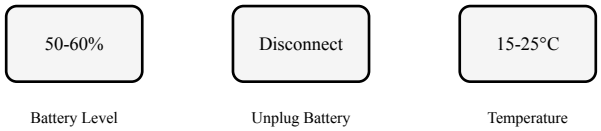


Figure 23: Storage preparation requirements

For extended storage (>2 weeks): charge the battery to 50-60% (storage charge), disconnect the battery from the rover, store in a dry location at 15-25°C, cover to protect from dust, and check battery monthly to top up if below 40%.

7.4 Troubleshooting

Common issues and their solutions.

Symptom	Solution
Rover won’t power on	Check battery connection, verify fuse
No video feed	Check LTE connection, verify camera USB
Motor not responding	Check CAN wiring, verify VESC ID
E-Stop won’t release	Check relay wiring, verify button not stuck
Poor LTE signal	Relocate antenna, check SIM data plan
Erratic movement	Verify VESC IDs match wheel positions

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