Blog Post 4: Modeling Specific Threats - Simulating Wildfires and Earthquakes in PANTHEON

In our previous posts, we outlined the methodologies, data strategies, and core conceptual models that form the foundation of the PANTHEON Smart City Digital Twin (SCDT). Now, we delve into how this framework is specifically applied to simulate complex disaster scenarios, focusing on two key PANTHEON use cases: **wildfires** and **earthquakes** in the Attica region, Greece.

Tailoring Models to Hazards

While the general lifecycle models (Preparation, Training, Simulation, Operation, Post-Event) provide a common structure, effectively managing specific hazards requires tailoring the inputs, simulation logic, and decision support outputs . The PANTHEON SCDT integrates hazard-specific data and predictive models within its broader conceptual framework.

Simulating Wildfires: A Step-by-Step Example

Managing a wildfire involves understanding its dynamic spread based on weather, terrain, and fuel availability. PANTHEON's SCDT addresses this through steps like:

1. **Real-Time Data Integration:** Continuously feeding the digital twin with data from satellite imagery (location/size), ground sensors (weather, fuel moisture), drones (thermal imaging), and community reports .
2. **Simulation of "What-If" Scenarios:** Using the live data, the simulator models potential fire spread under different wind conditions, predicts fire intensity (hotspots), and tests the effectiveness of various firefighting strategies (e.g., firebreaks, water bombers) . Statistical distributions identified earlier (e.g., Weibull for duration, Log-Normal for size) can inform these simulations.
3. **Feedback Loop:** Simulation outcomes (e.g., predicted change in fire direction) update the digital twin's model in real time .
4. **AI-Driven Decision Support:** The system processes the updated model to provide recommendations on evacuation orders, optimal resource deployment (personnel, equipment), and community alerts .
5. **Visualization:** End users (firefighters, emergency managers) interact with a map-based interface showing the real-time fire map, evacuation routes, resource locations, and predicted spread .
6. **Continuous Adaptation:** As conditions change (e.g., wind shift), the cycle repeats, ensuring response strategies remain relevant .

Simulating Earthquakes: Addressing Structural Impacts

Earthquake scenarios require a focus on structural integrity, infrastructure disruption, and potential aftershocks. The PANTHEON approach includes:

1. **Real-Time Data Integration:** Incorporating data from seismic sensors (magnitude, location), structural health monitors in buildings/bridges, transportation network sensors, and utility system monitors (gas, water, power) .
2. **Simulation of "What-If" Scenarios:** Modeling the likelihood of building collapse based on sensor data and earthquake parameters, simulating stress on infrastructure (bridges, roads) to predict failures, and assessing the impact of potential aftershocks on already weakened structures . Statistical models (e.g., Gumbel for maximum energy release) can refine these simulations .
3. **Feedback Loop:** Simulation results (e.g., predicted building collapse, road blockage) update the digital twin's representation of the affected area .
4. **AI-Driven Decision Support:** Providing recommendations for targeted search and rescue efforts, identifying safe evacuation routes, prioritizing infrastructure repairs, and issuing public safety alerts .
5. **Visualization:** Presenting users with real-time damage maps, status of critical infrastructure, functional evacuation routes, and resource deployment locations .
6. **Continuous Adaptation:** Updating the model and recommendations as aftershocks occur or new damage reports come in .

Conclusion: Towards Enhanced Preparedness

By applying its core conceptual models and leveraging hazard-specific data and simulations, the PANTHEON SCDT aims to provide a powerful, dynamic tool for managing complex disasters like wildfires and earthquakes. This integrated approach, detailed across this blog series based on our D4.2 report, moves beyond static plans, offering real-time insights and predictive capabilities to support more effective decision-making and ultimately enhance community resilience.