Future Infrastructure Forum 1
Newcastle University Research

EPSRC Network for Resilient & Sustainable Infrastructure

What I hope to get out of this meeting

- What should the proposals look like?
- How big, how many partners?
- Multidisciplinary/traditional?
- Individual detailed models or coarse integrated model?

- How will we maximise our chances of getting supportive reviewers?

What can Newcastle offer the network?

- GIS expertise – geomatics group
- Climate change Impacts – Climate model outputs, downscaling.

- Structural and ground Engineering

Ground Engineering and Structural Engineering @Newcastle (GEST)

Dr Colin Davie
High temperature (concrete), multi-phase flow

Dr Jean Hall
Engineering geology

Dr Gaetano Elia
Soil dynamics

Dr Paul Hughes
Soil stabilisation, slope stability

Dr Stephanie Glendinning
Soil stabilisation, electrokinetics, slope stability

Dr Mohamed Rouainia
Soil constitutive modelling

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Ground Engineering and Structural Engineering @Newcastle (GEST)

Dr Sean Wilkinson
Earthquake engineering
Critical Infrastructure Networks
(Resilient Communities)

Prof Peter Gosling
Fabric structures

Dr Ben Bridgens
Fabric Structures

Dr Richard Dawson
Resilient Cities
Climate Change Impacts

Dr Vladimir Vinogradov
Composite Structure constitutive modes and Finite Elements

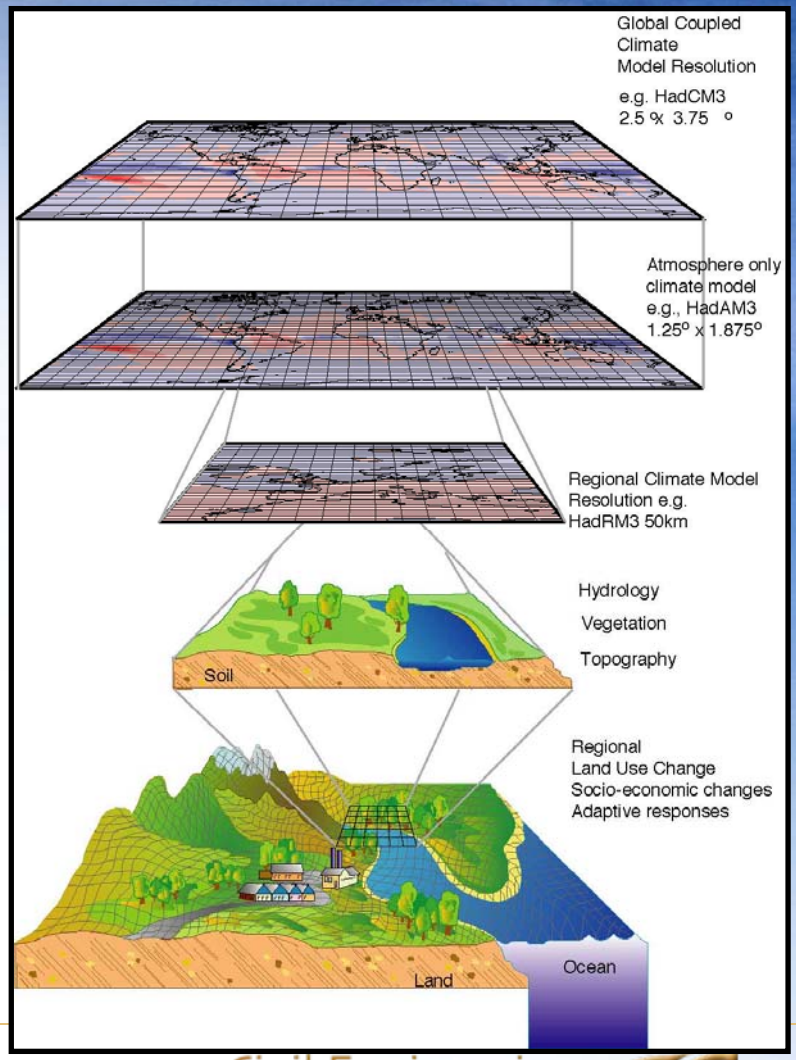
Professor Chris Kilsby,
Dr Hayley Fowler
Climate Change Impacts
ITRC

Newcastle University

Civil Engineering and Geosciences

Main Research Areas

- **Climate Change Impacts**
  - RESNET, ECLISE, CONVEX, RESILIENT FUTURES, CRANIUN, BETWIXT
- **Geotechnical Engineering and Structural Engineering (GEST)**
- **ITRC**



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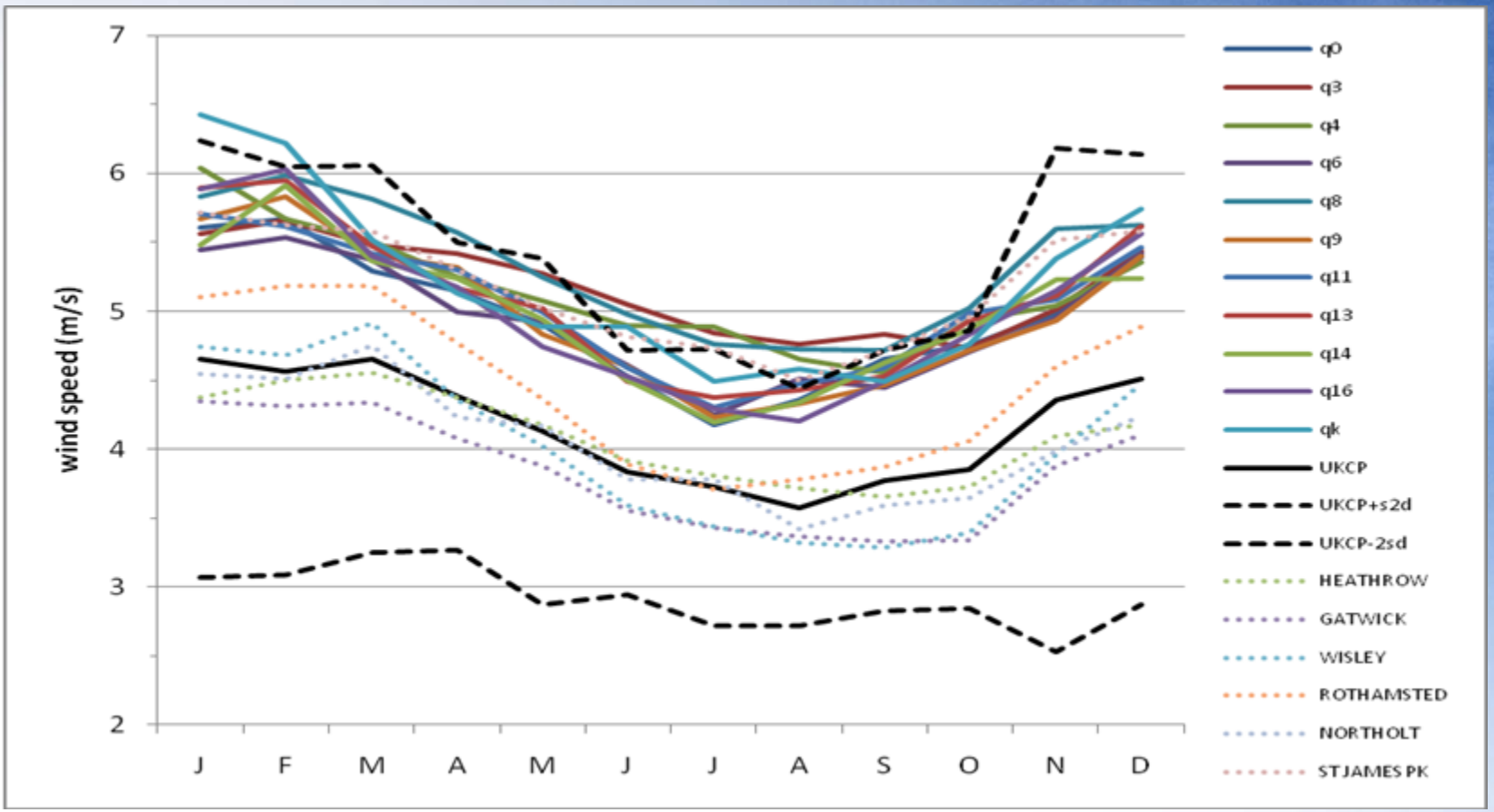
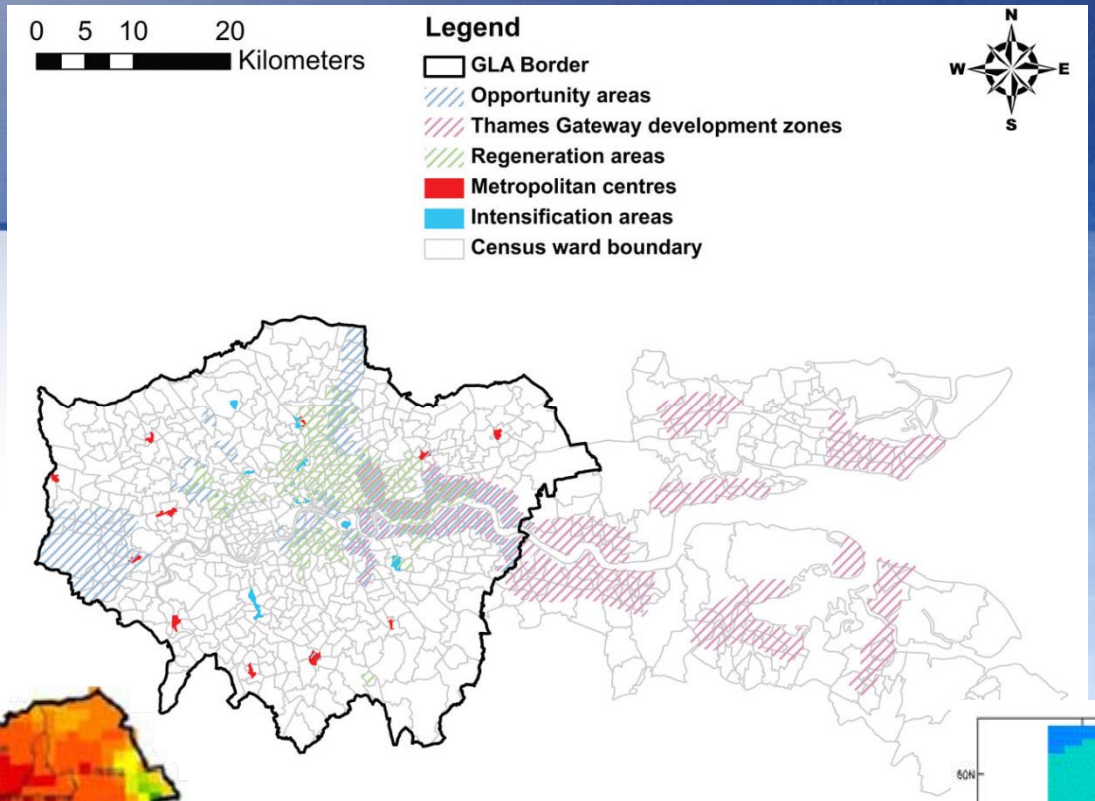
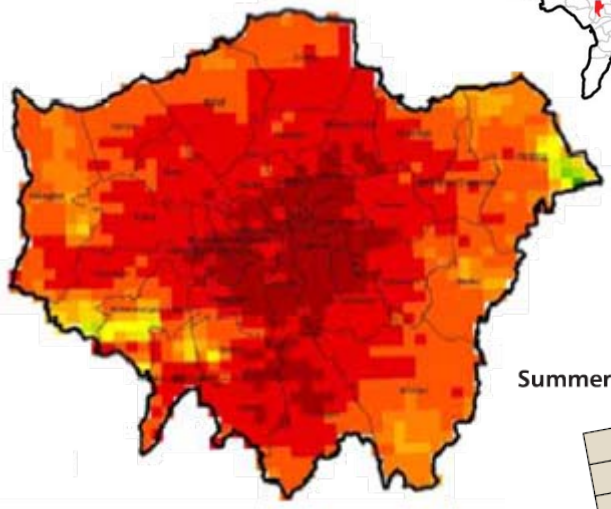
Future Wind Speed

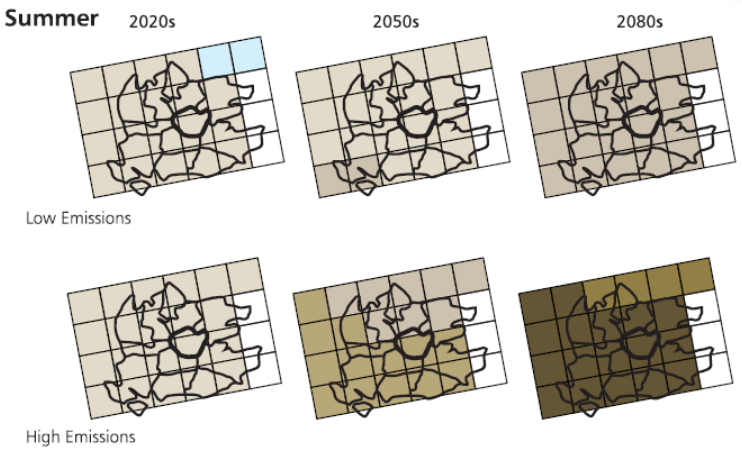


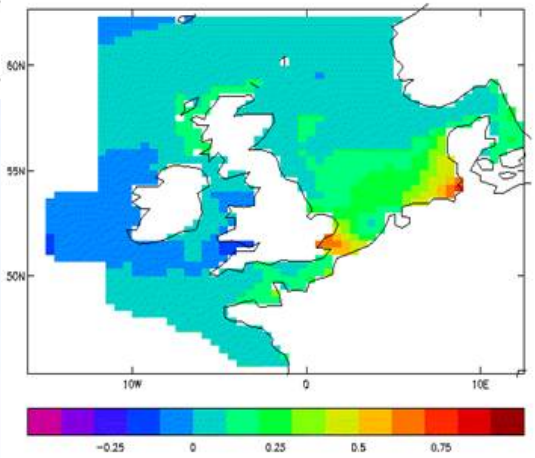




Heat island

Drought





Sea level rise

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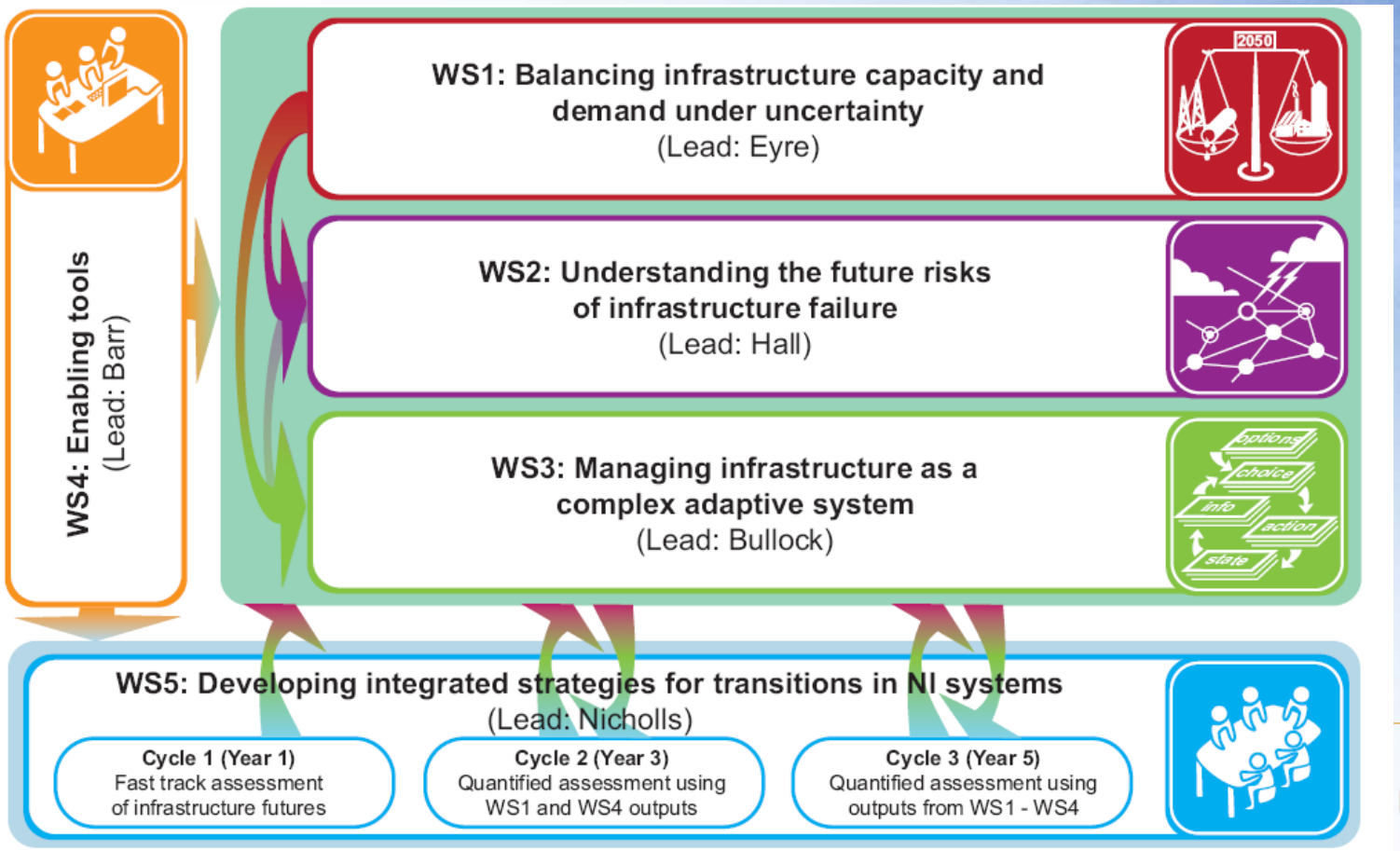
ITRC: The UK Infrastructure Transitions Research Consortium

Prof Jim Hall, Environmental Change Institute, University of Oxford

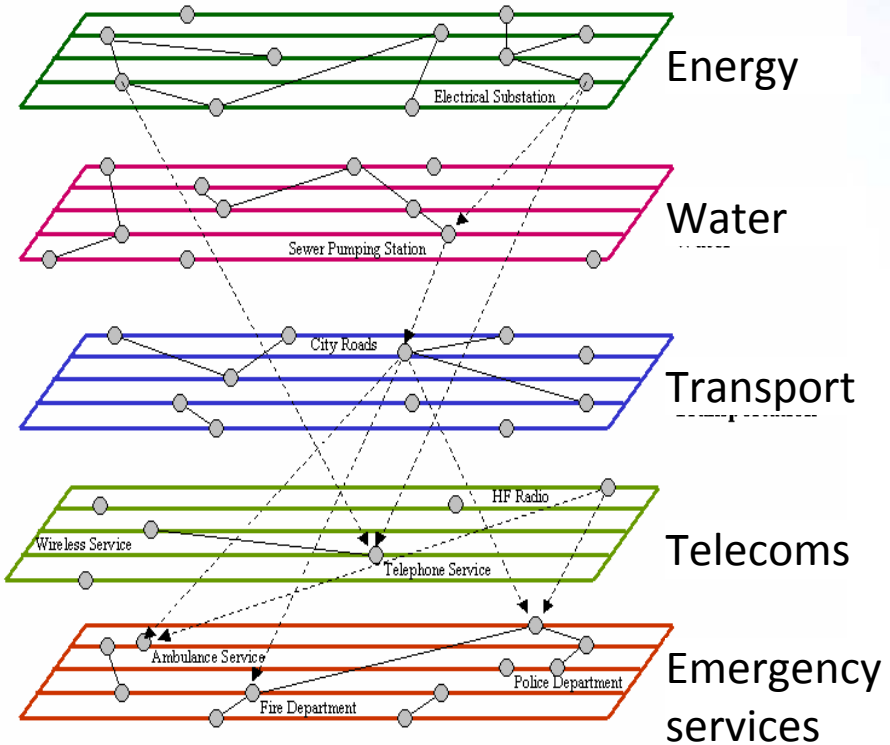
Newcastle – Kilsby, Curtis and Barr

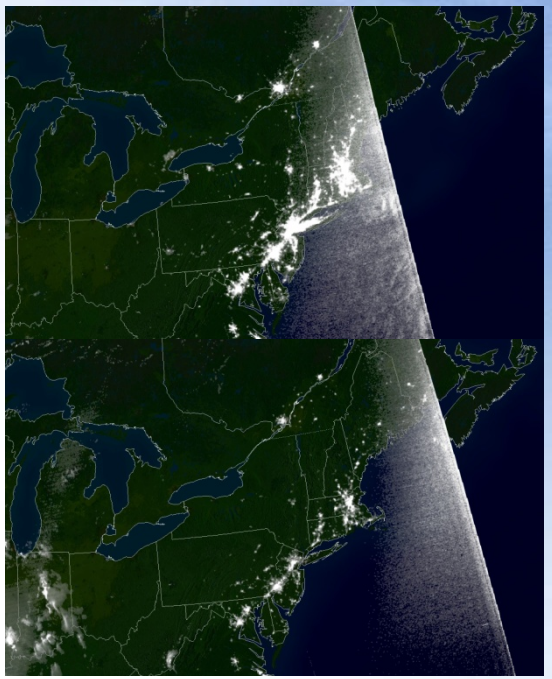
Aim: To develop a new generation of system simulation models and methods to inform analysis, planning and design of national infrastructure in the energy, transport, water, waste and telecoms sectors..



Resilient Futures

- Resilient Futures is a £1.4m EPSRC project that is looking at what our critical national infrastructure looks like in 2030? 2050, and beyond?
  - Current practices focused on single, isolated systems
  - Modern infrastructure is developing into an highly connected system
  - Interdependent networks respond differently in network disruption events
  - Can be more vulnerable than individual networks

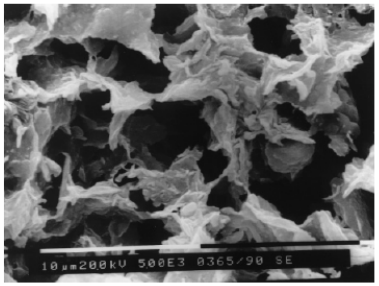


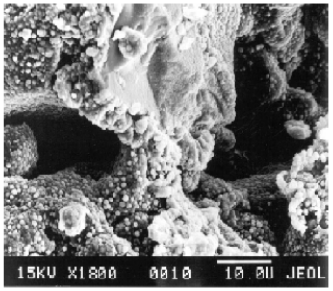


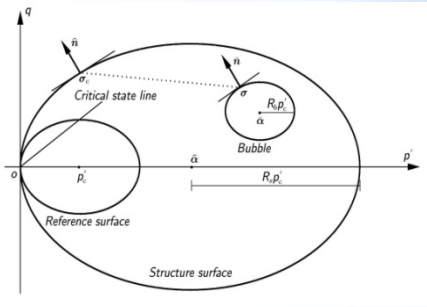
GEST Main Research Areas

- **Advanced characterisation of soils**
  - cyclic, dynamic, small strain

- **Constitutive Modelling of Geomaterials**
  - Cemented,structured and partially saturated soils, rocks, concrete.

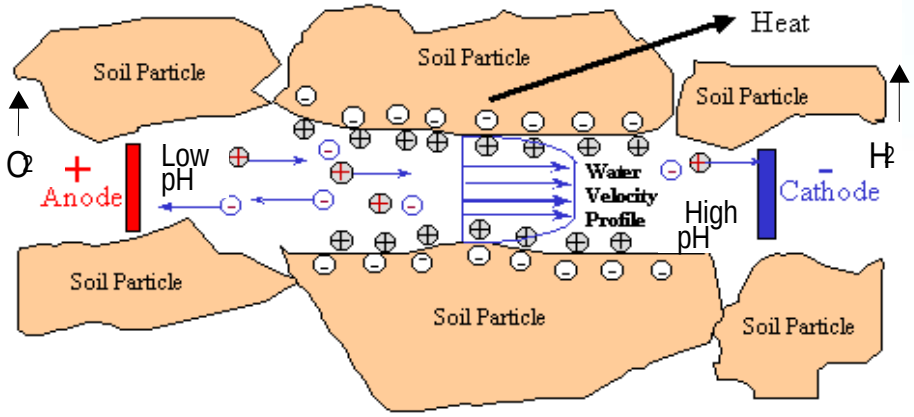


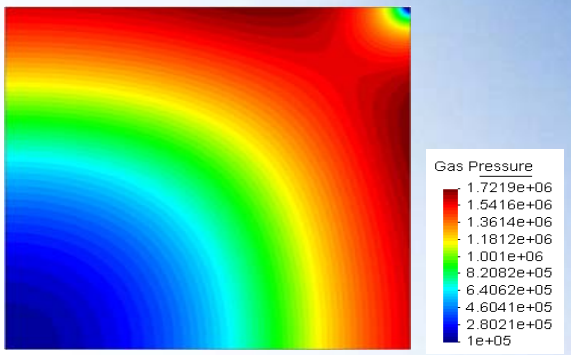




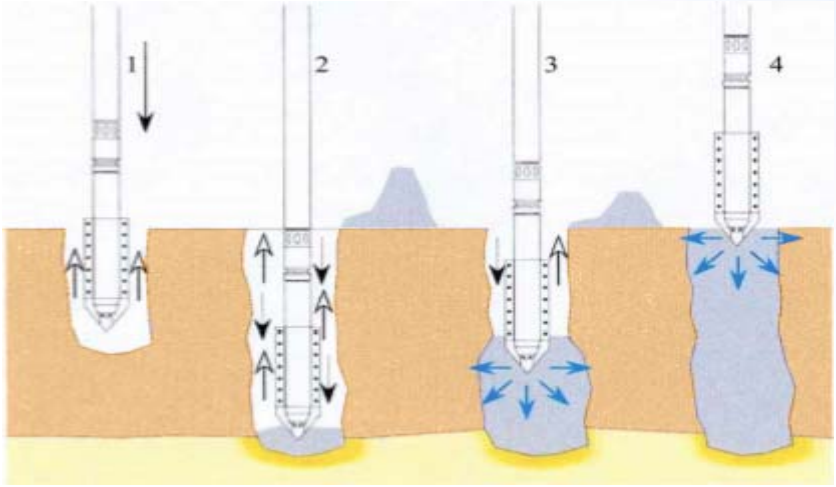
•Conductivity Modelling and Measurement

- Saturated and unsaturated flow in soil
- Electrokinetics
- Thermal behaviour of soils
- High temperature concrete

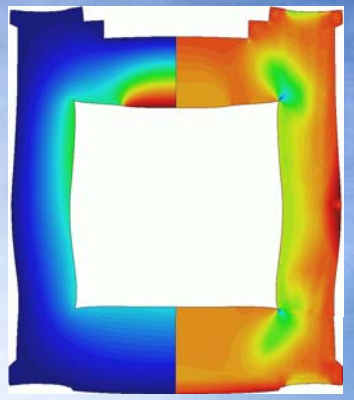




- **Slope Stability**
  - Slope stabilisation using cementitious materials
  - Slope stabilisation using electrokinetics
  - Effects of climate on long-term behaviour

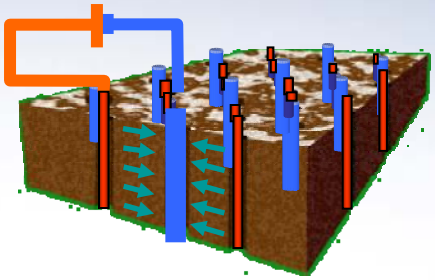


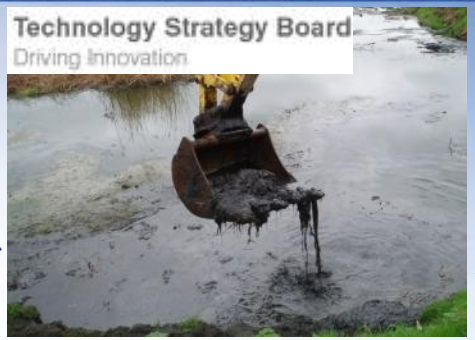
- **Extreme loadings**
  - Earthquakes
  - Cyclic
  - Wind/Waves
  - Fire



- **Legacy of mining**
  - Tailings treatment, mine gas, subsidence, void migration

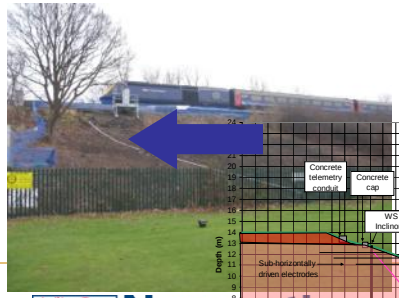
Ground Improvement and Waste Treatment

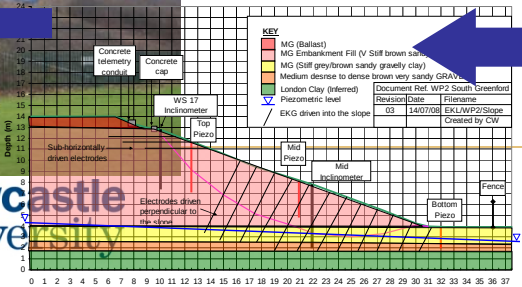




EPSRC

EKG
ACTIVE
GEOSYNTHETICS





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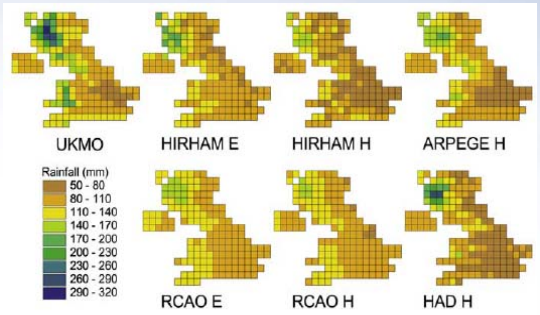
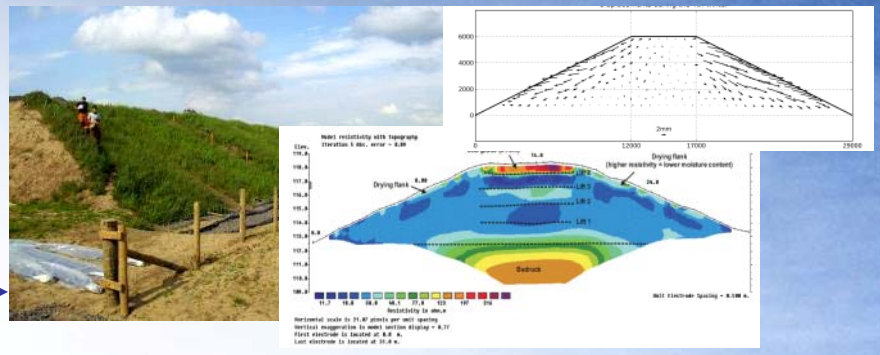
ELECTROKINETIC LIMITED

Slope stability and Climate Change

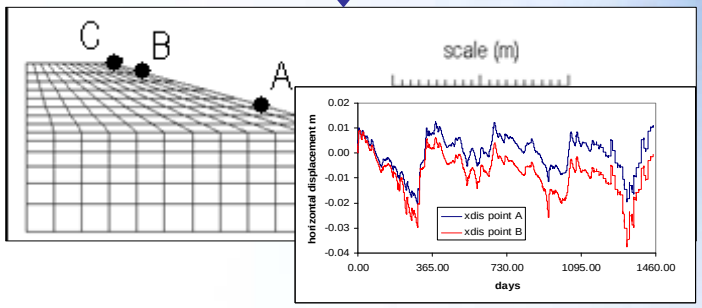


Climate predictions

Climate simulation



Full and model- scale testing and instrumentation



Validated numerical modelling of slope stability for predicted future climates

bionics

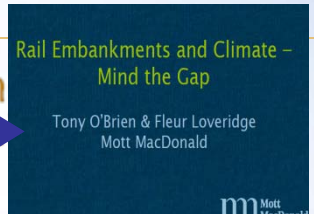
secondments

HIGHWAYS AGENCY

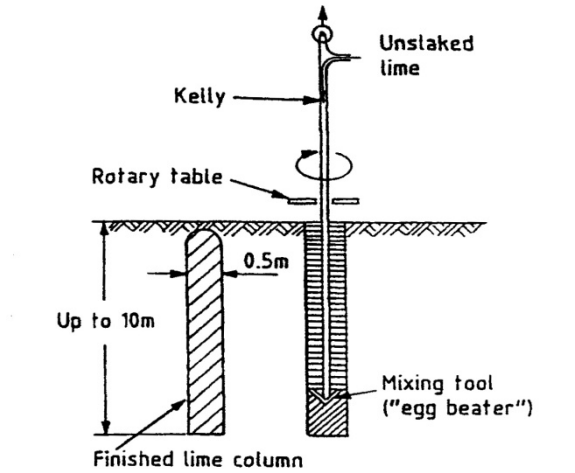
ATKINS

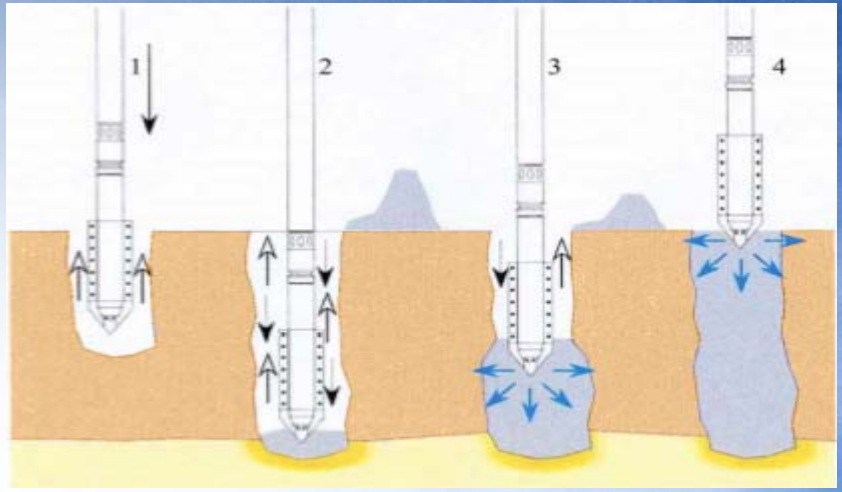
Civil Engin

Mott MacDonald

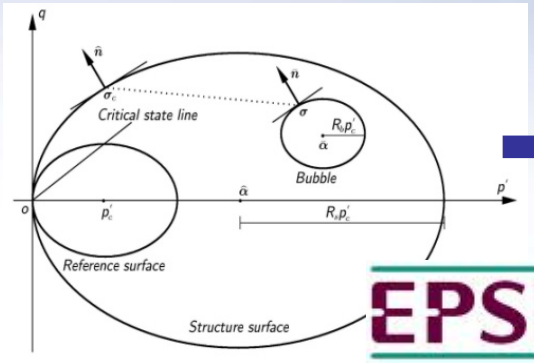


Re-use of waste materials and soil stabilisation





Constitutive and Numerical Modelling



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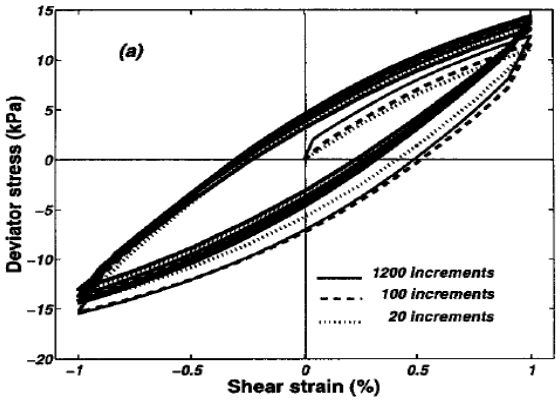

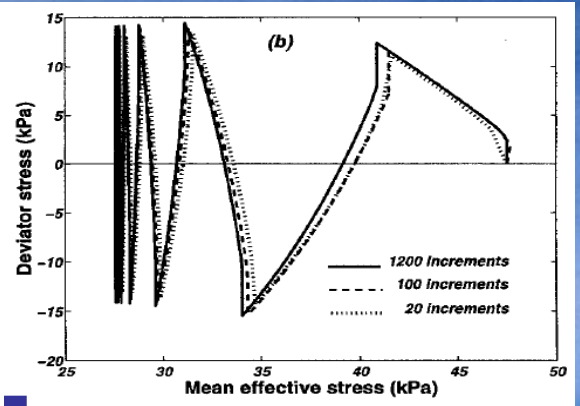

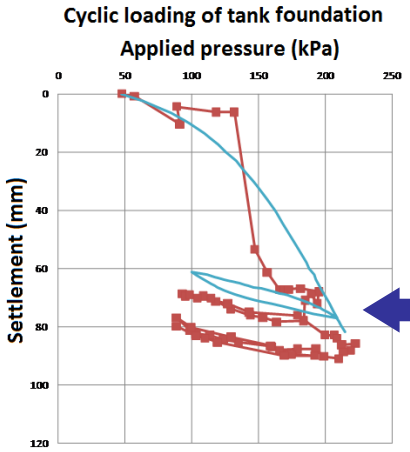

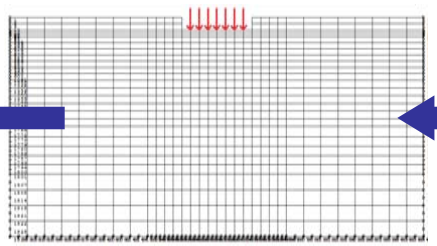

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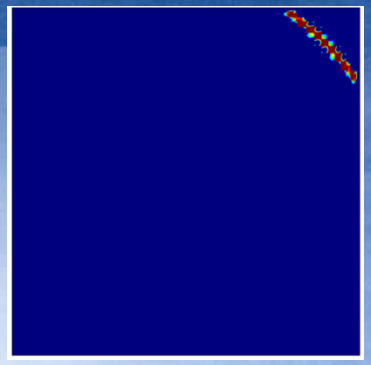
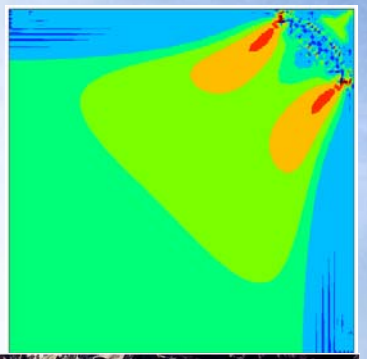
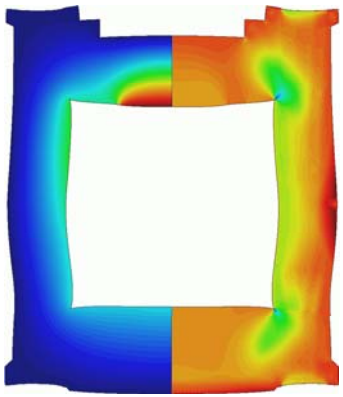
Concrete at high temperatures





Coupled hygro-thermo-mechanical modelling of concrete

- Complex, fully coupled, fully generalised 3D multi-phase model (finite element)
- Solid, liquid and gas components (partially saturated material)



- Numerical investigations of:
  - concrete exposed to isothermal drying
  - concrete exposed to fire
  - thermal spalling
  - nuclear power plant structures

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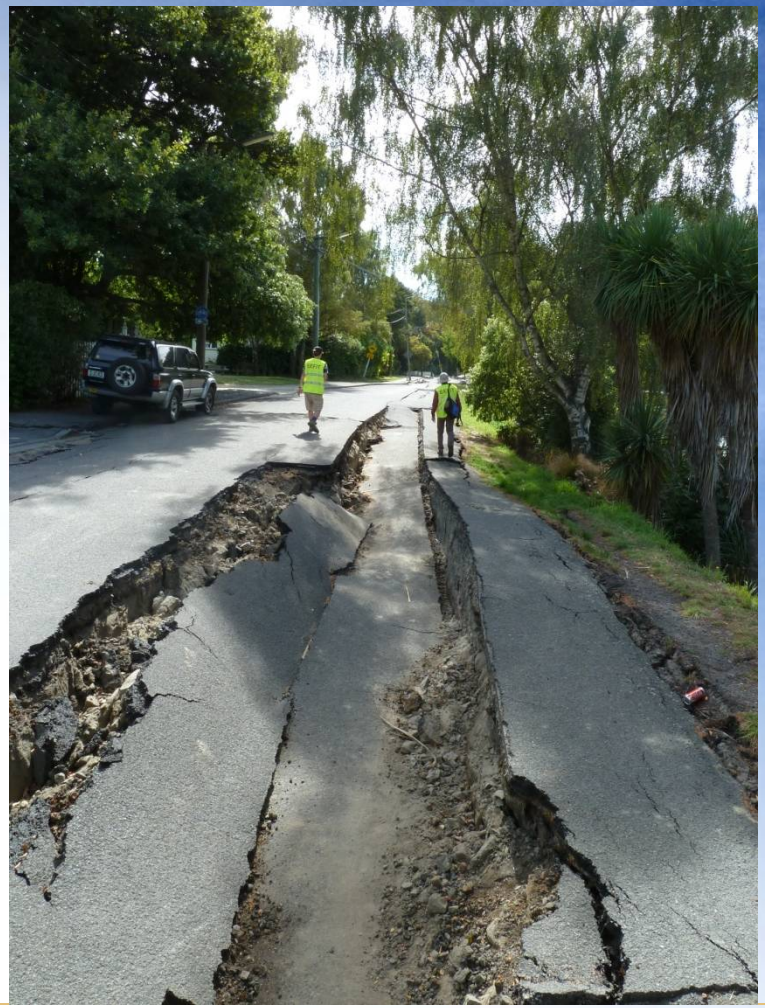
EEFIT EARTHQUAKE MISSION GRANT: FUNDING FOR IMPROVED RESPONSE AND DISSEMINATION



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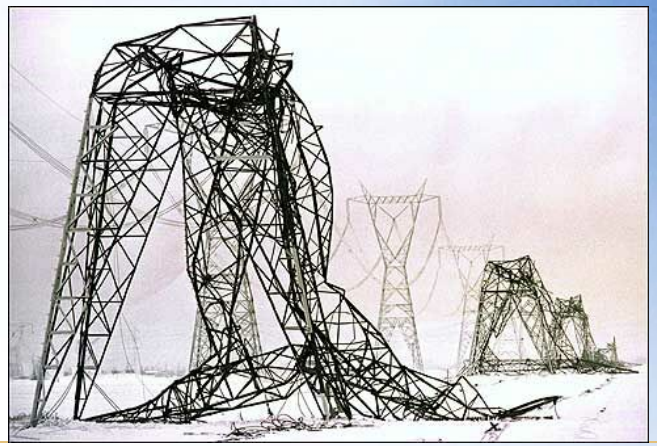
RESNET: Resilient Electricity Networks for Great Britain

- **Newcastle University**
- **Sean Wilkinson, Chris Kilsby, Richard Dawson**
- **The University of Manchester**
- **Kevin Anderson, Ian Cotton, Sarah Mander, Ruth Wood**



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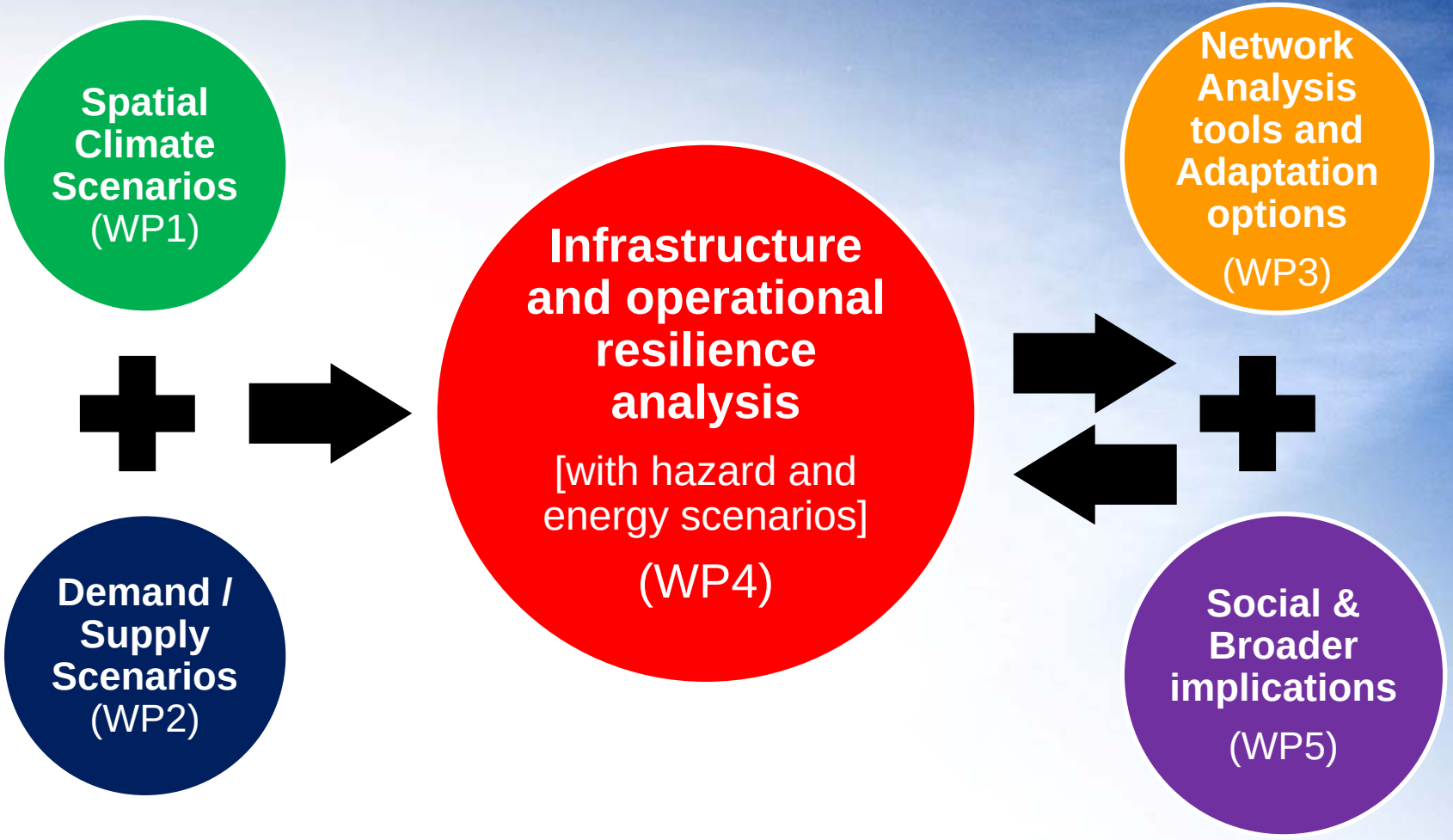
Project Aim

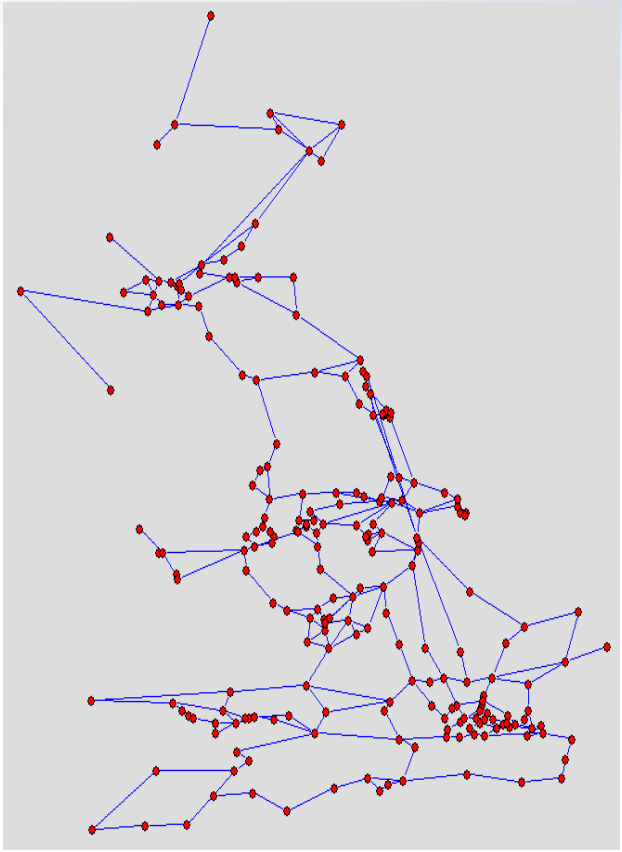
‘This project will develop and demonstrate a comprehensive systems-level approach to analysing, at the GB scale, the resilience of existing and future electricity networks.

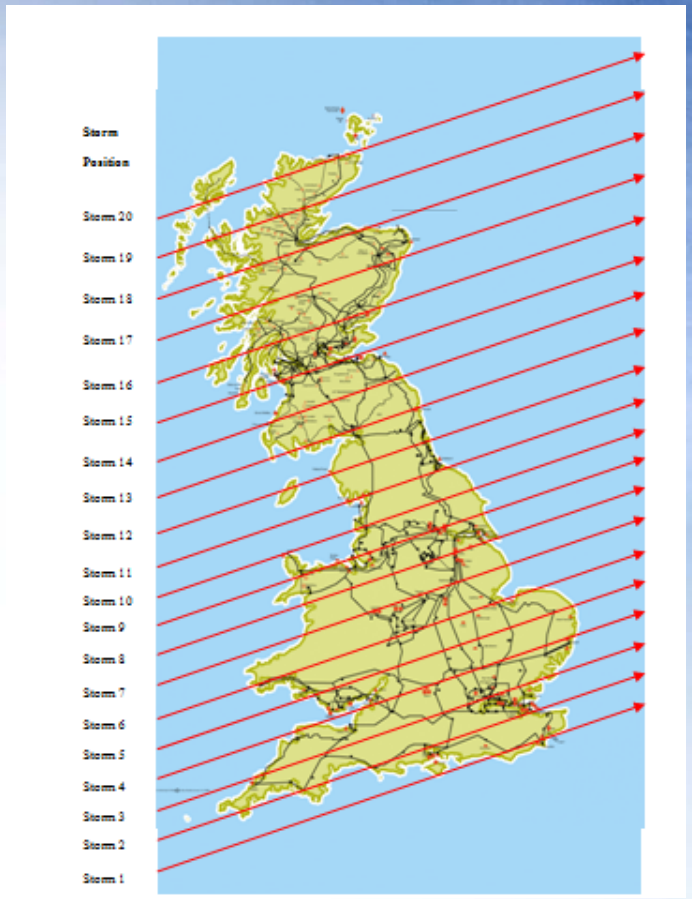
It will develop, test and refine tools for evaluating adaptation measures designed to enhance the resilience of the network including societal and technical adaptation.’

Project Work Packages



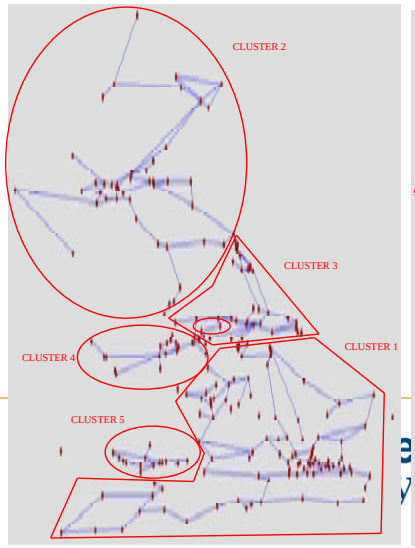
Preliminary Work

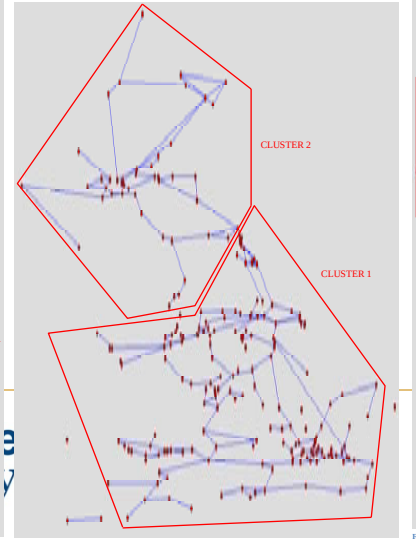




General Trends

- Isolation of Scotland/Northern England; however, demand met
- Isolation of South Wales – demand not met
- Isolation of London, Southern England and the Midlands – demand not met





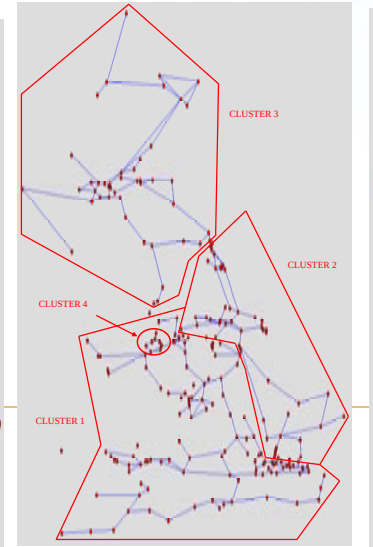
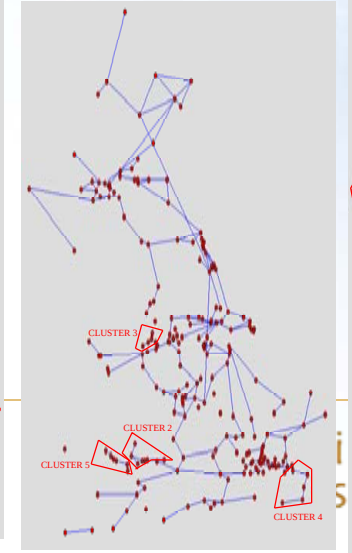
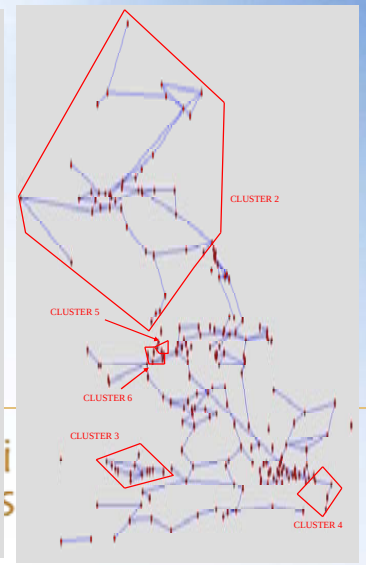


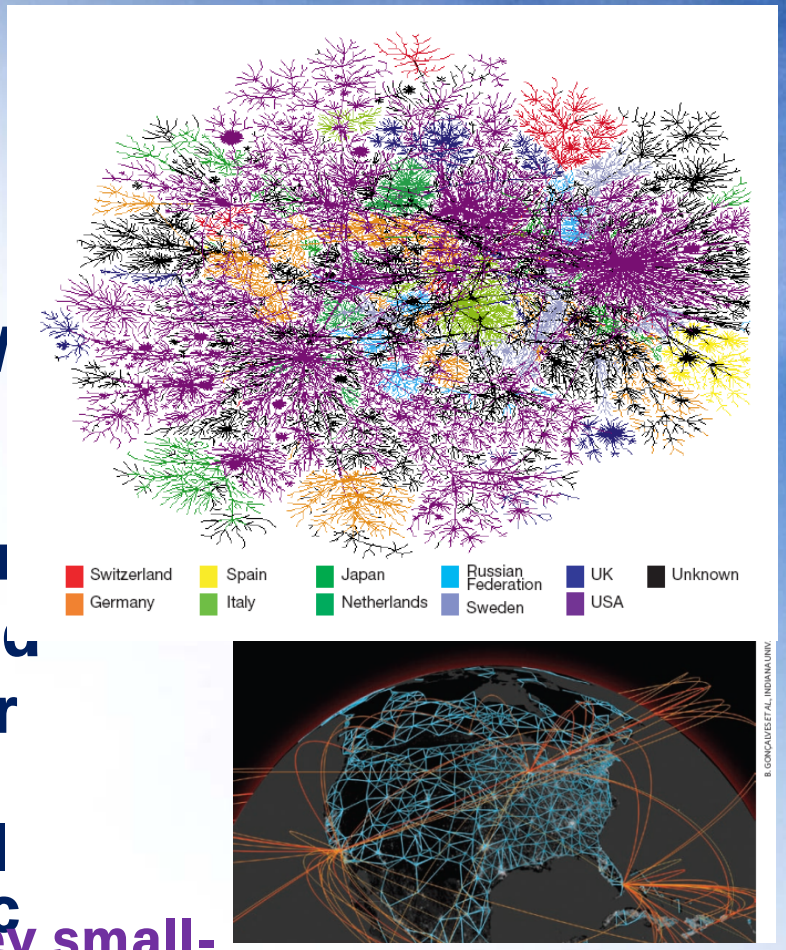
Figure 1: Trial three post storm network visualisation using coordinate system





Some Real World Networks

- Scale Free
  - Japanese air network
  - Internet
  - World Wide W
  - Us Air Traffic
- Exponential
  - USA power gr
  - UK power gri
  - Italian Power Grid
  - International Airport traffic
  - US Air traffic



Nojima (2006)
Albert, Jeong and Barabasi (2000)
Albert, Albert and Nakarado (2004)
Wilkinson and Henderson (2006)
Crucittia et al. (2004)
Amaral et al. (2000)
Balcan et al. (2009)

The layout of many real world infrastructure networks obey small-world scaling laws

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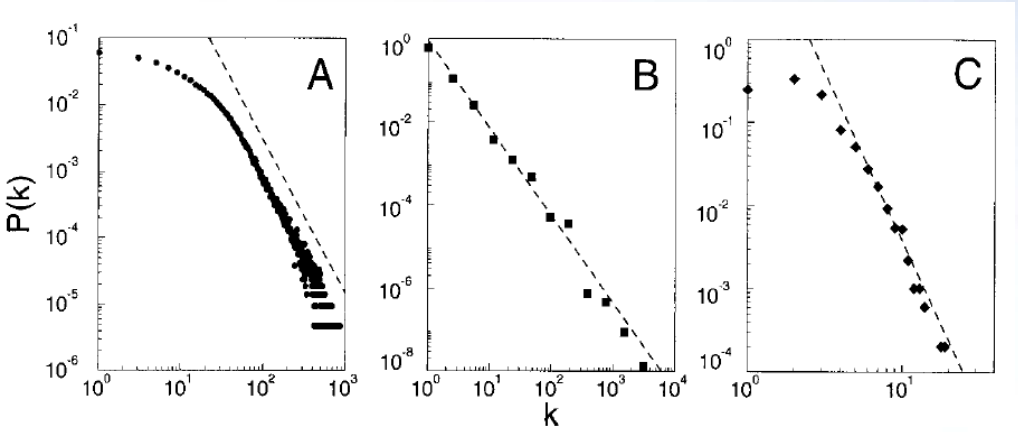
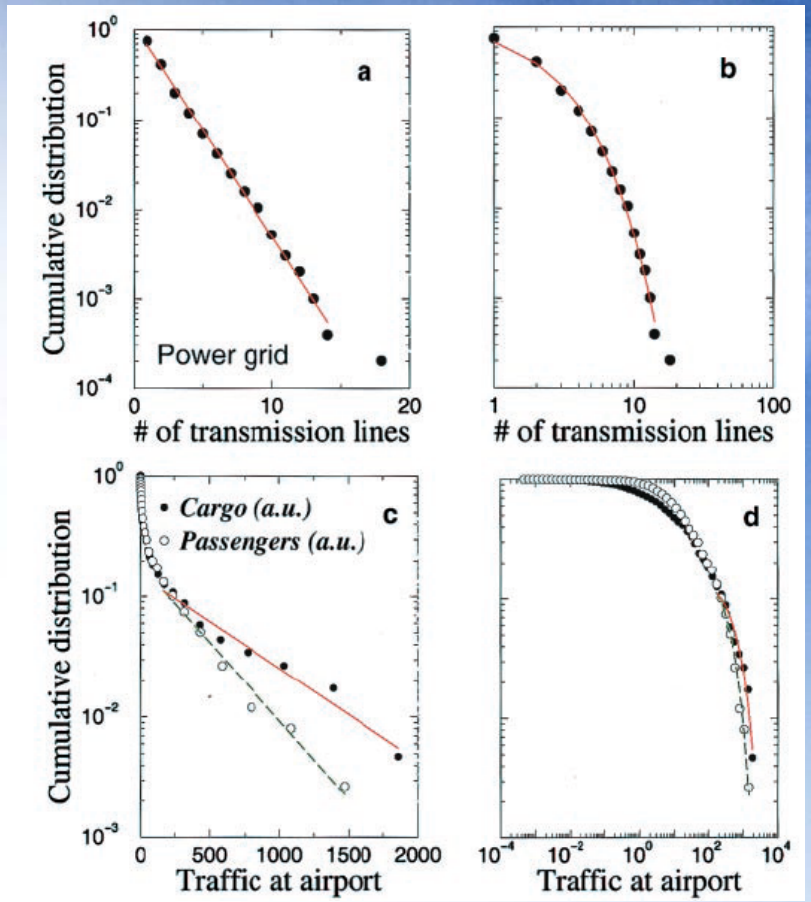
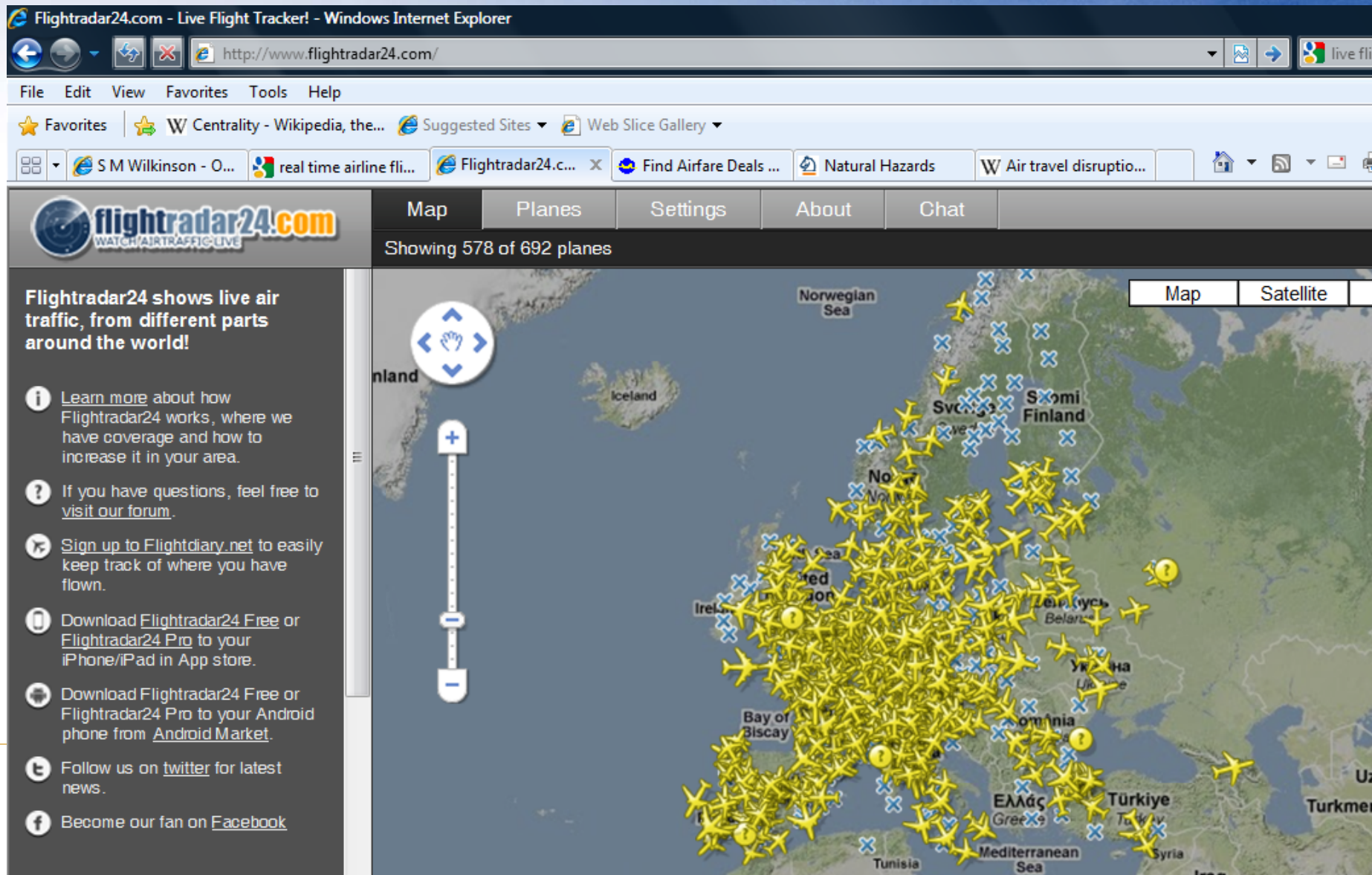
Network Architecture of Real World Networks



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Centrality - Wikipedia, the...
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Web Slice Gallery
S M Wilkinson - O...
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Planes
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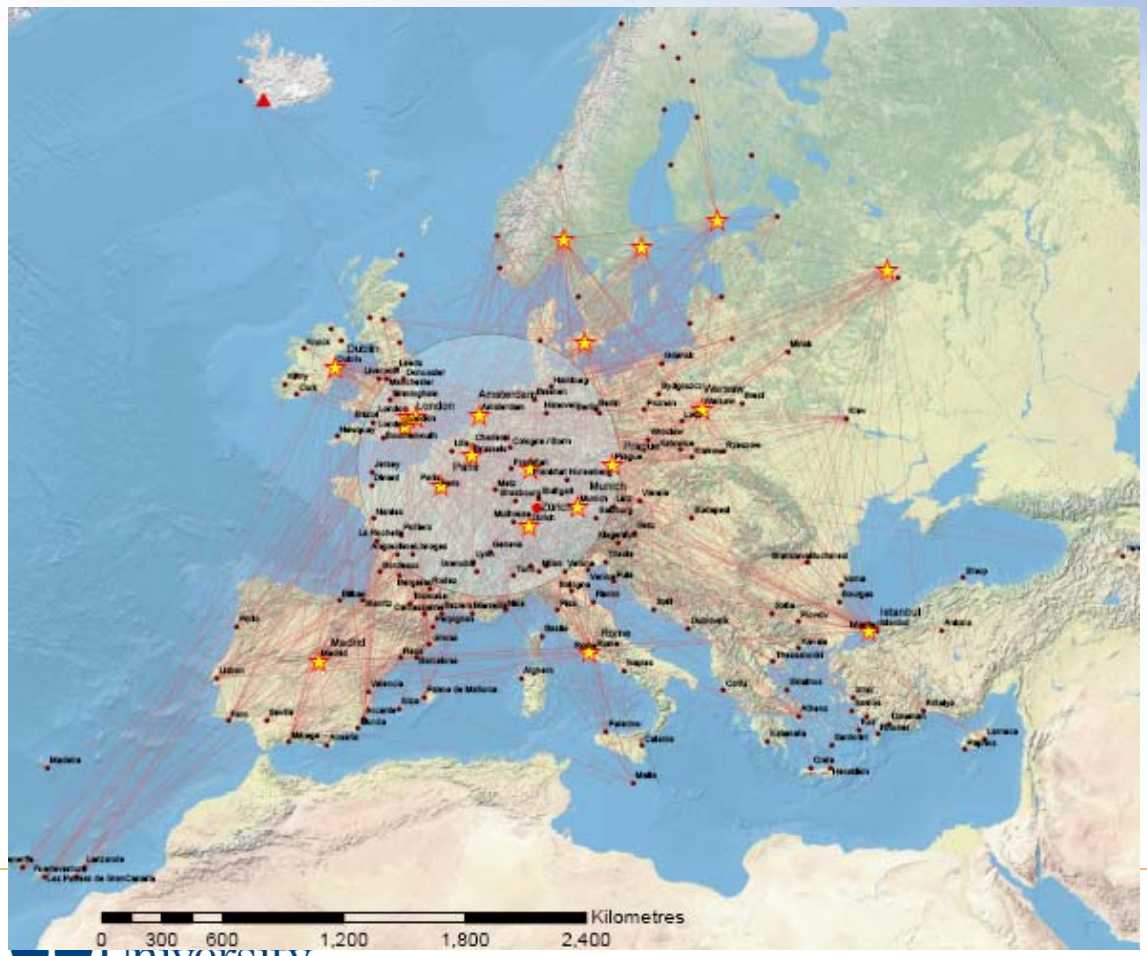
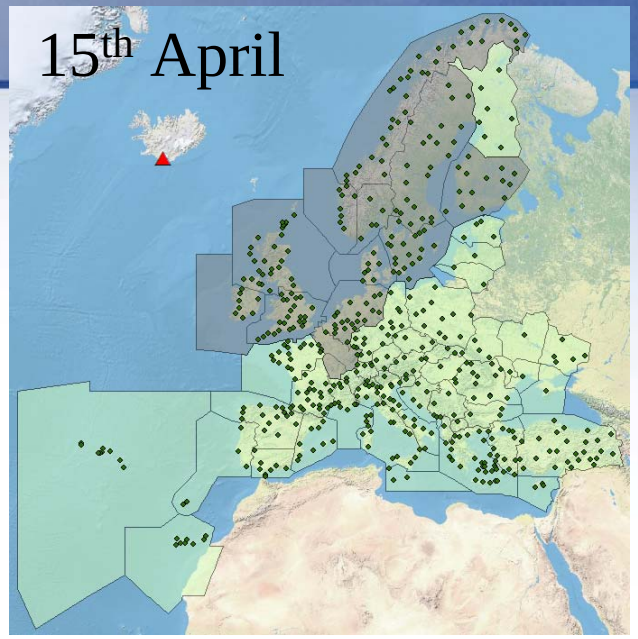
Satellite
Norwegian Sea
Iceland
Finland
Bay of Biscay
Ελλάς
Türkiye
Mediterranean Sea
Tunisia
Syria

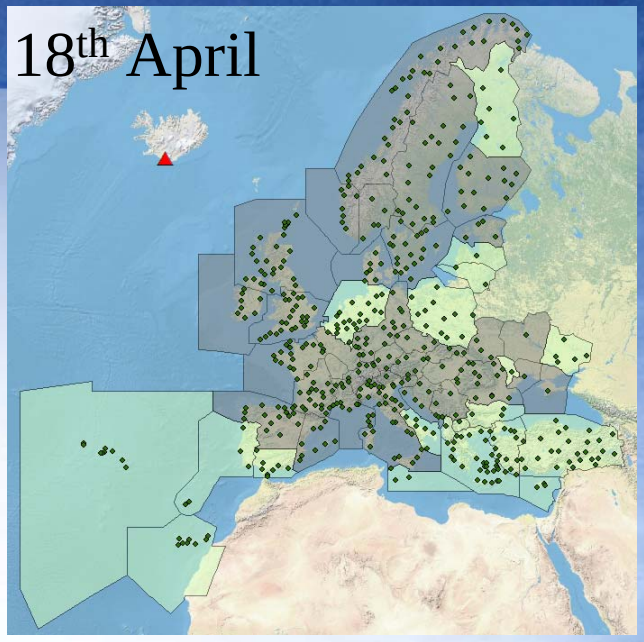
Flights on 17th April 2010

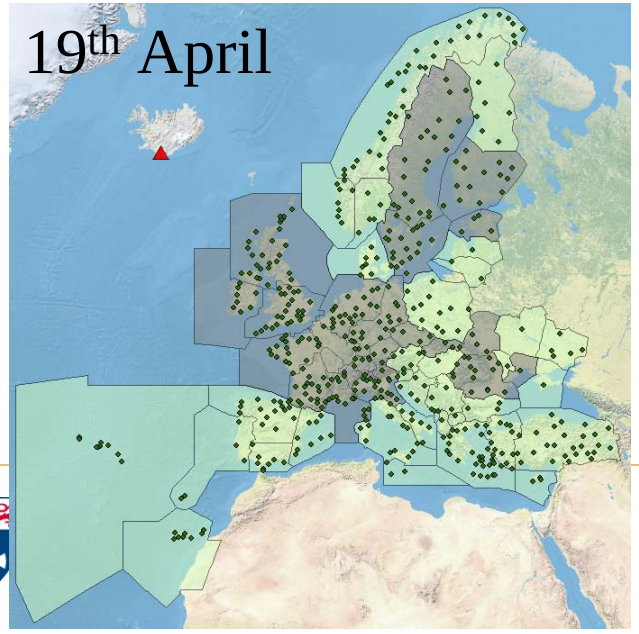
Data Set

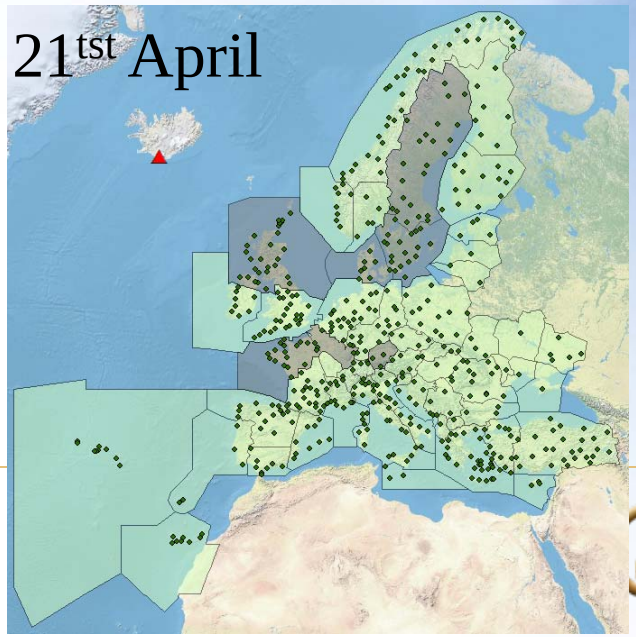


- 525 Airports
- 3886 air routes
- operated by 203 airlines

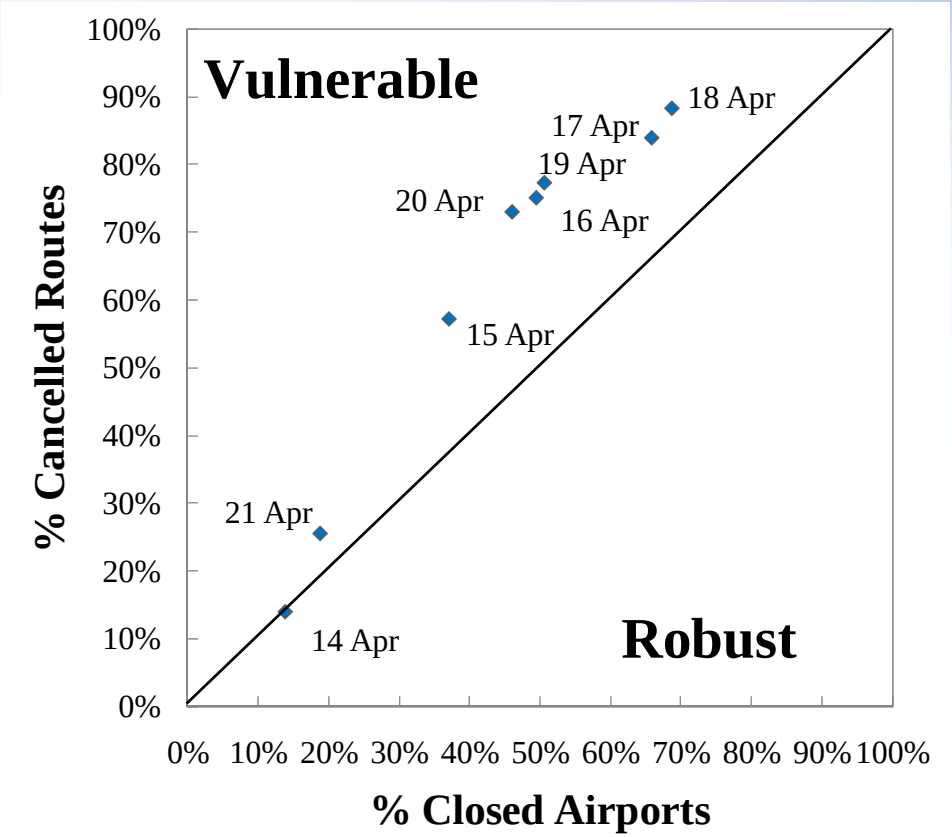

15th April

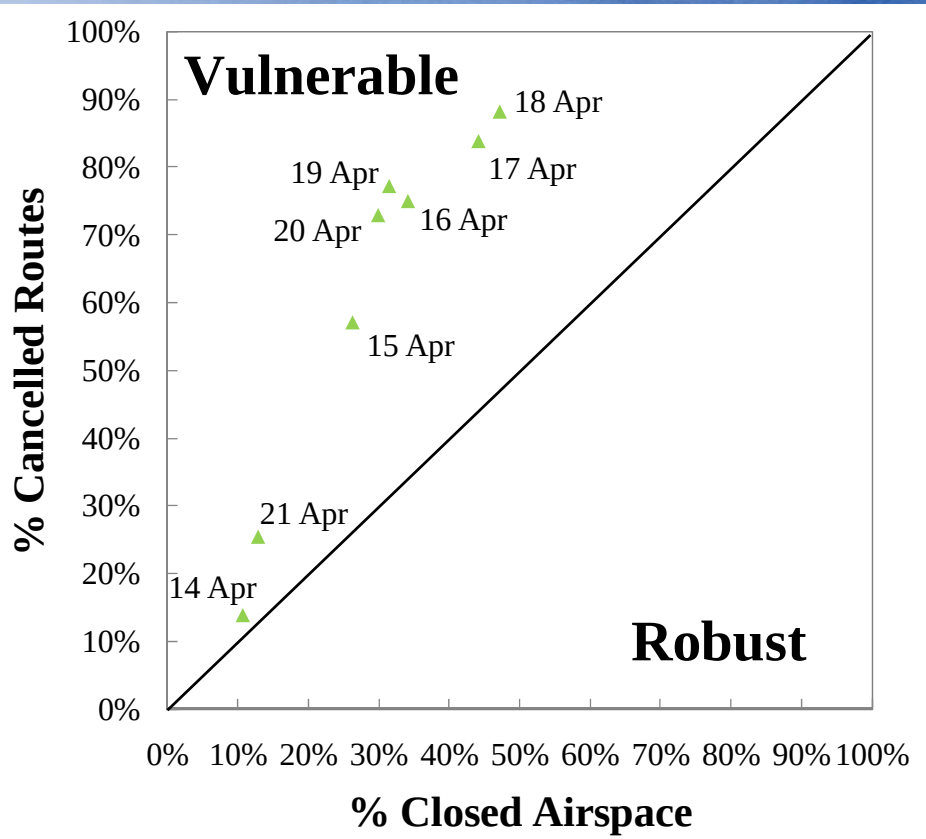

18th April


19th April


21tst April

Is the network Vulnerable?





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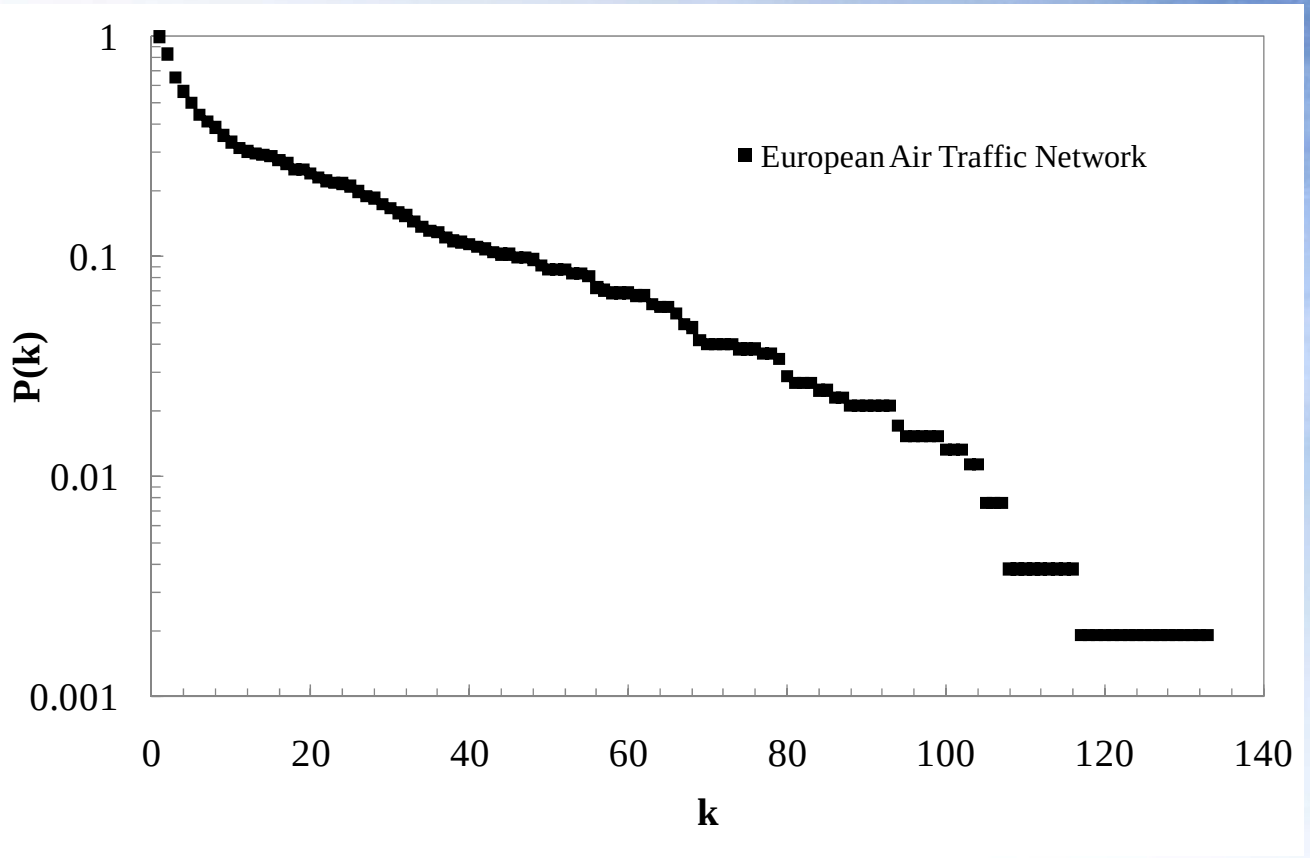
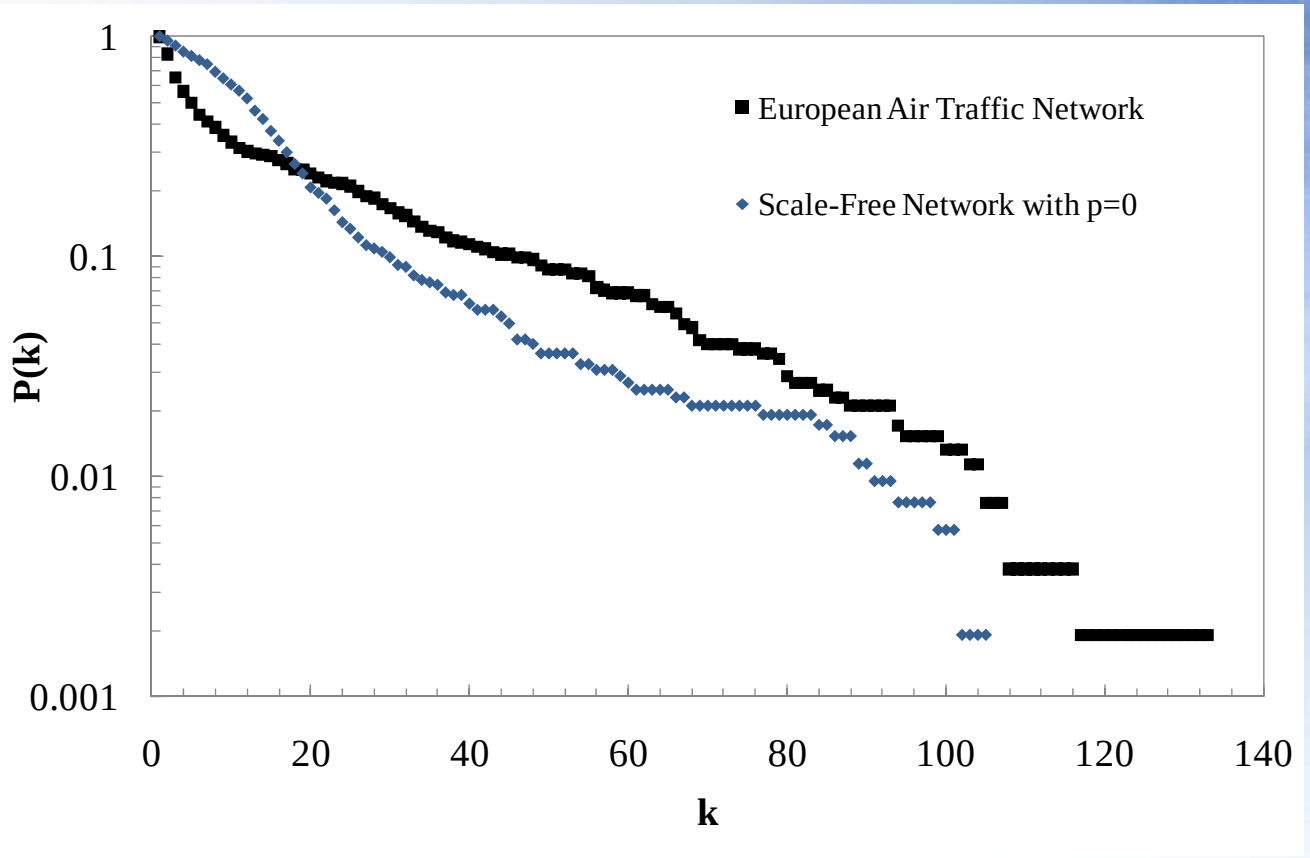
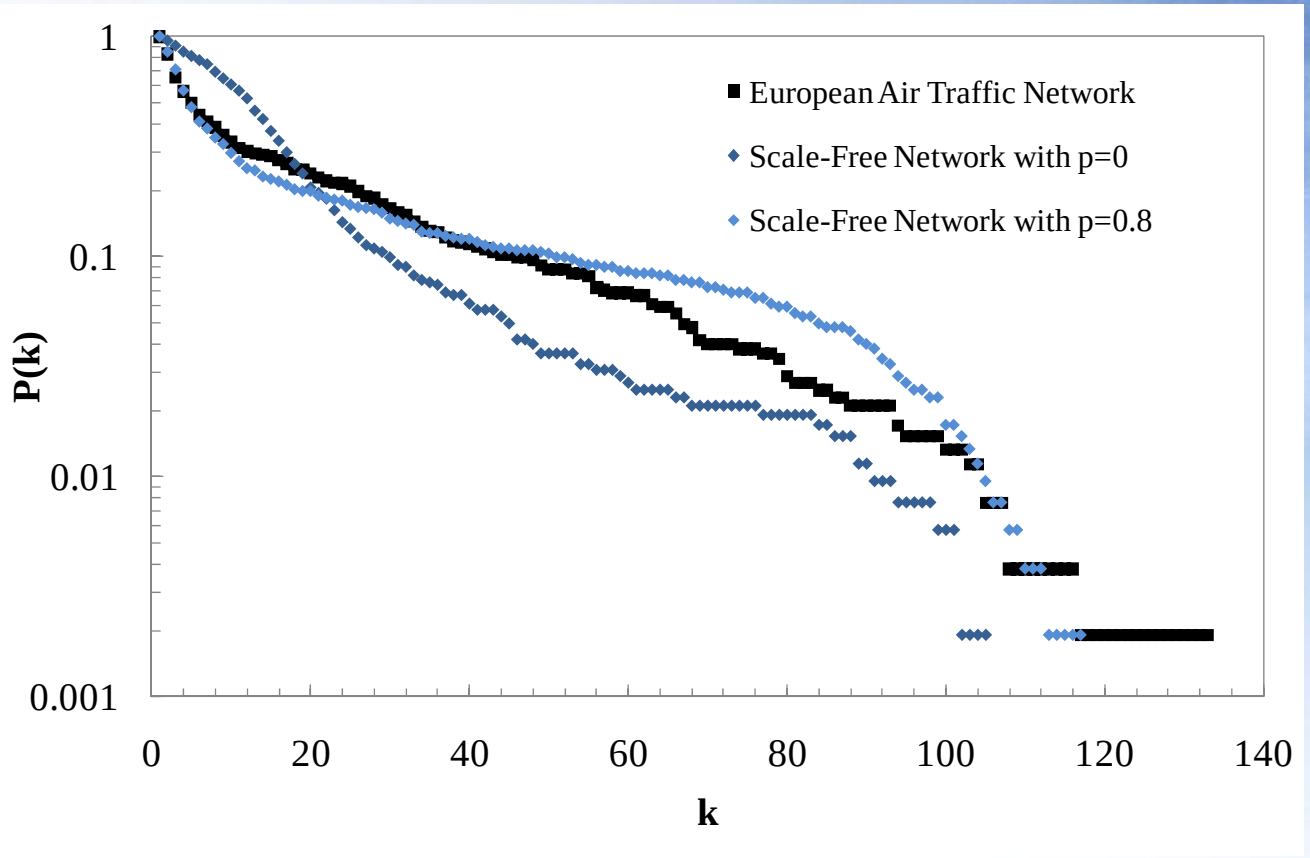
Degree Distribution - Data



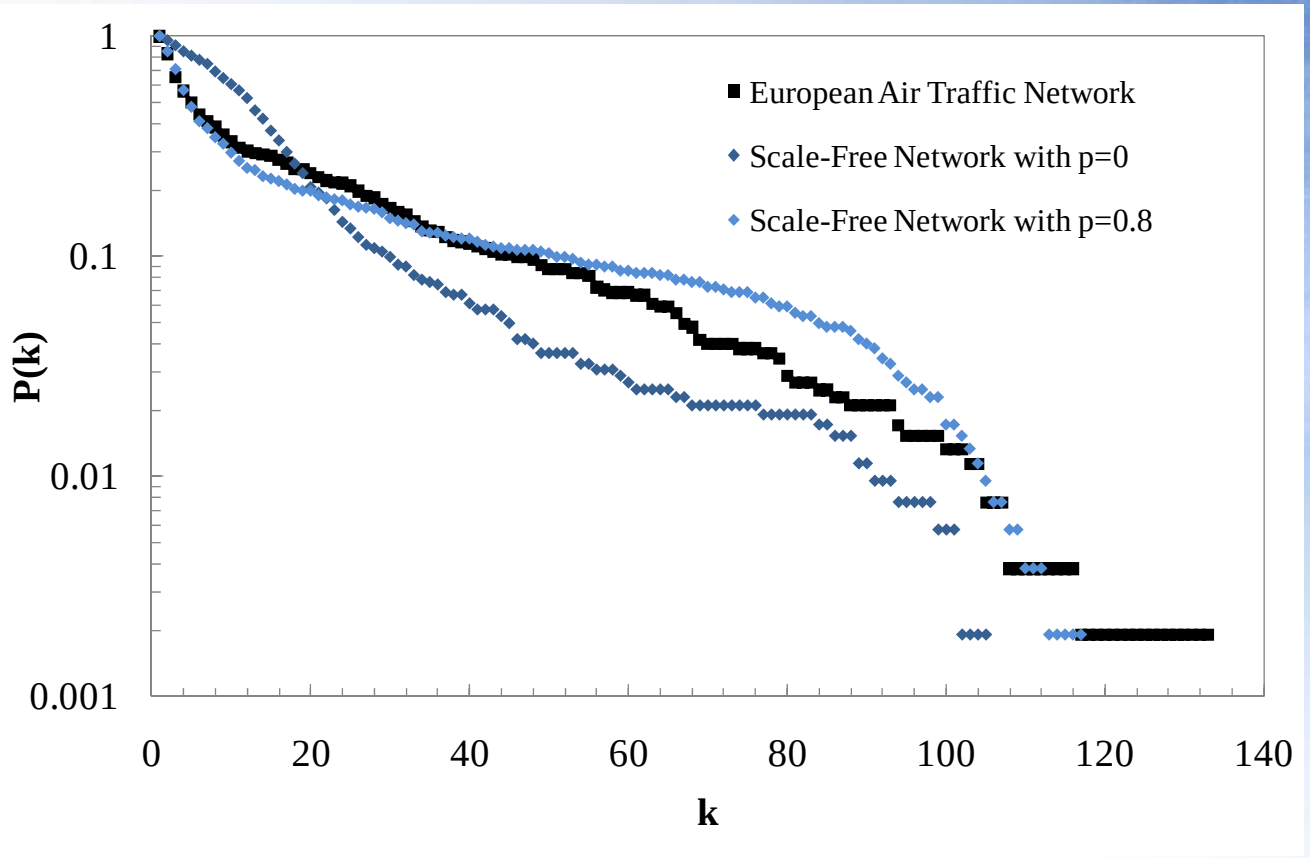
Degree Distribution – Scale Free



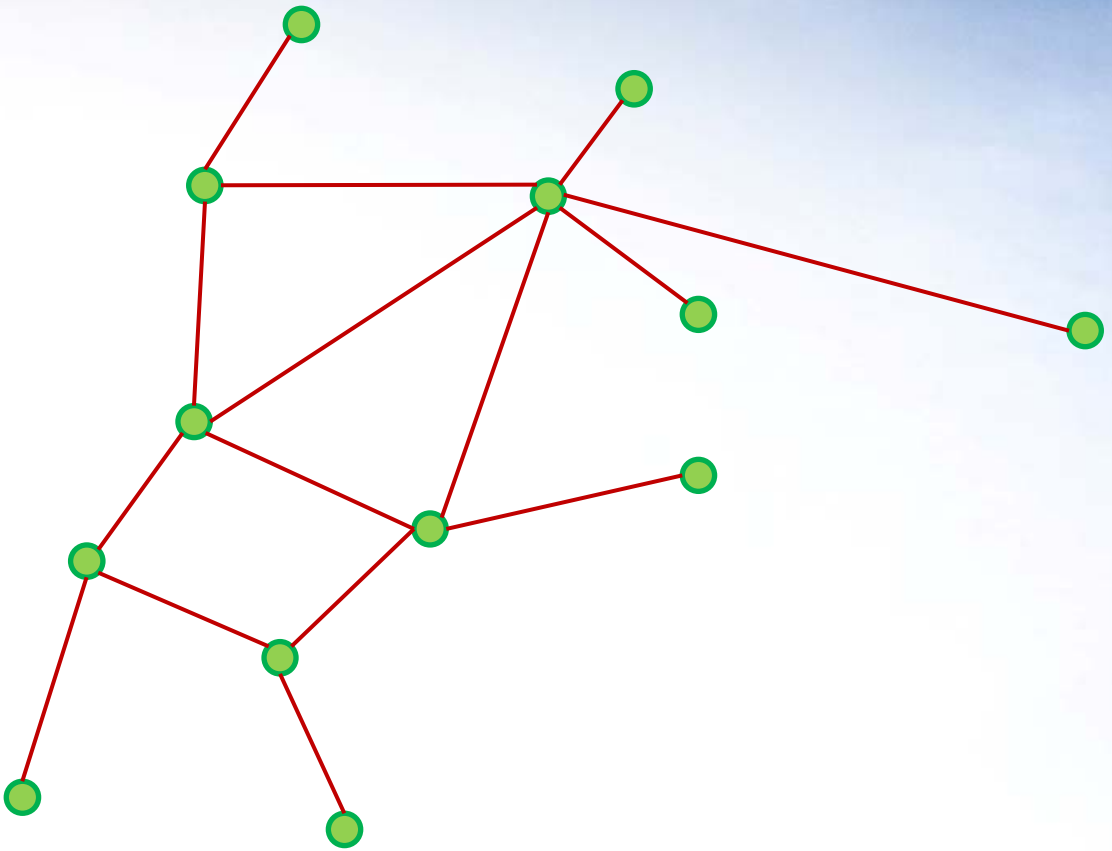
Degree Distribution –Scale Free with Reconfiguration



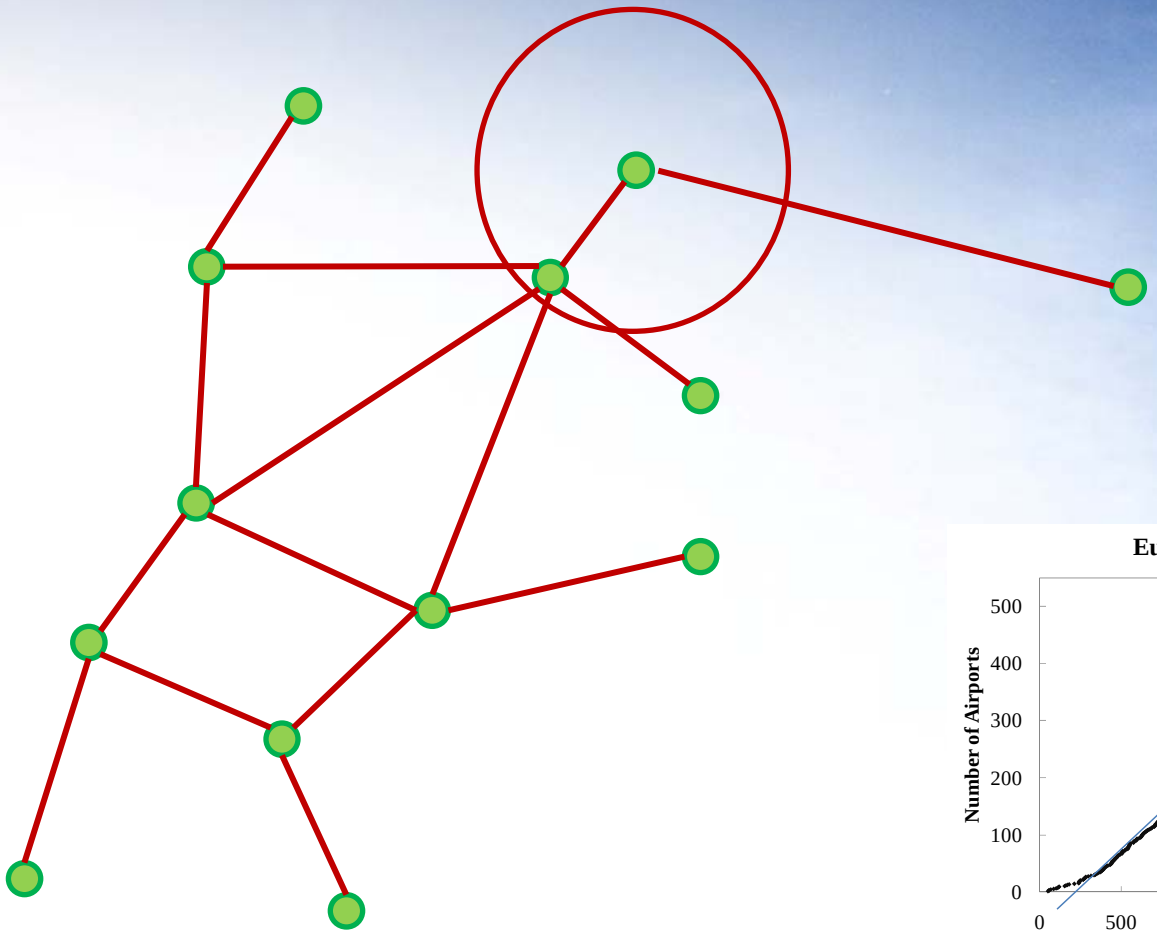
Degree Distribution – Scale Free with Reconfiguration

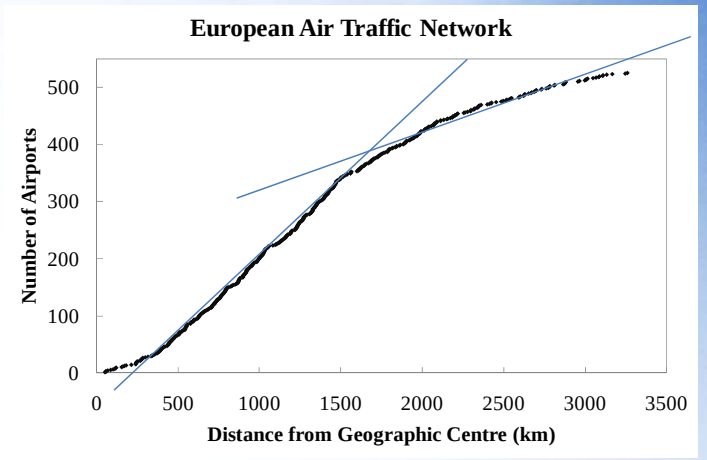


Synthetic Network generating algorithms



Continental Air Traffic Model





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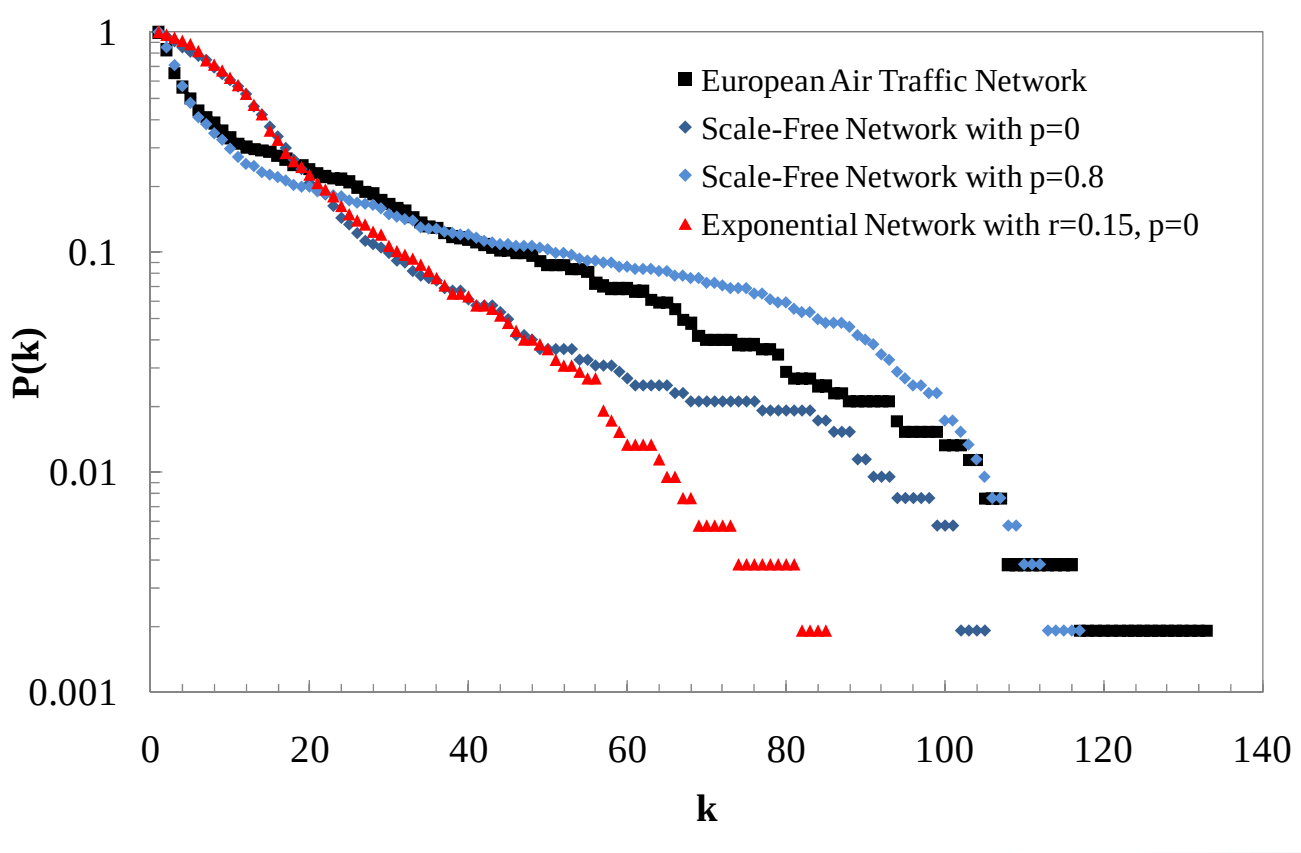
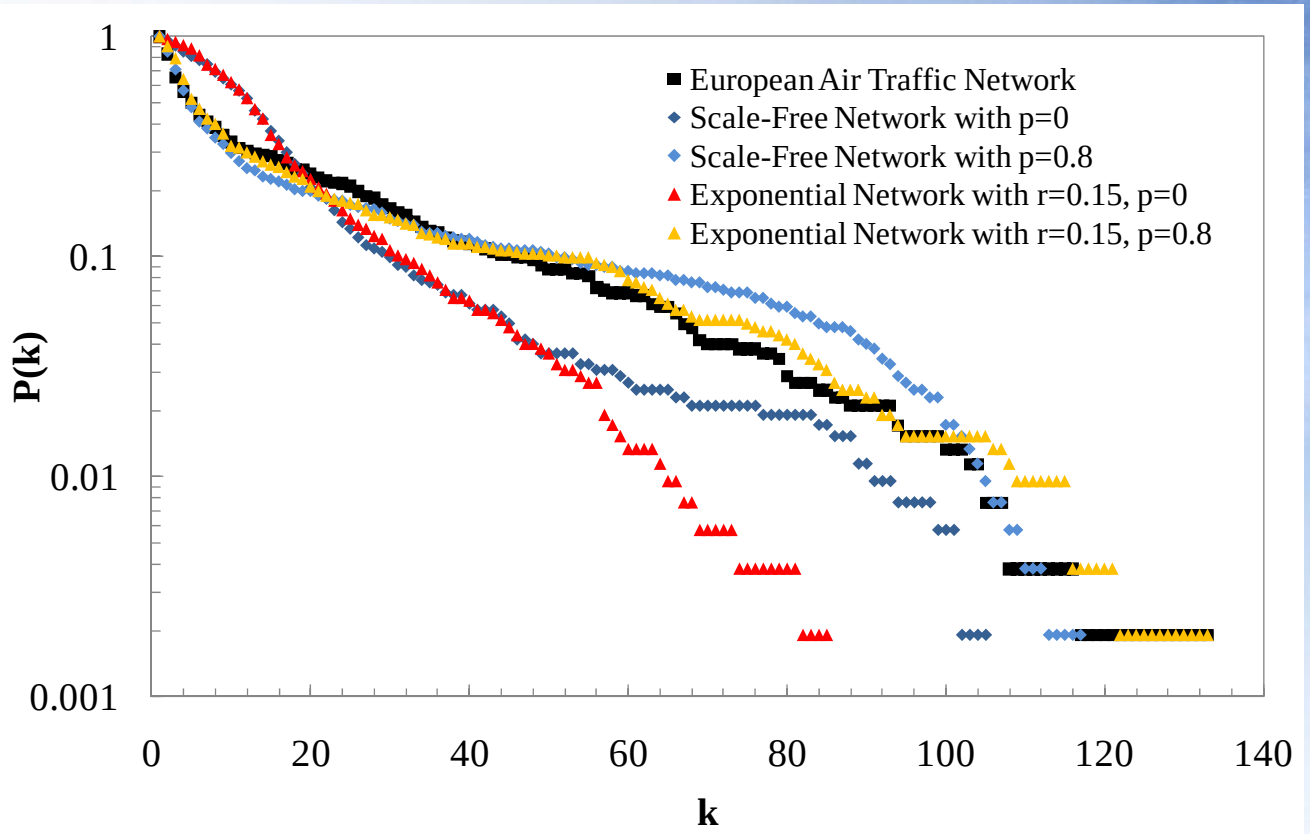
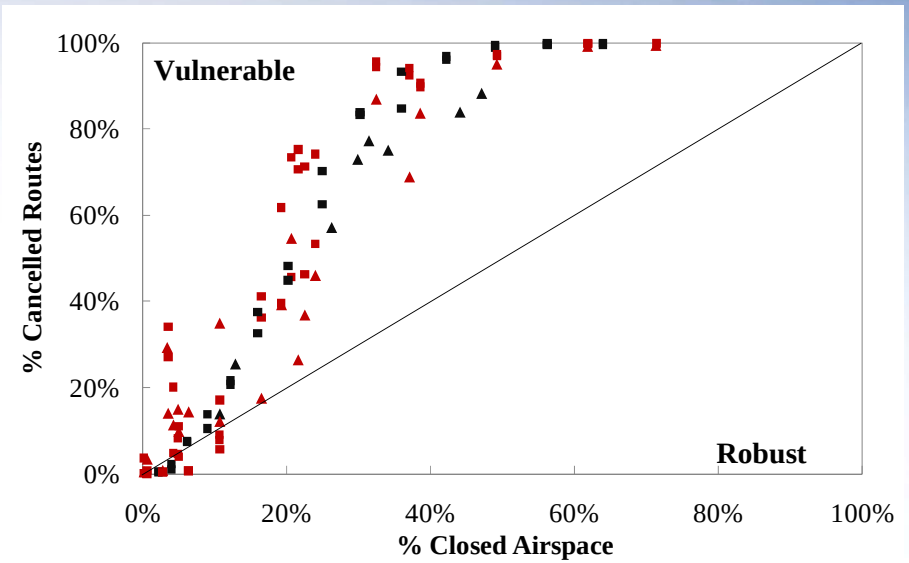
Degree Distribution - Exponential

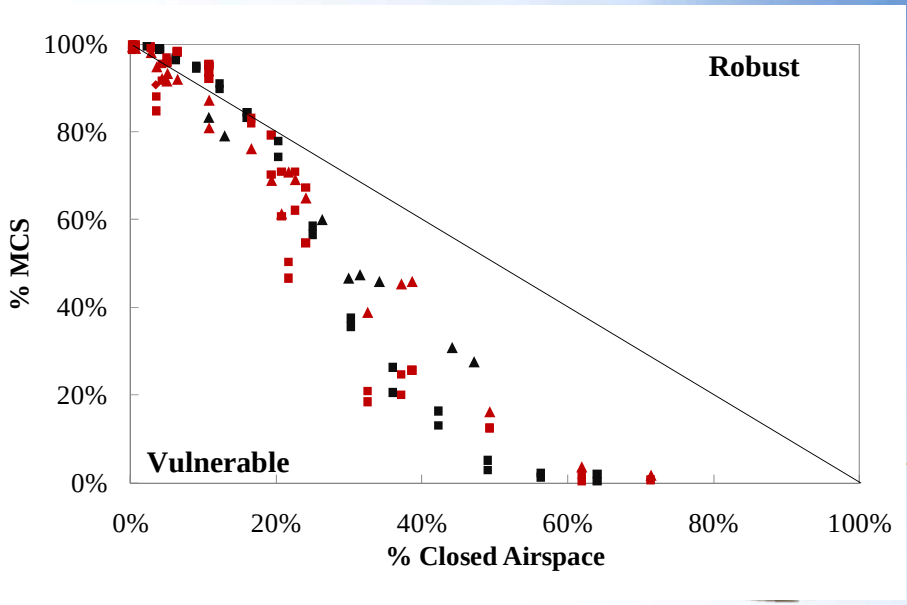


Degree Distribution – Exponential with Reconfiguration



Vulnerability Measures – Cancelled Routes





- European Air Traffic Network for Eyjafjallajökull Eruption
- Synthetic Network for Simulated Eyjafjallajökull Eruption
- European Air Traffic Network for Random Hazard
- Synthetic Network for Random Hazard

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Future Research

- **Use network graph theory to construct robust architectures**
- **Use traditional models to quantify resilience**
- **To do this we need**
  - Vulnerability curves for infrastructure
  - Soil vulnerability curves