Analysis of Severe Space Weather on Critical Infrastructures

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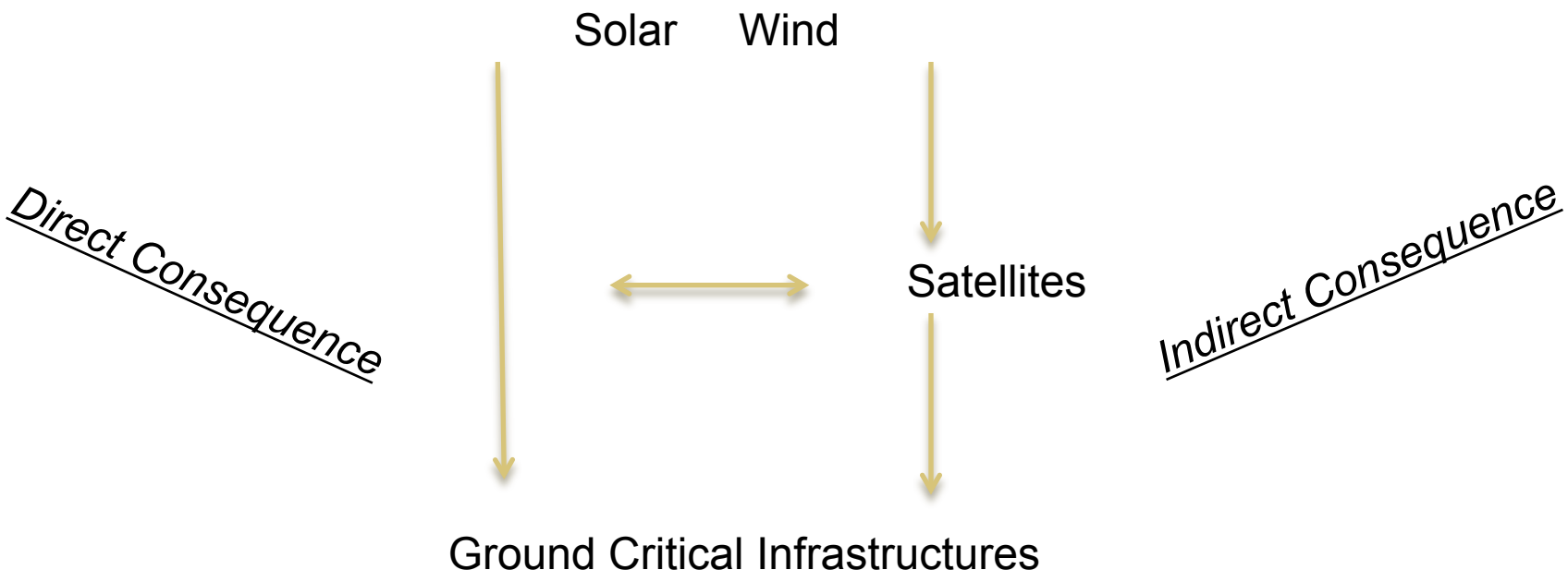
Outline

- *Overview about Space Weather*
- *Major Effects*
- *Case study*

Structure

Goal : Analyze the most significant threats posed by …



How: Using CISIA Platform
(Critical Infrastructures Simulation by Interdependent Agents)

Threats

Shooting Stars

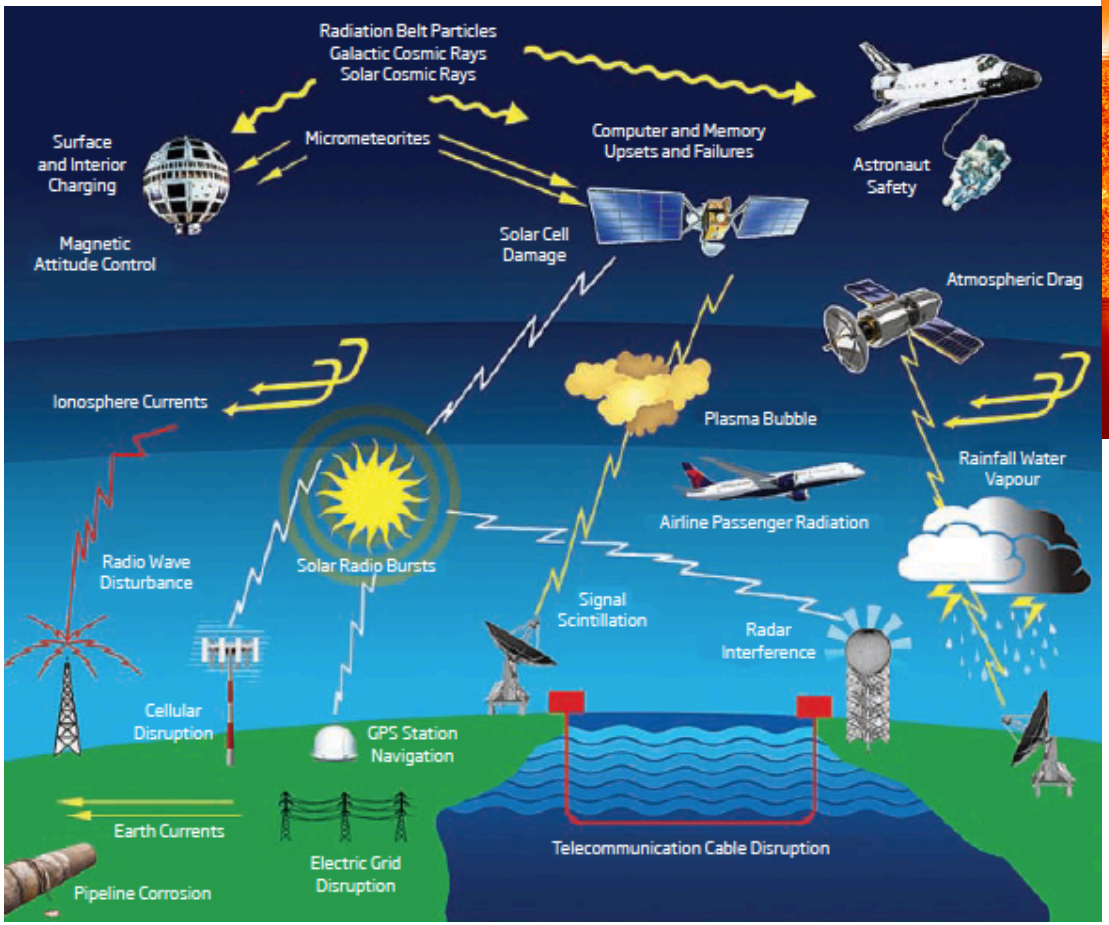
Solar Flares

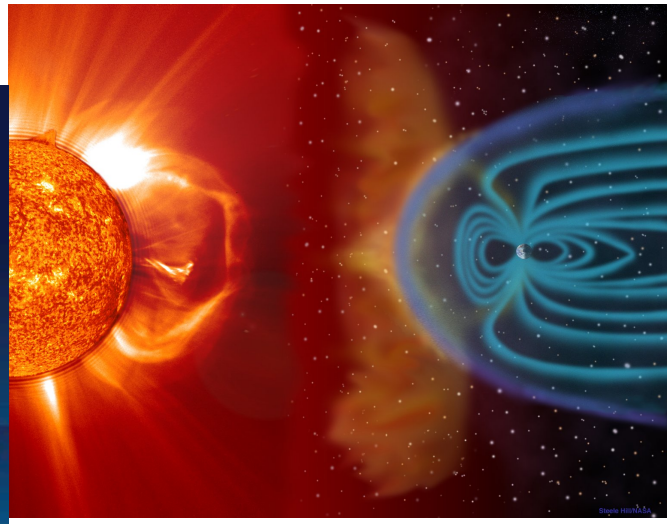
Comets

Gamma Ray Burts

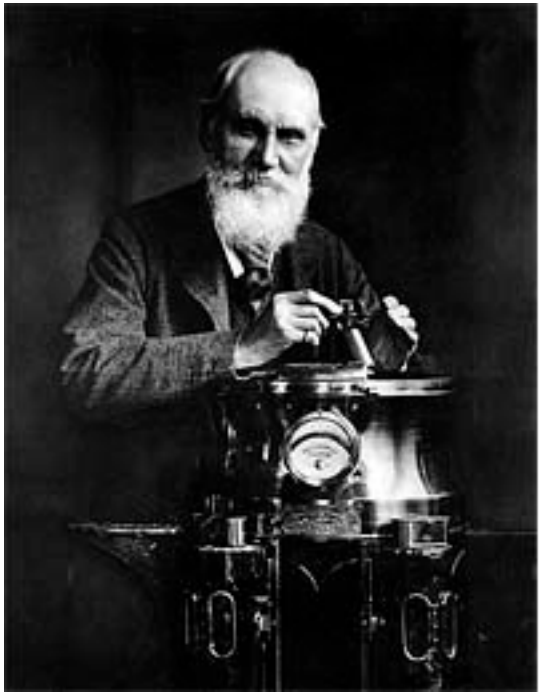
Supernovae

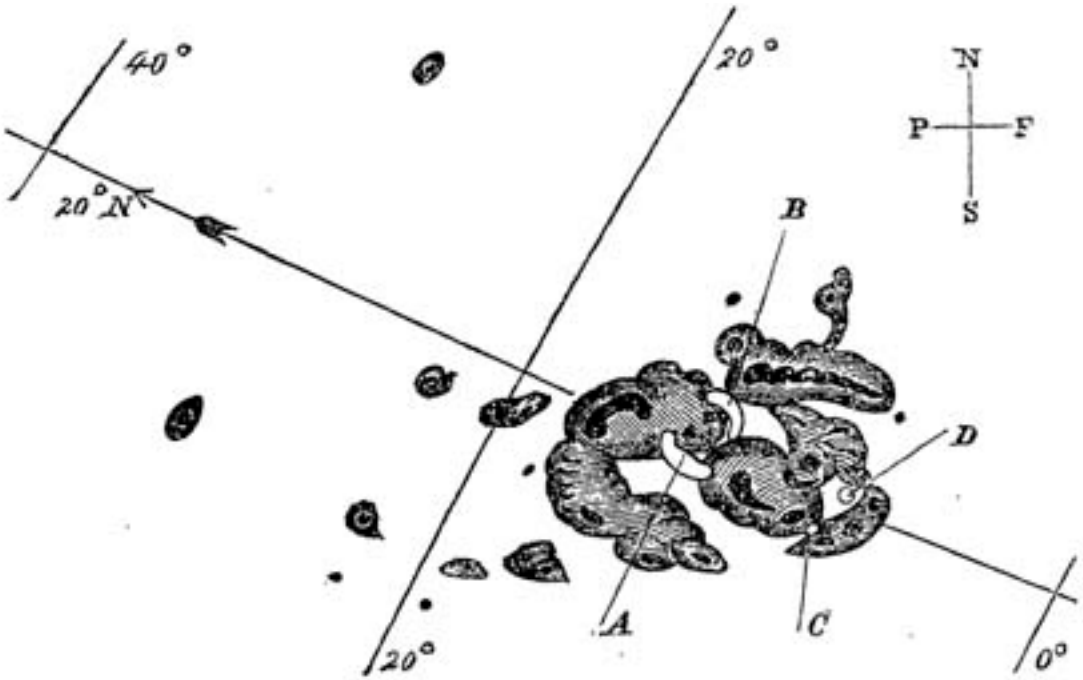
Solar Wind


Radiation Belt Particles
Galactic Cosmic Rays
Solar Cosmic Rays
Surface and Interior Charging
Micrometeorites
Computer and Memory Upsets and Failures
Astronaut Safety
Magnetic Attitude Control
Solar Cell Damage
Atmospheric Drag
Ionosphere Currents
Plasma Bubble
Rainfall Water Vapour
Airline Passenger Radiation
Radio Wave Disturbance
Solar Radio Bursts
Signal Scintillation
Radar Interference
Cellular Disruption
GPS Station Navigation
Earth Currents
Electric Grid Disruption
Telecommunication Cable Disruption
Pipeline Corrosion

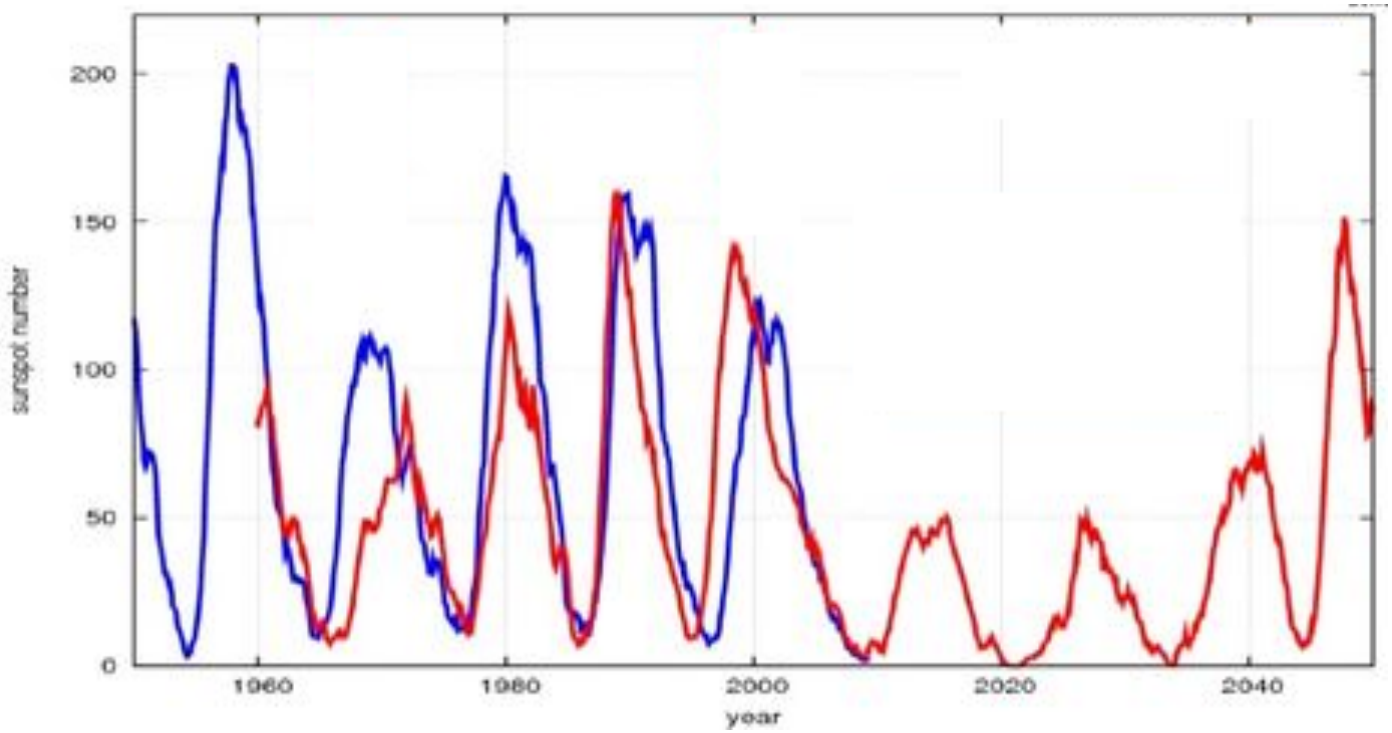


Carrington Event (1859)





Estimates of the Solar Activity Cycles



Recorded Activity

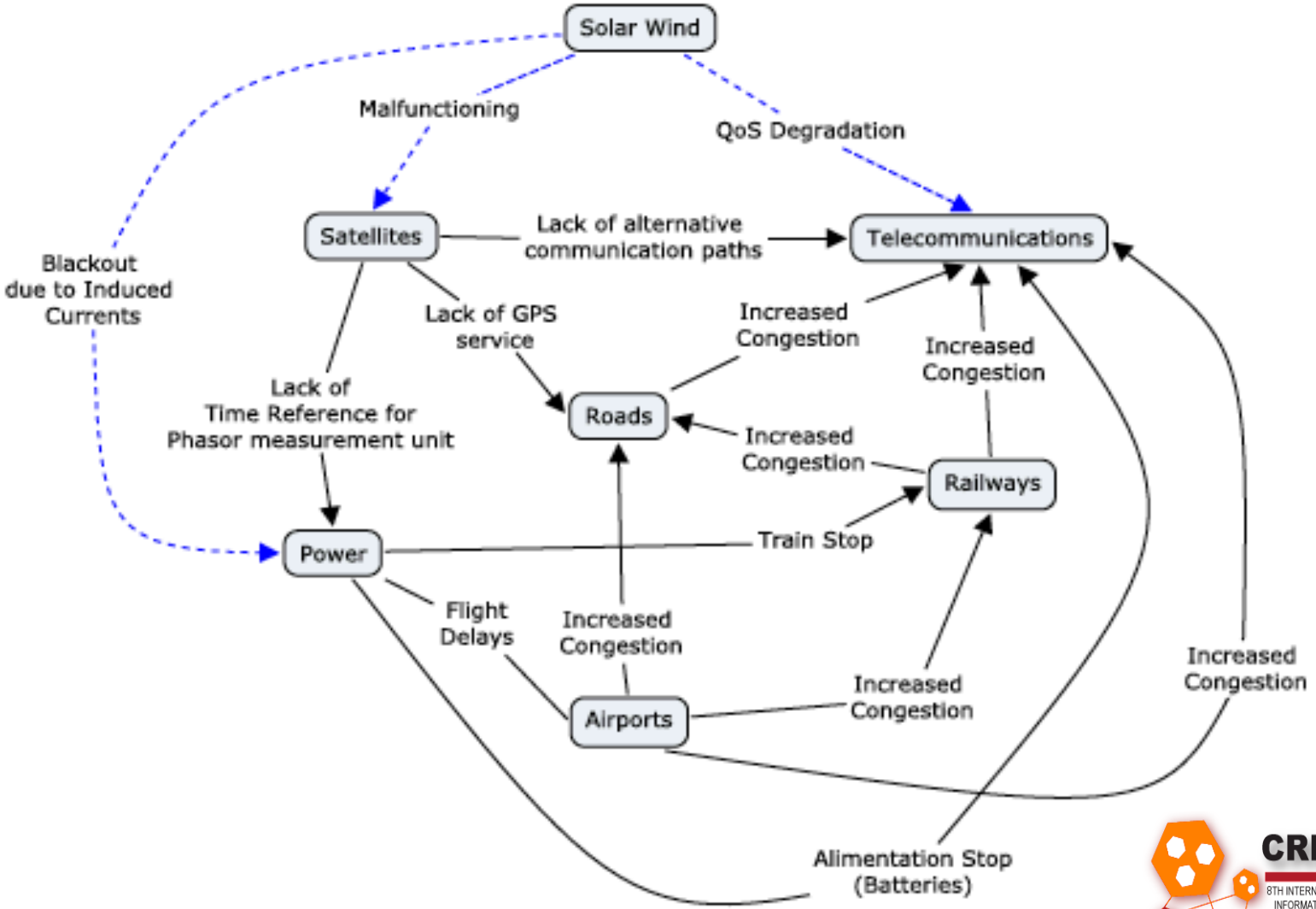
Estimated Activity

Examples of Space Weather Effects

Quebec Blackout Storm of March 1989

Halloween Storms of October/ November 2003

Modeling the effects of a solar wind on Ground Critical Infrastructures



Direct Effect

-The presence of an unstable magnetic field in the vicinity of a conductor generates a so called geomagnetic induced current (GIC)

-**GICs** are harmful to electrical transmission equipment, especially generators and transformers.

-In extreme cases, this heat may disable or destroy equipment, inducing a chain reaction that may overload transformers (Quebec Blackout Storm of March 1989)

-The solar atmosphere emits **radio waves** at all wavelengths and at all times

Indirect Effect

-Lack of Global Navigation Satellite System (GNSS) signal (e.g. GPS)

-The immediate effect of a lack of GPS signal to the transportation network is an inefficient distribution of the traffic flow, whose effects are particularly evident during rush hour

-The loss of synchronization leads to considerable problems to the whole system in terms of measurement (in the short term) and in terms of degradation of the power grid's performance (in the long term)

Design Choice

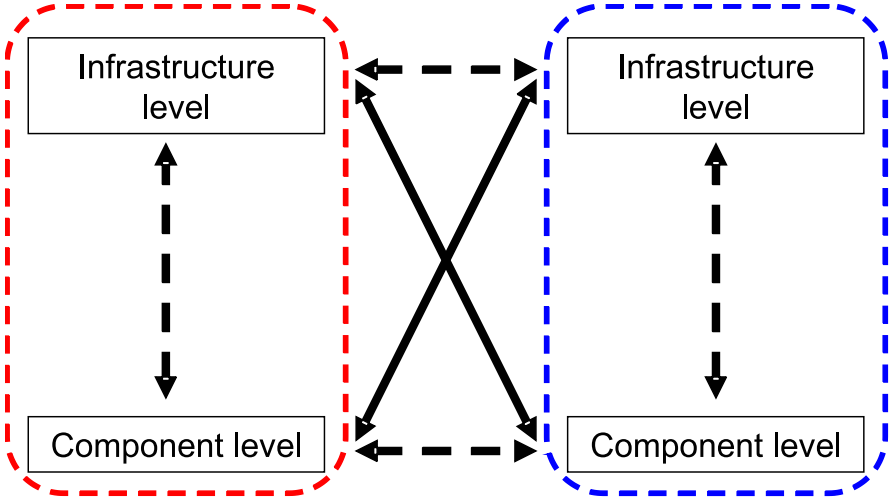
We have focused on the direct effects on telecommunication equipment and power distribution grid, and on the indirect effects due satellite malfunctioning.

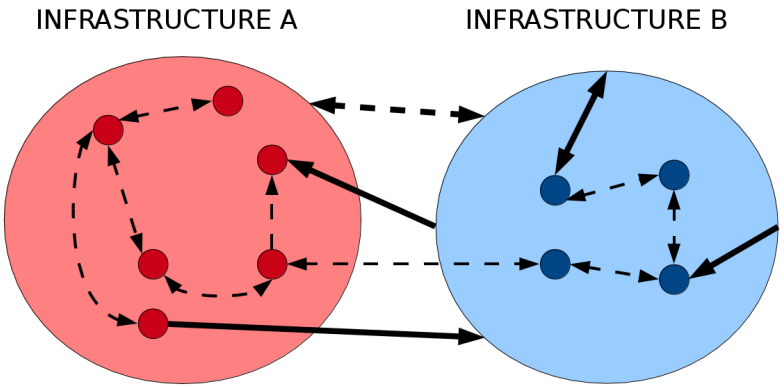
Effects much more well documented and better assessment in the short time.

We have assumed that the effect of a solar storm on the satellites consists in their temporary unavailability, while normal operations may be restored right after the event is concluded.

Cisia Simulator

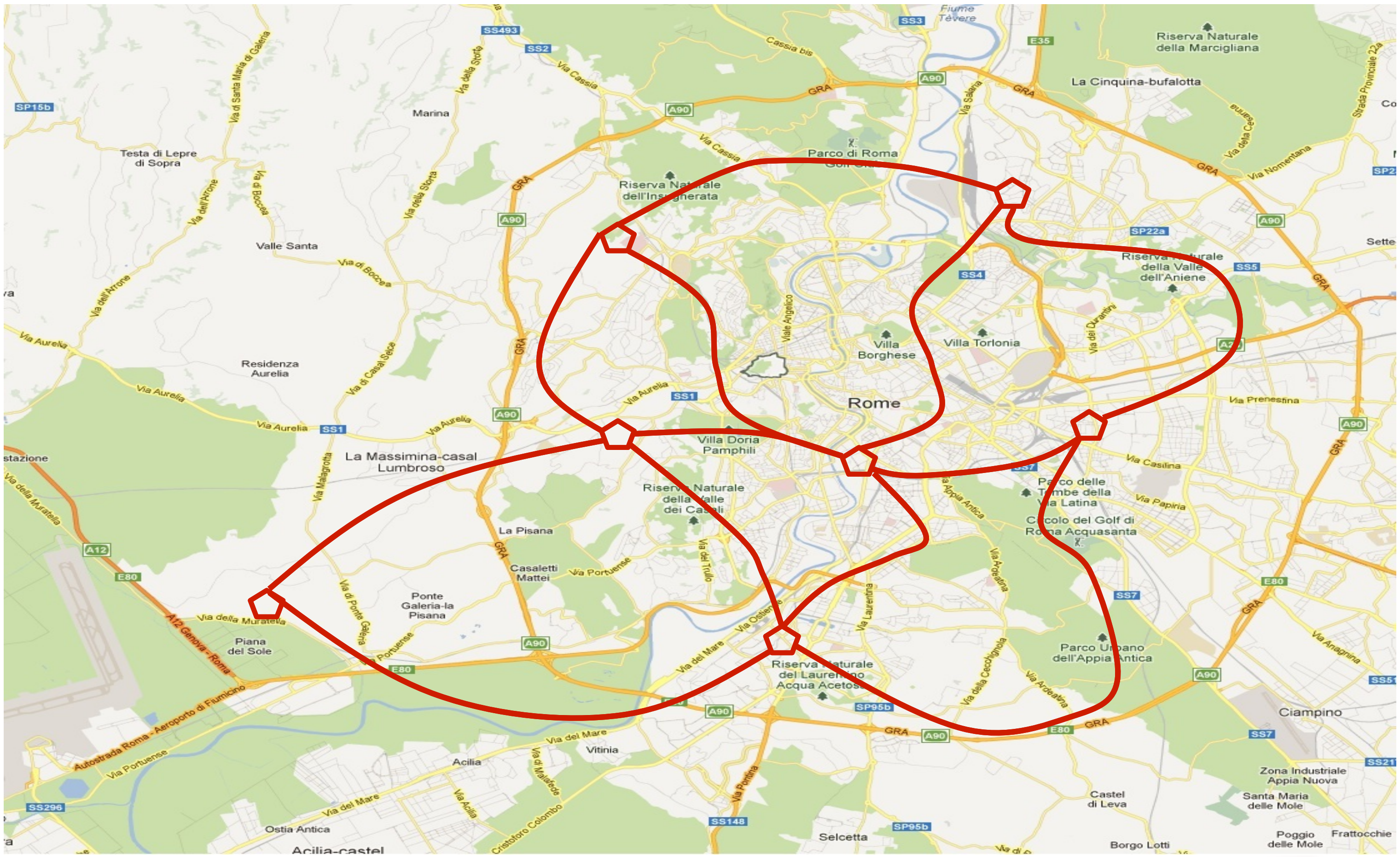
CISIA manages both levels



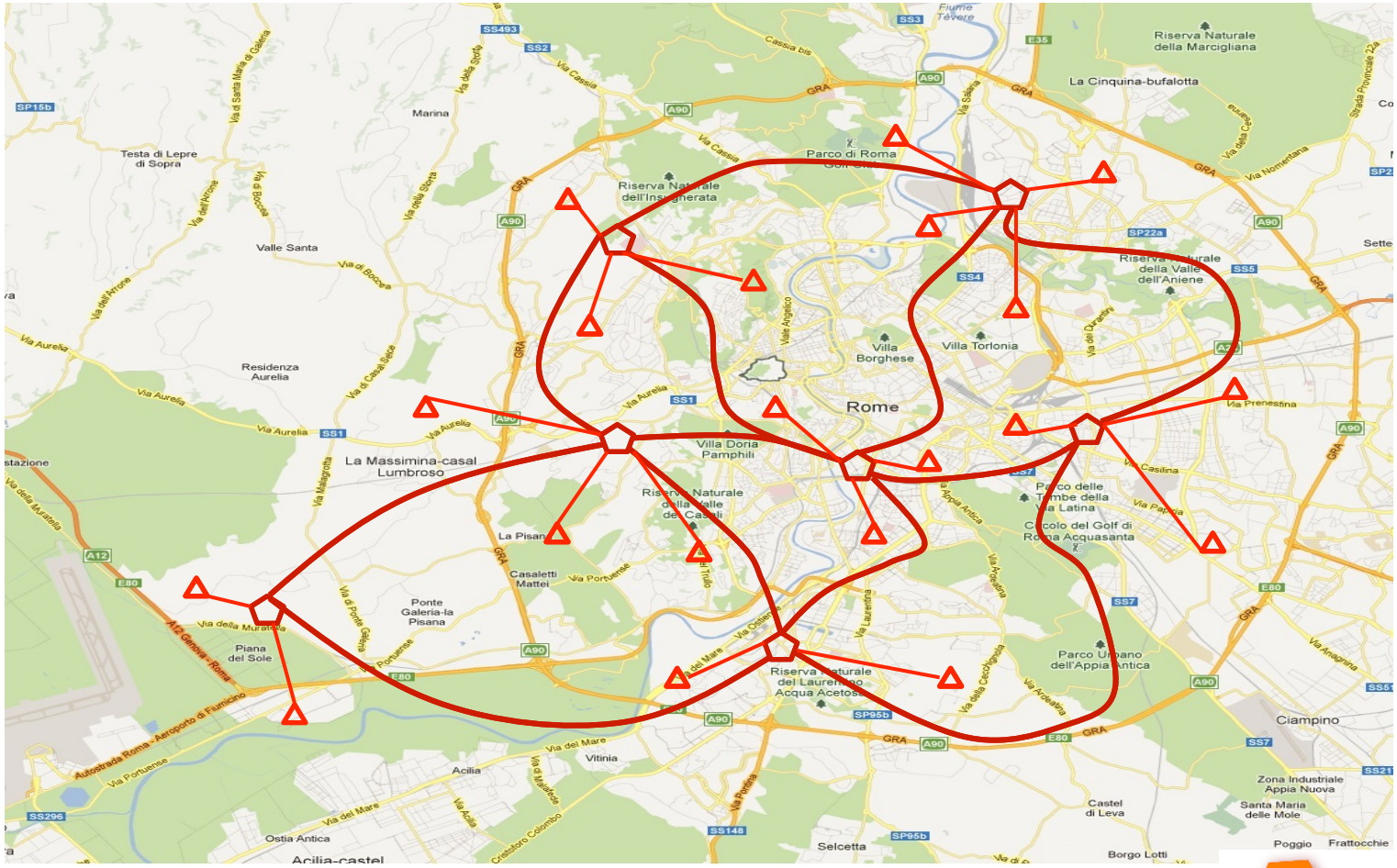


The high and low level entities can interact by exchanging resources and failures in order to simulate the domino effects

Case Study (I): Telephone Station



Case Study (II): Mobile phone



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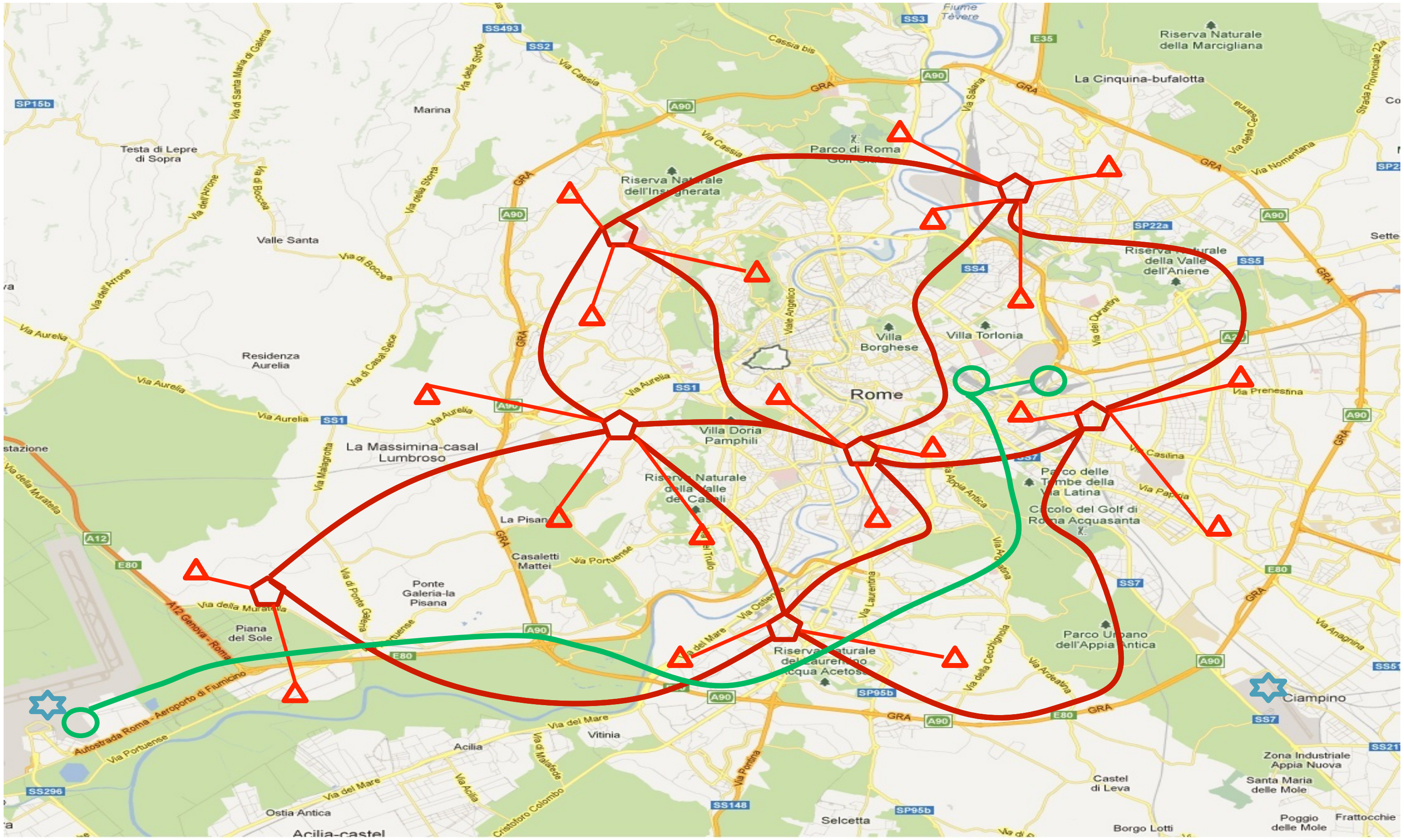
Case Study (III): Airports and Train Station



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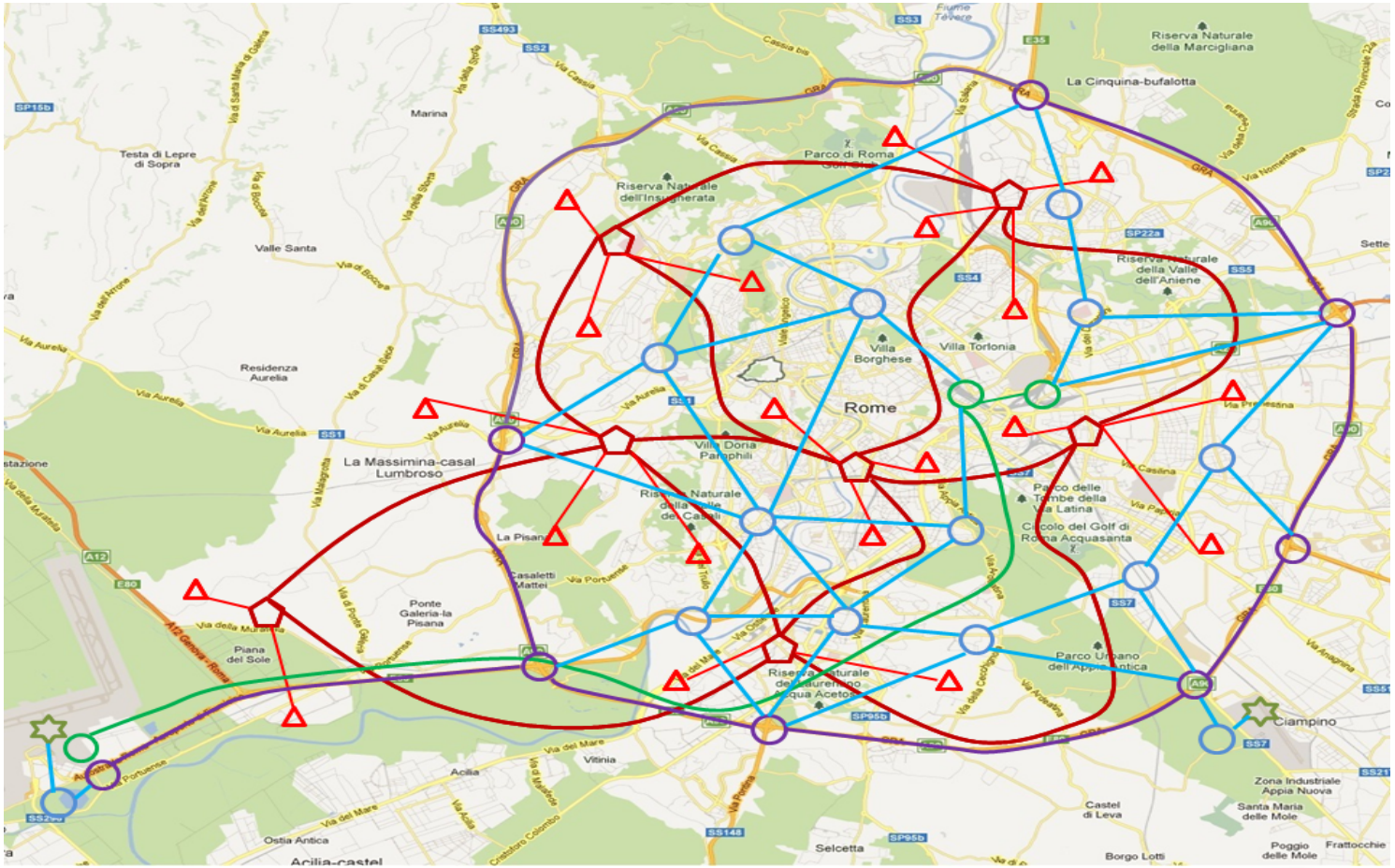
Case Study (IV): Roads and Higways



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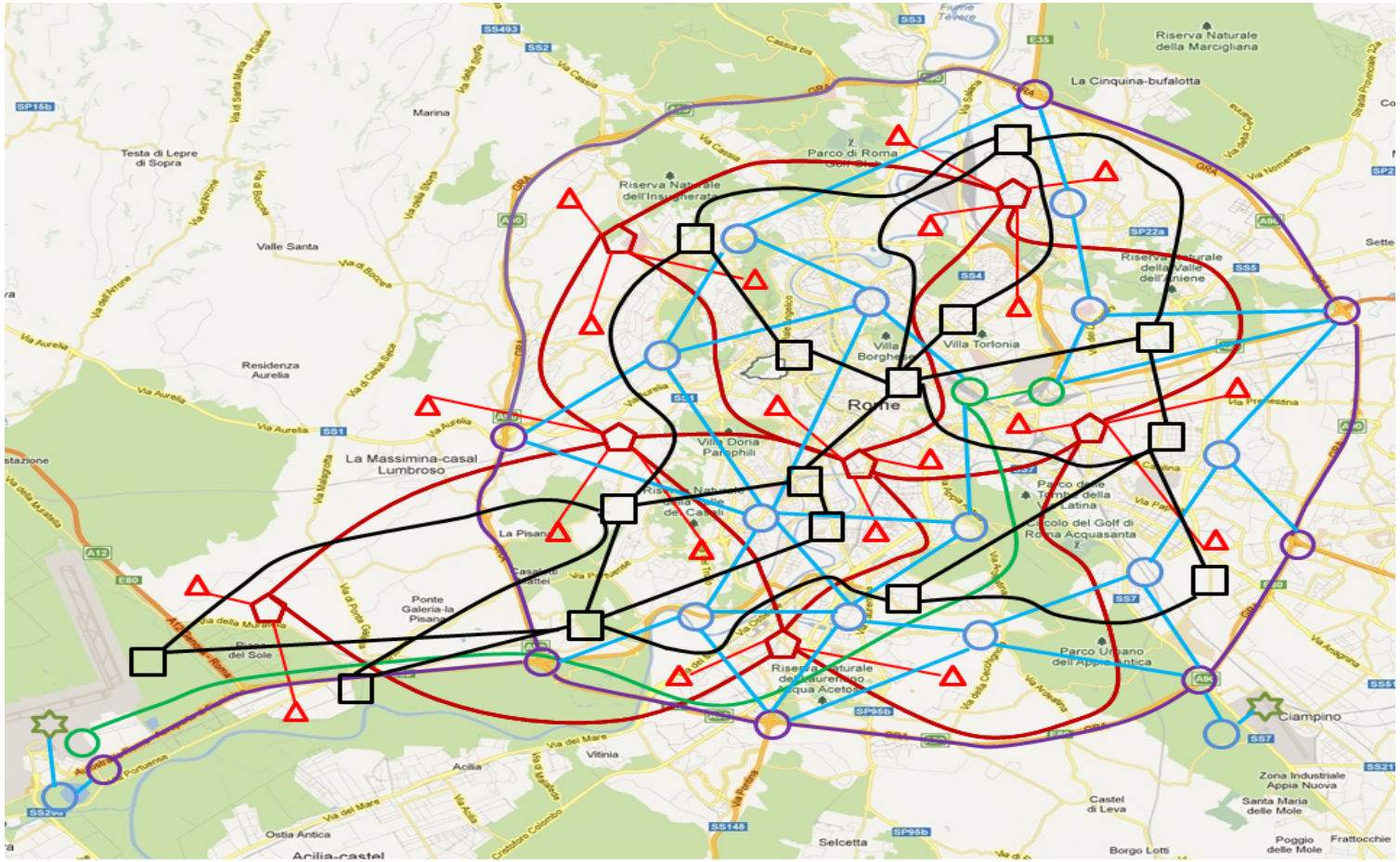
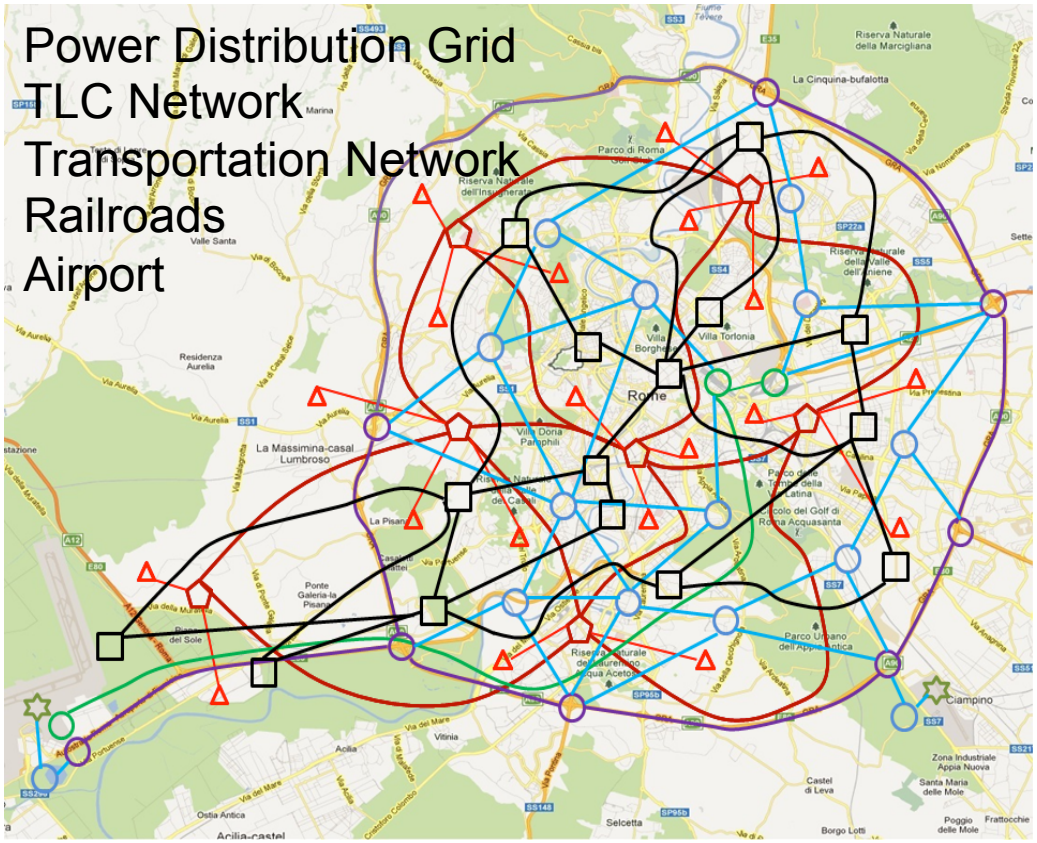
Case Study (V): Electric Substations



Case Study (VI)



Links and Nodes

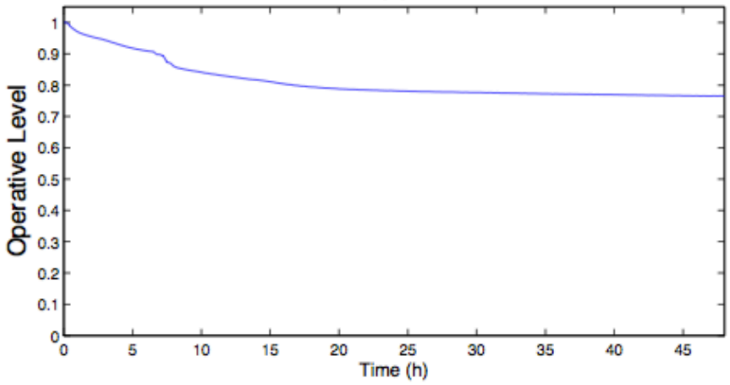
Node Type	Node Number	Link Number
Telephone Station	7	32
Mobile phone	18	72
Airport/Train Station	5	4
Roads/Higways	22	83
Electric Substation	14	65

Scenario

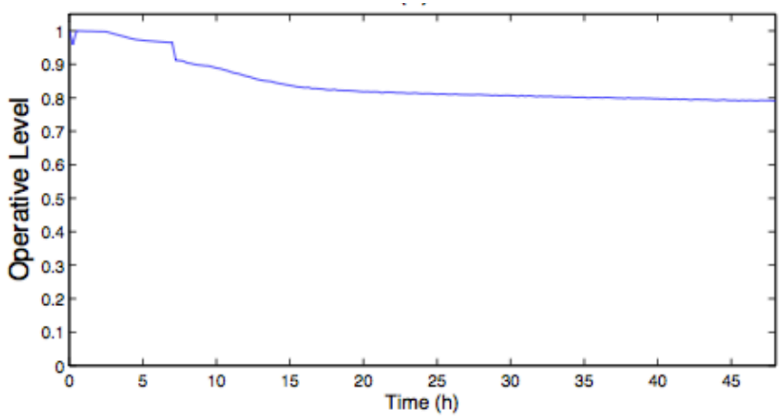
- 48 hours
- Solar Storm occours in t=0 lasts 4 hours
- Satellites services are unavailable until t=8 hours

Simulation Results (I)

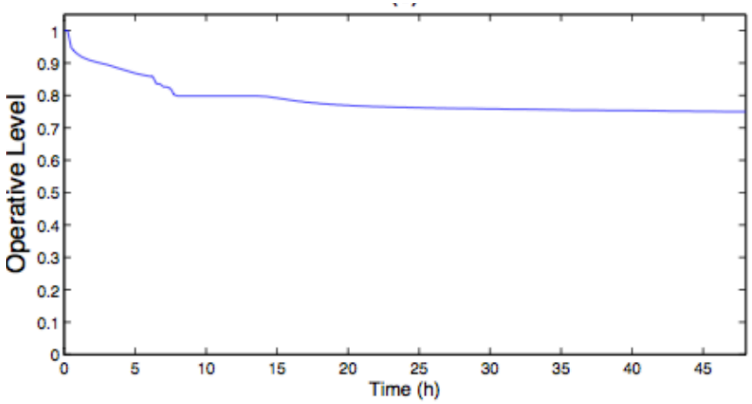
Area of Rome



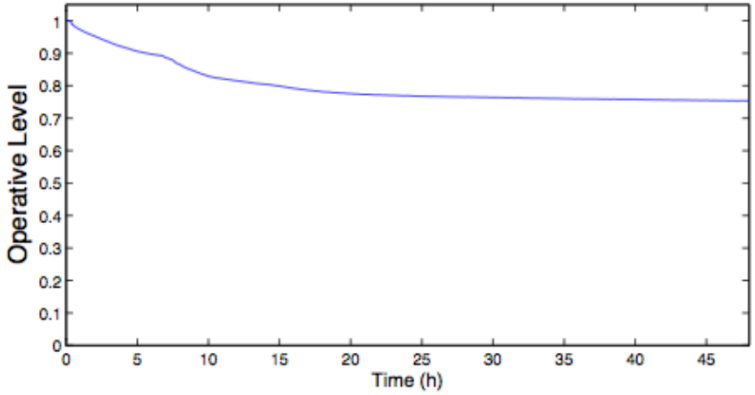
Holistic Transport



Holistic Power

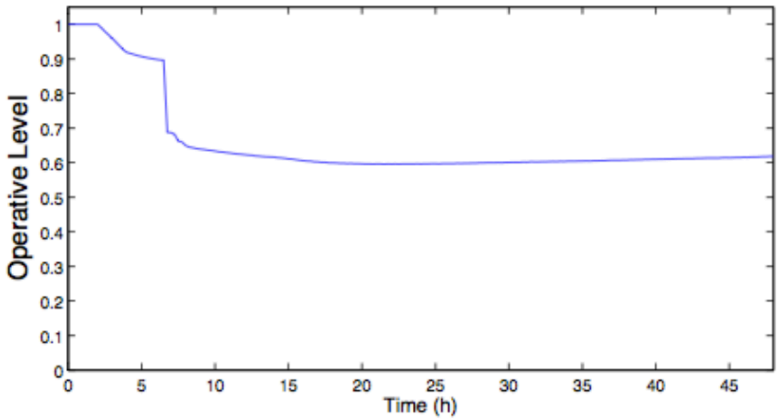


Holistic Node TLC

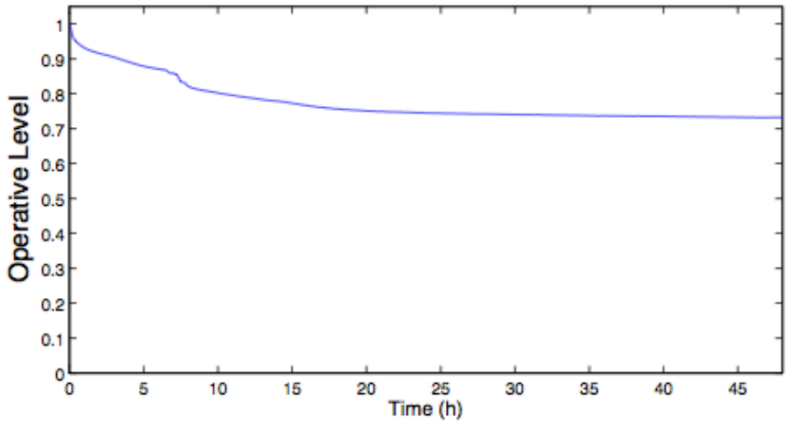


Simulation Results (II)

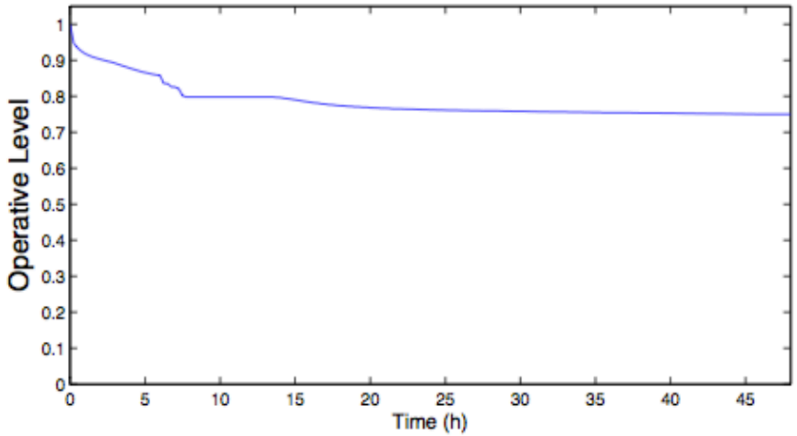
Fiumicino Train Station



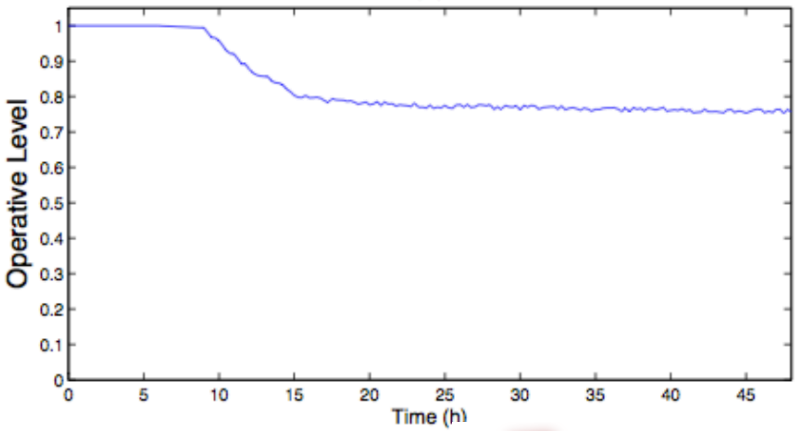
Fiumicino Phone Station



Electric Substation



Fiumicino Airport



Final Remarks and Future Works

-In this paper we have analyzed the most significant effects of solar wind in terms of induced malfunctioning on satellites and critical infrastructures.

-Enhancing the model involving the stakeholders, operators and technicians in the process.

-Complement our study with an economic model in order to provide an estimation of potential economic loss.

- Analysis of the effectiveness of possible counter-measurements.

Thanks for your attention!
Any Question?

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