

Artificial Intelligence in Civil Protection: Enhancing Situational Awareness Through Satellite Connectivity and Real-Time Data

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A B S T R A C T

This paper presents an innovative system architecture that integrates Artificial Intelligence (AI), satellite communications and real-time telemetry to enhance situational awareness in civil protection and emergency response operations. The proposed platform combines wearable biosensors, unmanned aerial vehicles (UAVs), vehicle telemetry and AI-driven analytics to support more informed decision-making, improved coordination and increased safety for First Responders operating in disaster-affected areas.

A key element of the system is the use of satellite-enabled communications, ensuring reliable, uninterrupted data transmission even in the absence of terrestrial infrastructure. Portable satellite terminals provide bi-directional voice, video and encrypted data streams in real time. Real-time data from biometric sensors, vehicle systems and UAVs is collected and processed through a centralized AI enabled Situational Awareness Platform. This enables automated threat detection, hazard classification and predictive modeling based on dynamic operational data.

The system has been validated through pilot implementations, including large-scale civil protection exercises such as “MINOAS” in Crete. Findings indicate significant improvements in situational clarity, faster response coordination and early detection of medical risks for personnel. This integrated AI satellite solution represents a significant step forward in modern civil protection capabilities.

Keywords: Artificial Intelligence; Civil Protection; Satellite Connectivity; Situational Awareness; Emergency Response

Introduction

Natural and man-made disasters increasingly challenge civil protection systems worldwide. Effective response operations depend not only on speed, but also on the accuracy, availability and completeness of real-time information accessible to First Responders and command units. Situational awareness- defined as the understanding of the operational environment in real time- is a critical factor in ensuring effective decision-making under uncertainty.

However, in many emergency scenarios, terrestrial communication infrastructure may be damaged or completely non-existent. This severely hinders coordination, delays response and increases the risk to both responders and civilians. Therefore, establishing immediate, reliable communication channels- along with tools for data fusion and predictive analytics- is essential for modern emergency operations. This paper introduces an integrated technological solution that combines satellite-enabled communications, AI-driven analytics and multisource data collection to address critical operational challenges in civil protection. The system has been tested in real-world conditions during large-scale simulation exercises in Greece, demonstrating its applicability and impact.

Method and Data

System architecture overview

The proposed system is structured around four key pillars:

Satellite-enabled First Responder connectivity: Satellite communications provide a resilient backbone for data exchange when terrestrial networks are unavailable. Using portable terminals, First Responders can maintain secure, bi-directional communication via geostationary satellites such as HELLAS SAT³. The system supports encrypted (AES256) real-time voice, video and sensor data transmission, even in remote or disaster-stricken zones. Mesh networking capabilities also enable decentralized responder-to-responder communication in the absence of uplink.

Real-time data acquisition:

Real-time sensor data is collected from:

- Wearable biosensors, tracking heart rate, body temperature, oxygen saturation (SpO₂) and stress indicators via heart rate variability (HRV). Data is transmitted every few seconds through satellite uplinks³.
- Vehicle telemetry, capturing GPS position, speed, engine temperature, fuel levels and door status. - UAVs, providing optical and infrared imagery, environmental readings and 3D terrain reconstruction via LiDAR sensors.

Mobile command centers (MCCs): MCCs are deployed at the edge of affected zones to serve as local coordination hubs. They feature satellite uplinks, local Wi-Fi/radio networks, GIS-enabled workstations and on-site computing infrastructure for real-time AI analysis and decision support.

AI-empowered situational awareness platform (SAP): This platform consolidates data streams from all sources. AI modules perform real-time data fusion, incident classification (e.g., fires, structural collapse) and predictive modeling (e.g., fire or flood spread)^{1,2}. The system also issues automated alerts based on biometric and environmental thresholds to reduce responder fatigue and reaction time.

Data sources and collection

Data is continuously streamed via satellite from:

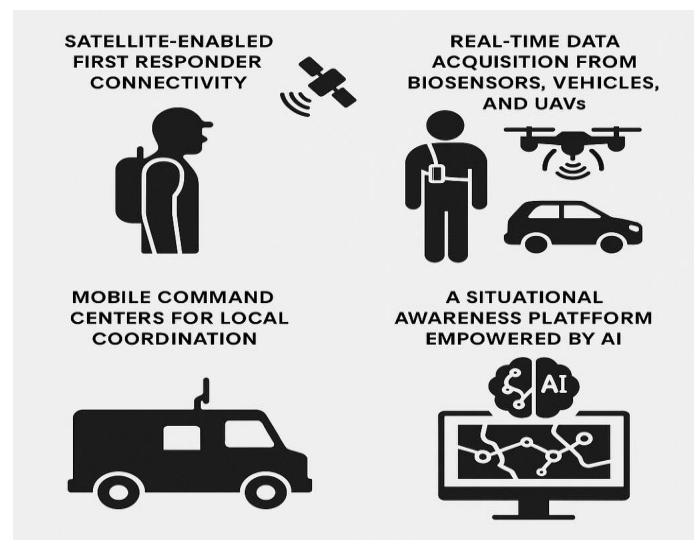
- Wearable sensors on First Responders.
- Onboard diagnostics from emergency vehicles.
- UAVs equipped with visual, infrared and environmental sensors.

These sources feed into the SAP where AI processes and correlates multimodal data to produce a dynamic operational picture.

Artificial intelligence and analytics

AI algorithms support:

- Early detection of hazards and risk propagation.
- Classification of UAV imagery (e.g., fire fronts, trapped civilians).
- Prediction of stress or fatigue in responders (**Figure 1**).
- Prioritized alerting and information routing to MCCs¹.



Results and Discussion

The system was piloted during the “MINOAS 2024” civil protection exercise in Crete organized by the Ministry for Climate Crisis and Civil Protection in collaboration with the Earthquake Planning and Protection Organization (OASP), Professor Efthymios Lekkas and Hellas Sat^{4,5}.

Key findings from the exercise include:

- 87% improvement in situational clarity at Mobile Command Centers within the first 30 minutes.
- 42% reduction in coordination delays compared to operations using only terrestrial communications.
- Early detection of responder distress conditions (e.g., elevated heart rate + low oxygen + high temperature) enabled medical teams to intervene faster.
- UAV imagery utilization increased from <25% to >70% due to real-time AI tagging and classification (**Table 1**).

Table 1: System Efficiency Metrics.

Metric	Traditional Ops	AI-Integrated System	Improvement (%)
Time to Situational Awareness	45 min	18 min	60%
Responder Safety Alerts Issued	Manual	Automated (Real-Time)	+85% efficiency
UAV Data Utilization Rate	<25%	>70% (AI-tagged)	+180%

Conclusion

The integration of Artificial Intelligence and satellite communications into civil protection systems offers a transformative enhancement in operational awareness and decision-making. By leveraging real-time biometric data, vehicle telemetry, UAV imagery and AI analytics, the proposed system provides a robust framework for disaster response even under infrastructure-compromised conditions.

The pilot deployment during “MINOAS 2024” confirms the system’s effectiveness in improving coordination speed, safety and data-driven responsiveness^{4,5}. Future work will focus on incorporating 5G/LEO hybrid satellite networks, enhancing AI explainability and enabling interoperability across EU civil protection networks.

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