

DRIVING URBAN TRANSITION – DUT 2025 CALL



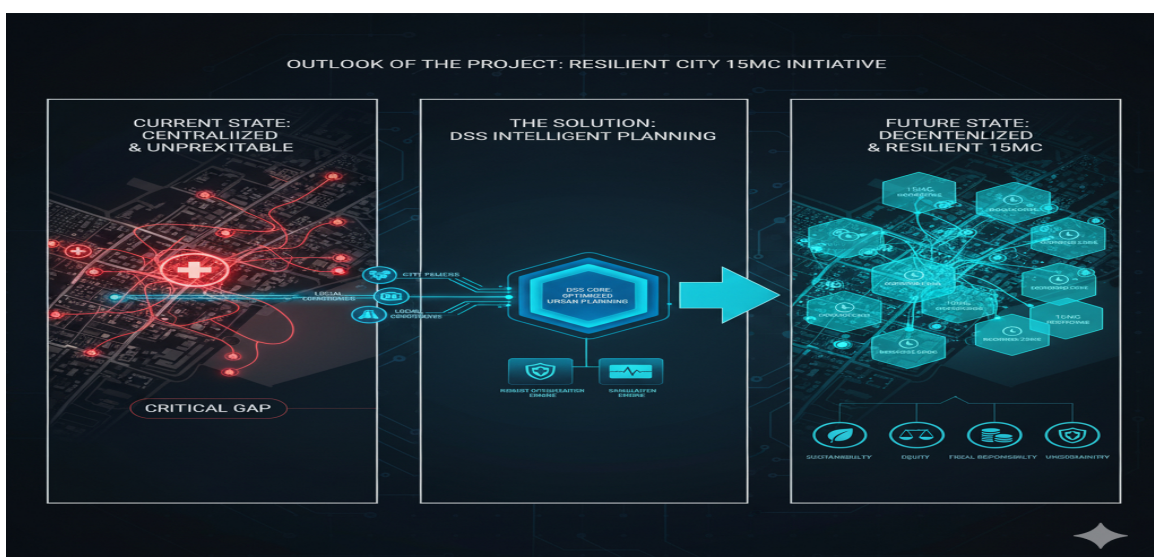
**A GUIDELINE FOR A RESILIENT AND
ECONOMICALLY VIABLE EMERGENCY
RESPONSE NETWORK: SECURING THE
15-MINUTE CITY TRANSITION**

Outlook of the project

This project addresses a critical gap in the 15-minute city (15mC) paradigm: the integration of a resilient emergency response system. While the 15mC model successfully prioritizes proximity for daily services, its current framework overlooks the essential need for rapid, reliable emergency care for human-made disasters, leaving a dangerous vulnerability in urban safety.

To bridge this gap, this initiative employs a science-backed and rigorous three-stage methodology. In the forecasting phase, collected datasets are analyzed, pre-processed, and then future incidents are forecast via cutting-edge machine learning (ML) tools. Additionally, risk mapping is conducted, and, core uncertainties of the system such as **variable travel speeds** and **path availability** are formulated. Then, robust optimization phase generates strategic and tactical plans that are **mathematically immunized against predefined uncertainties**. Lastly, these plans are subsequently validated by a comprehensive and data-driven simulation framework, which conducts dynamic stress-tests against stochastically generated incident forecasts. This integrated methodology ensures all outputs are **cost-minimizing** while **guaranteeing performance and resilience**, providing a scientifically grounded foundation for the transition.

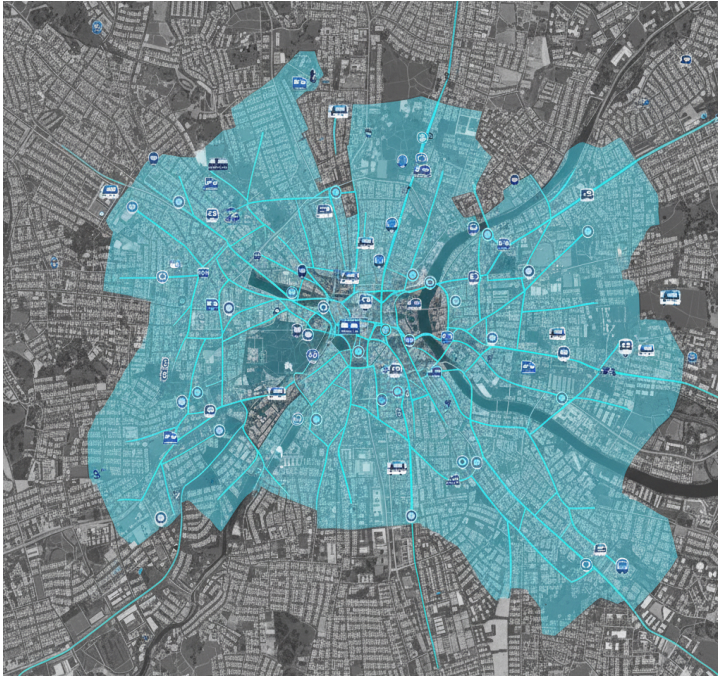
Central to this methodology is a **flexible** Decision Support System (DSS). Its architecture enables stakeholders to model diverse scenarios by integrating customized inputs, including **budget constraints**, **risk tolerance levels**, and **specific policy goals**. The system processes these parameters to generate **compliant, tailored** plans. This adaptable framework ensures the resulting strategic and tactical plans are **directly aligned with local priorities** and are **robustly designed to withstand core operational uncertainties**.



Assumptions

- ✱ **Disaster scope:** The model focuses primarily on human-made disasters, including traffic accidents, industrial accidents, complex mass-casualty incidents, and intentional attacks.
- ✱ **Incident occurrence:** Emergency incidents can occur at any location and at any time within the urban environment.
- ✱ **Response completion:** Emergency response is considered complete when the required number of emergency vehicles arrives at the incident location.
- ✱ **Travel speed uncertainty:** The travel speed of emergency vehicles is variable and subject to fluctuations during transit.
- ✱ **Path uncertainty:** The shortest path to an incident may be unavailable or sub-optimal due to factors like traffic congestion. Consequently, the actual travel path may be longer than the theoretical shortest route.





Outcomes of the project

This project will deliver a comprehensive blueprint for transitioning emergency response to the 15mC paradigm. It moves beyond **where to build response facilities** to specify **exactly how to run the system under uncertainty**. By leveraging robust optimization, all plans are designed to **minimize total cost while guaranteeing performance amid critical uncertainties**, such as variable travel speeds and path availability. This provides **mathematical and operational**

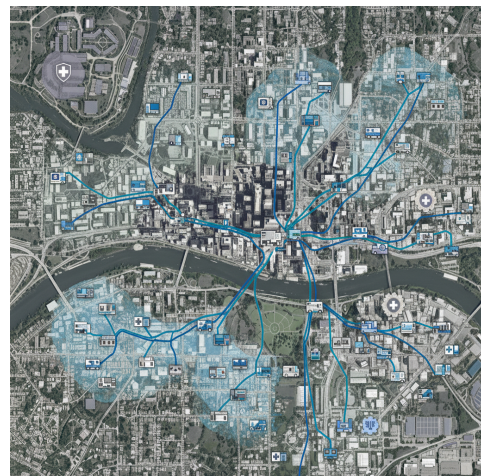
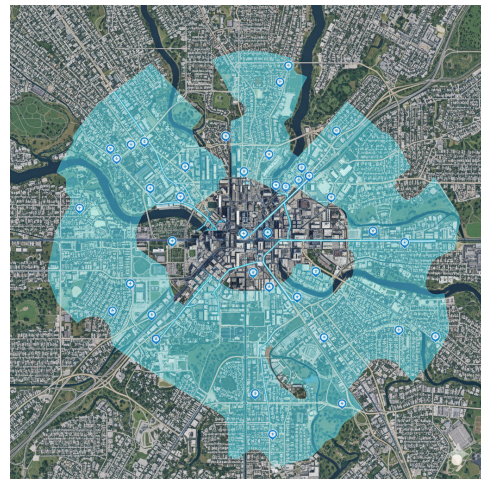
assurance for achieving the **sub-15-minute response target**. Furthermore, the optimization model's inherent flexibility **ensures** all resulting plans are **fully compliant with city's specific policy goals and constraints**.

Decision-makers will receive the following integrated set of strategic and tactical plans:

- ✳ **Decentralized network architecture:** Determines the number, locations, and capacity levels of emergency facilities along with their coverage areas, creating a resilient and low-cost web of coverage.
- ✳ **Strategic fleet composition:** Details the optimal type (e.g., rapid response vehicles, advanced life support ambulances) and total number of vehicles required for the entire city-wide network.
- ✳ **Long-term human resource planning:** Defines the total workforce size and required skill mix (e.g., paramedics, nurses, physicians, drivers) to operationalize the new network effectively.

- ✳ **Vehicle deployment:** Assigns each vehicle to a specific facility and shift, with integrated procedures for flexible, real-time tasking to ensure optimal coverage across the network on the basis of future incidents.
- ✳ **Shift schedules:** Creates detailed shift schedules for all personnel (e.g., paramedics, nurses, physicians, drivers).

Ultimately, these plans deliver a detailed blueprint for a **resilient (completely immunized against predefined uncertainties), economically sustainable, and cost-minimizing** emergency response system. This blueprint thereby enables a seamless and effective transition to the 15mC paradigm, specifically for emergency response services for human-made disasters.



What will be ensured?

✱ Transition to 15mC paradigm:

Despite uncertainty in their speed and path to the incident location, it is warranted that emergency vehicle(s) will reach to each incident location within 15 mins (or less) even when and where it happens throughout the city. This ensures a **realistic** and **resilient** transition of emergency response network to 15mC paradigm.

✱ Accurate strategic and tactical decisions:

Policy-makers and decision-makers will be provided with a data-driven, optimized



blueprint for transition of emergency response network to 15mC paradigm. This ensures that strategic and tactical decisions/plans (e.g., investing in infrastructure (e.g., where to build a response facilities), fleet composition, vehicle deployment, staff planning and scheduling) are **based on rigorous optimization, not guesswork**.

✱ **Economical viability:** The optimization model will explicitly balance cost with capability. It ensures that the proposed network is not only effective but also economically feasible, finding **the most cost-efficient way** to achieve the target level of resilience and response time.

✱ **Immunization against uncertainties:** The emergency response network will be using robust optimization to ensure reliable performance under uncertain conditions, specifically fluctuating travel times and variable road availability. The use of Robust Counterpart Approach (RCA) **mathematically guarantees** that the strategic and tactical plans (e.g., facility location, duties) remain **feasible, implementable, resilient, and economically sustainable**.

Modules of the developed decision support system (DSS)

✳ **Module 1. Data integration & geospatial management:** Serves as the central repository for all input data required by the optimization model. It will comprise of four main databases:

- ☐ **Geographic information system (GIS):** Imports and manages layers such as road networks, land use, building footprints of candidate facilities, and existing infrastructure.
- ☐ **Demographic data importer:** Integrates data on population density, age distribution, vulnerability indices, and prioritized citizens/areas (if any).
- ☐ **Resource database:** Contains data on existing resources such as total available budget, fleet, workforce, existing facilities, etc.
- ☐ **Historical incident log parser:** Imports historical emergency medical service call data to identify frequency and scale of incident locations.

✳ **Module 2. Constraint configurator:** Enables users to define specific requirements, policies, and constraints to guide the optimization and simulation runs. Configurable parameters include, but are not limited to:

- ☐ **Target response time:** Arranges target response time. Prioritization and differences across regions will be allowed.
- ☐ **Minimum coverage mandate:** Ensures emergency response to cover at least X% of the population within the target response time.
- ☐ **Maximum budget:** Indicates total available budget both for initial investment and operational expenses per year.
- ☐ **Dispatch rules:** Defines dispatch rules for emergency vehicles based on policy and procedure of the organization.
- ☐ **Work rules:** Determines shift lengths, required breaks staff mix, etc.
- ☐ **Uncertainties:** Sets up the uncertain parameters (i.e., average speed of the vehicles, the shortest path to the incident location).
- ☐ **Others:** Customer-specific policy constraints might be designed specifically.

✳ **Module 3. Data analysis & forecasting engine:** To transform raw data into actionable intelligence by forecasting future demand and characterizing urban risk, providing a trusted and usable parameters for the optimization and simulation modules.

❑ **Data preprocessing:** Cleanses and prepares raw datasets (e.g., historical EMS calls, traffic data, demographic structure). It handles missing values, normalizes data, and geo-codes incident locations to ensure quality and consistency for analysis.

❑ **Spatio-temporal forecasting:** Employs statistical and machine learning models to predict the likelihood, volume, and location of future emergency incidents.

❑ **Risk & vulnerability mapping:** Risk maps are generated on the basis of forecasts, population, and other gathered data.

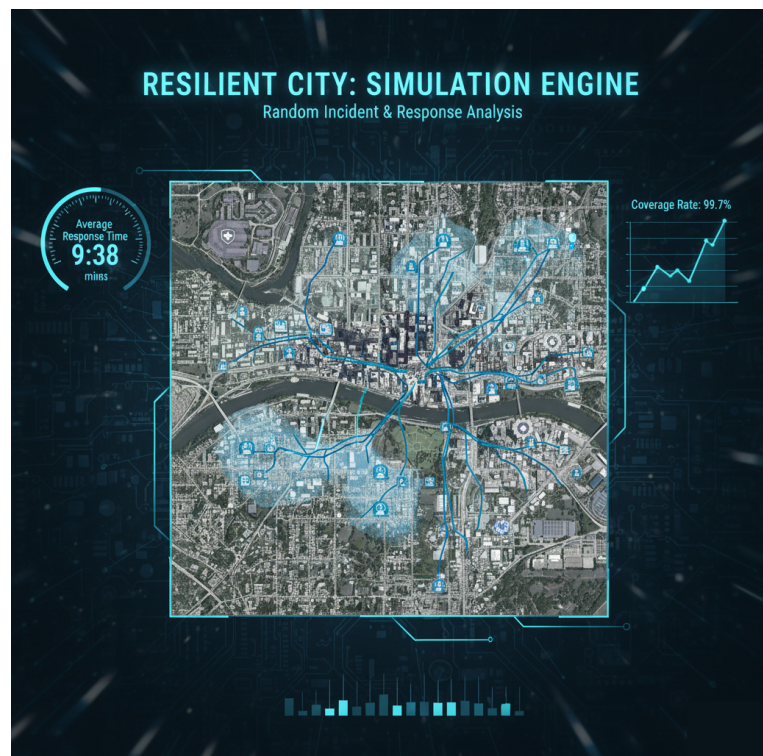
❑ **Shaping uncertainty:** The predefined uncertainties are analyzed and mathematically formulated.

✳ **Module 4. Optimization engine:**

Serving as the computational core of the DSS, this module executes the developed robust optimization algorithms. It processes all input data and user-defined constraints to generate the optimal strategic and tactical blueprint for the emergency response network.

✳ **Module 5. Simulation engine:** Acts as a dynamic testing ground for the strategic plans generated by the Optimization Engine. Instead of a mathematical proof, it performs dynamic, stochastic stress-tests on the optimized plans generated by Robust Optimization Engine. By

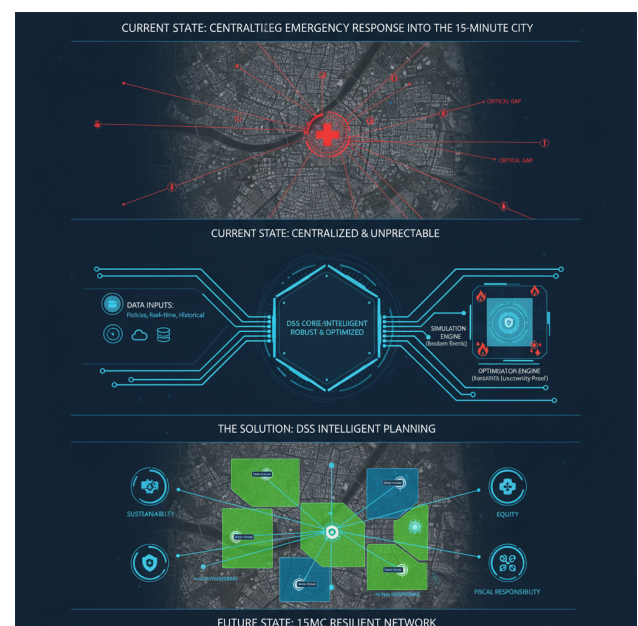
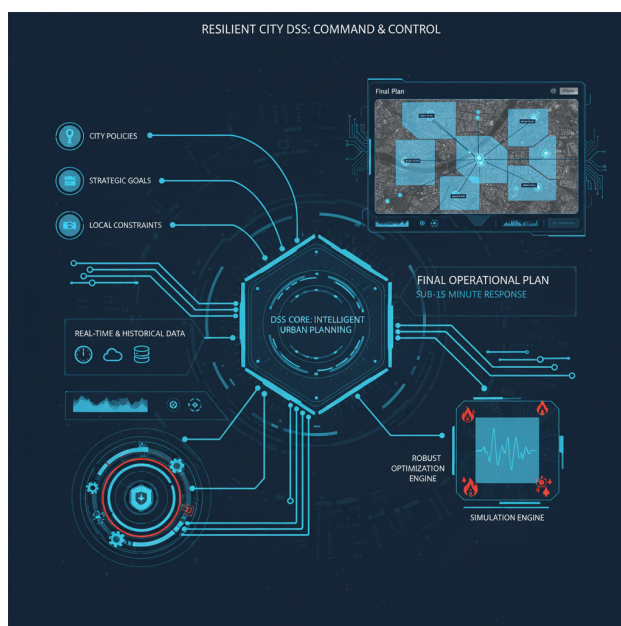
simulating numerous disaster scenarios with random incident patterns, it will provide performance metrics and identify potential bottlenecks. Its main mechanisms are provided below:



- ❑ **Initialization:** Imports the optimized strategic plan (facility locations, vehicle fleet, staff allocation) from the Robust Optimization Engine. It then creates a virtual copy of the real system.
- ❑ **Stochastic event generation:** Automatically spawns emergency incidents with random timing, location, and severity based on probabilistic models derived from historical dataset.
- ❑ **Operational logic execution:** Dispatches vehicle/staff to each incident on the basis of optimized network and its rules (eg coverage, staff scheduling, etc).
- ❑ **Tracking and recording:** Tracks and records status of the resources to create a meaningful benchmark framework.

✳ **Module 6. Visualization & reporting dashboard:** Translates complex algorithmic outputs into intuitive, visual, and actionable information for decision-makers. The core features are summarized below:

- ❑ **Interactive resource map:** Displays the optimized locations of facilities, color-coded by their capacity or type. Shows the assigned coverage areas for each facility.
- ❑ **Network performance viewer:** Allows side-by-side comparison of different optimized plans based on defined KPIs.
- ❑ **Automated report generator:** Creates a PDF report summarizing the key strategic decisions such as the number and location of facilities, vehicle and staff requirements, total estimated cost, and achieved performance KPIs.



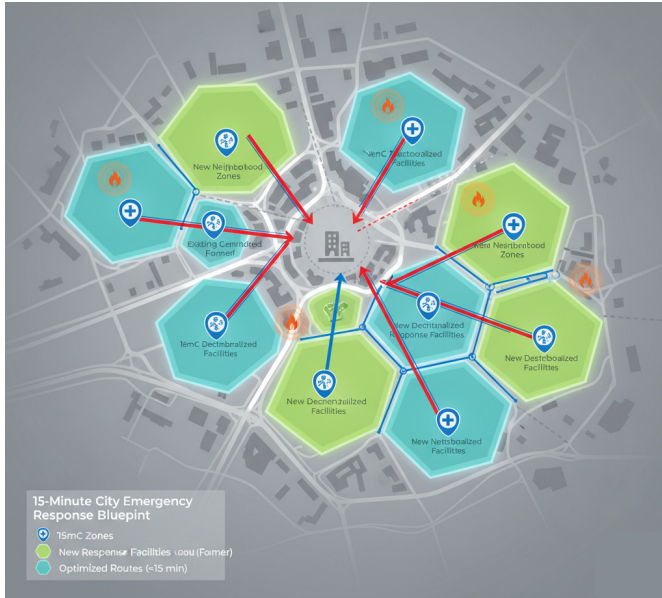
The DSS workflow

- ✳ **Data & config (Module 1–2):** User defines the problem through user–friendly interfaces.
- ✳ **Data analysis & forecast (Module 3):** This module analyzes historical patterns to forecast future emergency incident demand across time and location. It also generates data–driven parameters for uncertainty (e.g., speed distributions) and identifies high–risk areas.
- ✳ **Optimize (Module 4):** The Robust Optimization Engine generates a theoretically optimal strategic plan and its tactical plans, which are completely immunized against core uncertainties (ie average speed of the vehicle, the shortest path to the incident venue).
- ✳ **Simulate & validate (Module 5):** The Simulation Engine takes these plans and stress–tests them under dynamic, uncertain conditions, producing realistic performance metrics.
- ✳ **Analyze & refine (Module 6):** The user views the optimization and simulation results in the Dashboard. In this module, the user is allowed to adjust constraints (eg increase budget, add more facilities, etc) and return to Module 2 to re–optimize the problem.
- ✳ **Finalize plan:** This loop continues until the user has validated plans that are not only mathematically optimal but also verified based on their performance metrics resulted in simulation framework.



Out of scope

- ✳ **Construction:** The project will **not** involve the physical construction of facilities or the procurement of vehicles and staff. It provides **the plan** and **the business case** for such implementation.
- ✳ **Operational plans/decisions:** The project focuses on **strategic planning** (where to build facilities, creating duties for vehicles and staff, assigning coverage area to response facilities, etc). It will **not** develop a dispatch system **nor** optimize routes for active incidents.
- ✳ **Tracking and communication system:** Any tracking and communication system will **not** be established in the project.
- ✳ **Other disaster types:** While the model may be adaptable and usable, the primary focus is **not** on slow-onset disasters (e.g., pandemics, etc) or large-scale natural disasters (e.g., large-scale earthquakes, floods, etc), which have fundamentally different spatial and temporal dynamics.
- ✳ **Full-scale clinical trials:** The validation will be based on simulation and historical data analysis, **not** on the live clinical trials during actual disasters.
- ✳ **Development of medical protocols:** The project will **not** define clinical procedures (e.g., how to intubate a patient, etc). It will **optimize** the resource allocation and **ensure** 15mC paradigm for emergency response activities.
- ✳ **Total coverage of 15mC services:** The scope is limited to **emergency response**. It does **not** cover other aspects of the 15mC, such as access to education, green spaces, or non-emergency healthcare.



Requirements

- ✳️ A governmental authority that provides real data for the validation phase.
- ✳️ A governmental authority that is interested to reshape its emergency response network through the project.
- ✳️ A governmental authority and/or individual expert that is willing to feed the project with know-how and expertise. Individual experts need to demonstrate their expertise.
- ✳️ A partner demonstrating strong scientific and practical background on machine learning such as deep learning, time series mining, etc.
- ✳️ A partner with solid experience in back-end coding, front-end coding, and/or database building.
- ✳️ A partner having a strong expertise in environmental issues.

Final words

- ✳️ Since there is not much time, acting promptly is required in case of collaboration.
- ✳️ Project proposal is almost ready. It needs to be tailored based on contribution of the partner(s).
- ✳️ For more information about Pallas, you may visit: <https://www.pallasconsultancy.com>.
- ✳️ If you foresee a synergetic contribution for this project, please feel free to contact to aykanakincilar@pallasconsultancy.com.

