

# Cascading Interdependencies Simulator (CIS)

by KIOS CoE

## About

The Cascading Interdependencies Simulator (CIS) is a simulation tool designed to model the interactions and interdependencies among critical city infrastructure networks, such as electricity, telecommunications, and transportation. It abstracts the finite states and transitions of these networks to simulate their behavior during digital breakdown scenarios.

Modern infrastructure systems (power, roads, telecom) are deeply connected. A failure in one can quickly affect others — hence 'cascading failure.' Hazards like storms and floods make these failures worse. Smart tools like CIS can help emergency teams understand cascading risks before they happen.

CIS will be deployed and evaluated in a collaborative, multi-infrastructure setting as part of the SPARROW project, which aims to improve societal resilience and crisis management in the face of digital breakdowns.

Initially, CIS will be tested in the Cyprus pilot. However, the framework is designed to be easily adapted for other SPARROW pilots (Trikala in Greece, Pilsen in Czechia) by adjusting data layers and hazard inputs.

## Use case

A regional emergency management authority wants to understand the cascading consequences of a strong windstorm affecting both the power and communication networks.

Using CIS, the user (first responder) loads infrastructure data (electrical substations, poles, and telecommunication towers) and defines a windstorm hazard scenario.

The tool simulates power line failures and propagates their impacts to communication towers dependent on these substations. It dynamically quantifies key indicators such as Demand Not Served (DNS), number of failed assets, and the population affected by communication outages.

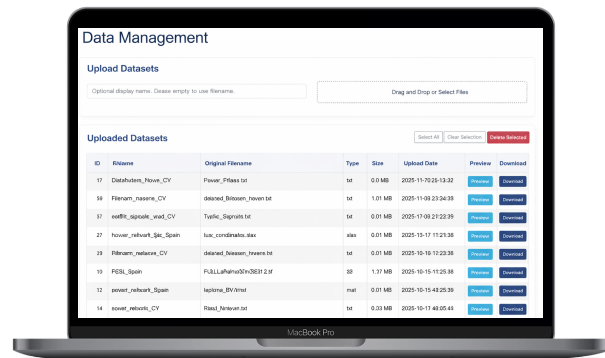
By visualizing these impacts over time, the authority can evaluate the benefits of mitigation strategies such as introducing backup power at telecom sites or reinforcing vulnerable network sections.

The output provides a data-driven basis for resilience planning and emergency preparedness.

## How to use CIS?

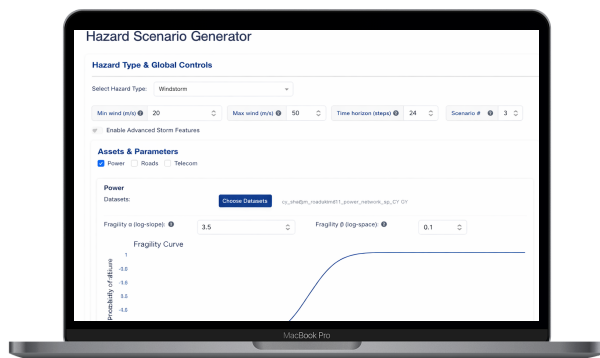
### 1) Upload datasets

Users import power, road, and telecom network data in supported formats (CSV, GeoJSON, MATPOWER, etc.) and the system validates the supplied information.



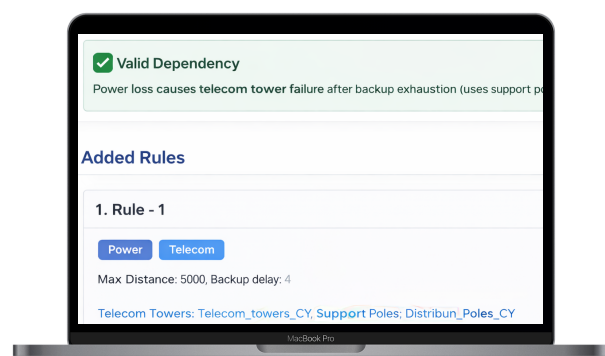
### 2) Create hazard scenarios

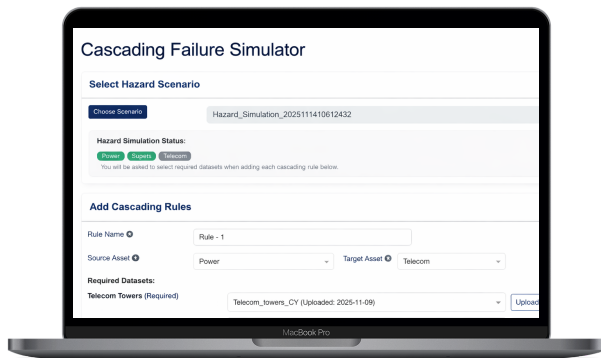
Storm parameters and hazard characteristics are defined using static inputs or real-time weather data. CIS generates multiple Monte-Carlo-based scenarios to capture uncertainty and variability.



### 3) Map interdependencies

Users define dependency rules between infrastructures and generate a dependency matrix. This establishes how failures in one network influence others.



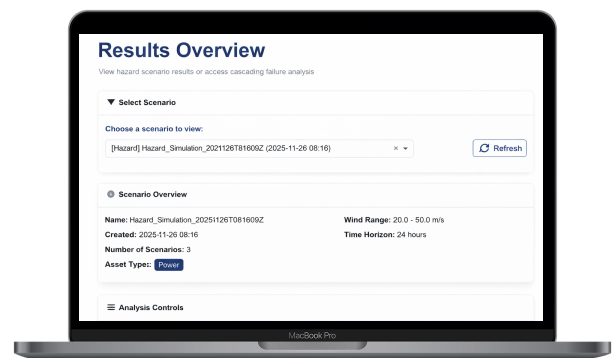


#### 4) Model cascading failure

CIS simulates how initial asset failures spread across interconnected systems. Fragility curves, restoration parameters, and dependency rules drive the propagation logic.

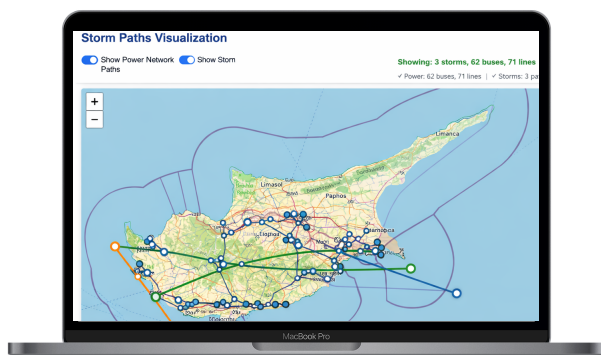
#### 5) Analyse and export results

Interactive dashboards, maps, and charts reveal vulnerabilities, hotspots, and system-wide impacts. Results can be exported in multiple formats for reporting or further analysis.



#### 6) Integrate results into decision support

Simulation outputs feed tools like CITWIN and CESER to support planning, training, and operational response. This final step turns analytical insights into actionable preparedness and mitigation strategies.



## End users

- **Emergency support:** Dispatchers, planners, coordinators, analysts
- **Non-emergency authorities:** Public agencies involved in resilience planning
- **Reseachers and professionals:** Experts in critical infrastructure interdependencies

## Capabilities

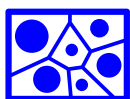
- Multi-hazard simulations (windstorms, floods, fires)
- Real-time weather integration
- Infrastructure interdependency modelling
- Interactive analysis dashboard
- Export to CSV, JSON, GeoJSON, SVG

## Integration

- REST API connection
- Export to GIS tools (QGIS, ArcGIS)
- Post-analysis in Python, MATLAB, R
- Automated alerts through disaster management systems
- Other SPARROW tools (e.g. CITWIN)

## Benefits

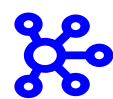
CIS is a graph-based spatiotemporal modelling tool that captures how failures propagate between interdependent critical infrastructures. It quantifies resilience using indicators such as power demand not served, asset failures, and affected population due to communication losses. Unlike static methods, CIS integrates hazard dynamics, infrastructure coupling, and geospatial impact analysis to provide a realistic, data-driven understanding of cascading events. When connected with CITWIN, it allows users to visualize simulated crises within an urban environment. This integration makes CIS a cornerstone for resilience analysis and emergency preparedness in SPARROW.



**Graphical  
spatio-temporal  
modelling**



**Indicator-based  
resilience  
quantification**



**Dynamic  
multi-hazard  
simulation**



**Cascading  
interdependency  
mapping**



**Integration with  
industry  
tools**



**Broad end-user  
base across  
sectors**



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