



Cambridge Centre for Risk Studies
Advisory Board Research Showcase – 13 January 2016

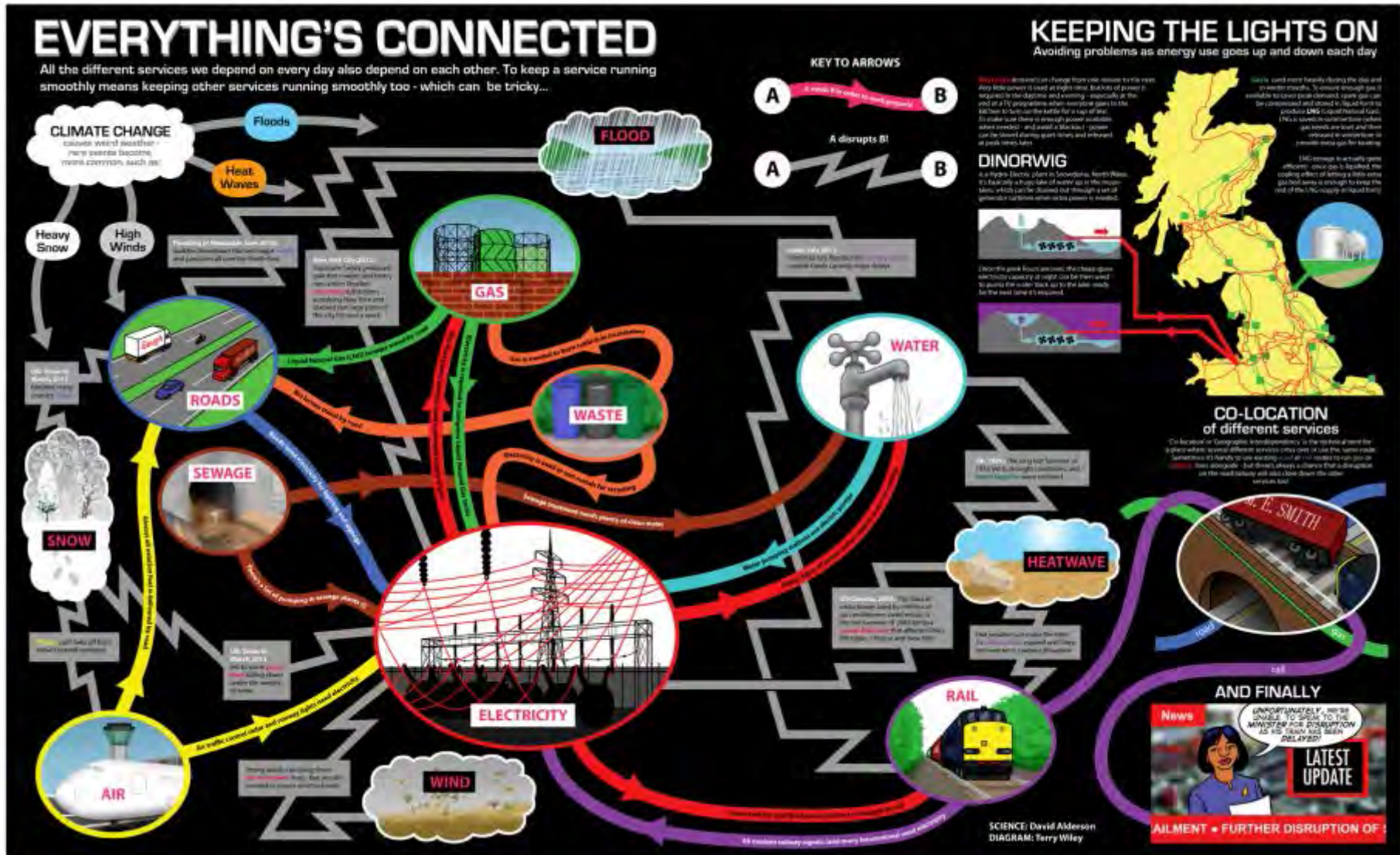
Critical Infrastructure Interdependencies (CII)

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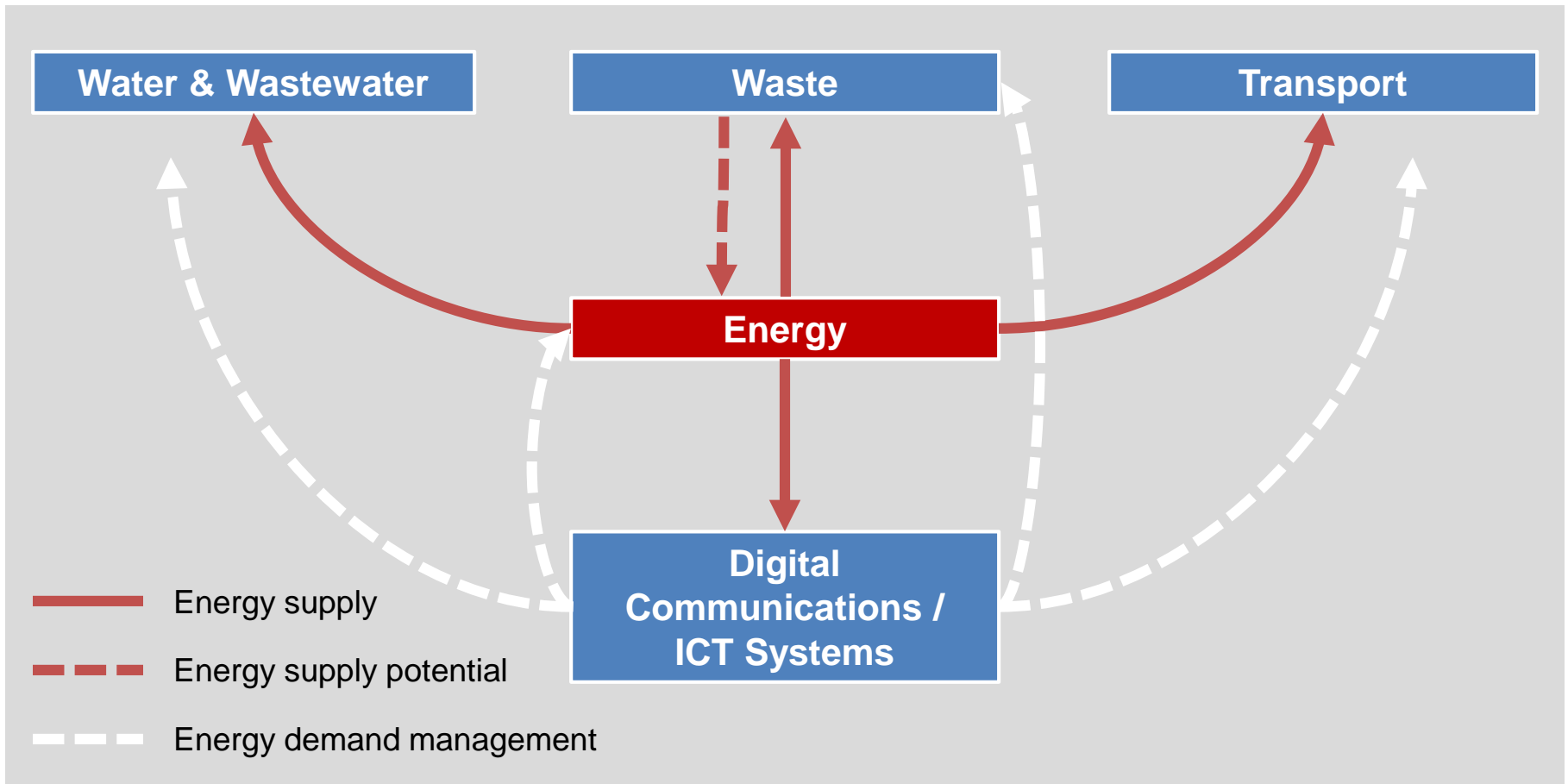


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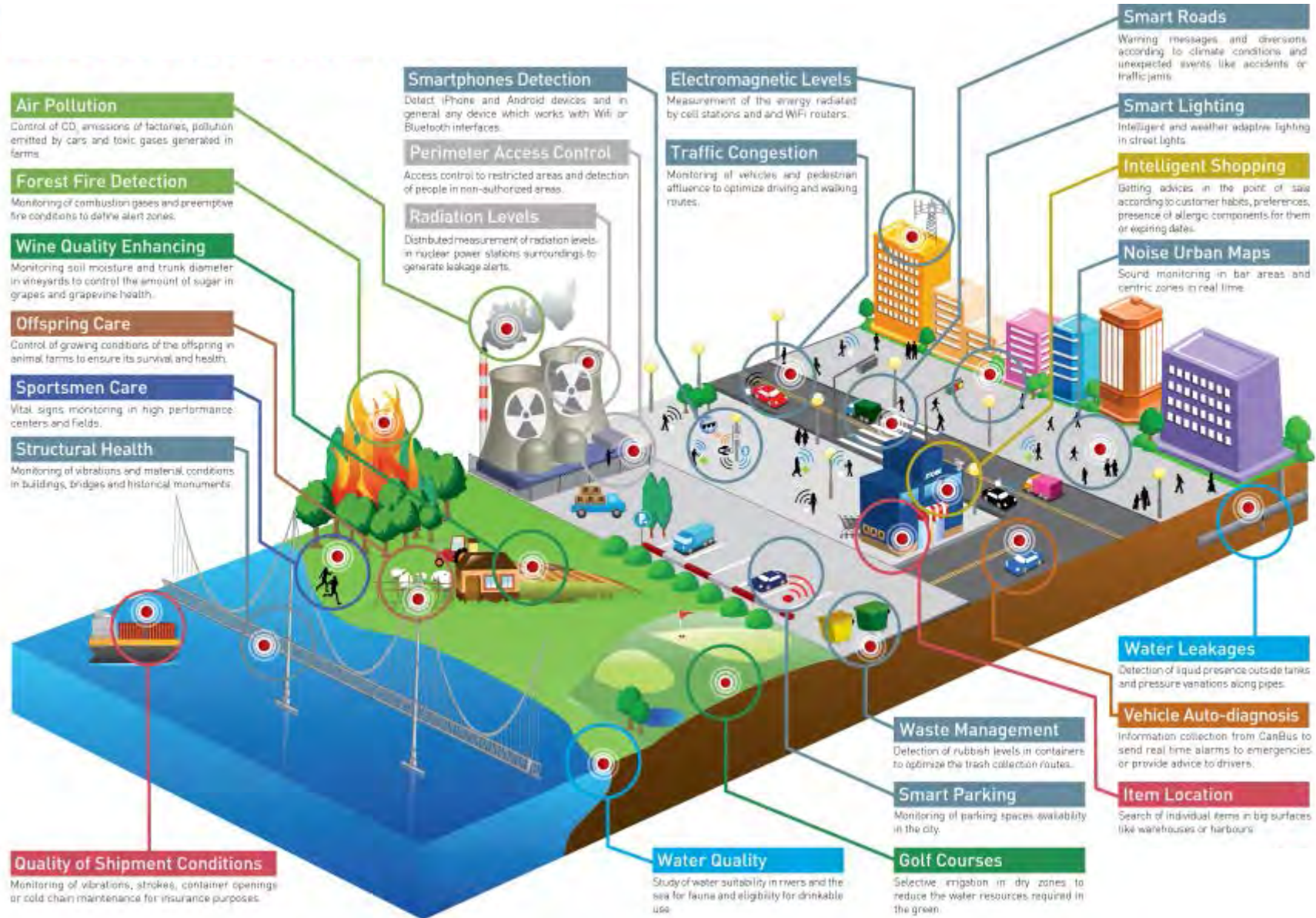
Analysis of Critical Infrastructure Interdependencies



Growing Interdependency



'The Internet of Things'



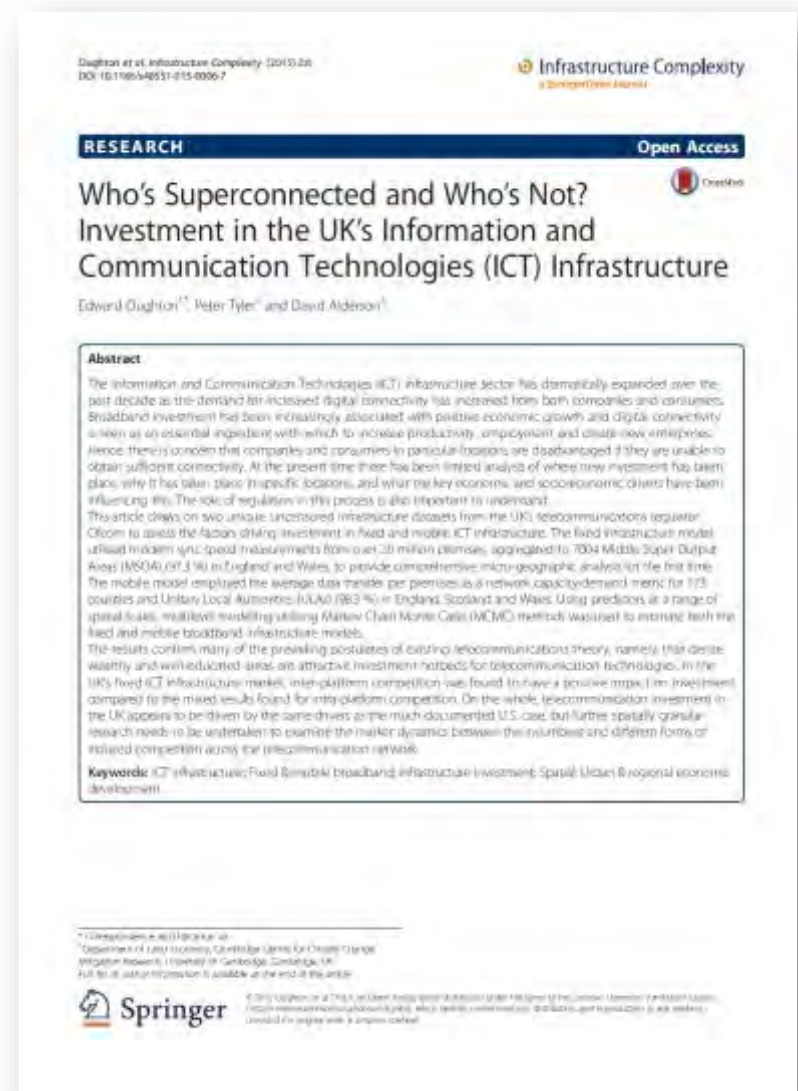
Methodological Expertise

*Pioneering the
system-of-systems
analysis of
infrastructure systems*



Methodological Expertise

Advancing the multiscale assessment of infrastructure systems



Methodological Expertise

Developing our understanding of the economic role of infrastructure systems in global supply chains

Netw Spat Econ
DOI 10.1007/s11067-015-9302-x



Exploring Vulnerability and Interdependency of UK Infrastructure Using Key-Linkages Analysis

Scott Kelly¹ · Peter Tyler² ·
Douglas Crawford-Brown¹

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Abstract It has been argued the UK has experienced significant underinvestment in critical infrastructure over the last two decades. This in turn has resulted in infrastructure that is less capable of assisting the UK economy to grow. This article seeks to undertake an in-depth analysis of the inter-linkages and economic contributions from infrastructure within the UK. It explores the relationship between nine infrastructure sectors and how these sectors contribute to the rest of the UK economy using key-linkage analysis. Each infrastructure sector is shown to be unique in the way it interacts with other economic sectors and in the form of contribution it makes to the economy overall. Infrastructure is found to be a necessary and important part of economic development. The analysis finds that over the last 23 years there has been a decline in the relative economic contribution from infrastructure to UK GVA. Only two infrastructure sectors increased their relative contribution to GVA since 1992. These were the water transport sector and sewerage and sanitary services sector. Railway transport and gas distribution have had the largest relative decline in contribution towards UK GVA with relative contributions decreasing by over 50 % since 1992. The three most important infrastructure sectors contributing to UK GDP are land transport, electricity production and distribution and telecommunications respectively.

Keywords Input-output analysis · Key-linkages · Infrastructure · Multiplier effects · Interdependencies · United Kingdom

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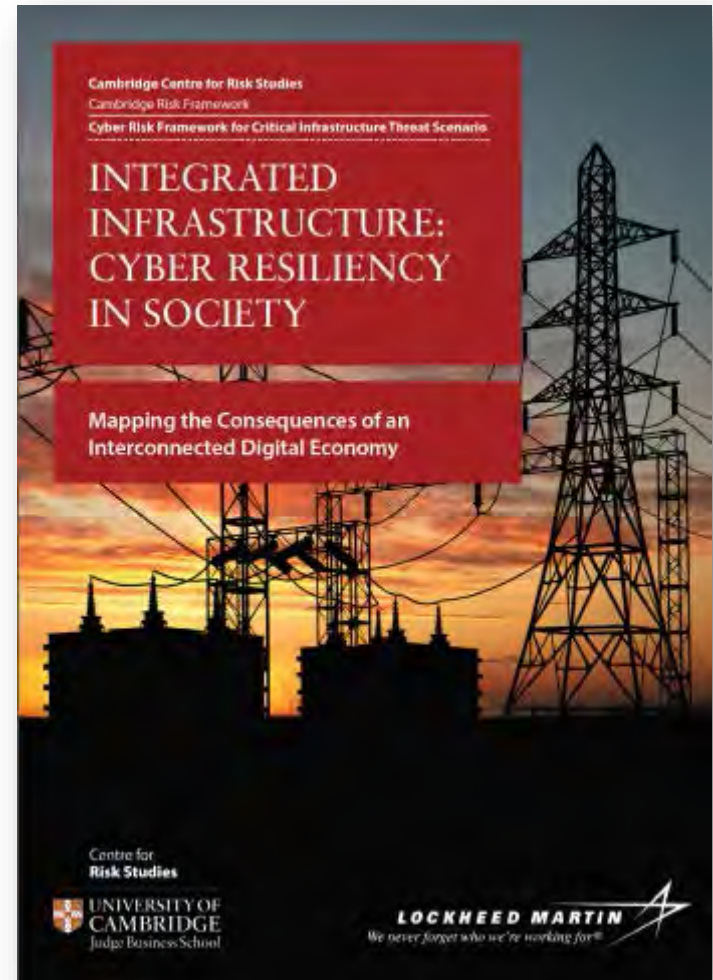
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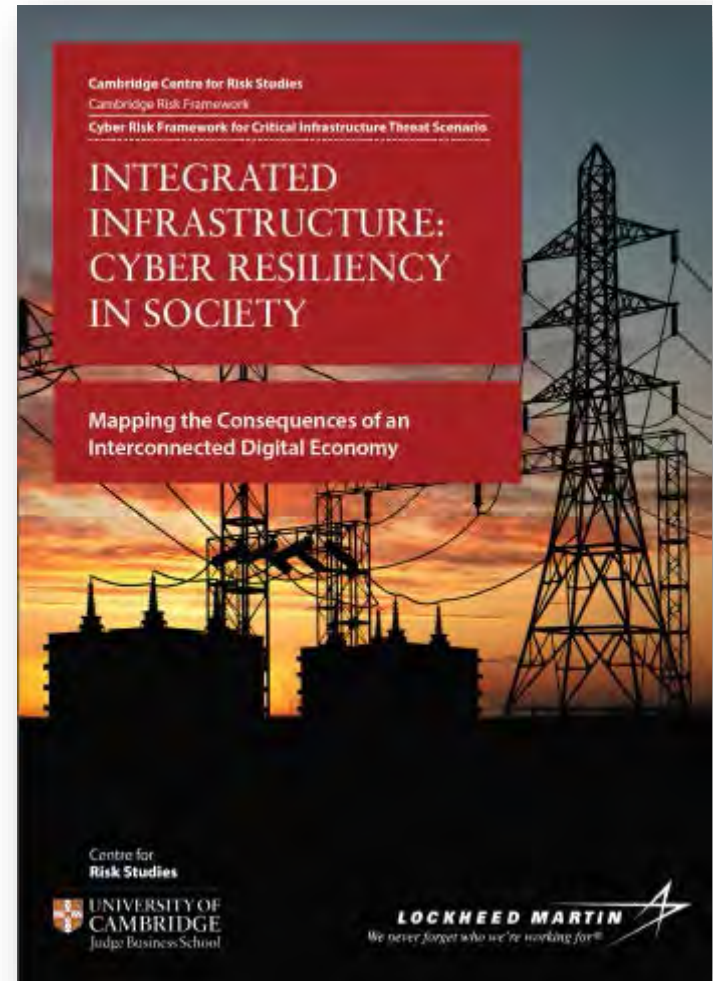
Examples of CRS Recent Work

- Estimating the direct impact on industrial production systems



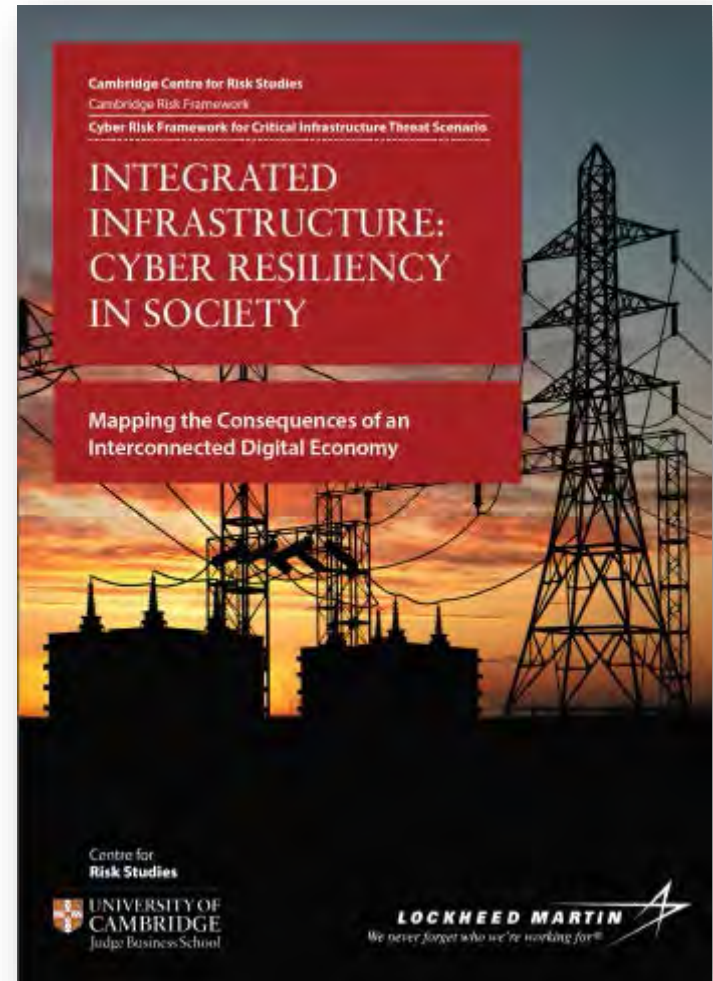
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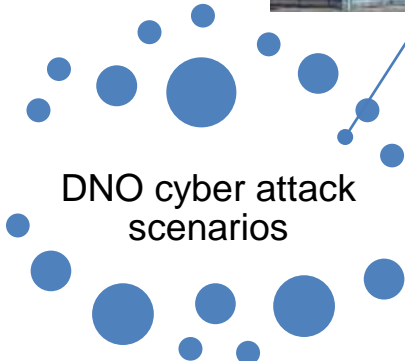


Examples of CRS Recent Work

- Estimating the direct impact on industrial production systems
- Quantifying the indirect impact on supply chains
- Valuing the total cost to the UK economy



Scenario Modelling Process

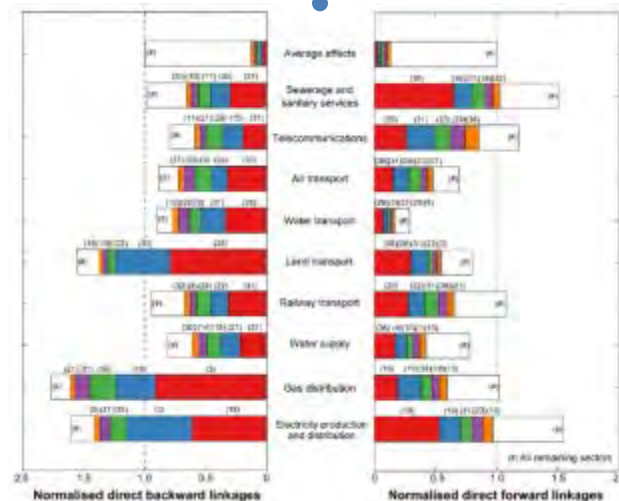
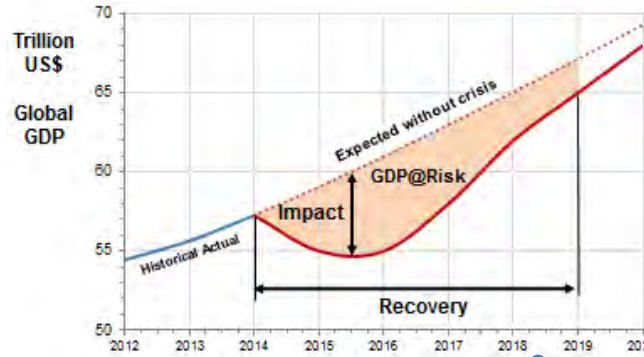


DNO cyber attack scenarios

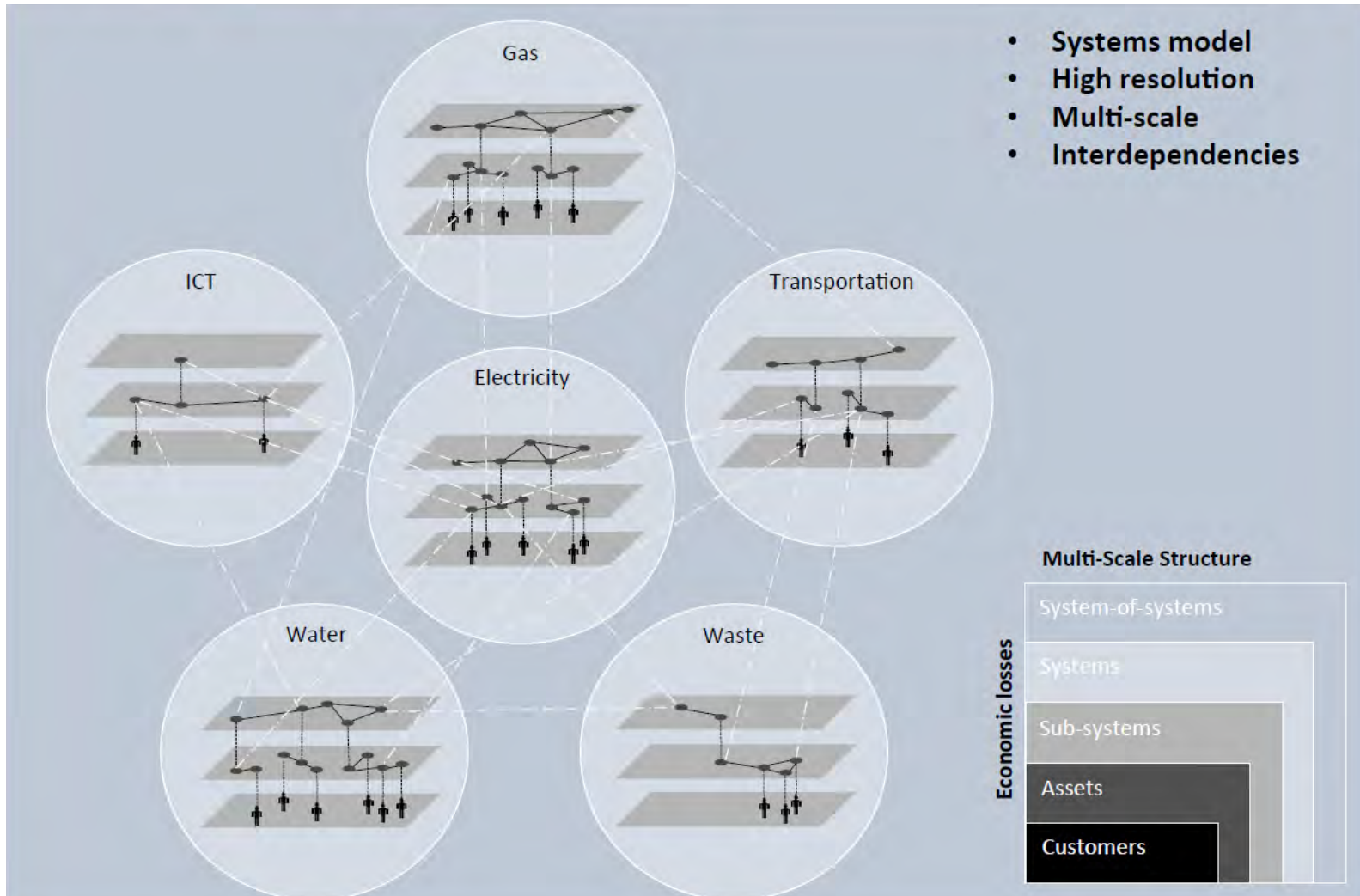
Run Infrastructure Network Vulnerability Assessment Model: Estimate customers disruptions

Shock UK IO model: Estimate direct and indirect economic losses by industry

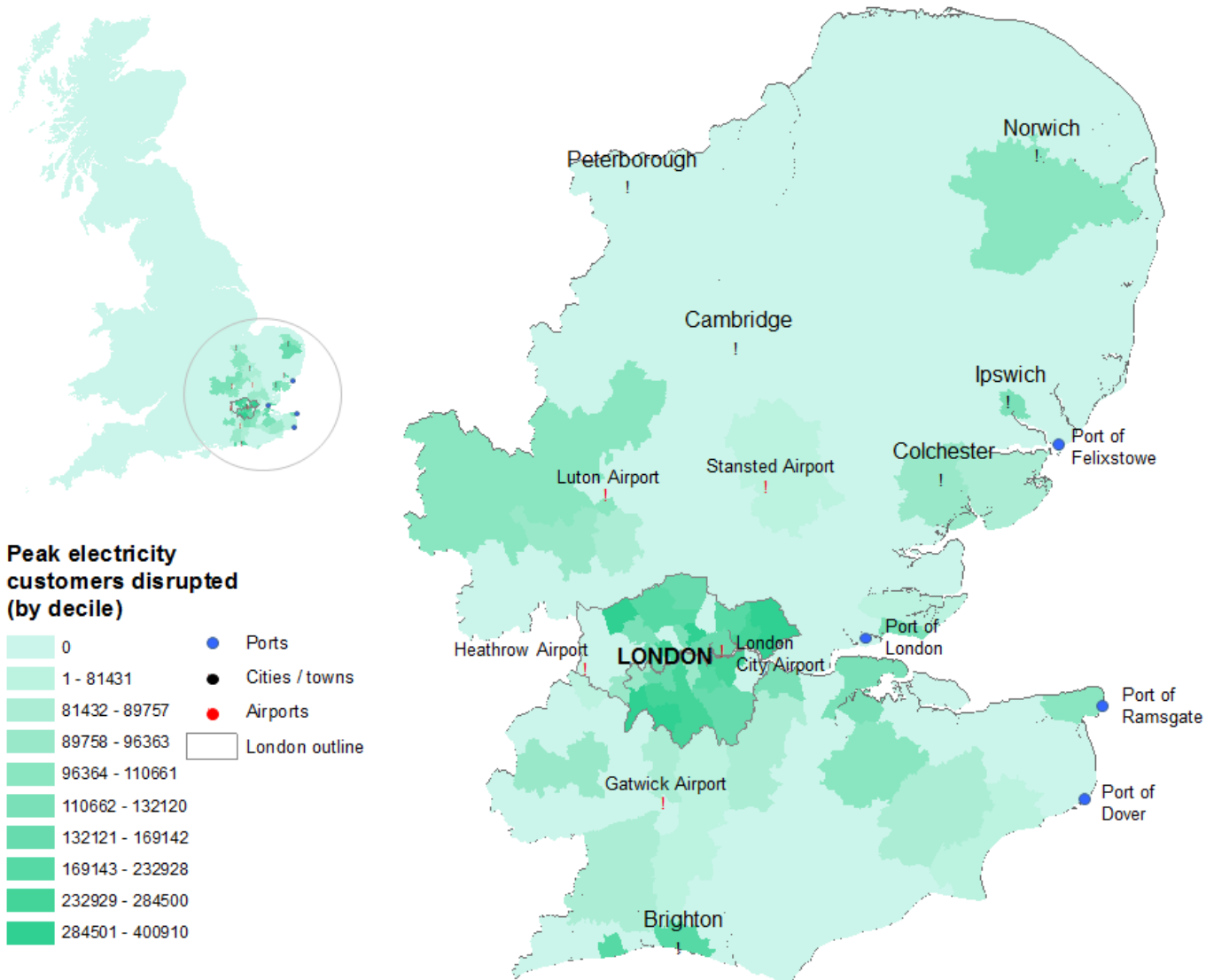
Produce simulations using OEM model: Estimate 5 year GDP@RISK



A System-of-Systems Approach to Infrastructure Interdependencies

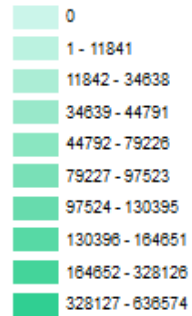


Electricity customers disrupted

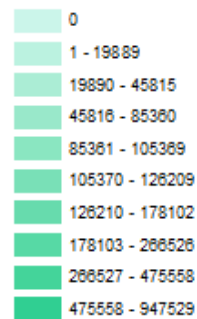


Critical infrastructure customers disrupted

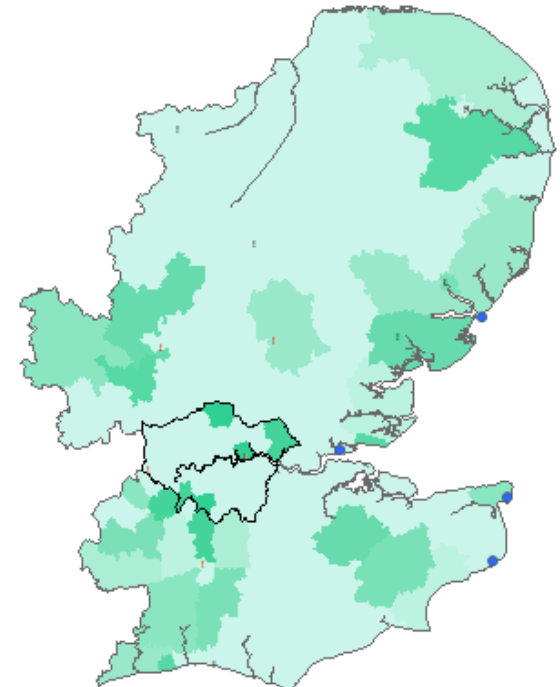
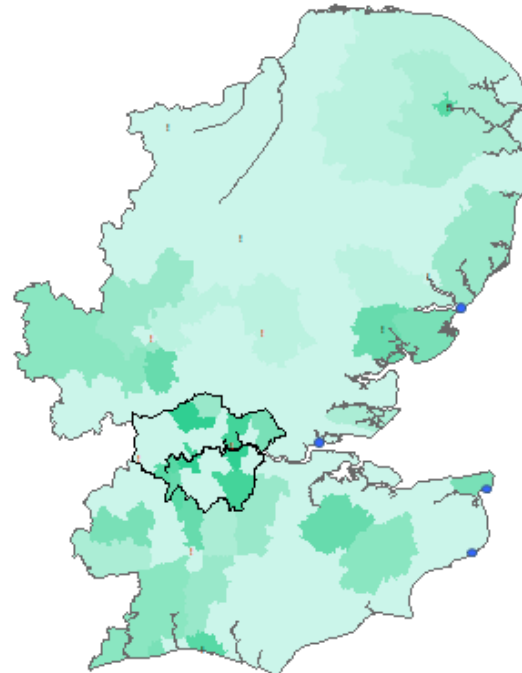
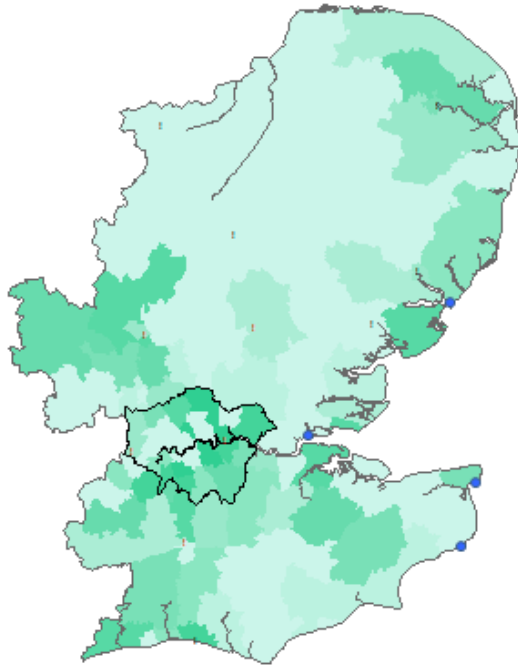
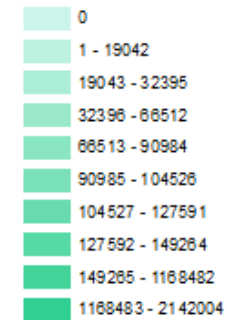
Peak digital communications customers disrupted (by decile)



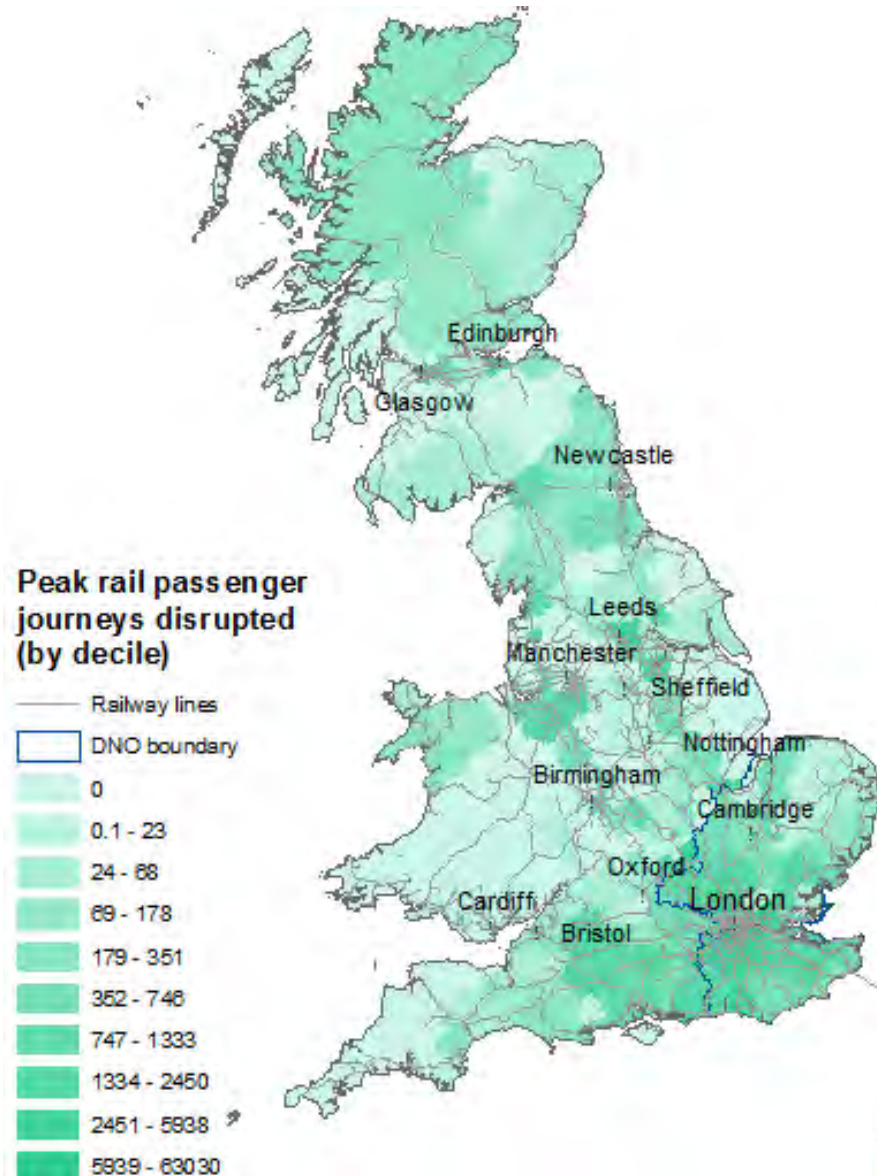
Peak fresh water customers disrupted (by decile)



Peak waste water customers disrupted (by decile)



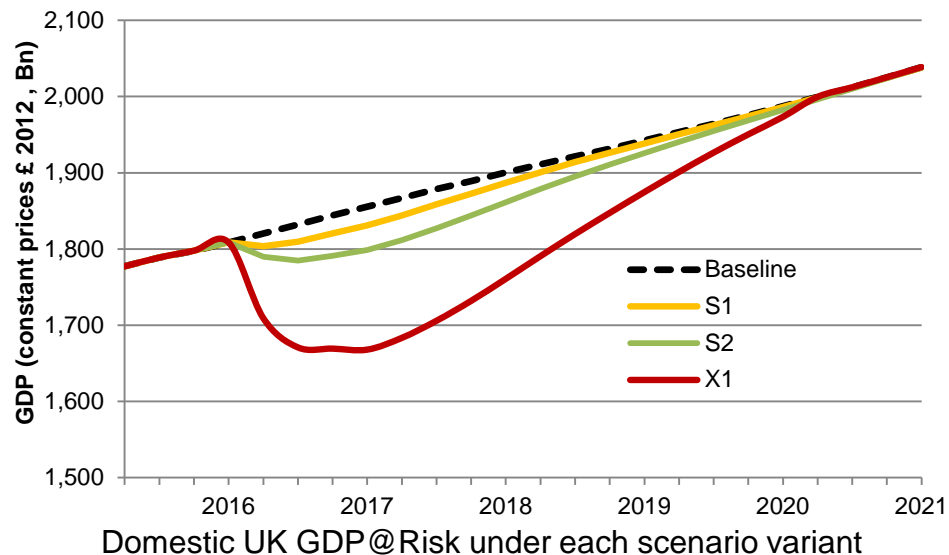
Railway customers disrupted



Direct and Indirect Economic Losses by Industry

	S1		S2		X1	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Financial Services	897	419	2,175	1,039	5,325	2,870
Wholesale and Retail trade	770	505	1,950	1,263	6,126	3,710
Real Estate Activities	820	388	2,063	956	6,295	2,601
Professional Services	700	335	1,736	834	4,857	2,369
Construction	428	406	1,088	1,020	3,574	3,123
Manufacturing	354	379	922	953	3,442	2,922
Health	402	255	1,013	638	3,101	1,900
Administrative Services	362	211	902	524	2,613	1,489
Transportation	304	252	762	628	2,317	1,822
Education	441	114	1,113	286	3,451	859
Information Technologies	440	96	1,085	239	2,776	672
Government And Emergency Services	318	206	797	515	2,407	1,511
Other Services Activities	361	42	900	104	2,550	296
Accommodation and Food Service Activities	205	135	511	338	1,473	1,006
Communications	82	139	205	345	578	983
Food	63	135	162	341	589	1,079
Arts, Entertainment and Recreation	120	64	300	159	901	457
Water Supply and Waste Management	62	54	160	135	529	402
Energy (Oil and Gas)	12	74	30	184	80	529
Electricity	17	64	44	160	133	467
Defence Manufacturing	22	55	57	139	186	412
Agriculture, Forestry and Fishing	28	37	75	94	318	294
Mining	2	9	6	23	21	68

Estimation of Economic Loss



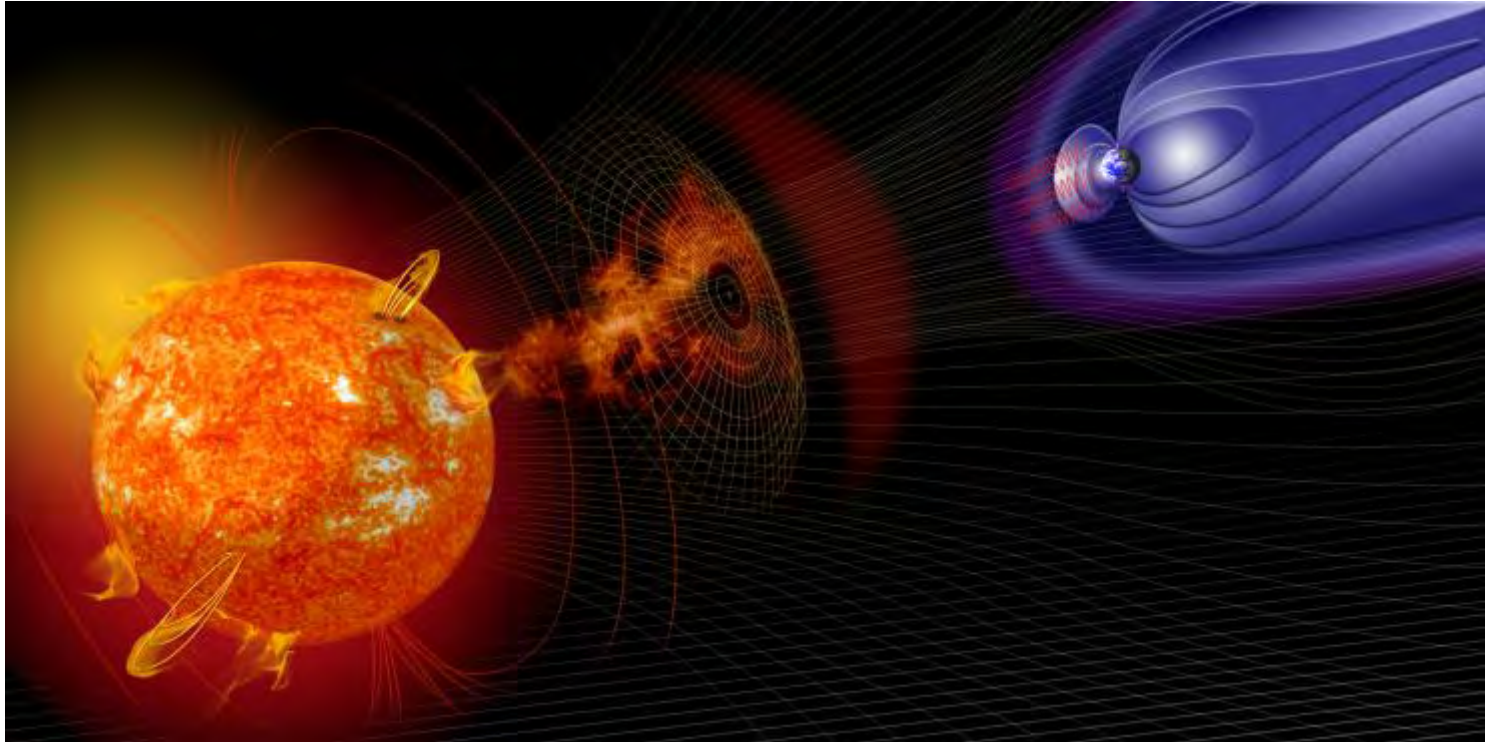
Scenario Variants	Lost Power (TWh)	Direct Industrial Production Losses (1 Yr) £ billion (from IO modelling)	Indirect Losses to Supply Chains (1 Yr) £ billion (from IO modelling)	GDP@Risk (5 Yr) £ billion (from macroeconomic modelling)
S1	10.3	7.2	4.4	49
S2	19.8	18.0	10.9	129
X1	39.6	53.6	31.8	442



Helios Solar Storm Scenario

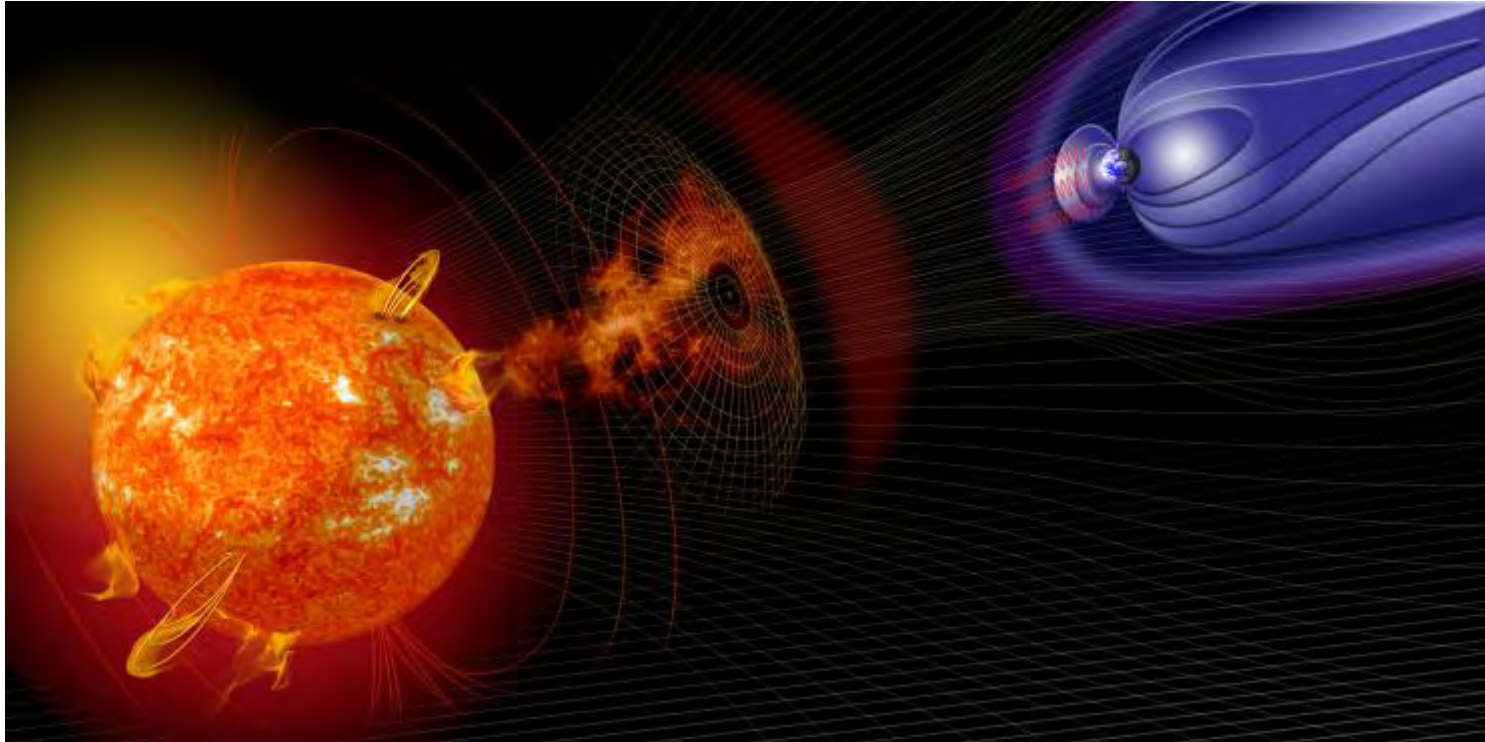
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Advances in CRS CII



- Development of global IO model

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- Development of global IO model
- Assessment of global supply chain linkages between major economies

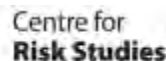
MISTRAL: Multi-scale InfraSTRucture systems AnaLytics

Modelling and Analysis of UK and Global Infrastructure Transitions

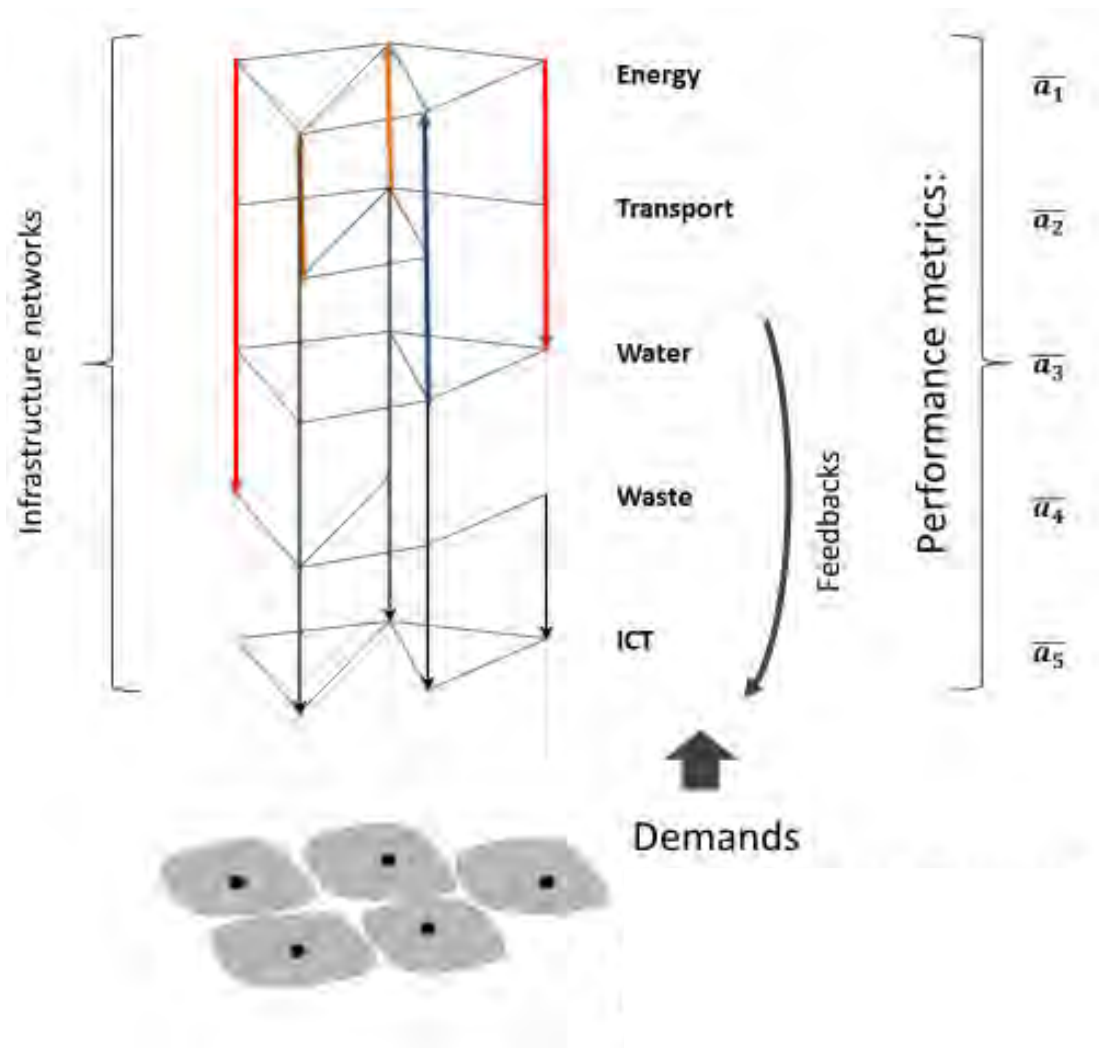
Energy | Transport | Digital Communications | Water | Waste

Consortium Leader – Professor Jim Hall (Oxford)

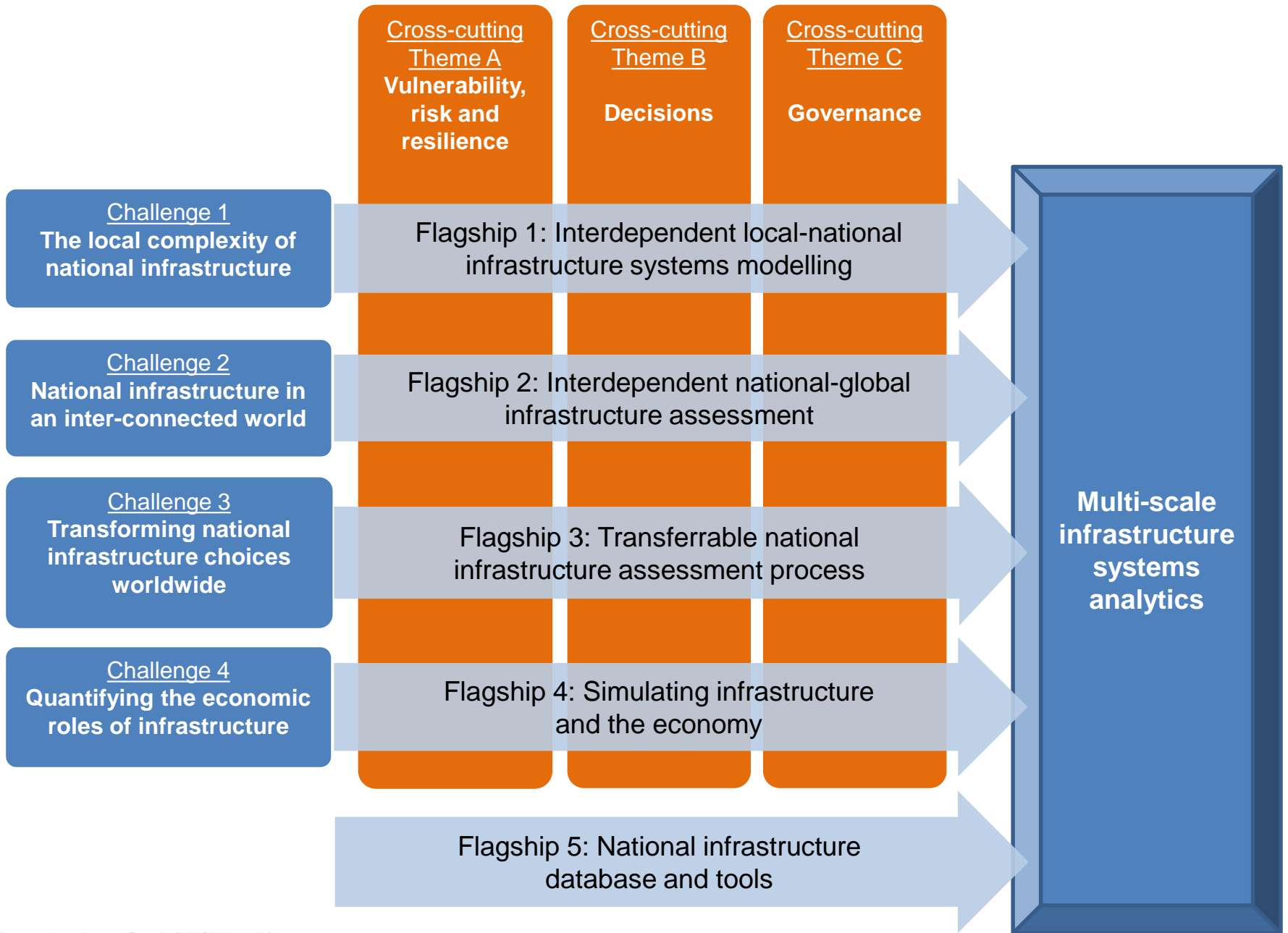
- Support from EPSRC ~ £5 million
- University contributions ~ £1 million
- Industry contributions ~ £2 million



MISTRAL: Multi-scale InfraSTRucture systems AnaLytics



A generalised representation of interdependent infrastructure performance



Future Research

- Going upscale
 - *Global infrastructure modelling platform*

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- Going across
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- Being more probabilistic
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 - *Highlighting the uncertainty of risk*
- European critical infrastructure interdependencies
 - *Electricity - Value of Lost Load (VOLL)*
 - *Digital communications - Value of Lost Data (VOLD)*

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