ALEC for Electric Vehicles & Automotive

Edge Compression for Telemetry, BMS, OTA & Connected Car Platforms

The Challenge: The Connected Car Data Explosion

A modern electric vehicle generates 25 TB of data per day from cameras, LiDAR, radar, BMS, and hundreds of embedded sensors. Yet only a fraction reaches the cloud -- limited by cellular bandwidth costs, OTA update windows, and edge processing constraints.

Battery Management Systems (BMS) alone produce continuous streams of cell voltage, temperature, current, and State of Charge data across thousands of cells. Transmitting this raw data for fleet-wide analytics is prohibitively expensive. Traditional compression fails on these small, streaming sensor messages -- gzip actually increases payload size on typical 24-byte readings.

80-95%	2 KB	<1 ms	Per-msg
Data Reduction	RAM per Sensor	Encode Latency	Real-time Stream

How ALEC Solves This

ALEC uses an evolving shared context between encoder (in-vehicle) and decoder (cloud/edge) to achieve streaming compression on every individual message. No batching, no buffering -- real-time data flow with 80-95% size reduction.

Capability	Automotive / EV Benefit
Streaming compression (per-message)	Real-time BMS telemetry, OBD-II diagnostics, and CAN bus data without buffering delays
80-95% data reduction	5-10x reduction in cellular data costs for fleet telematics; more data per OTA window
2 KB RAM, <1ms latency	Runs on automotive-grade MCUs (Cortex-M, Infineon AURIX, NXP S32) -- no additional hardware
Priority tagging (P1-P5)	Safety-critical alerts (thermal runaway, brake failure) always transmitted first; routine telemetry compressed and batched
Evolving context learning	Adapts to each vehicle's unique sensor patterns -- better compression over time
Rust implementation, C bindings	Memory-safe, MISRA-compatible integration path; no garbage collector, no runtime

Automotive & EV Use Cases

Application	Data Types	ALEC Impact
Battery Management (BMS)	Cell voltage, temperature, current, SoC, SoH	Continuous fleet-wide battery health monitoring at 1/10th the data cost
OTA Updates & Diagnostics	Firmware diff, DTC codes, ECU logs	Smaller update packages; faster rollout; reduced cellular costs
Fleet Telemetry	GPS, speed, acceleration, energy consumption	10x more vehicles monitored per data plan; real-time fleet optimization
Predictive Maintenance	Vibration, motor temp, inverter data, brake wear	Edge-compressed sensor streams enable CBM without cloud dependency
Connected Car Services	Infotainment telemetry, driver behaviour, ADAS events	Richer data for insurance, navigation, and personalization at lower bandwidth
V2X Communication	Vehicle-to-vehicle/infrastructure messages	Compress safety messages for congested V2X channels

Focus: Battery Management System Optimization

A typical EV battery pack has 96-400+ cells, each monitored for voltage, temperature, and current. At 1 Hz sampling, a 96-cell pack generates 17 MB/day of raw BMS data. For a fleet of 10,000 vehicles, that is 170 TB/day.

ALEC reduces this to 1.7-3.4 TB/day while preserving full resolution -- enabling fleet-wide battery health analytics, degradation modelling, and thermal runaway prediction that would otherwise be economically impossible.

Metric	Without ALEC	With ALEC
Data per vehicle/day	17 MB (96-cell pack)	1.7 MB (90% reduction)
Fleet data (10K vehicles)	170 TB/day	17 TB/day
Cellular cost/vehicle/month	$15-25 (data plan)	$1.50-5.00
Battery anomaly detection	Cloud-only, delayed	Edge + Cloud, real-time
Cell-level granularity	Sampled / averaged	Full resolution preserved

ALEC + Complexity: Predictive Battery Intelligence

Combined with ALEC Complexity (Quantitative Complexity Theory), the platform detects anomalous battery degradation patterns, thermal precursors, and cell imbalances 70% earlier than threshold-based BMS alerts. The Complexity module works directly on compressed data streams -- no additional bandwidth required.

Integration & Compatibility

Integration Point	Details
Automotive MCUs	C bindings for ARM Cortex-M/R, Infineon AURIX, NXP S32K/S32G, Renesas RH850
Communication protocols	CAN bus, LIN, Ethernet, cellular (4G/5G), V2X (C-V2X, DSRC)
Telematics / T-Box	Integrates into existing TCU firmware for compressed cloud upload
Cloud decoders	Linux/Windows server-side SDK; REST API available
Evaluation SDK	Available on crates.io (Rust) + C/C++ bindings; 160+ test suite

Why ALEC vs. Traditional Compression

	Traditional (gzip/LZ4)	ALEC Codec
24-byte BMS reading	44 bytes (+83% LARGER)	4 bytes (-83%)
Streaming mode	Fails -- expands data	Native per-message
Automotive MCU fit	32+ KB RAM minimum	2 KB RAM
Learning sensor patterns	No	Yes -- evolving context
Safety priority routing	No	P1-P5 built-in
MISRA-compatible path	C library, complex deps	Rust + C bindings, minimal deps

Ready to Evaluate ALEC for Your Vehicles?

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