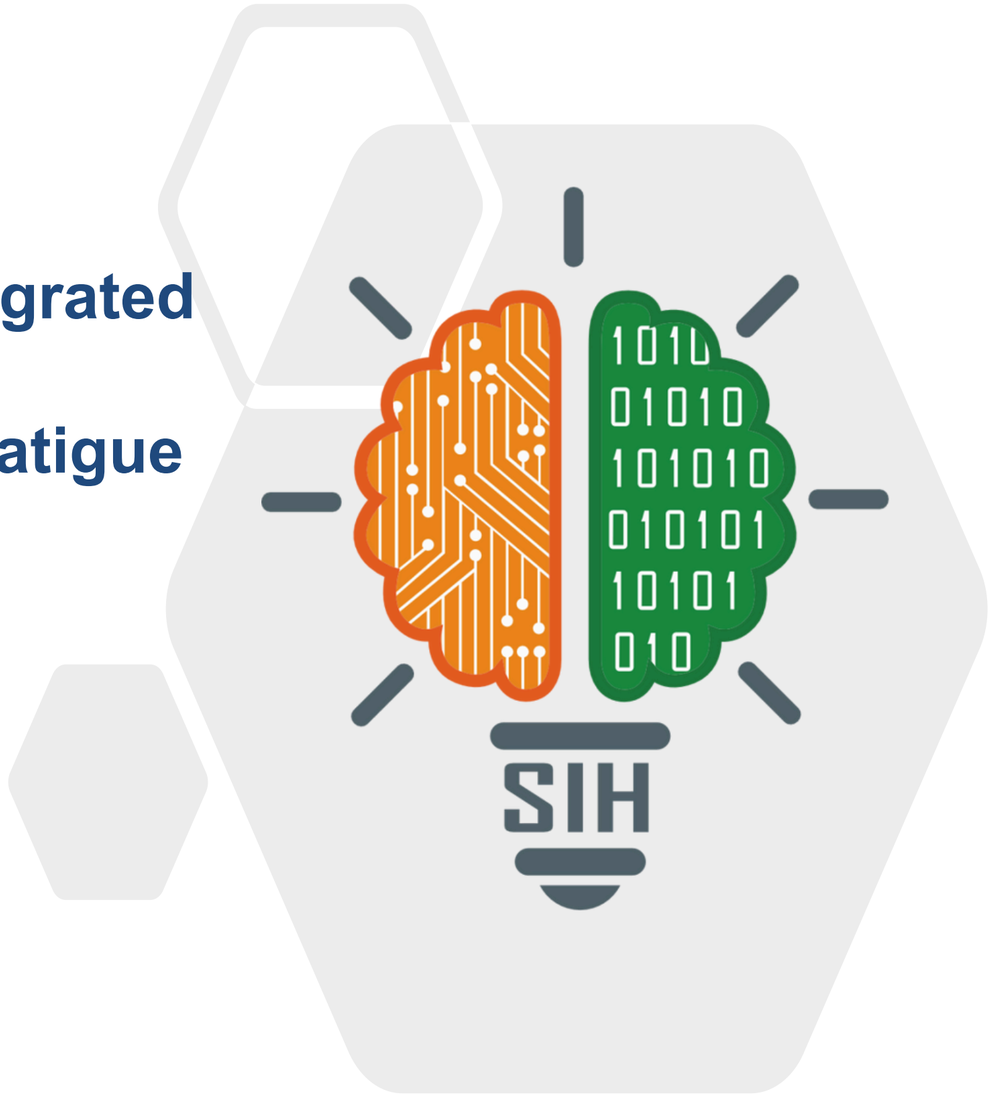
# SMART INDIA HACKATHON 2025

- **Problem Statement ID - 25213**
- **Problem Statement Title - Integrated Wearable for Vitals, Gas, and Fatigue**
- **Theme - Disaster Management**
- **PS Category - Hardware**
- **Team ID - 109956**
- **Team Name - Bit Masters**



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# IDEA TITLE

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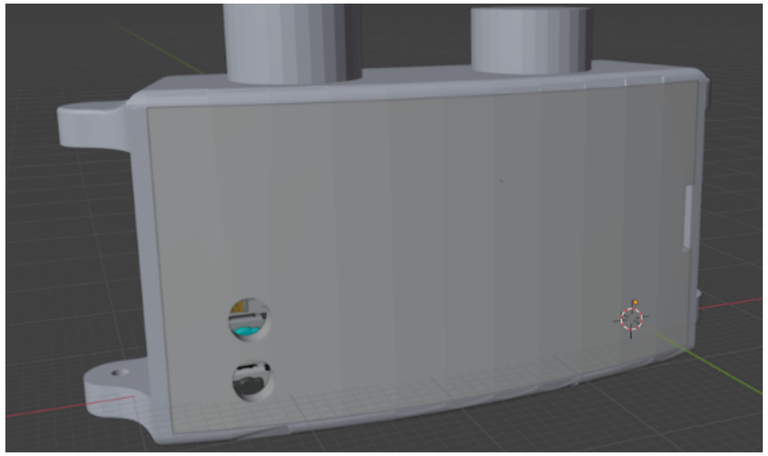
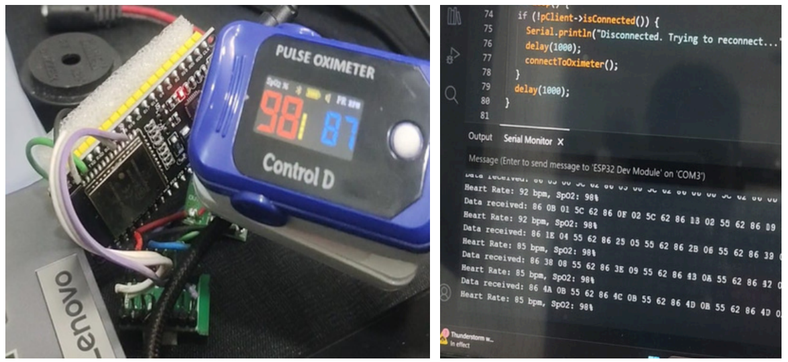
| PROBLEM | EXISTING SOLUTION | PROPOSED SOLUTION |
|---|---|---|
| 1. **Responder Fatigue in Harsh Conditions** – Long hours in toxic, humid, and high-stress rescue environments lead to exhaustion and unnoticed health risks. | **Manual observation & fitness bands** – supervisors rely on visual checks; consumer wearables (Fitbit, Apple Watch) are not reliable in extreme conditions. | **Field-grade monitoring** – ECG, $SpO_2$, HR, respiratory rate with fatigue prediction, tuned for disaster environments (not clinical diagnosis, but early warning system). |
| 2. **Toxic Gas Exposure in Disaster Sites** – CO, $NO_2$, $NH_3$, VOCs silently affect responders during chemical leaks or industrial fires. | **Imported gas detectors** – Blackline, Honeywell devices exist but are bulky, expensive, and not for long-term wear. | **Wearable multi-gas band** – compact, affordable, continuously tracks gases, sends instant alerts if unsafe levels detected. |
| 3. **No Real-time Communication of Risk** – Commanders don't know which officer is in danger until collapse happens. | **Handheld tools & fragmented systems** – data is scattered, no centralized live sync with command centers. | **Live sync to command centers** – Bluetooth transmit responder data in real-time to supervisors for quick decisions. |
| 4. **High Cost & Foreign Dependence –** Current imported devices are expensive, rely on subscriptions, and are not scalable for deployment across all NDRF teams. | **Standalone Solutions –** Gas detectors and medical wearables work well individually, but they are fragmented, costly, and miss fatigue monitoring. | **Our rugged integrated band combines** only the essential vitals, gas, and fatigue monitoring — reducing cost, simplifying logistics, and purpose-built for NDRF conditions. |

## Prototype Model



https://drive.google.com/file/d/1MxexH_Jt1Noi0WxuXKwY5npctULWiS7n/view

## Prototype Demo – ESP32 BLE Receiving $SpO_2$ & Heart Rate (One of the Core Modules of Our Wearable)

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# TECHNICAL APPROACH

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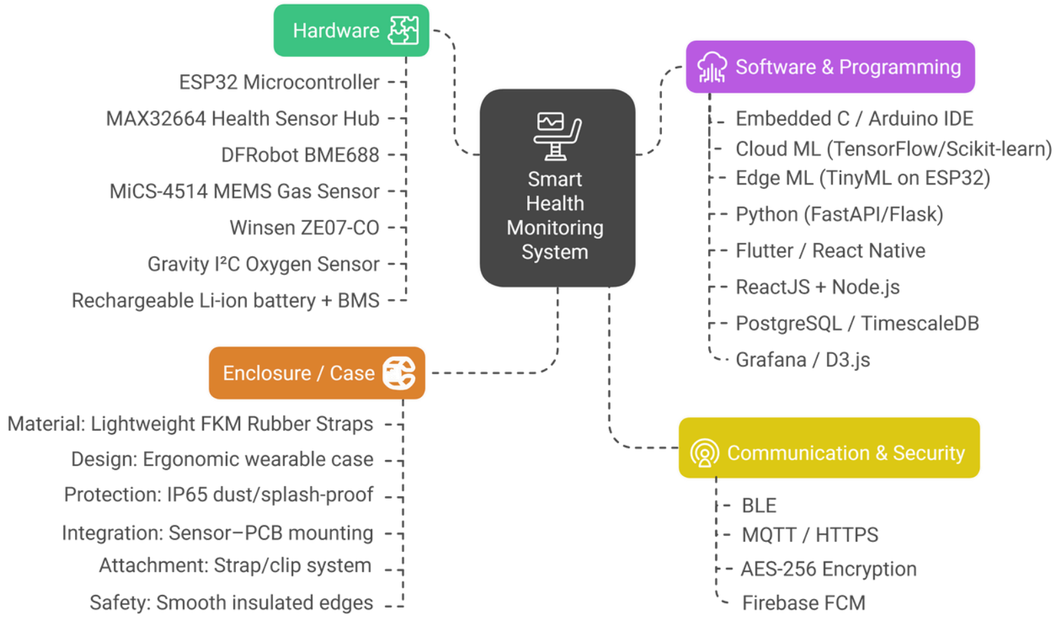
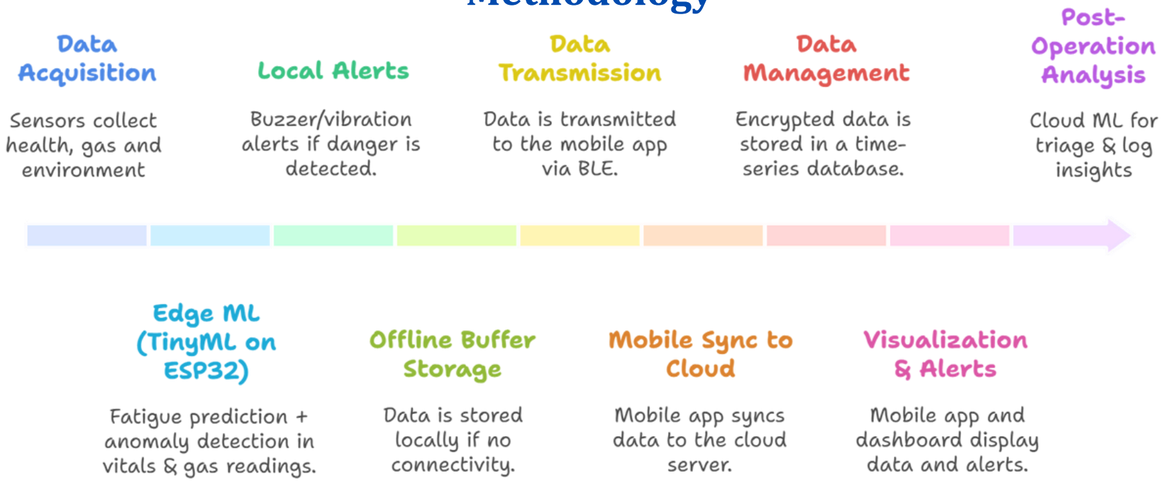
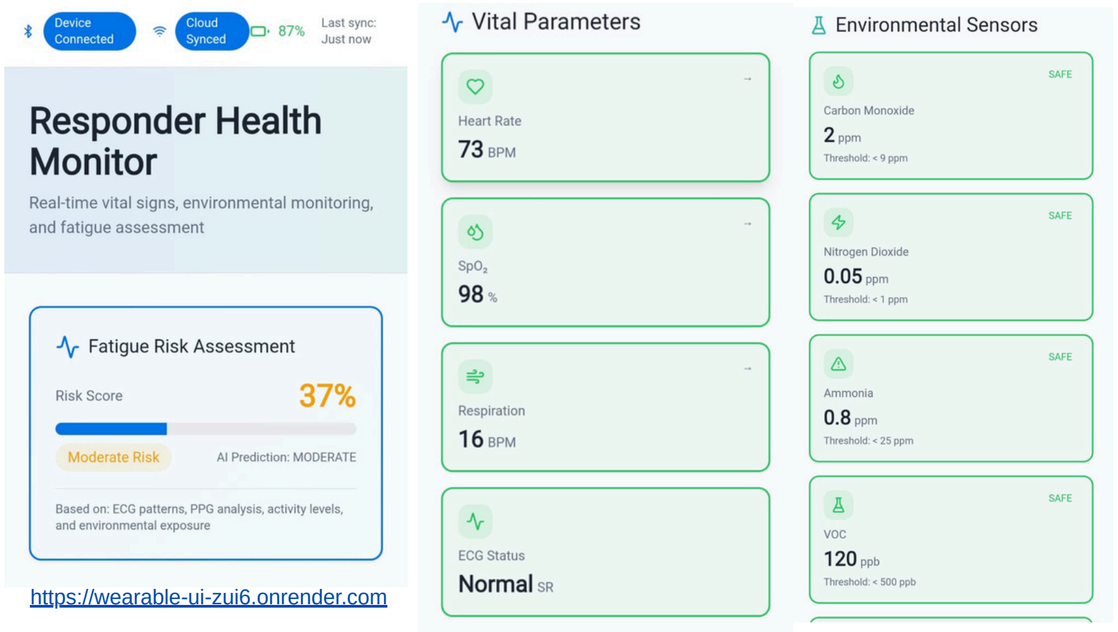
## Technologies




## Methodology




## Prototype dashboard ready; extendable to mobile.




https://wearable-ui-zui6.onrender.com

## Hardware to be used

- **MAX32664 – BP, HR, SpO2, Respiratory Rate, Motion**
- **BME688 – VOC, Temp, Humidity, Pressure**
- **MiCS-4514 – Alcohol, $NO_2$, $NH_3$**
- **ZE07-CO – CO (Electrochemical)**
- **$O_2$ Sensor (DFRobot I²C) – Oxygen levels**
- **ESP32 – Processing + Wi-Fi + Bluetooth**
- **Battery + BMS + Charger – Power supply**
- **OLED Display + LEDs + Buzzer + Vibration – Alerts & UI**
- **Rugged Strap/Enclosure – Wearable form factor**

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# FEASIBILITY AND VIABILITY

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## FEASIBILITY

**Integratable with existing modules –** The MAX32664 hub, ESP32, and commercially available gas sensors (BME688, MiCS-4514, ZE07-CO, $O_2$ sensor) can communicate through $I^2C$ or UART, making a single-band integration technically achievable.

**Supports continuous monitoring and wireless data flow –** The ESP32 offers BLE/Wi-Fi with low-power operation, enabling real-time vitals and environmental data transfer without draining the battery excessively.

**Prototype-ready** and scalable – Off-the-shelf sensor modules allow quick prototyping and field validation, and the design can later evolve into a compact custom PCB and ruggedized enclosure for deployment.

## VIABILITY

**Aligned with NDRF operations –** A lightweight band that monitors gases and health vitals provides frontline responders with real-time situational awareness, directly supporting their mission in hazardous environments.

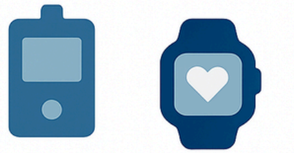
**Improves command-center decisions –** Aggregated data from multiple responders can be sent to a central dashboard, enabling better triage, rotation, and resource planning during rescue operations.

**Future-proof design –** The modular sensor setup and ESP32 base allow upgrades (e.g., LoRa, GSM, 9comms), ensuring long-term viability and adaptability across different missions and terrains.

| Challenges | Strategies |
|---|---|
| Gas and vital sensors may struggle with reliability under mixed or extreme conditions. | Combine multiple sensor inputs and recalibrate for stable results. |
| Motion and stress can distort physiological readings. | Use motion data to refine and stabilize health readings. |
| Continuous monitoring and transmission drain power quickly. | Optimize sampling, connectivity, and battery design for long use. |
| Harsh environments and device placement reduce effectiveness. | Build rugged, ergonomic enclosures and flexible sensor placement. |

## INNOVATION

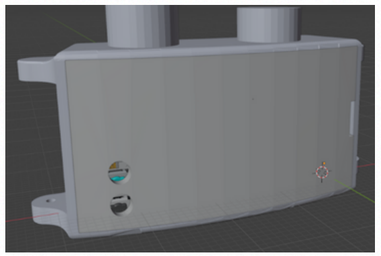
### STANDALONE



GAS DETECTOR | MEDICAL WEARABLE

Perform well individually, but costly and fragmented

### INTEGRATED RUGGED BAND



Multiparameter vitals, gas, and fatigue monitoring

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# IMPACT AND BENEFITS

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## IMPACT

01 **NDRF Responders:** Improved safety and reduced health risks during long disaster operations.

02 **Command Center Officers:** Real-time awareness of responder status, enabling quicker decisions and interventions.

03 **Medical Teams:** Early detection of fatigue or toxic exposure → faster medical attention, fewer casualties.

04 **Government & Nation:** Reduced dependency on costly foreign imports; a scalable, Swadeshi solution for disaster management.

05 Maps **hazard zones dynamically**, aiding safe evacuation and planning.

## BENEFITS

01 **Social: Protects frontline heroes,** saves lives, boosts trust in technology for disaster response.

02 **Economic: Affordable "Make in India" solution under ₹20k,** reducing dependence on costly imports and scalable nationwide.

03 **Environmental:** Continuous monitoring of toxic gases reduces prolonged exposure; helps in mapping hazardous areas for safer rescue operations.

04 **Operational:** Ensures mission continuity even in low-connectivity zones via local data storage and post-sync capabilities.

05 Enhances **public trust** through visible commitment to responder safety.

## Applications :


The solution enhances NDRF operations by providing real-time health tracking, toxic gas detection, fall detection in floods, and remote team monitoring, ensuring safety and efficiency in disaster response.

# RESEARCH AND REFERENCES




- MAX32664 Health Sensor Hub – Maxim Integrated (Analog Devices) Documentation
- MAX32664 User Guide / Reference Design
- A Framework for Selecting and Assessing Wearable Sensors Deployed in Safety-Critical Scenarios
- Wearable Sensor-Based Fatigue Classification Under Diverse Thermal Conditions
- A Data-Driven Approach to Physical Fatigue Management Using Wearable Sensors
- Assessment of Fatigue Using Wearable Sensors: A Pilot Study
- Monitoring Inattention in Construction Workers … Using ECG & GSR Sensors
- RespNet: Extracting Respiration from PPG using Deep Learning
- Wearable Respiration Monitoring: Interpretable Inference with Context and Sensor Biomarkers
- Energy-Efficient Real-Time Heart Monitoring on Edge-Fog-Cloud IoMT
- Wearable Gas Sensor Platforms for Environmental Monitoring and Encountered Challenges in Optimization