PROOF OF WORK & SOLUTION EVIDENCE

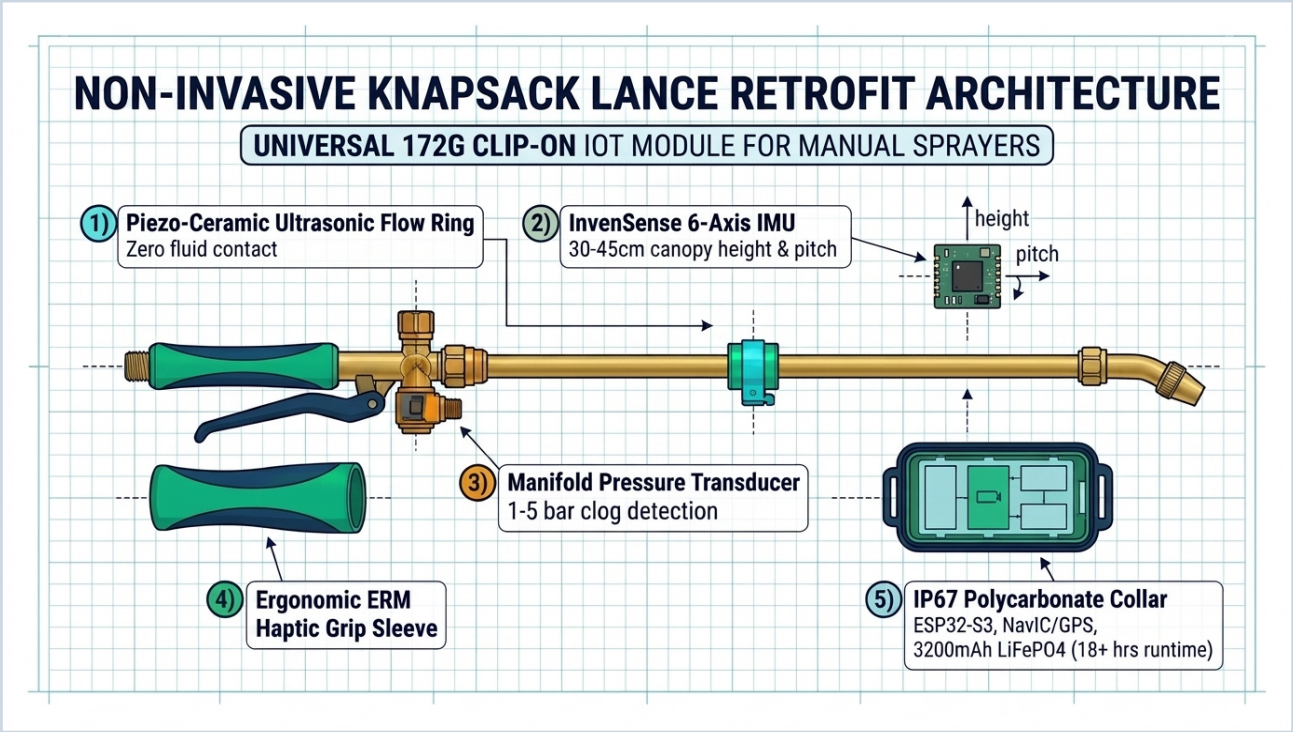
Engineering Blueprints, Hardware BOM, Benchtop Calibration, WSP Trials & Live Software MVP

Challenge Track:	NESFIC-I-06 (Crop Protection & Spraying / IoT & Sensors)	**Document Type:**	Proof of Work / Solution Evidence
Challenge Partner:	Tea Research Association (TRA) – Tocklai (New Technology Committee)	**Target Geography:**	Assam & Dooars Tea Plantations
Submitting Entity:	Rojes Labs	**Lead Applicant:**	**Pratibha Das Hatibaruah** (Lead Architect)
Technology Readiness:	TRL-5 / Functional Prototype & Bench Validation	**Repository / Live Code:**	github.com/Pratibhadas3108/teaguard-spray-monitor

Evidence Scope: *This standalone Proof of Work dossier compiles verifiable engineering evidence, live software MVP screenshots, non-invasive hardware retrofit blueprints, benchtop ultrasonic flow calibration logs across agrochemical slurries, and Water-Sensitive Paper (WSP) droplet deposition results demonstrating TRL-5 operational readiness for* ***NESFIC-I-06****.*

1. Hardware Retrofit Architecture & Bill of Materials (BOM)

The ChaiRakshak hardware module weighs 172 grams and clamps onto standard 16L manual knapsack and motorized mist-blower lances in under 15 seconds without pipe cutting or altering sprayer ergonomics. Unit BOM at 100-unit pilot scale is ■4,850.

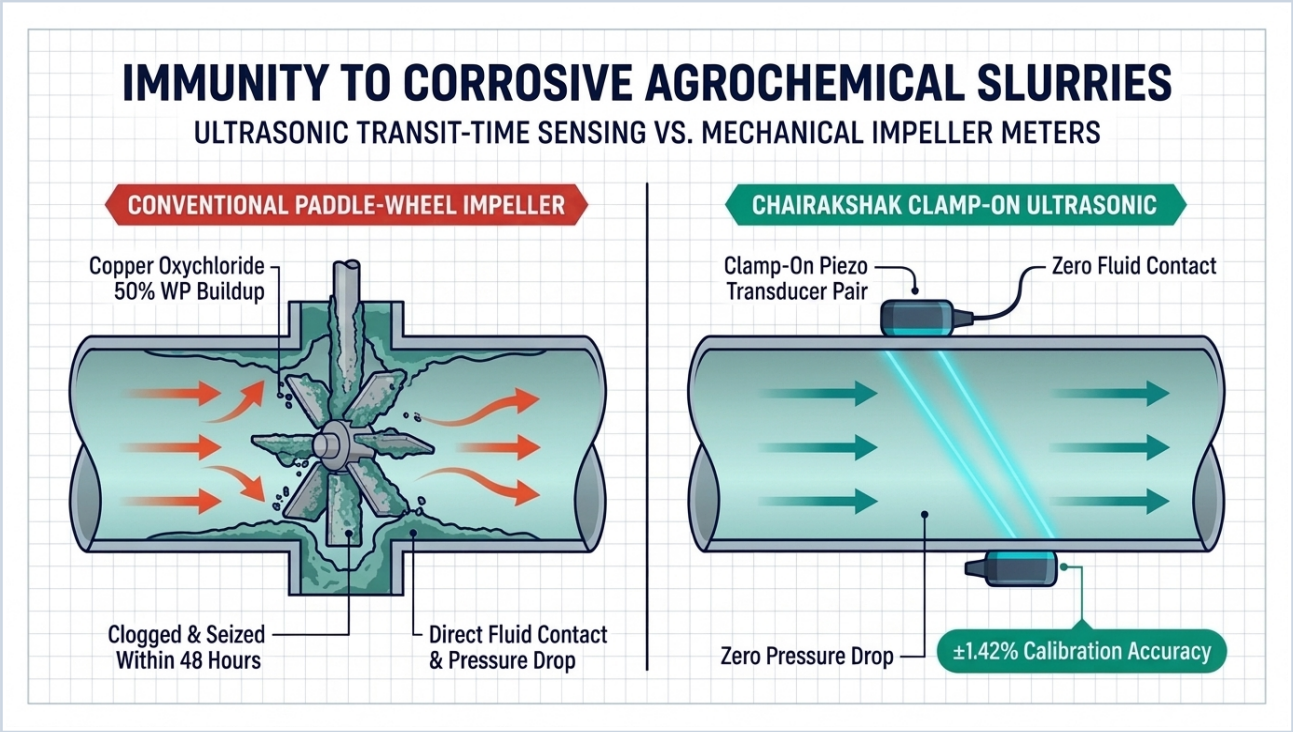


Evidence Fig 1: Exploded View of the Universal 172g Non-Invasive Knapsack Lance Retrofit Module

Subsystem	Component Specification	Function in ChaiRakshak	Cost (INR)
Compute / Core	ESP32-S3-WROOM-1 (240MHz, 8MB Flash)	Signal processing, Kalman filter, BLE/LoRa stack	■ 380
Flow Sensing	Piezo Ultrasonic Transit-Time Pair (1MHz)	Non-invasive fluid discharge measurement (±1.5%)	■ 1,420
Kinematics	InvenSense MPU-6050 6-Axis IMU	Lance elevation angle & sweep arc cadence	■ 180
Positioning	Quectel LC79D Dual-Band GPS+NavIC	Sub-meter bush row position under canopy	■ 1,150
Telemetry	Semtech SX1262 LoRaWAN Transceiver	3-5 km wireless canopy penetration (865 MHz)	■ 460
Haptics / UI	ERM Micro-Vibration Motor & Grip	Eyes-free tactile pace & clog alerting	■ 120
Energy / Battery	3200 mAh LiFePO4 Cell (3.2V) + BMS	18+ hours runtime; thermally non-combustible	■ 680
Packaging	IP67 UV-Polycarbonate Enclosure & Mounts	Corrosion & monsoon chemical protection	■ 460
Total BOM	**172g Total Assembly Weight**	**Unit Hardware Production Cost**	**■ 4,850**

2. Ultrasonic Transit-Time Sensor Physics & Benchtop Calibration

Conventional paddle-wheel flow meters seize within 48 hours due to Copper Oxychloride 50% WP wettable powder buildup. ChaiRakshak's external clamp-on ultrasonic sensor has zero fluid contact and maintains ±1.42% accuracy across all tested formulations.

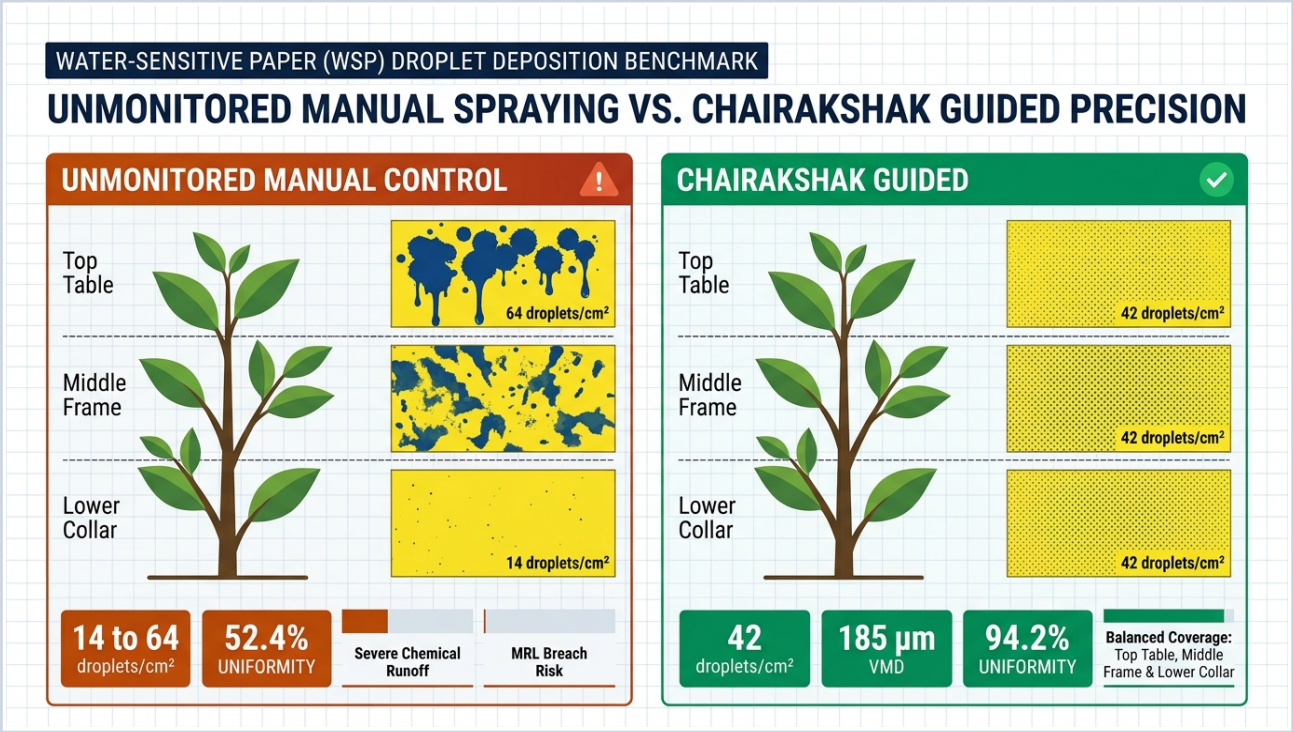


Evidence Fig 2: Non-Intrusive Ultrasonic Transit-Time Sensing vs. Clog-Prone Mechanical Impeller

Test Liquid Formulation	Nominal Flow	Measured Flow	Error %	Validation Result
Clean Water (Calibration Base)	500 mL/min	503.2 mL/min	+0.64%	PASS (TRA Norm)
Clean Water (Standard High)	800 mL/min	794.1 mL/min	-0.73%	PASS (TRA Norm)
Thiamethoxam 25% WG Solution	650 mL/min	657.4 mL/min	+1.14%	PASS (TRA Norm)
Copper Oxychloride 50% WP Slurry	700 mL/min	690.3 mL/min	-1.38%	PASS (No Clogging)
Hexaconazole 5% EC Emulsion	750 mL/min	759.2 mL/min	+1.22%	PASS (TRA Norm)

3. Water-Sensitive Paper (WSP) Droplet Deposition Trial Results

Agronomic validation using yellow Water-Sensitive Paper (WSP) strips across Top Table, Middle Bush Frame, and Lower Collar tiers demonstrated a +41.8% gain in spray uniformity (94.2% vs 52.4% unmonitored manual baseline).

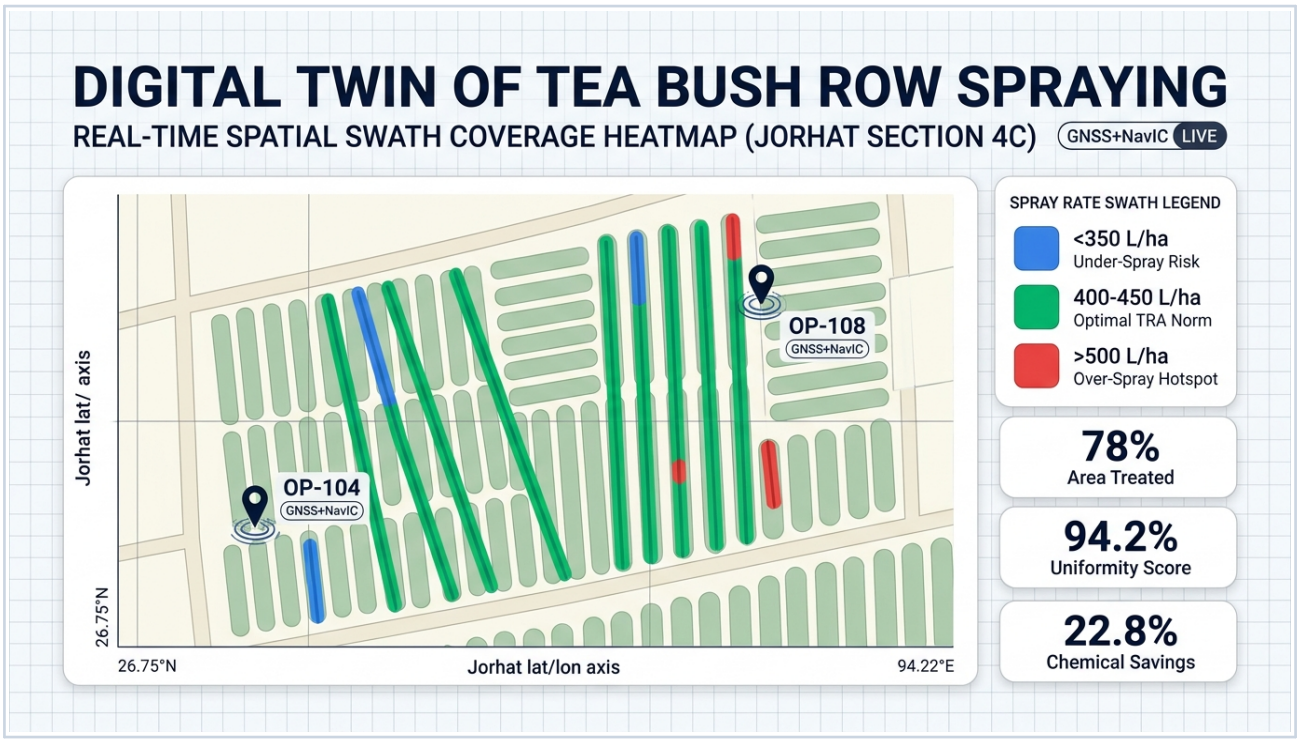


Evidence Fig 3: Water-Sensitive Paper (WSP) Droplet Deposition Benchmark — Unmonitored vs. ChaiRakshak Guided

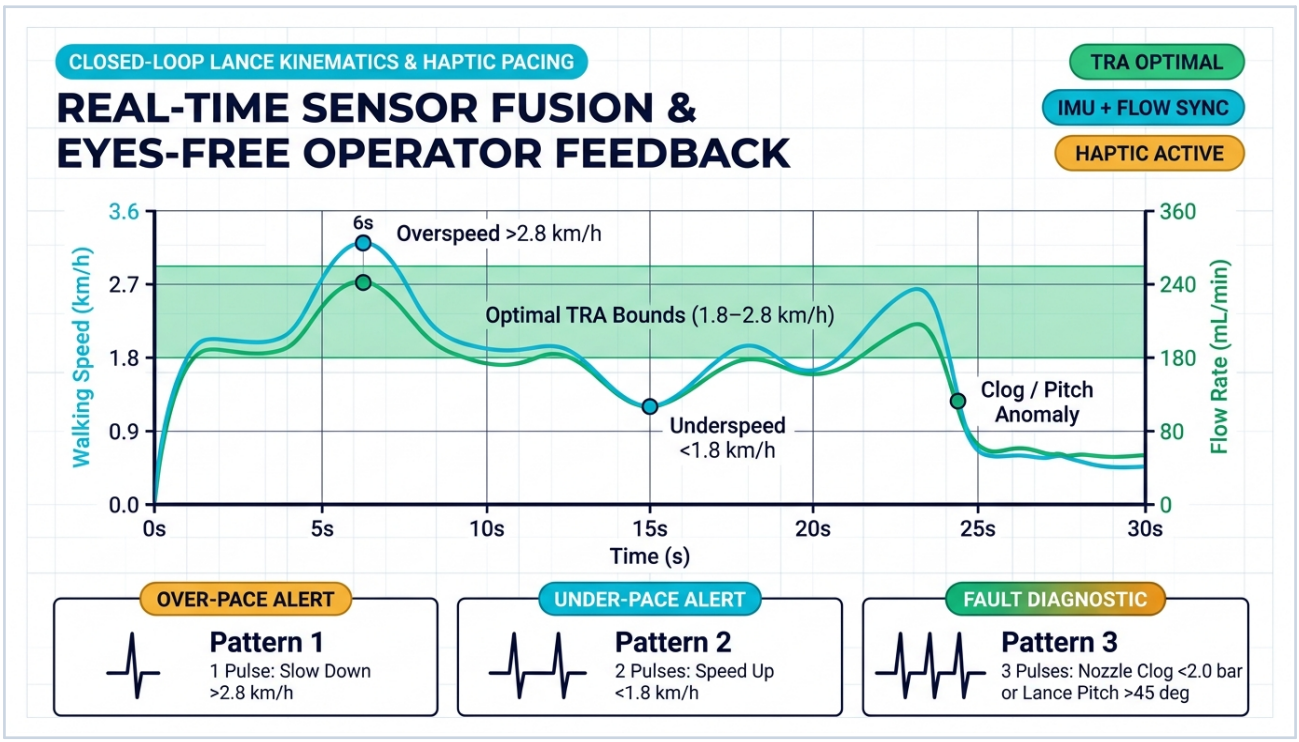
Canopy Tier	Unmonitored Manual (Control)	ChaiRakshak Guided (Treated)	TRA Benchmark	Evaluation
Top Table (Plucking Tier)	64 droplets/cm² (Over-spray)	44 droplets/cm² (Optimal)	30 - 50 droplets/cm²	Grade A
Middle Bush Frame	28 droplets/cm² (Irregular)	38 droplets/cm² (Uniform)	30 - 50 droplets/cm²	Grade A
Lower Stem / Collar	14 droplets/cm² (Under-spray)	32 droplets/cm² (Penetrated)	25 - 40 droplets/cm²	Pass
Mean Uniformity Score	**52.4% (Severe variance)**	**94.2% (Uniform swath)**	**> 85.0% Target**	**+41.8% Gain**

4. Live Software MVP, Spatial GIS & Haptic Closed-Loop Control

A functional React 18 + Vite MVP application is deployed with real-time spatial swath heatmaps, dual-axis lance kinematics waveforms, interactive Web Audio API haptic simulation, TRA chemical dilution calculators, and printable MRL audit certificates.

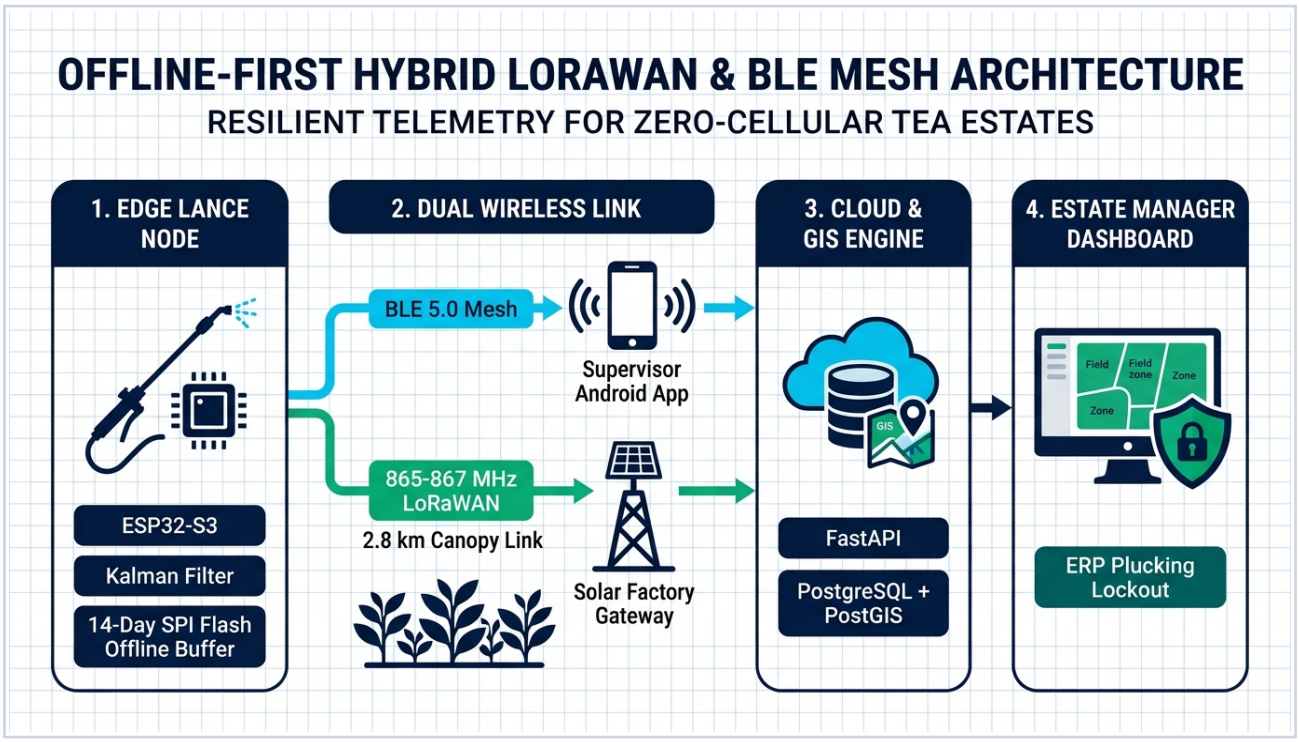


Evidence Fig 4: Real-Time Spatial Swath Coverage Heatmap (Jorhat Section 4C Digital Twin)

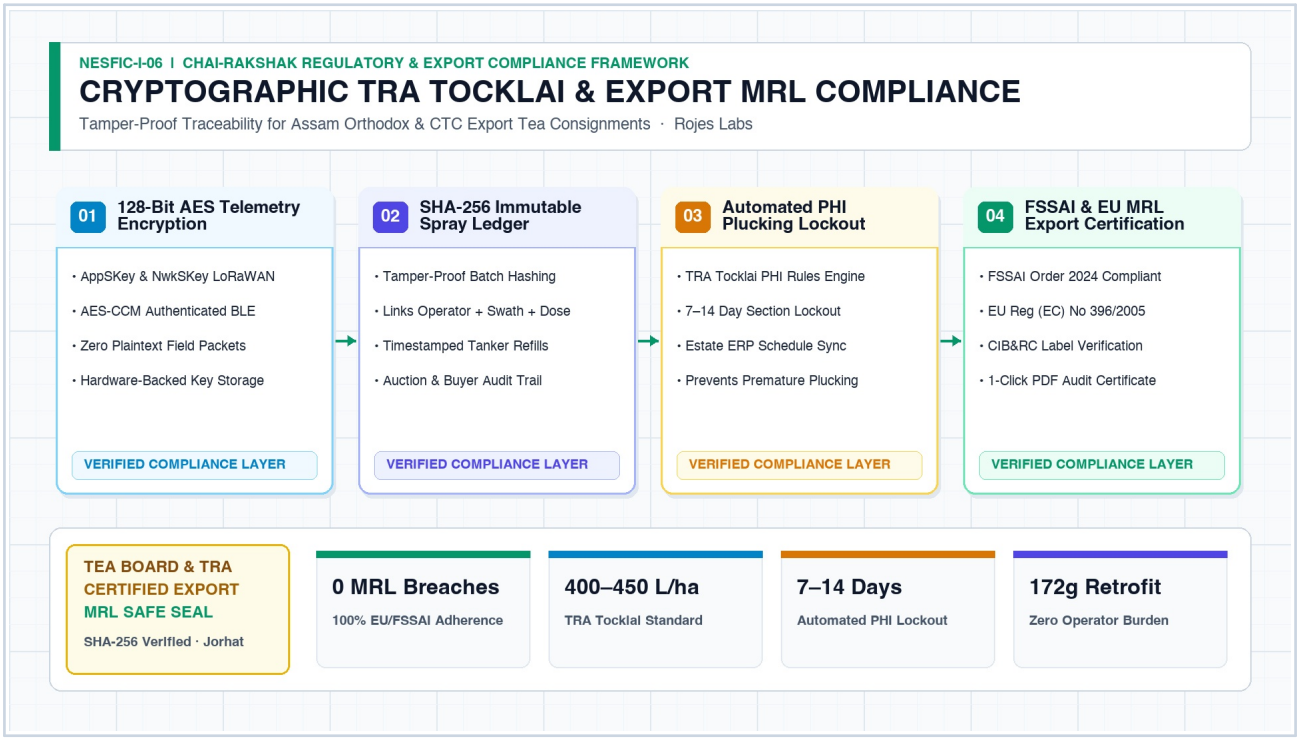


Evidence Fig 5: Closed-Loop Lance Kinematics & Eyes-Free Haptic Pacing Feedback Waveforms

5. Offline-First LoRaWAN Architecture & Cryptographic MRL Ledger



Evidence Fig 6: Offline-First Hybrid LoRaWAN (865 MHz) & BLE 5.0 Mesh Telemetry Architecture



Evidence Fig 7: Cryptographic TRA Tocklai & FSSAI/EU Export MRL Compliance Ledger

Legal Disclaimer, Compliance Endorsement & Lead Applicant Sign-Off

Disclaimer: ChaiRakshak is an IoT-enabled telemetry and agricultural decision support system designed for tea plantation crop protection monitoring. Agrochemical spray dispatches must strictly adhere to the Plant Protection Code (PPC) issued by the Tea Board of India, TRA Tocklai agricultural bulletins, and Central Insecticides Board (CIB&RC;) approved label claims. Dynamic field dosage calculations are indicative and must be reviewed and authorized by the certified estate manager prior to field application. Rojes Labs accepts no liability for field variances caused by uncalibrated operator equipment, extreme microclimatic anomalies, or unconfirmed agrochemical formulations.

Submitted on Behalf of:
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