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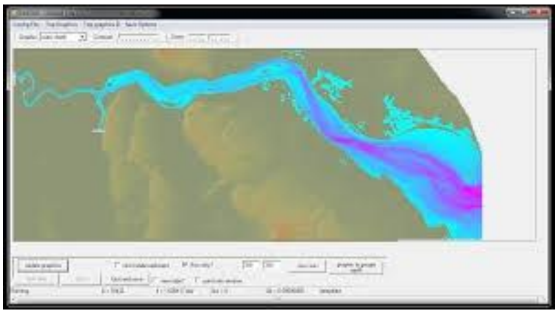

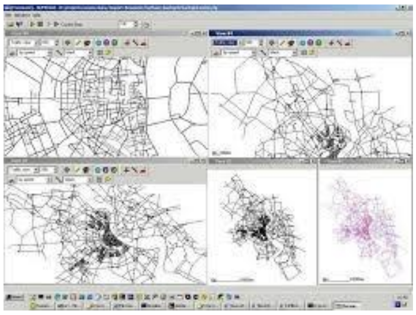

SMART CITY CHALLENGE 2024

Solution idea for the city challenges

Solution Idea Title - Integrated Resilience Intelligence Platform

Planned pilot project duration – 24 months

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1. Which urban challenge or problem are you planning to provide a solution to?

Safety in case of natural or human disasters

https://finestcentre.eu/challenge-proposal/city-resilience-to-natural-hazards/

2. The solution you are proposing

The solution is a Flood & Multi-Hazard Resilience Platform for cities, built around four core components: LISFLOOD, SUMO, FIWARE, and Cell Broadcast, plus an innovative deep-learning layer.

2.1. Data & Flood Modelling Layer (LISFLOOD)

A dedicated modelling service runs LISFLOOD / LISFLOOD-FP on calibrated catchments covering, its upstream rivers, and coastal/low-lying areas. LISFLOOD ingests numerical weather prediction (rain, snow, wind), sea-level and storm-surge forecasts, snowpack and soil-moisture data to compute grid-based runoff, river stages, and 2D floodplain depth/velocity maps for lead times from hours to days.

Outputs (for each time step) are exposed as geospatial services (raster tiles, vector polygons) and published into FIWARE Orion Context Broker as entities like FloodCell, RiverReach, CoastalZone with attributes such as waterDepth, arrivalTime, maxVelocity.

2.2 Traffic Simulation & Accessibility Layer (SUMO)

A high-resolution Eclipse SUMO model covers Pärnu's urban network and the regional links that connect to Saaremaa (including key ports, bridges, and ferries).

A "Network Adapter" microservice listens to FIWARE:

- When LISFLOOD predicts >X cm water depth on a RoadSegment, it marks the edge as closed or penalised in SUMO.
- Real-time traffic from probe vehicles, buses, emergency fleets, and induction loops updates demand and speeds.

SUMO then simulates:

- Which roads remain open, realistic travel times, and congestion under evacuation or detour scenarios.
- Reachability to hospitals, shelters, power repair depots, and ferry ports for the next 1–6 hours.

Results are republished to Orion (isReachable, ETA, altRoutes) so city dashboards and routing apps can consume them.

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2.3. IoT / Context Management Layer (FIWARE)

A FIWARE stack (Orion + IoT Agents) is the real-time context hub for both territories:

- IoT sensors: water-level gauges, tide buoys, rain gauges, road-side units, weather stations, power substation sensors, and telecom site telemetry are integrated via FIWARE IoT Agents (including OPC UA where SCADA is used).
- Each asset (road segment, bridge, transformer, cell tower, hospital, ferry terminal) is represented as an NGSI entity (RoadSegment, CriticalFacility, etc.) with attributes: status, waterDepth, drivabilityIndex, powerStatus, backupRuntime, etc.
- Orion subscriptions push changes to downstream services (AI, SUMO, alerting) whenever thresholds are crossed.

2.4. Public Warning & Cell Broadcast Orchestrator

A Public Warning Orchestrator microservice consumes AI outputs and context from Orion and drives Cell Broadcast via the national Cell Broadcast Centre (CBC) using ETSI/3GPP Public Warning System interfaces (EU-Alert/ETSI TS 102 900, 3GPP TS 23.041).

Key features:

- Dynamic geo-targeting polygons that match predicted hazard and accessibility zones (e.g., “all devices in areas that will lose road access within 2 hours but still have one safe corridor”).
- Multi-lingual, template-based messages tailored to scenario (coastal flood in Pärnu, severe winter plus power outage in Saaremaa, combined storm + cyber-degraded telecom).
- Feedback loop: delivery/coverage stats from mobile networks are merged into the context model, allowing the AI to adapt routes and warning strategies when parts of the network fail.

This integrated solution gives authorities a live, predictive map of safe roads and resilient services, and uses Cell Broadcast to reach everyone in-area with clear, time-sensitive guidance.

2.5. Innovative AI Layer: Spatio-Temporal Resilience GNN

Beyond what LISFLOOD, SUMO, and FIWARE offer individually, the platform adds a deep-learning “Resilience Brain”:

A spatio-temporal graph neural network (ST-GNN) models a multi-layer graph of roads, power lines, telecom sites, and critical services across cities.

Inputs:

- LISFLOOD fields (depth, arrival time, flow velocity)
- IoT sensor time series (water, wind, temperature, loads)
- SUMO outputs (link speeds, queue lengths, reachability)
- Event logs (past storms, winter events, cyber incidents, outages, social unrest).

The ST-GNN predicts, with uncertainty:

- Probability that each road remains passable, each feeder remains powered, and each cell tower stays on-air over the next hours. Emerging “islands of isolation” (settlements likely to be cut off).
- Recommended control actions: priority repair tasks, temporary road reversals, convoy windows, shelter opening times.

These forecasts are not available from any single API today; they emerge from learned cross-dependencies between water, traffic, power, and telecom.

2.6 Specific Feedback-Based Features

- As according to the needs of city Jelgava, Latvia, the solution will also include a modeling and prediction of the over-flooding of the city’s drainage system.
- As according to the needs of the Bağcılar municipality, the architecture of the solution will be adaptive, allowing for the smart integration of existing city’s solutions.

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3. Innovation and piloting of your pilot solution.

This solution is technically superior because it integrates real-time IoT, hydrodynamics, traffic simulation, power/telecom resilience, and AI forecasting into a single operational stack—something QGIS, HEC-RAS, or SaferPlaces do not provide. QGIS is a GIS viewer, not a dynamic prediction or decision engine. HEC-RAS supports hydraulic modelling but lacks real-time ingestion, multi-hazard fusion, and traffic accessibility simulation. Furthermore, HEC-RAS has an ultra-restricted open source license, which forbids any changes to the software, rendering HEC-RAS practically obsolete. SaferPlaces focuses on flood analytics but not live road possibility, infrastructure interdependencies, or Cell Broadcast integration. The added spatio-temporal GNN predicts cascading failures (roads, power, communications), enabling proactive, system-wide resilience decisions rather than isolated flood mapping. Furthermore, SaferPlaces is a proprietary product, and not open source. Sooner or later, its utilization would lead to vendor-lock in.

What do the cities need for piloting the proposed solution? How the piloting could work?
All components needed for the solution are open source. No additional are required. Both LISFLOOD and FIWARE are solutions of very large, well-funded EU projects, therefore LISFLOOD and FIWARE are extremely stable, well-tested in the field and well maintained. SUMO is best of breed in its domain. Given the experience of TalTech and its partners, we will achieve a Technology Readiness Level TRM 7 (System prototype demonstration in operational environment) for the pilot.

Capabilities of the research and development proposed team.
We have two decades of experience in designing and implementing large-scale disaster management systems, data-driven systems, always leading-edge and innovative:

From the team of Dirk Draheim:
https://ieeexplore.ieee.org/abstract/document/8698814
https://ieeexplore.ieee.org/abstract/document/8759905
https://ieeexplore.ieee.org/abstract/document/9672370
https://ieeexplore.ieee.org/abstract/document/6059830
https://ieeexplore.ieee.org/abstract/document/9678347

From the team of Arun Kumar Sangaiah:
https://www.sciencedirect.com/science/article/pii/S2444569X23000963
https://ieeexplore.ieee.org/abstract/document/10352941
https://www.sciencedirect.com/science/chapter/edited-volume/abs/pii/B9780128133149000098

4. Expected impact of your pilot solution.

The solution significantly enhances urban resilience by enabling cities to anticipate, prepare for, and respond to natural hazards and infrastructure disruptions with greater accuracy and coordination. Real-time risk intelligence and optimized emergency routing reduce human and economic losses, while improved continuity of essential services supports overall sustainability. Citizens benefit from timely, targeted alerts and safer mobility, strengthening public trust and reducing vulnerability. For city planners, integrated simulations and digital twins enable smarter long-term investments in climate-resilient infrastructure. Overall, the platform fosters safer, more adaptable, and more sustainable urban environments in the face of escalating climate and security challenges.