R-BOX · VEHICLE-MOUNTED MEASUREMENT UNIT

R-Box Measurement Unit

Multi-source capture · Unified time base · Fault injection · Tamper-evident

Datasheet v1.0 · 2026-11 · Competition / dual-vehicle coordination / simulation replay / education

R-Box is a vehicle-mounted measurement black box that operates independently of the competing vehicle. It maintains a unified time base under GNSS denial and constrained communications, records multi-source sensors, vehicle state, coordination links and fault events, and retains ACK receipts for standardized fault commands. The goal is not to collect more data, but to make every evaluation result reproducible, auditable and citable.

> Status: five EVT units built; in-vehicle capture and R-Eval integration verified. Specifications below are design targets. Production is subject to DVT and 60-unit pilot validation; unmarked figures still require bench and field confirmation.

01 Core capabilities

Capability	Description
Unified time base	IEEE 1588-v2 PTP with PHC hardware timestamping; GNSS 1PPS disciplining; ≤1 ms device-to-device target
Fault injection	Standardized commands: vision loss / perception noise / frame drop / localization drift; logs command, ACK and start/end times
Tamper-evident	Physical seal and removal audit log; competition-mode logic lock; controlled firmware and configuration
Multi-dimensional capture	7 mandatory dimensions + 21 optional, enabled per scenario; samples and events share one store
Local storage	≥512 GB NVMe (1 TB recommended) + microSD fallback; current sector flushed on power loss
Real-time uplink	Wi-Fi 6 / GbE; continuous local recording during outages; resumable upload with idempotent dedup

02 Acquisition dimensions

Seven dimensions are mandatory (radiation may be marked N/A for ground scenarios); the rest are enabled per scenario. Competition and dual-vehicle scenarios enable all by default.

Category	Content	Rate / trigger
Mandatory 7	Temperature, pressure, gravity/acceleration, radiation, power, device health, link latency	≥1 Hz (accel ≥100 Hz)
Vision / point cloud	Global-shutter cameras (front / surround); LiDAR (optional)	30 fps / 10 Hz
Inertial / position	Angular rate, attitude, wheel speed, RTK position, heading	≥100 Hz
Actuators / battery	Motor current, voltage, temperature; battery voltage / current / temperature	≥10 Hz
Compute / safety	NPU / GPU load, memory, power mode, e-stop and watchdog state	1 Hz / event
Coordination / task	Teammate ID, role, distance, relative speed, packet loss; VLA tasks and voice quota	event / ≥1 Hz

03 Technical specifications

Item	Specification (target)
Compute	RK3588 EVT; Linux 5.10; single C++20 business process
Time sync	IEEE 1588-v2 PTP / PHC; GNSS 1PPS; ≤1 ms device-to-device; sub-microsecond hardware timestamp target
Storage	≥512 GB NVMe (1 TB recommended) + microSD fallback; supercapacitor power-loss protection
Network	Wi-Fi 6 (2.4 / 5 GHz), optional 4G / 5G; GbE; USB 3.0
Power	9–36 V DC; ≤5 W typical; reverse / overvoltage / surge / overcurrent protection
Size / weight	≤150 × 100 × 50 mm (excl. connectors and antennas); ≤400 g (incl. enclosure and connectors)
Environment	−20 to +65 °C (competition target); IP54; 50 mm / 10 s shallow-water crossing
Concurrency	≥8 units uploading on one timeline; ≥16 units registered
Protocol	rbox.telemetry.v1 (Protobuf); CSV / JSON export for third-party analysis

04 Interfaces

Category	Interface
Sensors	I2C / SPI / UART / isolated RS-485 / CAN 2.0B
Vision	MIPI CSI-2 ×2; GMSL ×2 (optional)
Point cloud	GbE
Vehicle bus	CAN / CAN-FD / GbE / RS-232
Position & time	Dual-band RTK SMA; PTP Ethernet; 1PPS in/out; GNSS antenna
Storage	NVMe M.2 / microSD
Power	9–36 V DC input, independent fuse
Expansion	R-Link: fault-injection control, telemetry, VLA logs
Safety	Remote e-stop input; e-stop dry contact output; hardware watchdog

05 Fault injection and scoring chain

- 1. R-Box receives or issues a standardized fault command and logs the UTC timestamp.
- 2. The vehicle returns an ACK; no receipt is recorded as “unconfirmed”.
- 3. The fault takes effect; start/end time, category, intensity and target unit are logged.
- 4. The vehicle degrades or compensates; events and coordination data enter the log.
- 5. R-Eval computes CRI sub-scores from ACK, timing and coordination behavior.

> Competition rules V4.2: without an ACK, or if the vehicle receives the ACK but bypasses the fault command, the coordination score at that checkpoint is zero. R-Box ACK records are the key evidence for CRI.

06 Status and boundaries

Item	Status
EVT units	5 built; in-vehicle capture and R-Eval integration verified
Pending DVT	≤1 ms sync, 72 h continuous run, 8-unit concurrency, IP54 shallow water, EMC
Production	60-unit pilot validation before delivery
Role	Measurement and evidence device; does not replace judges
Compliance	Data pseudonymization and authorization; cross-border transfer assessed per local law

Contact: info@r-power.hk · r-power.hk · R-Power Technologies Limited (Reg. No. 79936367)