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DR ANDREW GRAINGER

NOTTINGHAM UNIVERSITY BUSINESS SCHOOL

KAMAL ACHUTHAN

NOTTINGHAM UNIVERSITY BUSINESS SCHOOL

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Introduction

The aim of this conceptual paper is to help stimulate further research and enquiry into UK Port Resilience and is a product of the EPSRC funded Knowledge Transfer Collaboration between the University of Nottingham and the Department for Transport (DfT). The paper draws on collaborative work between the authors and senior policy makers within the DfT, as well as on workshops, meetings and an extensive interview series with members of the UK's port sector in order to address four key questions:

- How important are ports for the UK?
- How vulnerable are UK ports?
- How do ports currently prepare themselves against vulnerabilities?
- How can port resilience be improved?

Interim drafts of the paper were also circulated across Whitehall for further comment and input. The views presented in this paper as well as any errors or misrepresentations remain those of the authors alone.

1 How important are ports for the UK?

The UK is an island and ports play a significant feature within its economy. They help tie the UK to global markets and provide access to critical supplies. In light of prevailing lean management practices and just-in-time type operations, it is thought that a disruption at one (or several) of the UK's major ports is likely to quickly ripple down the supply chain with immediate impact upon manufacturing and production. In severe cases, such as a tidal surge, prolonged port disruptions are also thought to have a direct impact on daily life, especially if access to critical supplies in energy and food is severely limited or cut-off.

UK ports cater for about 95% of the UK's foreign trade. In tonnage terms that trade amounts to a handling of 519 million tonnes in 2011[1].Of this tonnage 46% is in liquid form, mainly gas, oil and oil products; 20% can be classified as dry bulk-cargo, such as cereals, coal and cement; 11% is in containers, usually of a higher value or time-critical, such as consumer goods, textiles, and perishables (e.g. meat and vegetables).19% of the UK's maritime trade comes in Roll-On/Roll-Off (RORO) units, such as trucks and truck trailers, mostly between the UK and its European neighbours (DfT 2012).

Although the UK has about 1040 ports, 120 are described by the Department for Transport as commercially active and 52 are viewed as "major ports[2] and handling 97 per cent of the UK's maritime traffic (507 Mt). The top ten ports carry 69% of the UK maritime traffic (in tonnage terms) and most types of maritime traffic tends to be concentrated on less than a handful of ports (DfT 2012). For example, in oil and gas, containers, and dry-bulk shipping the largest port operates at or close to twice the tonnage (or units) as its nearest competitor, sometime significantly more (Figure 1).

[1] In comparison, airfreight landed at UK airports in 2011 was just shy of 2.3 million tonnes (CAA 2011, Table 13.2); the Eurotunnel Group operating the channel tunnel carried in 2011 the equivalent of 16.4 million tonnes in cars and coaches, and 1.32 million tonnes in rail freight (Eurotunnel Group 2013).
[2] These are ports handling over one million tonnes per year, and a small number of other key ports.

Moreover, ports often have a deep symbiotic relationship with production facilities that co-locate within their premises. One example of such symbiotic relationship are the oil and gas refineries at the ports of Milford Haven and Southampton, handling 34.4% of the UK's oil and gas traffic (Figure 1a). Likewise, the port of Immingham is very significant for UK coal imports, 19.9% (Figure 1b); and Dover's capacity to handle and turn around car-passenger ships, 41.5% (Figure 1e) dominates the ferry passenger business.

While the current level of specialisation and scale helps keep costs per unit or tonne down, and helps UK ports compete effectively with other European ports for traffic[3], it does limit the choice of alternative port options (if any). In the event of a failure at any one of the UK's dominant ports, it is unlikely that sufficient spare capacity can be found to replace the loss in capacity in full. In some cases, where ships and port equipment have been developed hand-in-hand (such as the berthing facilities at Dover, designed to accommodate the supper-ferries on the Dover-Calais route) there are likely to be no alternative choice in the short to mid-term.

Figure 1: Key port statistics, top 5 ports for selected traffic types: 2011

(a) Major ports: all oil and gas traffic	Thousand tonnes	Percent
Milford Haven	47,866	*21.9*
Southampton	25,106	*11.5*
Forth	22,848	*10.5*
Tees and Hartlepool	20,495	*9.4*
Grimsby & Immingham	20,314	*9.3*
All major UK ports	**218,547**	***100***

(b) Major ports: dry-bulk traffic	Thousand tonnes	Percent
Grimsby & Immingham	20,566	*19.9*
London	11,630	*11.3*
Liverpool	8,108	*7.8*
Clyde	7,564	*7.3*
Port Talbot	7,051	*6.8*
All UK major ports	**103,408**	***100***

(c) All goods vehicle and unaccompanied trailer traffic	Thousand units	Percent
Dover	2,049	*32.7*
Grimsby & Immingham	522	*8.3*
Liverpool	441	*7.0*
Belfast	357	*5.7*
London	334	*5.3*
All ports of United Kingdom	**6,272**	***100***

(d) All container traffic	Thousand units	Percent
Felixstowe	1,980	*40.2*
Southampton	965	*19.6*
London	429	*8.7*
Liverpool	404	*8.2*
Medway	240	*4.9*
All ports of United Kingdom	**4,927**	***100***

(e) All ports: accompanied passenger cars	Thousand units	Percent
Dover	2,565	*41.5*
Portsmouth	697	*11.3*
Holyhead	452	*7.3*
Belfast	270	*4.4*
Stranraer	217	*3.5*
All ports of United Kingdom	**6,188**	***100***

(f) Ship arrivals (2009)	Number of vessels	Percent
Dover	20,127	*15.5*
London	8,616	*6.6*
Liverpool	8,489	*6.6*
Grimsby & Immingham	7,923	*6.1*
Belfast	5,623	*4.3*
All ports of United Kingdom	**129,587**	***100***

Adapted from Tables 0103 and 0302, Maritime Statistics Compendium

Source: (Department for Transport 2011, 2012)

There are many further examples of where the UK is highly dependent on UK ports for specific types of goods, which may not necessarily be immediately apparent in current statistical reporting but will be known to the ports and shippers concerned. For example, the port of Portsmouth handles 70 per cent of

[3] In comparison to other European countries the tonnage handled in the UK is right at the top, almost on equal footing with the Netherlands (DfT 2012)

all the bananas eaten in Britain as well as all Moroccan citrus fruit (Portsmouth Port 2013). The Tate & Lyle Sugars Refinery at Silvertown on the Thames – located within the wider Port of London river system – has a cane-sugar refining capacity of 1.2 million tonnes per year and is one of the largest cane-sugar refiners in the world. It caters for much of the UK's and EU's sugar demand (Port of London Authority 2010; Tate & Lyle Sugars 2013).

Unfortunately, detailed sector studies examining their dependencies on specific ports are rare. One notable exception is a study commissioned by DEFRA. It highlights that London, Liverpool and Felixstowe handle 60% of all UK food imports received from non-EU country of origins, carried by a variety of shipping modes (bulk, break bulk, container and RoRo). The report also suggests – reflecting on the fact that significant UK accompanied and unaccompanied trailer traffic (much of it refrigerated) at Dover and the Channel Tunnel, and to a lesser extent the Humber ports and London – that these three ports handle the majority of food imports from EU countries (Peter Baker and Andrew Morgan 2012). Considering that the UK imports about 50% of its food of which 91% comes in by sea (DEFRA 2010), it is fair to assert that the resilience of the UK's ports in terms of safeguarding UK food supply is of particular public interest.

Further detailed industry studies would be desirable, though the prevalent use of containers in today's global production system does suggest a particularly high dependency on ports catering for container traffic – especially Felixstowe and Southampton (Figure 1d). For example, as illustrated in Figure 2, 72.6% of all UK textile imports[4] enter the UK via these two ports.

Figure 2: Textile imports falling under tariff Chapters 50-63 by port in million tonnes, 2011

Port	Million tonnes	Percentage
Felixstowe	754.5	45.3
Southampton	453.3	27.3
All Sea and Airports	1,662.4	100

(Source: extracted from the UKtradeinfo.com database)

Unfortunately, very little research has been conducted to assess the UK's current berth and port terminal capacity or the respective operator's reliance upon specialist handling equipment. Policy makers currently rely on anecdotal evidence and their personal knowledge of the sector when making judgement about critical equipment and spare capacity, if any. Further research, perhaps a national inventory of port capacity and critical port resources, would be desirable.

It also needs to be noted that ports do not only serve ships and trade, they are also locations at which many people work and reside as well as choose to spend their leisure time. The Port of London, to give one extreme example, extends along the entire tidal Thames and at its boundaries has the world's main financial centre – Canary Wharf – and just a little bit further upstream, the Houses of Parliament. The tidal

[4] Import figures shown in Figure 2 do not include any arrivals of textiles from within the EU.

Thames is also the location for the annual Oxford-Cambridge Boat Race and the location at which many choose to moor and sail their private yachts and leisure boats.

Key-point summary

- The UK has around 1040 ports of which 120 are commercially active. The top 10 ports account for 69% of all UK port traffic by tonnage. Most large ports are highly specialised and the largest of which often handles twice as much cargo (if not more) in its respective area of specialisation (e.g. oil, gas, containers, and ferries) as its nearest competitor.
- In the absence of any alternative transport capacities (such as air or rail) the UK, as an island and net importer, is very dependent upon its ports.
- Policy makers currently rely on anecdotal evidence and their personal experience of the maritime transport and port sector when making judgement about critical equipment and spare capacity. Further research, perhaps a national inventory of port capacity and critical port resources, would be desirable.
- In addition to supporting trade and access to goods and products, ports are also places where many people choose to reside and spend their leisure time. An extreme example is the Port of London, which at its boundaries includes Canary Wharf and the Houses of Parliament.

2 How vulnerable are UK ports?

The Cabinet Office (2013) highlights in its National Risk Register of Civil Emergencies a wide range of scenarios with impact on the UK's national security (Figures 3a/b). They include tidal surges, industrial actions, fuel shortages, industrial accidents, the pandemic flu, and severe weather, amongst others. Cyber Security (Cabinet Office 2011) and Space Weather (Cannon 2013) are also seen amongst policy makers as significant sources of threat to the UK's critical infrastructure. Ports and their reliance on electronic systems and technology in operations – especially in communication, navigation and automation – are thought to be particularly vulnerable[5].

In practice, many things can go wrong in a port and extend significantly beyond the cursory risk indications made by the Cabinet Office and other UK policy makers. For example, when 18 UK Port Harbour Masters were asked in a survey (conducted by this paper's authors) at their 2012 annual Port Harbour Masters conference to list the top 5 scenarios for complete port closure or severe disruption in order of likelihood, a wide diversity of issues were raised. The main three being: I) a blockage in the marine access channel caused by, for example, a marine accident or the grounding of a ship; II) poor weather, such as prolonged strong winds, fog and ice, as well as natural disasters, such as a flood; and III) the failure of infrastructure and breakdowns, such as damage to cranes and quays. Further issues raised include industrial action, fire, terrorism, oil pollution, financial collapse and the loss of business (traffic) as well as the flu and other epidemics (Figure 4). Interestingly, under the label of "Other"

[5] Though awareness of cyber security threats and adverse space weather outside of Whitehall is still thought to be poor.

reference was also made to port access issues caused by suicides from a bridge onto the main highway linking to the port, as well as loss of quay space subsequent to the arrest of a calling ship.

Figure 3a: High consequence risks facing the United Kingdom: Risk of terrorist and other malicious attacks

5		Catastrophic Terrorist Attacks			
4					
3		Cyber Attacks: Infrastructure	Attacks on Infrastructure Smaller Scale CBR Attacks	Attacks on Crowded Places	Attacks on Transport Systems
2					
1					Cyber Attacks: Data Confidentiality
	Low	**Medium Low**	**Medium**	**Medium High**	**High**

Figure 3b: High consequence risks facing the United Kingdom: Other risks

5				Pandemic Influenza	
4			Coastal Flooding Effusive Volcanic Eruption		
3	Major Transport Accidents	Major Industrial Accidents	Other Infectious Diseases Inland Flooding	Severe Space Weather Low Temperatures and Heavy Snow Heatwaves	
2			Animal Diseases Drought Public Disorder	Explosive Volcanic Eruption Storms and Gales	
1			Severe Wildfires	Disruptive Industrial Action	
	Between 1 in 20,000 and 1 in 2,000	**Between 1 in 2,000 and 1 in 200**	**Between 1 in 200 and 1 in 20**	**Between 1 in 20 and 1 in 2**	**Greater than 1 in 2**

Source: Cabinet Office, National Risk Register (2013)

Figure 4: UK port harbour masters' survey findings, 2012

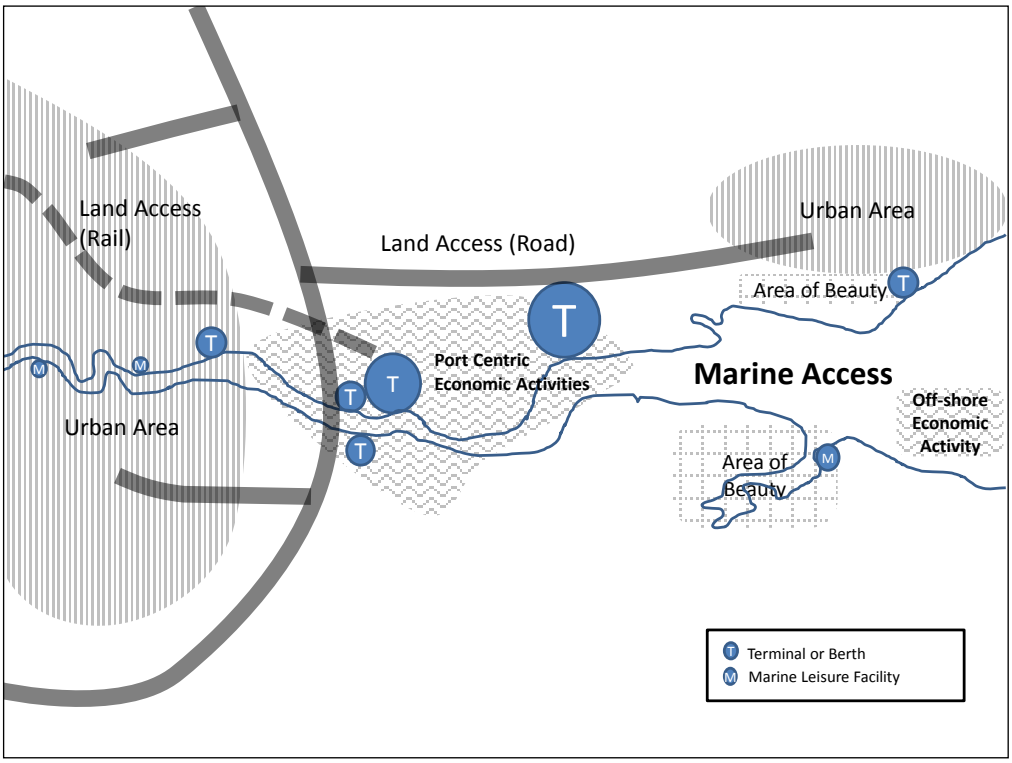
Cause for complete closure or severe disruption / Count of reporting UK port harbour masters, ranked in order of likelihood from 1 to 5	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Total Count	Weighted Count
Channel blockage (accident, grounding)	*6*	*9*	*2*	*2*	*3*	22	16
Poor weather/natural disaster	*7*	*1*	*2*	*2*	*1*	13	10
Port infrastructure failure / breakdown	*3*	*2*	*3*	*5*	*1*	14	9
Industrial action (Pilot/Tug/Port staff/Lorry drivers)	*0*	*3*	*4*	*5*	*3*	15	7
Terrorism/Fire	*0*	*2*	*2*	*2*	*5*	11	5
Oil pollution	*1*	*1*	*2*	*0*	*1*	5	3
Other	*0*	*0*	*2*	*1*	*2*	5	2
Financial collapse / loss of business	*1*	*0*	*1*	*1*	*0*	3	2
Flu / Epidemic	*0*	*0*	*0*	*0*	*2*	2	0

(Source: survey of 18 UK Port Harbour Masters, 2012)

Most types of risk to the continuity of a port transcend organisational boundaries and are not managed by any one single organisation. Indeed, ports can be best described as a system of interdependent stakeholders and its geography includes: the marine and land access channels; the businesses and industries located around the berths and terminals; and the berths and terminals themselves. Areas of beauty, such as recreation parks and national parks as well as marine leisure facilities add a further dimension to the port's geography (Figure 5). An event within the confines of one specific area – for example the sinking of a ship in the marine access channel or the destruction of a major land link (road, rail, pipeline) to the port – will have an impact on the functioning of the entire port system. To some extent, risks dependencies reach beyond the port itself and depend on wider shipping networks and partnering (linked) ports. For example, within the Dover-Calais system blockades in Calais by French fishermen and dock workers have an immediate impact on operations in Dover.

Port systems are probably best described as complex technological and sociological environments which are exposed to a very diverse range of risks. Drawing on the work of Mansouri et al. (2010) risks to a port might be categorised into natural disasters, organisational factors, technological factors, and human factors. To that one might add marine and land access factors, network factors, and economic factors. Figure 6 is a fishbone diagram, which was developed by reflecting on an extensive interview series within the UK's port sector and the input of senior officials within the DfT. The Figure aims to show the breadth of risks; though it needs to be highlighted that there is a high degree of interdependency between the various types of risks. Moreover, organisational factors can be described as compound factors, which add to the impact of any port disruption – or, if well managed, such as through business continuity and resilience planning – act against lasting impact.

Figure 5: Illustrative map of the geography of a port system located on a river



(Source: Authors)

Many of the risks outlined in Figure 6 reflect upon relatively recent events, such as: the shortage of salt to make roads and terminals safe for operations during the icy winters of 2010 and 2011; the Icelandic volcanic ash-cloud incident in 2010 necessitating the closure of most of the Europe's airspace and leading to the biggest maritime focused repatriations of people since Dunkirk (mostly stranded holiday makers); lasting destruction of cranes alongside Felixstowe's quay after a container ship[6] carrying (ironically) a load of cranes broke free in 2008; the toppling of a dock-crane at Southampton Container Terminal, leading to a temporary terminal closure to enable a Health and Safety investigation as well as a clean-up operation (which to the frustration of some shippers was during the same period that the destruction of cranes in Felixstowe occurred); regular near misses and marine accidents at the UK's main ports, including the significant environmental disaster at Milford Haven in 1996; industrial action, such as blockages at fuel depots in 2007; regular heightened alertness brought about from terrorist threats; the current economic down-turn impacting upon the income and financial resources available to ports; conflicting uses of maritime space, such as the development of off-shore wind farms, amongst others. Continued fear of unexploded World War 2 ordnance, the 60th anniversary of the big North Sea Flood in January 1953 and the severe North Sea tidal-surge of 5th December 2013 play further on the minds of those concerned with safeguarding the UK's port infrastructure.

Most risks outlined in Figure 6 could also impact upon a multiple of UK ports. For example, a tidal surge in the UK similar to the "Big Tide" in 1953 is likely to have an impact along the entire North Sea coast,

[6] The "Zhen Hua 23"

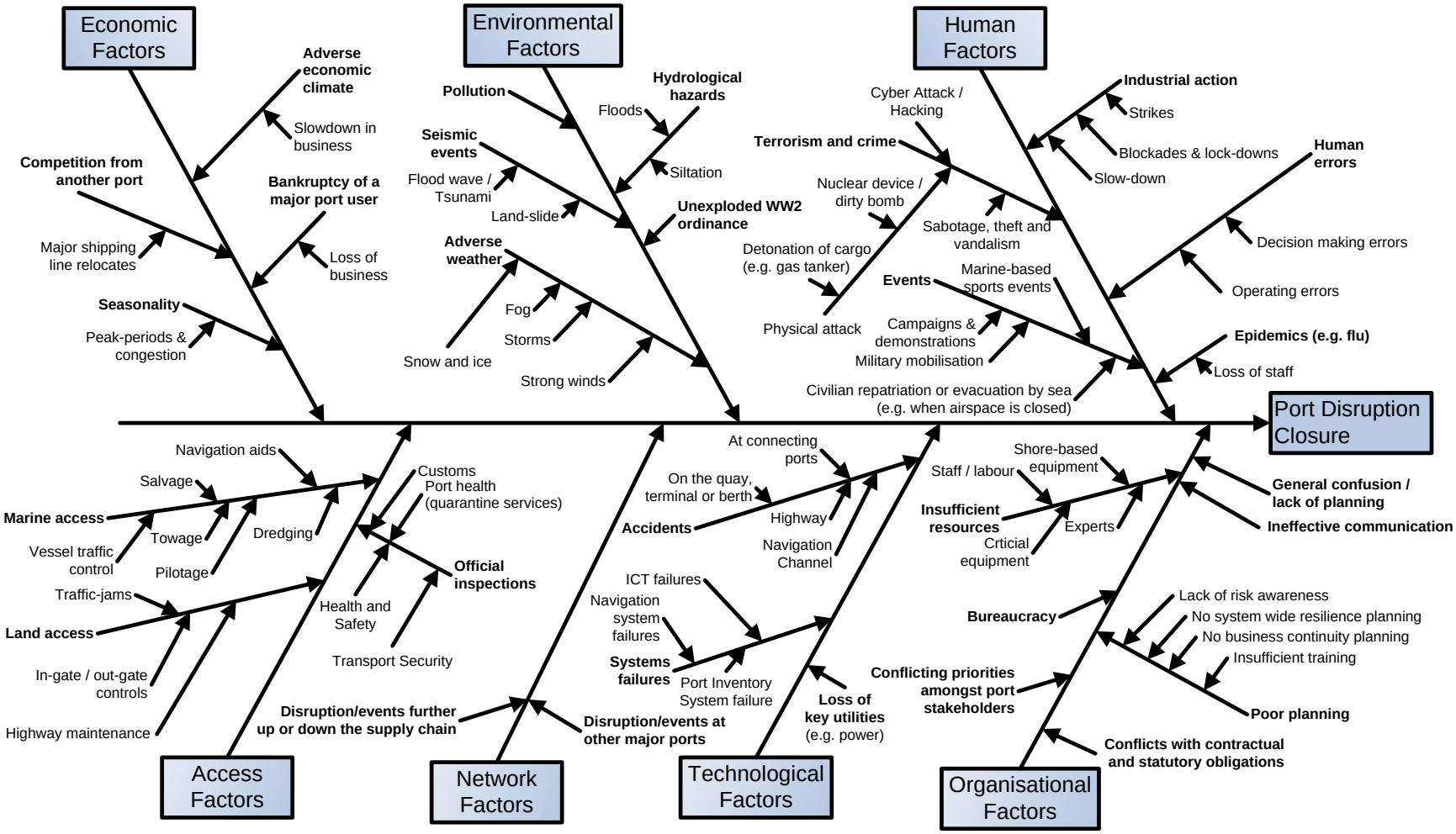
including Grimsby and Immingham, Felixstowe and Harwich as well as all of the Thames, serving 49% of the UK's imports (DfT 2009)[7]. It would also impact upon the continental North Sea ports, including Rotterdam and Hamburg, severely disrupting shipping networks and any alternative shipping options to the UK.

While it is easy to list possible risks to the continued operations of ports, the perceptions of their impact will differ significantly amongst port stakeholders – and for that matter the wider public – depending who has most at stake. For example, a marine accident within the port's access channel would probably be primarily an insurance issue for the ship-owner. For the port terminals and berths the temporary closure of the access channel would result in short-term loss of business until the salvage and clean-up operations are completed. For importers relying on that port for critical supplies the disruption will be more keenly felt, very likely forcing them to identify alternative sources of supply via different shipping routes, possibly utilising different modes of transport. It may also translate into a sustained loss of business where competitors with different logistics options are able to fill the gap. For particularly critical goods and those where businesses do not keep sufficient strategic stockpiles or inventories (e.g. coal, grain, winter salt, medical equipment), there are also likely to be public policy considerations, including rationing. For local residents any resulting pollution, such as oil-spillage, will have long term effects on the quality of their environment, not to mention the risk to their drinking water. It is fair to assume that perceptions of vulnerabilities and subsequent impact will differ significantly amongst the port's stakeholders.

Indeed, the list of participants within a port system is long and very diverse, and spreads across the port's entire geography (Figure 5). Broadly, stakeholders can be grouped into those directly involved in the operations of the port. These have been categorised in Figure 7 under the heading "Primary Stakeholders" and include those involved in the operations of the berths and terminals as well as the maritime and land access. A second group can be labelled as "Dependent Stakeholders" and includes all those relying on the port in the context of land based or off-shore based economic activities, as well as those that provide supporting services to the port and its users. Finally, there are those "Linked Stakeholders", who may not have any direct interest in the port's operations, but are nevertheless able to influence port policy and operational conditions, be it through direct executive powers or by virtue of co-location.

[7] The authors are currently also involved in follow-on work to evaluate the impact of the North Sea tidal-surge on 5th December 2013 upon the UK's ports.

Figure 6: Possible threats to continued port operations



(Source: adapted from Mansouri et al. (2010) by drawing on findings made in interviews with the UK port sector and in consultation with policy makers at the UK's Department for Transport)

Figure 7: Participants and Stakeholders in Port Operations by Grouping

	Groupings	Participants and Stakeholders in UK Port Operations
Primary Stakeholders	**Terminals and Berths**	• Terminal and berth operator • Stevedoring companies and Stevedore agency services • Crane operators • Shipping lines and their agents • Mooring and berthing services • Freight forwarders, customs brokers and agents • Port Community Systems Providers (ICT)
	Marine Access to Terminals and Berths	• Ships' masters and their crews • Shipping lines and vessel owners • Port Harbour Masters and Port Authorities • Pilots • Pilot cutters, harbour launches, workboats and water taxis • Tug operators • Vessel Traffic System (VTS) operators
	Land Access to Terminals and Berths	• Highways Agency and their contractors • Network rail and their contractors • Rail freight operators • Road haulage and logistics companies • Port security (In-gate/out-gate)
Dependent Stakeholders	**Land Based Port-centric Economic Activity**	• Port based manufacturing, processing and utility companies • Port dependent supply chains and their constituents • Transport and logistics companies, including offices and their facilities • Warehouse, depots and storage companies • Cargo consolidation and packaging companies • Off-shore service companies and their facilities (e.g. wind farm maintenance companies) • Electricity, telecommunications, water, sewage treatment, and other utilities supporting port operations
	Port Dependent Off-shore Economic Activity	• Fishing • Off-shore wind farms • Ship-to-ship fuelling/bunkering • Ship-to-ship loading and unloading • Off-shore aggregate dredging • Off-shore rigs and other off-shore installations
	Supporting Marine Services	• Dredging services • Salvage and towage operators • Ship repairers • Ship provisioning/ bunkering • Insurance companies • Trade and ship-finance companies • Maritime surveyors • Terminal handling equipment manufacturers and repairers
Linked Stakeholders	**Officials, Inspectors and other Executive Powers**	• Unions and their stewards • Department for Transport • Local Authorities • Marine Accident Investigation Branch (MAIB) • Maritime and Coastguard Agency's SOS-Representative • HM Revenue and Customs (HMRC) officers • Environment Agency officers • UK Boarder Agency • Officers for the Marine Management Organisation • Port Security, Port police, County Police and Special Branch • Port Health Authority Inspectors, including: Environment Health Officers, and Official Veterinary Officers • DEFRA - Animal Health and Veterinary Laboratories Agency • Phytosanitary Inspectors and Horticulture and Marketing Inspectors • Maritime and Coastguard port state control ship survey • Health and Safety Executive • Marine Classification Societies and Accreditation Bodies
	Co-location, Residential and Environmental	• Urban areas and their residents • Urban transport and utilities networks which are integrated into the port system • Areas of beauty, national parks and nature reserves • Marinas and leisure facilities

(Source: Authors)

Key-point summary

- Ports are vulnerable and the list of potential risks is diverse and long.
- Lack of planning will compound the impact of disruptive events (risks) upon the port
- Risk perceptions are often informed by recent events, though long-term memory of particularly catastrophic events – such as the Big Flood in 1953, or increasing alertness brought about through perceived threats in International Terrorism, play a significant consideration, too.
- Many stakeholders are involved in the operations of any port; their perceptions of risks are likely to differ significantly.

3 How do ports currently prepare themselves?

Debate about resilience in the UK appears to be largely driven by the government's concern for critical national infrastructure and the preparedness of the UK's key sectors: communications, emergencies services, energy, finance food, government, hazards sites, health nuclear, transport and water (Cabinet Office 2012). Critical national infrastructure is defined by the UK government as "those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of the essential services upon which the UK relies, the loss or compromise of which would lead to severe economic or social consequences or to loss of life". Transport features explicitly within the Cabinet Office's Strategic Framework and Policy Statement on Improving the Resilience of Critical Infrastructure to Disruption from natural Hazards (Cabinet Office 2010). Likewise, transport infrastructure is also the concern of the Centre for the Protection of National Infrastructure (CPNI), which provides advice and guidance with regards to vulnerabilities of critical national infrastructure to national security threats. Much of the UK government's work is focused on regulated industries, such as energy, health, rail and aviation. While port and docking companies operate under powers conferred to them by Parliamentary Acts, ports fit uneasily under the umbrella of regulated industries as most stakeholders within the wider port system (Figure 7) remain largely free from any economic regulation.

The main instrument at the UK government's disposal to help foster improved resilience planning is the Civil Contingencies Act (2004). It provides for structured co-operation and information sharing between so-called Category 1 and Category 2 responders. Within the wider context of ports Category 1 responders for England and Wales include: the Secretary of State, in so far as his functions include responding to maritime and coastal emergencies (excluding the investigation of accidents); the county and district councils; the emergency services, including HM Coast Guard; the port health authorities; and the Environment Agency. Category 2 responders within the context of ports are limited to the harbour authorities only.

Under the Act Category 1 responders have four core duties: risk assessment, business continuity management (e.g. ISO22301; ISO 2012), emergency planning, and warning and informing the public.

Category 2 responders have the duty to cooperate, share information, and support Category 1 responders. The principle mechanism for cooperating between Category 1 and 2 responders are the so called Local Resilience Forums[8], which as part of their work may also look at their responsibilities towards the port industry. However, the vast majority of organisations involved in the running and functioning of a port (Figure 7), with the exception of the port harbour authorities, are not directly represented within the Category 1 and Category 2 frameworks. This raises the question of whether the framework of the Civil Contingency Act is suitable for the UK's port sector and whether it needs to be modified (e.g. by re-categorising Category 1 and 2 members) or by setting-up supporting institutional mechanisms that embody all stakeholders within the wider port system and the Primary Stakeholders outlined in Figure 7, in particular.

Irrespective of the Civil Contingency Act, port authorities are required by reference to Port Marine Safety Code to manage marine safety specific risks, such as those arising from marine accidents (DfT 2009). Likewise, some of those organisations within the wider port system may choose to manage risks specific to their own business, as required by good corporate governance practice (FRC 2012). However, these provisions fall short of managing risks that extends across organisational boundaries within the wider port as illustrated in Figure 5.

As already outlined, risks are likely to be perceived differently and will be dependent on the organisation's particular commercial appetite for risk, often changing in line with economic climate and pressures on managing costs. A particular challenge in bringing various port stakeholders together is that their interests are seldom aligned, and that those organisations best placed to manage a particular risk may not necessarily be the most incentivised to put mitigating measures in place – or, for that matter, lend resource to resilience planning. The alignment of interests will ultimately have political dimensions and requires suitable mechanisms.

Key-point summary

- Resilience planning is thought to be largely driven by the respective UK government departments. The main instrument at the UK government's disposal is the Civil Contingencies Act (2004). However, the Act's mechanisms and institutions focus on specific individual organisations (especially the harbour authority), but fail to consider the many other organisations involved in keeping the port operational, or have an interest in resilient port operations.
- The interests amongst port stakeholders are unaligned and those best placed to manage risks may currently not necessarily be suitably incentivised. The alignment of interest for the greater public good will require some political commitment supported by suitable mechanisms.

[8] There are a total of 43 Local Resilience Forums (LRFs) in England and Wales, additional groups exist in Northern Ireland and Scotland (see: https://www.gov.uk/local-resilience-forums-contact-details). In some cases, such as along the river Thames, multiple LRFs converge at the boundaries of a port system (Figure 5) and raising further doubts about their suitability for the port industry.

4 How can UK port resilience be improved?

Probably the main challenge for policy makers tasked with fostering greater resilience in ports is the wide diversity in stakeholders and the fact that these are largely driven by their own commercial interests, which may not necessarily be aligned with wider public interests. Current regulatory instruments for the protection of Critical National Infrastructure and Resilience Planning are ill suited for ports as they fail to recognise the mechanisms necessary to help the various stakeholders within the wider port system (Figure 7) come together. Following ideas for Activity packages (A1-A6) might help improve upon the current situation:

A1: Raise awareness and visibility about potential vulnerabilities within the port system and their mitigation

Most primary stakeholders within the wider port system (Figure 7) are aware of the risks within their specific organisations, but not necessarily about the impact such risks might have on other stakeholders. Occasional workshops at national and local level can help raise awareness about risks that transcend organisational boundaries.

A2: Identify scope for mitigating risks as well as plan for port system disruption and recovery

Various options are available and should all be considered. They range from ad-hoc workshops and exercises to the development of dedicated institutions and tools:

- Ad-hoc workshops and exercises (such as those run by the DfT): These might be risk specific, such as to explore the impact and response to a particular type of event (e.g. a tidal surge) in detail by bringing together relevant interest groups (Figure 7) and facilitate an exchange of views on impacts to their respective organisations as well as subsequent planning requirements. Well run workshops can help:
  - create visibility of risks across organisational boundaries
  - identify requirements for derogations from statutory requirements
  - identify spare capacity and resources in mitigation of any impact from the event
  - help identify the scale of potential disruption
  - help inform on the various workshop participants' own business planning

- Institutional approaches: Considering the range and diversity of potential risks to continued port operations (Figure 6) and the UK's debendency upon the ports, it would be in the public interest to help foster a suitable resilience culture within the wider port sector. Rather than taking an ad-hoc approach as outlined in A1, more regular forums (maybe with a dedicated secretariat) could be set-up to help wider resilience planning.

- Development and adoption of standardised planning and business continuity standards: To help give stakeholders within a wider port system a common framework it might be worth developing a common standardised framework. Inspiration may be taken from the ISO 22301

(formerly BS25999). The drafting and use of simple templates and checklists may (perhaps building on work already undertaken by the DfT) could be a good starting point.

Simulation Tools: The authors of this paper are actively involved in developing a simulation tool that can be used to help inform upon the impact of specific events taking place as well as the outcome of subsequent resilience planning choices. While computer simulation helps inform upon planning choices, the key to successful planning relies on collaborative work between the various port stakeholders (Achuthan, Grainger et al. 2013).

A3: Identify incentive mechanisms to ensure stakeholder interests are aligned with regard to the overall resilience of critical national port infrastructure.

Resilience has a cost and the appetite for risk will differ significantly amongst port stakeholders. Further consultation and research is required in order to establish how interests might be aligned, especially with regard to developing appropriate incentive mechanisms.

A4: Exchanges, field-work and case-studies

The UK is not alone in its need for resilient infrastructure. Valuable lessons can be learnt from other sectors with multiple stakeholders, such as energy and health, as well as from the experiences and institutions in other countries, such as Japan and the USA. Likewise, exchanges in knowledge and experience within the UK and across Europe are likely to be very helpful in developing awareness and skills, too. It would be prudent to help facilitate such activity, for example within the framework of European research funding and bilateral exchanges with countries that have a similar interest in port resilience.

A5: Further detailed research

- At present understanding of risk and resilience within a quantifiable cost-benefit context is limited. This needs to be redressed. In the absence of robust cost-benefit figures it might be difficult to mobilise necessary resources – unless, of course, there is an overriding political will

- Within the UK, policy makers have little visibility of whether and where there might be any redundancy (if any) within the wider UK port sector that could be utilised in the event of an emergency. It would be useful to conduct some explorative studies in this area. Such research might look at how shipping lines may choose to re-route their vessels or how ports may choose to forgo certain types of traffic in favour of another.

A6: Improve upon early warning and communication systems

Much of the planning is dependent on the time-period available for action prior to the event. Any enhancement in early warning and communications capabilities significantly widens the scope of options in planning for resilience at UK ports.

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