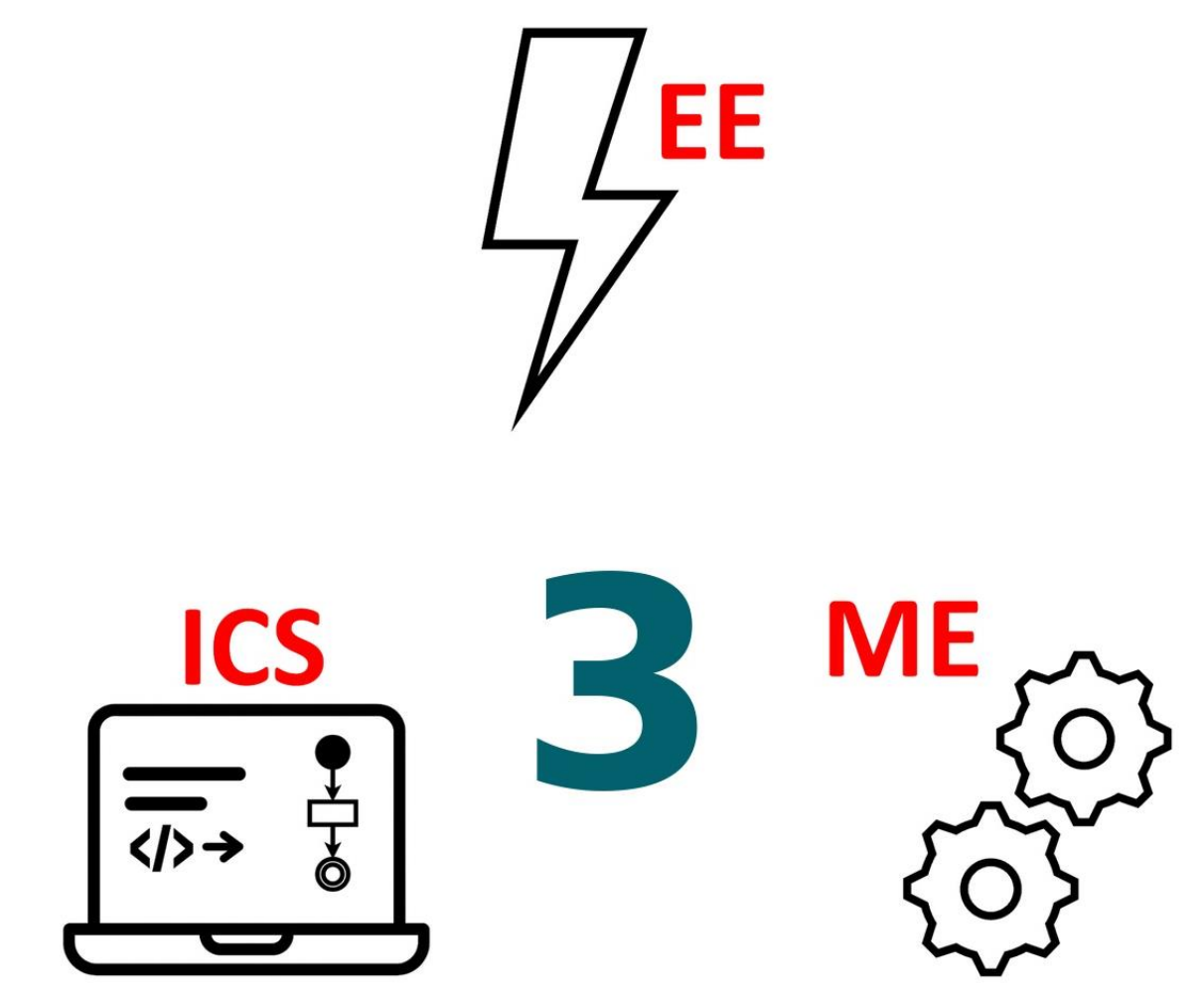


Integration of Passive Bistatic Radar and Infrared Sensing on a CubeSat for Hypersonic Target Detection

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Problem Statement

Hypersonic targets are difficult to detect due to their extreme speed and low radar visibility. Traditional detection systems are expensive, power-intensive, and limited in coverage, reducing effectiveness in real-time monitoring. This project develops a CubeSat-based system that combines passive radar and infrared sensing to enable reliable detection with real-time monitoring and alerts.

Specifications

- Temperature measurement accuracy maintained within $\pm 2^\circ\text{C}$ in ≤ 5 s
- channel synchronization within ± 50 ns
- Signal detection achieved up to 5 km with $\text{SNR} \geq 10$ dB
- Range–Doppler results within 5 s
- Provides structural strength ≥ 500 Mpa
- Uses anodized aluminum, $R_a \leq 1.6$ μm
- Fits within 6U with ≥ 1 mm clearance
- User notification latency ≤ 60 s
- False alarm rate maintained below 5%
- System reliability $\leq 1 \times 10^{-5}$ failures/hour
- Provides position accuracy within 10 m
- Updates target data within 60 s
- Power stability $\pm 5\%$, uptime $\geq 90\%$

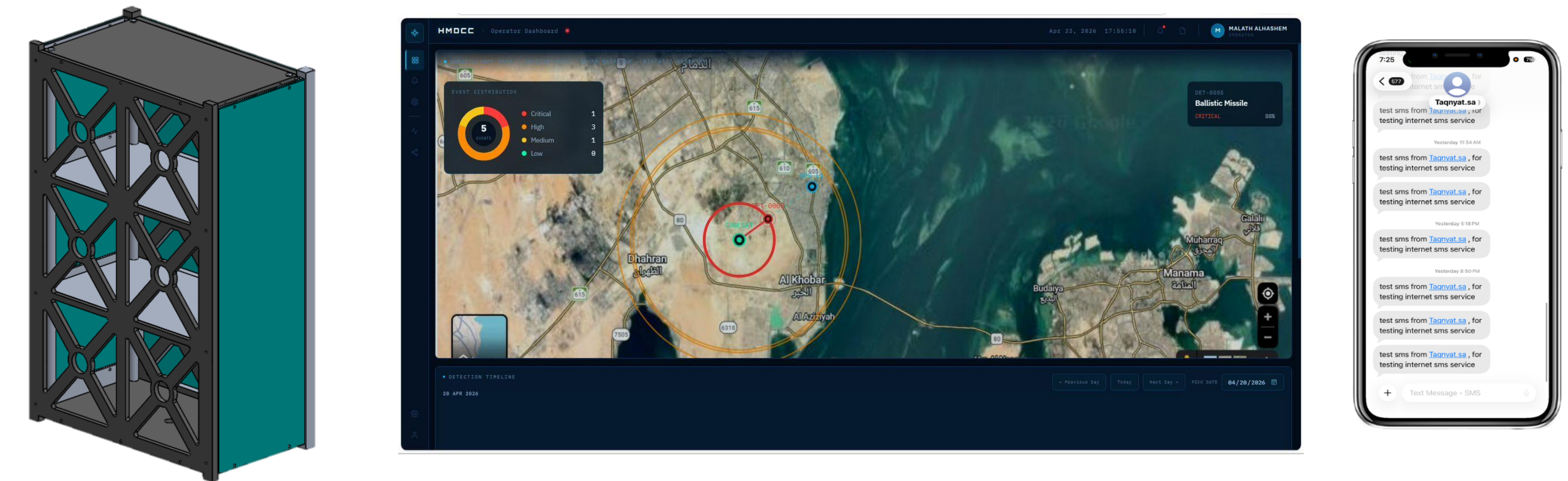
Constraints

- Limited by sensor resolution, refresh rate, and processing power
- Must separate direct/reflected signals
- Must detect DVB-T reflections
- Must follow 6U CubeSat dimensions (10×20×30 cm)
- Center of mass within ± 20 mm
- Structure made of 7075-T6 aluminum
- Deployed on GCP using a single VPC architecture
- High data storage needed

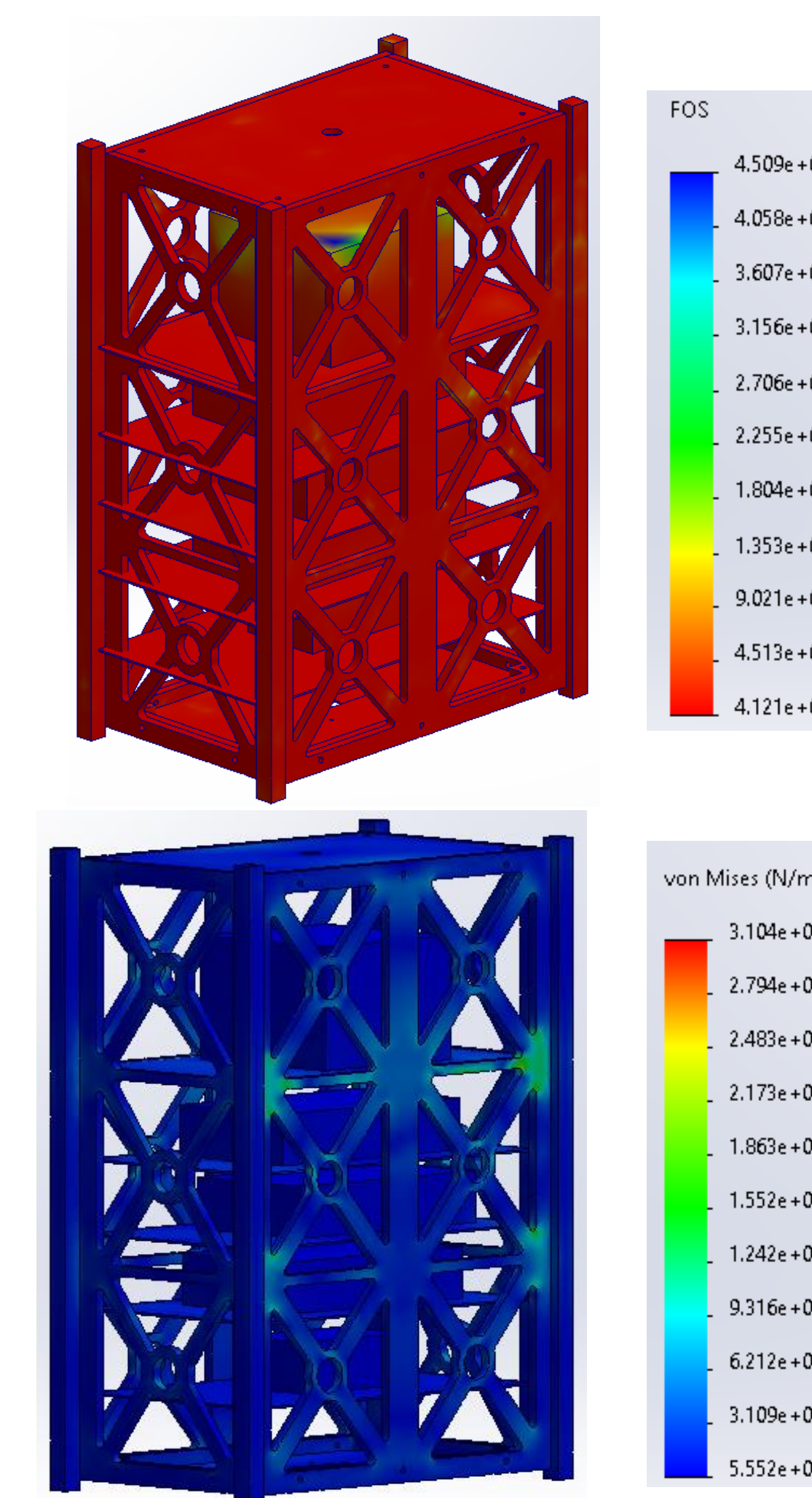
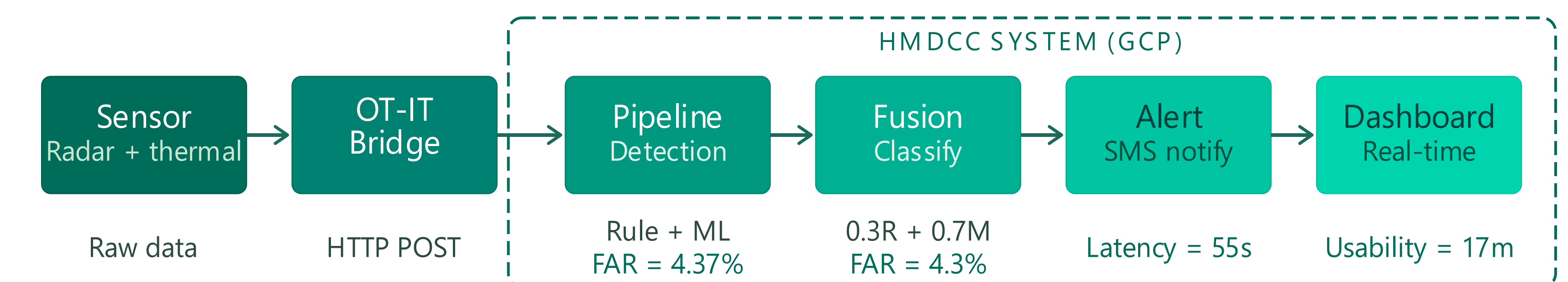
Conclusion

The proposed system successfully demonstrates a CubeSat-based solution for hypersonic target detection using passive bistatic radar and infrared sensing. The system achieved reliable detection, met key specifications including SNR, response time, and false alarm rate, and provided real-time visualization and alerts. Mechanical validation confirmed structural integrity and compliance with CubeSat constraints through analysis of strength and stability. Results confirm the effectiveness of the multi-sensor approach in improving detection performance within CubeSat limitations.

Prototype Design and Detection System



Testing / Validation



- GPS signals processed using GNU Radio (IQ acquisition, filtering, FFT-based correlation)
- Reference and surveillance channels synchronized using a shared GPS clock
- Range–Doppler map successfully detected target peak
- SNR remains ≥ 10 dB within operating range \rightarrow reliable detection
- Real-time thermal data transmission (1 Hz) with accurate pixel readings with clear hot vs. cold object detection