TEAM
F006

Industrial Workers Evacuation System: Integrated Tracking, Alerting, and Mustering with AI-Driven Insights

Zainab Alturaiki, Fatema Alabdullah, Renad AlZahrani, Noor Al Gazwi, Yara Alhomedy, Noor Alqatari
Coach: Ms. Reem Alyami

ICS EE ME 4 ISE

1. Problem Statement

Industrial facilities rely on manual headcounts at muster points during emergencies. When a worker is missing, supervisors take time to determine their location and safety. GPS is unreliable in confined spaces, and no continuous tracking shows the workers location, movement, and safety condition. This delays rescue and prevents post-incident analysis.

2. Solution

A helmet-mounted device integrating UWB localization, IMU fall detection, and RFID muster verification to track worker location, falls, and muster arrival, streaming data to a dashboard where supervisors monitor safe arrivals, missing workers' zones, and man-down alerts in real-time. Post-evacuation, an analytics dashboard delivers performance metrics with AI-generated insights

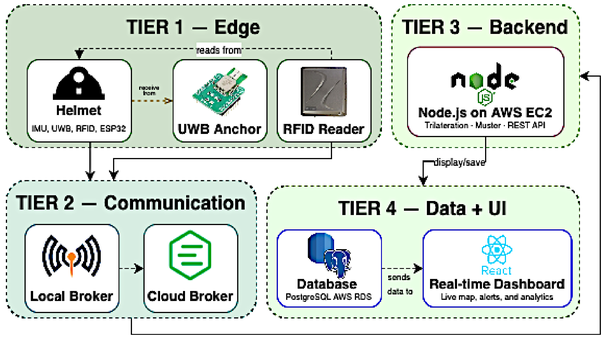
3. Specifications

Helmet mass ≤ 400 g	Battery life ≥ 8 h	Drop resistance 1 m
Zone accuracy ≥ 95 %	RFID range ≥ 3 m	Dashboard latency ≤ 1 s
Edge processing ≤ 100 ms	Man-down detection ≥ 95 %	Setup & maintenance ≤ 10 min
IP54 splash sealing ≥ 10 min	UWB anchors / zone ≥ 2	System efficiency ≥ 80 %

4. Constrains

Wireless bands CITC-compliant	Battery life per charge ≥ 8 h
Helmet unit mass ≤ 400 g	Setup & maintenance ≤ 10 min
Deployment cost / worker ≤ 4000 SAR	System efficiency ≥ 80 %
Software compliance NIST standards	

5. System Flow

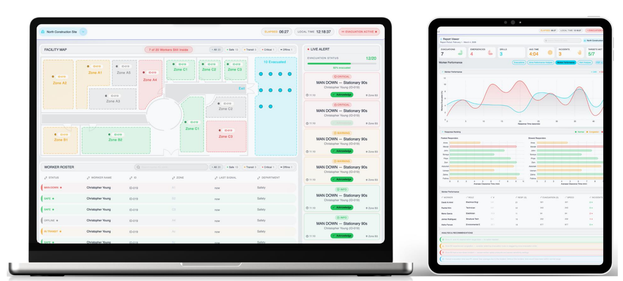


6. Prototype

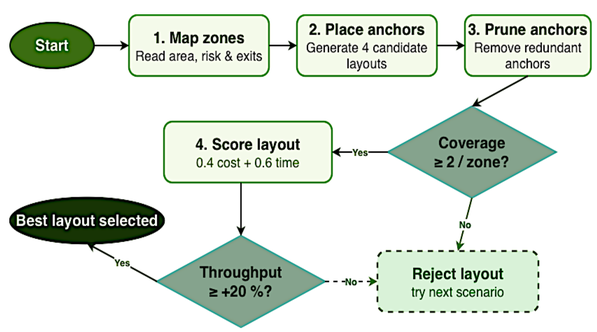
Anchor

Helmet Enclosure

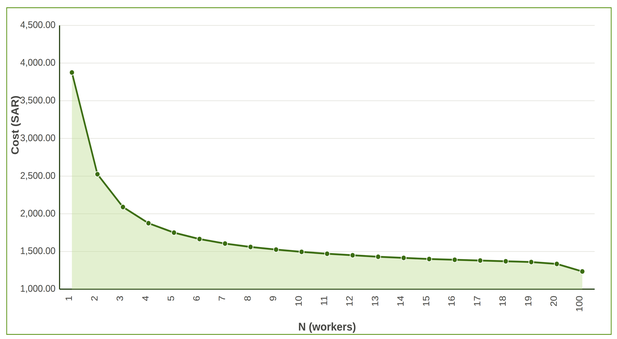
Real-time Dashboard



7. Layout Simulation Model



8. Cost per Device (SAR)



9. Testing and Validation

Hardware Testing

Weight
Enclosure with all components
201 g
Target: ≤ 400 g
Within Limit ✓

Battery Life
3.7 V · 3000 mAh battery
8 h
I_total 241.7 mA · 420 mA budget
Within capacity ✓

Drop Resistance
1 m drop · ABS-PC enclosure
FoS = 2.78
σ_yield 60 / σ_max 22.57 MPa · target ≥ 1.5
Structurally sound ✓

Signal Distance
RFID detection · 4 distinct tags
A ID: 6021e B ID: 2e0227
C ID: 15e0222 D ID: 186021e
Target: ≥ 3 m range
Distinct IDs at ≥ 3 m ✓

System Testing

UWB Localization
Zone classification accuracy

Acc	Prec
0.986	0.983
Rec	**F1**
0.982	0.982

Target: ≥ 95% on all metrics
Zone accuracy ≥ 98% ✓

Man-Down Detection
Fall FSM (30,000 samples)

Acc	Prec
0.951	1.000
Rec	**F1**
0.861	0.925

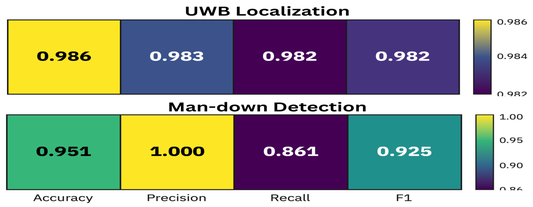
Target: ≥ 95% accuracy
Detection ≥ 95% ✓

Dashboard Latency
ESP32 → MQTT → React UI
< 1 s
Target: ≤ 1 s
Sub-second updates ✓

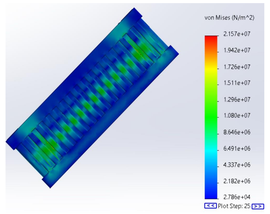
Report Generation
PDF analytics pipeline
19.6 s
Target: ≤ 60 s
Within 1 minute ✓

10. Conclusion

The system demonstrates effective worker monitoring through UWB, IMU, and RFID, with AI-driven analytics guiding corrective action. This approach enables faster rescues that help prevent loss of life within a compact, lightweight design.


UWB Localization
0.986
0.983
0.982
0.982
0.986
0.984
0.982
Man-down Detection
0.951
1.000
0.861
0.925
1.00
0.95
0.90
0.86
Accuracy
Precision
Recall
F1

Drop Test


von Mises (N/m^2)
2.157e+07
1.942e+07
1.726e+07
1.511e+07
1.296e+07
1.080e+07
8.646e+06
6.491e+06
4.337e+06
2.182e+06
2.786e+04
Plot Step: 25


UNIT
ON
TARE
Max:5000g d=1g