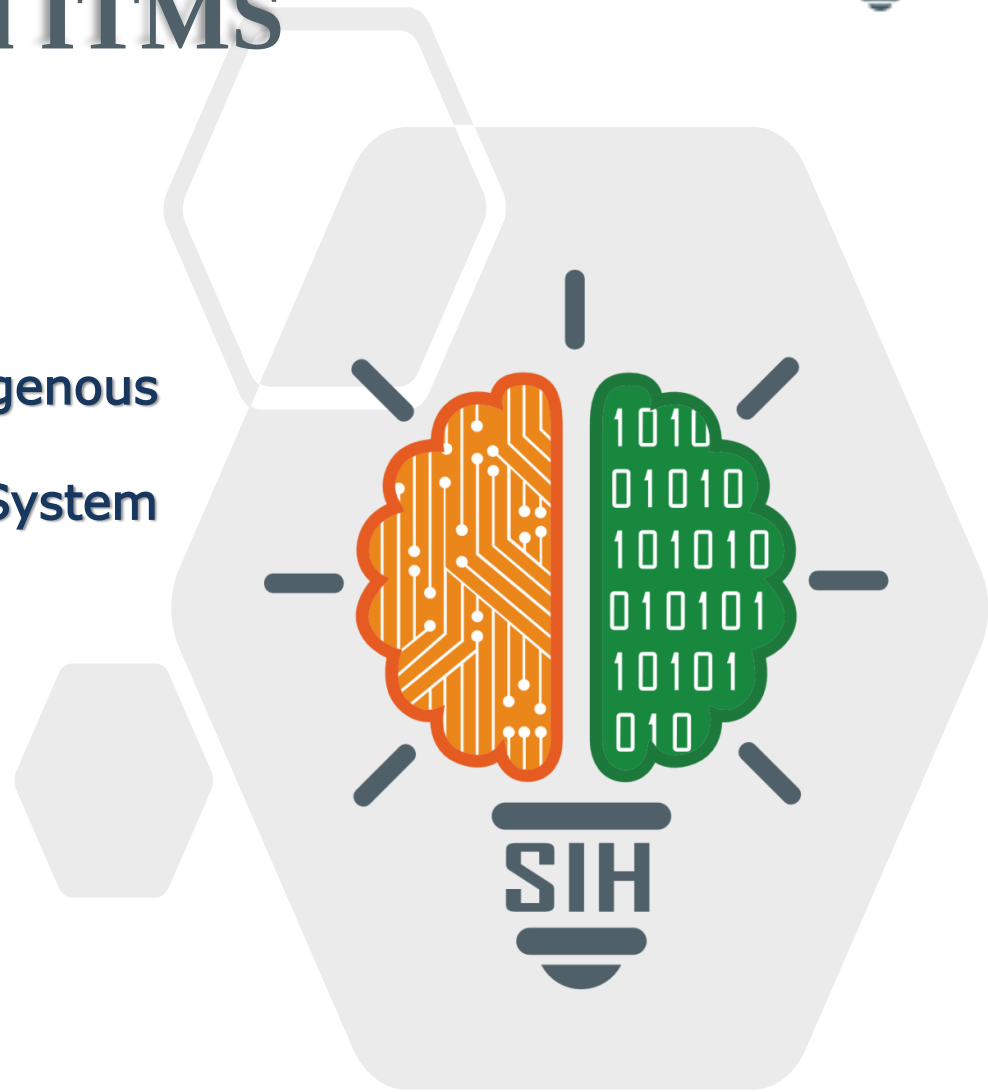
SMART INDIA HACKATHON 2025

Smart Rail ITMS

- Problem Statement ID – SIH25020
- Problem Statement Title- Development of indigenous contactless Integrated Track Monitoring System (ITMS) for Track Recording on Indian Railways
- Theme- Smart Automation
- PS Category- Hardware
- Team Name – Sparkz Plugs
- Team ID – 96932



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Proposed Solution:

*We propose A **Contact less integrated Track Monitoring System(ITMS) - Smart Rail***

- *Continuous real-time monitoring*
- *Portable & cost effective*
- *High accuracy with Sensor Fusion*
- *Early Fault detection & predictive maintenance*

How it Addresses the Problem:

- *Turns **every regular train into a moving track inspectors** instead of TRC that runs each month.*
- *Scans the rails for cracks , geometry faults and hidden defects at **full speed** working effectively at **day and night , even rain , fogs***
- ***Major defects are detected instantly** by the onboard computer , and complete data is securely transmitted to GSM*
- *Gives railway team **a clear , near real time picture of track health at 25-cm Sampling interval** , cutting accident , risks and maintenance costs*

Innovation & Uniqueness:

Golden reference calibration:

- *It first records the track data when the track is perfectly healthy . It is named as "Golden Reference"*
- *Every live reading is compared with this "Golden Reference" to spot even tiny changes.*

Edge Processing(Edge PC+ AI):

- *The comparison process of these reading is done onboard using AI/ML model.*
- *As soon as the system detects a difference , its marked as an defect and immediately alerts the railway engineers.*

Modular & Scalable Design:

- *Compact plug-and-play kit that can be **mounted on any passenger or goods train***

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TECHNICAL APPROACH

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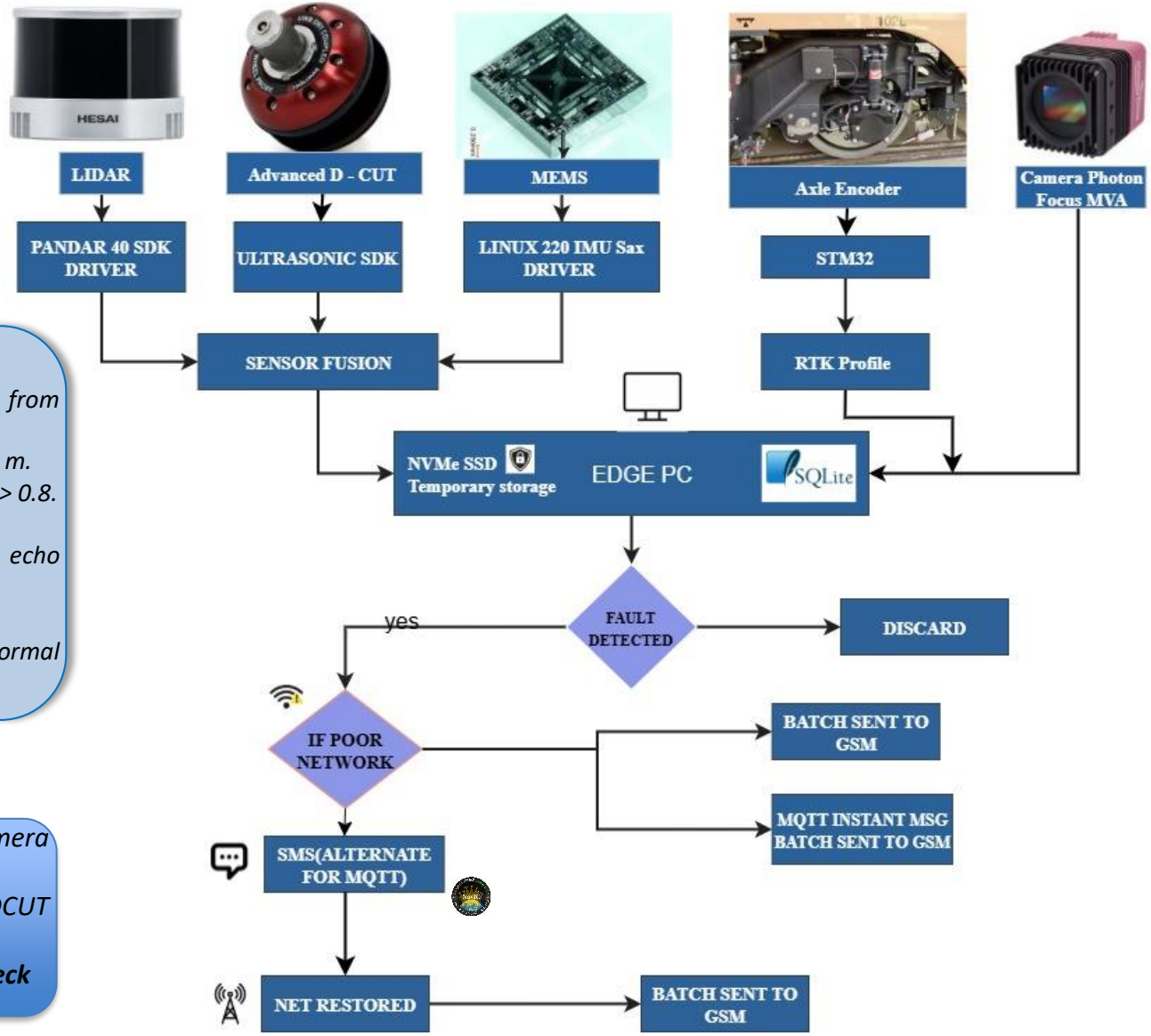

Rules:

Per-sensor thresholds :

- **Gauge deviation (LiDAR)** *> ±6 mm from golden reference.*
- **Cross-level / Twist (LiDAR)** *> 3 mm per m.*
- **Crack / Missing fastener (Camera ML)** *> 0.8.*
- ***Vertical vibration spike (IMU) >** 3 g.*
- **Ultrasonic/D-cut wear** *> 3 mm or echo amplitude loss > X %.*

Fusion : *Fault confirmed if ≥ 2 sensors abnormal at same chainage tick.*

Sensors placement:

- *Front LiDAR + profilometer and Camera – **Forward Track view***
- *Under carriage ultrasonic /DCUT internal flaw scan – **internal flaw scan & post pass check***

Sensor Specifications:

LiDAR (Hesai XT16\32)+Profilometer(ADTS)-
*For High precision **2D/3D mapping** and crack detection*

Camera(Photon focus MV8)-
*Captures **High resolution images** of **Track at High speed***

Pan\ Tilt Turret(Camera Lens)-
*This lens ensures **clarity even in Rain and fog condition***

MEMS(VectorNav VN-300)-
*Measures **tiny vibrations, stresses, motion changes** on the Tracks*

Axle Encoder-
*Measures **wheel rotation and displacement** precisely*

Ultrasonic Sensor(D-CUT)-
*Used to **measure internal flaws***

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FEASIBILITY & VIABILITY

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OBJECTIVES	TRC	SMART RAILS
Monitoring Frequency	Periodic runs (weeks gap)	Continuous monitoring (every tip)
Safety Impact	Faults may remain ***undetected between runs***	Early detection -> ***derailment risk reduced***
Cost	***20-30 Cr.*** /TRC	***35-50L*** per kit(1-100th of TRC)
Scalability	***Limited Units*** , can't cover all routes	Kits deployable ***on any passenger or good trains***
Response Time	Post-processed (delayed)	Real time AI alert -> ***Immediate maintenance***
Indigenous Support	***Mostly imported*** O&M cost	Locally built easy to maintain ,***"Make in India"***
Track Geometry	Laser chord, ***IMU, RTK, GNSS***	***Vision + LiDAR, IMU, Wheel , odometer , RTK<GNSS***

Challenges & Solutions

Connectivity Gaps- *in remote stretches, uploads can slow or pause.*

Offline + Sync *: Local Storage , SMS alerts, secured uploads.*

Cost Hurdle- *Equipping thousands of trains at once can stretch budgets*

Phased Deployment *: Standard kits, low-cost , simple upkeep.*

Tough Conditions- *dust, rain, fog and vibration can throw sensors off their game.*

Rugged Hardware*: IR/thermal sensors, shock-proof.*

Data Overload- *LiDAR and camera streams can overload onboard storage and processors.*

Edge AI- *Filters, compress, prioritize faults.*

Security*; Encryption , firewalls, safe APIs*

Security Concerns- *on train sensors and links need to be kept safe from being hacked.*

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IMPACT AND BENEFITS

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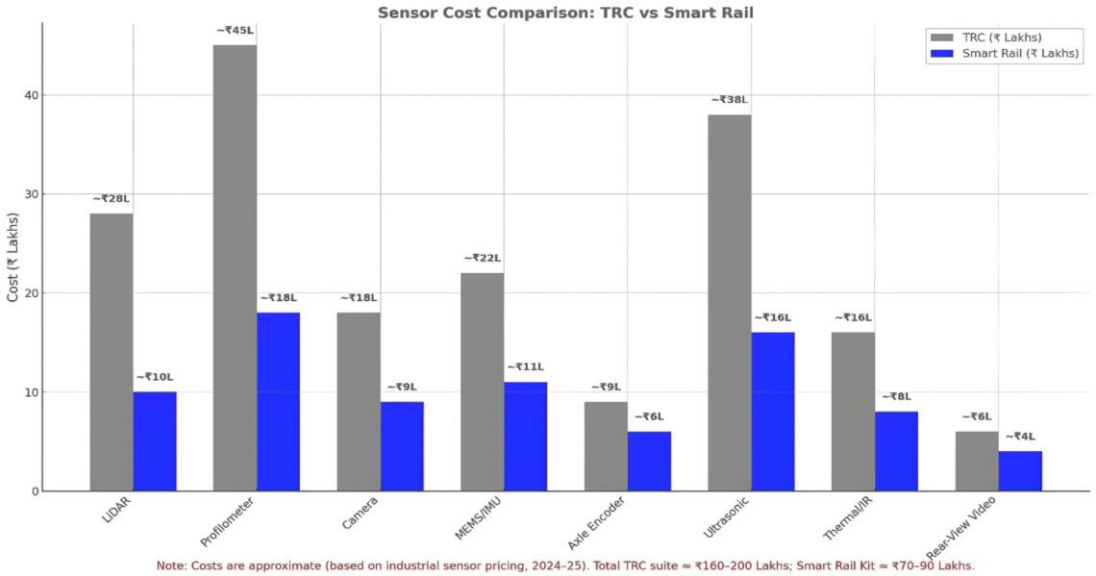
Benefits

- *Cost per train much lower than a full Track recording Car.*
- *Modular design **makes rollout and maintenance easy.***
- *Indigenous system **reduces import dependence**.*
- *Scalable solution for India's entire railway network.*
- *Even in remote areas, the system knows the fault location from **NavIC** and can transmit a lightweight **SMS alert.***



Impacts

- **Continuous Monitoring-** *Tracks checked on every train trip.*
- **High accuracy-** *Golden Reference + multi –sensors ensure TRC-level precision*
- **Real-Time *Alerts-*** *instant AI – based warnings for quick maintenance.*
- **Cost-Effective** – *1/100th the cost of TRC(lakhs vs crores).*
- **Scalable Nationwide**- *Easy to install on passenger & freight trains.*

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RESEARCH AND REFERENCES

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IEEE /International Paper: *Advanced track monitoring system using IOT sensors and AI for predictive railway maintenance:* https://www.ijset.in/wp-content/uploads/IJEST_V12_issue1_600.pdf

Foreign Working Model: UK-developed low-cost. cab-based railway track monitoring using on-board GSM-R cab radio and MEMS sensors: https://www.tandfonline.com/doi/full/10.1080/00423114.2020.1755045

Internal Failure Detection Using IR Thermography and Characterization of Composite Insulators | IEEE Journals & Magazine | IEEE Xplore **Tripathi, A. N., & Verma, A. R. (2025). Internal Failure Detection Using IR Thermography and Characterization of Composite Insulators. *IEEE Transactions on Dielectrics and Electrical Insulation*.**

Automated Railway Track Crack Detection and Emergency Halt System | IEEE Conference Publication | IEEE Xplore **Manasa, K., Sreeja, C., Reddy, D. M., Reddy, S. V., Natarajan, K., & Devi, T. A. (2025, April). Automated Railway Track Crack Detection and Emergency Halt System. In *2025 5th International Conference on Trends in Material Science and Inventive Materials (ICTMIM)* (pp. 261-265). IEEE.**

Research on Rail Flaw Detection, Damage Causes, and Prevention in Universal Speed Railway | Science Progress and Humanity **Zhao, J. (2025). Research on Rail Flaw Detection, Damage Causes, and Prevention in Universal Speed Railway. *Science Progress and Humanity*, *1*(1), 44-49.**