

Problem statement

Landmines in conflict zones endanger soldiers due to slow, inaccurate, and unreliable detection methods.

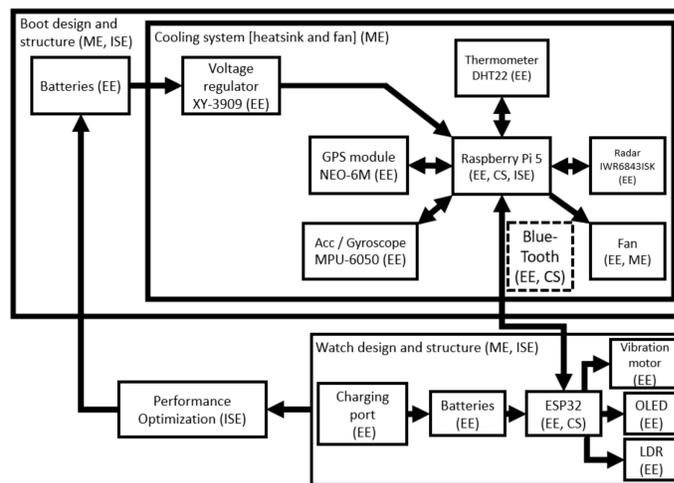
Constraints

- Weight and size (≤ 2 kg & ≤ 1000 cm)
- Cost limitations (less than 9000 SAR)
- 5200 mAh power source
- High quality and durability
- Detection quality (speed & accuracy)

Target specifications

- Speed of detection ($\leq 2s$)
- Detection Depth (up to 10cm)
- Resistance to temperature
- 4 hours of operation period
- +98% detection accuracy
- ≤ 300 ms transmission delay
- $6m^2$ ahead of coverage
- Resistance to impact (durability)
- Compactness (≤ 500 cm³ & $\leq 1kg$)

Prototype block diagram



Components selection

$$\text{Max } z = \sum_i \sum_j S_{ij} x_{ij}$$

subject to:

$$\sum_j x_{ij} = 1, \quad \forall i$$

$$\sum_I \sum_J x_{ij} V_{ij} \leq 500$$

$$\sum_I \sum_J x_{ij} P_{ij} \leq 10.58$$

$$\sum_I \sum_J x_{ij} M_{ij} \leq 500$$

$$\sum_i \sum_j C_{ij} x_{ij} \leq 9000$$

Where:

$x_{ij} = 1$ if option j is selected to be component i , 0 otherwise

S_{ij} = AHP output (rating/10)

V_{ij} = volume (cm³)

P_{ij} = Power (W)

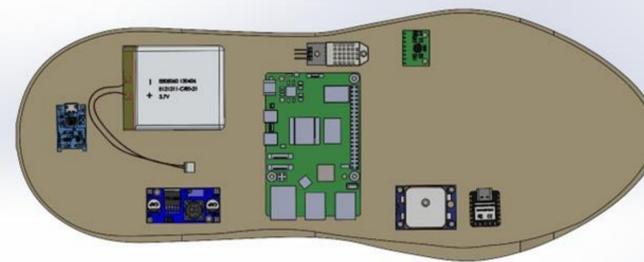
M_{ij} = Mass (g)

C_{ij} = cost (SAR)

Detection calculations

	Equation	Dry Sand	Moist Sand
Penetration Depth	$d_p = \frac{c}{2\pi f} \cdot \frac{1}{\sqrt{\epsilon_r} \cdot \tan \delta}$	5.941	0.252
Detection Area	$= \text{Ground Width} \times \text{Ground Length}$	$20.580 \times 3.182 = 65.527$	$0.873 \times 0.135 = 0.118$
Range Resolution	$\Delta R = \frac{c}{2B}$	0.0375 m	0.0375
Velocity Resolution	$\Delta V = \frac{\lambda}{2T_{obs}}$	0.025 m/s	0.025 m/s
Max Unambiguou s Range	$R_{max} = \frac{c \cdot T_{PRI}}{2}$	7.5 km	7.5 km
Max Unambiguou s Velocity	$V_{max} = \frac{\lambda}{4 \cdot T_{PRI}}$	90 km/h	90 km/h
Signal-to-Noise Ratio	$SNR = \frac{P_t G^2 \lambda^2 \sigma T_{obs} e^{-2\alpha d_p}}{(4\pi)^3 R^4 K T F L B}$	12.2 dBi	48.2 dBi

Final prototype design



Novelty and Creativity

- Developed intelligent software using AI/ML (CNNs) to detect landmines from radar data.
- Notifications and alert system implemented via wearable watch
- Utilized mmWave radar with ensured secure communication measures between components.
- Compact, power efficient, and fully integrated.

Meeting specification

- Voltage Stability: 5.18V \pm 5% achieved (Test 1).
- 3.3V Rail: Stable 3.28V output (Test 2).
- Battery Runtime: 4h 12m under load (Test 3).
- Depth Detection: 9.5 cm accuracy (Test 4).
- GPS Error: ≤ 2.1 m deviation (Test 5).
- Motion Data: Zero loss (Test 6).
- Temp Precision: $\pm 0.3^\circ\text{C}$ error (Test 7).
- Alert Latency: 280 ms (Test 8).
- High-Temp Operation: Stable at 82°C (Test 9).
- Interference Check: No overlap (Test 10).

Conclusion

The ILDS enhances soldier safety by delivering fast and accurate landmine detection in a compact, boot-integrated system that is durable, power-efficient, and reliable under harsh field conditions.