UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

BUILDING CAPACITY TO MANAGE RISKS AND ENHANCE RESILIENCE

A Guidebook for Ports

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The guidebook was edited externally by Mark Bloch, and Kathleen Morf did the design and formatting.

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ACRONYMS /ABBREVIATIONS

AAR	after-action review
AI	artificial intelligence
AEO	authorized economic operator
APEC	Asia-Pacific Economic Cooperation
BBC	British Broadcasting Corporation
BCI	Business Continuity Institute
BCM	business continuity management
BCOs	beneficiary cargo owners
BCP	business continuity plan
BIA	business impact analysis
BIMCO	Baltic & International Maritime Council
BPA	British Ports Association
CFT	cross-functional team
CISG	United Nations Convention on the Internal Sale of Goods
CMS	contract management software
CPFR	Collaborative planning, forecasting, and replenishment
CRC	Cyber-Resilience Centre
DCSA	Digital Container Shipping Association
DoS	denial of service
ERCC	Emergency Response Coordination Centre
ERDS	Extreme rainfall detection system
ERM	Enterprise Risk Management
FIRMS	Fire Information for Resource Management System
GDACS	Global Disaster Alerting and Coordination System
GDP	Gross Domestic Product
GPG	Good Practice Guidelines
GPHA	Ghana Ports and Harbours Authority
GRC	Governance, Risk and Compliance
GSCPI	Global Supply Chain Pressure Index
HR	Human resources
HS	Horizon Scanning
IACS	International Association for Classification Societies
ICDs	Inland Container Depots
IMO	International Maritime Organization
ISM	International Safety Management Code
ISO	International Organization for Standardization
ISPS	International Ship and Port Facility Security Code

JICA	Japan International Cooperation Agency
KRI	key risk indicators
KPI	key performance indicators
LDC	least developed country
LLDC	landlocked developing country
LSCI	Liner Shipping Connectivity Index
MDST	MDS Transmodal
MMI	Modified Mercalli intensity scale
MTPD	maximum tolerance periods of disruption
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NGO	non-governmental organization
NIST	National Institute of Standards and Technology
PCS	Port Community System
PEMA	Port Equipment Manufacturers Association
RACI	responsible, accountable, consulted and informed
RMIS	risk management information system
RPO	recovery point objective
RPN	Risk priority numbering
RTO	recovery time objective
RPP	risk response plan
SIDS	small island developing States
SCRM	Supply Chain Risk Management
SLAs	service-level agreements
STS	ship-to-shore
TEU	twenty-foot equivalent unit
TtR	time to recovery
UNCTAD	United Nations Conference on Trade and Development
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCWA	United Nations Economic and Social Commission for West Asia
VaR	value-at-risk
VPN	virtual private networks
VUCA	volatility, uncertainty, complexity, ambiguity
WCO	World Customs Organization

BUILDING CAPACITY TO MANAGE RISKS AND ENHANCE RESILIENCE

A Guidebook for Ports

The guidebook presents a step-by-step approach to resilience building in the maritime supply chain. It sets out risk identification, assessment and management tools and techniques, and describes a resilience-building process for ports. The guidebook emphasizes lessons learned and good practices and highlights relevant measures that can be implemented to prepare, respond and recover from disruptions. Three types of mitigation and response measures are identified in the guidebook:

1. **Before the disruption materializes (ongoing):**
   Mainly strategies that aim to anticipate, plan, prepare, forecast, and integrate uncertainty through scenario planning, as well as invest in data and intelligence gathering for greater preparedness. Relevant measures include scanning and monitoring mechanisms to trace and track evolving risks and stay up to date.

2. **During a disruption (immediate).**
   Such as protocols and emergency responses.

3. **After a disruption (medium to long term).**
   Includes actions that seek to mitigate impact, enable recovery and ensure adaptation to an emerging "new normal".

The guidebook is aimed at stakeholders across the maritime supply chain involved in building port resilience, and more specifically key actors and stakeholders participating in the port ecosystem while operating, managing or regulating port-related transport and logistics chains. These can be organized in layers representing their respective importance and level of intervention, and include: (i) governmental planning and regulatory agencies; (ii) port authorities; (iii) port operators and port management companies; (iv) terminal operators; and (v) infrastructure managers. Other relevant stakeholders include: (i) freight forwarders; (ii) customs authorities; (iii) carriers and shipping companies; (iv) shippers and cargo owners; and (v) inland carriers and inland logistics operators (e.g. dry ports, inland container depots, warehouses, logistics and distribution centres). Collaboration between each of these stakeholders is key to achieving resilience.

The guidance focuses on container ports. Although containerized shipments only represent about 16 per cent of world maritime trade by volume, they account for more than 70 per cent of its value. Container shipping and ports are particularly relevant to commercial and retail supply chains on which consumers directly depend upon. In this context, ports represent potential single points of failure in the maritime supply chain.

This Guidebook is organized around four parts:

PART I | PART II | PART III | PART IV

PART I

Sets out the key concepts and relevant approaches to risk identification, assessment, and management, including response and recovery measures. It addresses port disruption and resilience and features a stepwise methodology and a ***Toolbox for Port Risk Management and Resilience-Building***.

PART II

Expands on Part I and further details the various hazards and risks that can disrupt port activity.

PART III

Presents case studies relaying port disruption experiences from different regions, a compilation of good practices and lessons learned.

PART IV

Features an Annex including definitions and concepts, a list of relevant resources and additional information on the ***Port Risk Management and Resilience-Building Toolbox*** presented in Part I.

PART I

BUILDING PORT RESILIENCE: **TOOLS AND METHODS**

1. THE RESILIENCE-BUILDING IMPERATIVE

Maritime transport underpins world economic interdependency and global supply chain linkages. Shipping and ports handle over 80 per cent of global merchandise trade by volume, and more than 70 per cent of its value. Supply chain disruptions caused by stressors spanning economic crises, political events, natural disasters, cybersecurity incidents and the COVID-19 pandemic, and more recently the conflict in the Black Sea region, underscore the role of maritime transport as an important transmission channel – one which can send shockwaves across supply chains and bring world trade and business to a halt.

Port resilience is not only an imperative for supply chains, but also for the national economies they support. Safeguarding the integrity of the maritime transport chain is a sustainable development imperative, particularly as developing countries have become major players in maritime transport and trade. Ensuring the integrity and the well-functioning of maritime transportation is critical for all economies, developed and developing alike, in particular small island developing States (SIDS) and least developed landlocked countries (LLDCs). These vulnerable economies depend heavily on maritime transport networks for their livelihood and access to the global marketplace. Furthermore, they are already burdened by disproportionately high transport costs and low shipping connectivity, which makes their trade uncompetitive, volatile, unpredictable and costly.

COVID-19 and related restrictions have caused serious disruptions in ports; risks at the port level can be multiplied across extended supply chains and across borders. Various industries faced challenges along their supply chain. These included: (i) raw material shortages; (ii) lead time issues; (iii) blank sailings by ocean carriers; (iv) port closures; (v) reduced working hours; (vi) equipment shortages; (vii) labour shortages; and (viii) truck/transport capacity constraints. This situation has put pressure on the integrity of global supply chains and has the potential to erode the benefits resulting from efforts made over the past decades and aimed at enhancing supply chain operations.

A paradigm shift has been unfolding since the COVID-19 pandemic, with risk management and resilience-building raising new policy and business concerns. In this context, business continuity plans (BCPs) and emergency-response mechanisms have again shown to be vital.

The pandemic has underscored the need for future maritime transport to be calibrated to risk exposure and for enhanced risk management and resilience-building capabilities. Understanding exposure, vulnerabilities and potential losses is key to informing resilience-building in the sector. Industry players and policymakers are expected to increasingly focus on developing emergency-response guidelines and contingency plans to deal with future disruptions. Criteria and metrics on risk assessment and management, digitalization and harmonized disaster and emergency-response mechanisms are likely to be increasingly mainstreamed into relevant national and regional transport policies. It can be expected that early warning systems, scenario planning, improved forecasts, information-sharing, end-to-end transparency, data analytics, business continuity plans and risk management skills, will feature higher on relevant policy agendas and industry plans.

Building the capability of countries to anticipate, prepare for, respond to and recover from significant multi-hazard threats is crucial, and requires enabling agile and resilient maritime transport systems. Investing in risk management and emergency response preparedness, to face future pandemics but also other disruptive events, is crucial to future proof ports and the broader maritime supply chain. The potential risk of future pandemics and other disruptive events calls for investment in risk management and emergency preparedness with a view to future proofing ports and the broader maritime supply chain.

2. RESILIENT PORTS: KEY FOR A RESILIENT MARITIME SUPPLY CHAIN

Ports are part of a continuum that includes the **shipping network** and their **hinterland** and for which they act as an interface (figure 1). Occasionally, a disruptive event (or multiple events) will occur along this landscape, which could have various causes, some predictable, some random but expected, and some unexpected. The resilience of ports and the maritime supply chains they support comprises both internal and external factors.

Internal factors generally relate to aspects over which ports and the shipping industry have a level of control. Supporting global supply chains is internal to the port and shipping industry and is related to the configuration of shipping networks and a port's handling capacity to support demand. The development and expansion of container terminals by port authorities and terminal operating companies also consider changes in global supply chains and related shipping networks.

External factors relate to the forces that generally affect the demand for maritime transport and therefore impact the **volumes** handled by shipping and port services. In general, ports and maritime shipping have little or no control over these factors, including economic growth affecting trade flows. Furthermore, agencies outside the shipping industry usually provide investments in equipment and infrastructure. Securing such funding could be contingent upon the type of risk created by the disruption(s). Some external factors can, however, be influenced, including by facilitating investment and funding. Therefore, these factors are to some extent considered as "internal". For external factors that are more difficult to influence, it is generally recommended to establish monitoring mechanisms and scenario analysis to inform planning and preparedness action.

Disruptions can result from both internal and external factors, depending on the nature of the event. Several disruptions are specifically under the control of infrastructure managers and operators. Examples include breakage of equipment due to improper maintenance, a breach in security, or a lack of cybersecurity measures. These disruptions are within the realm of possible intervention by an actor within the shipping and port industry, and are subject to ownership structure, and regulatory oversight in the various modes of transport, equipment and infrastructure.

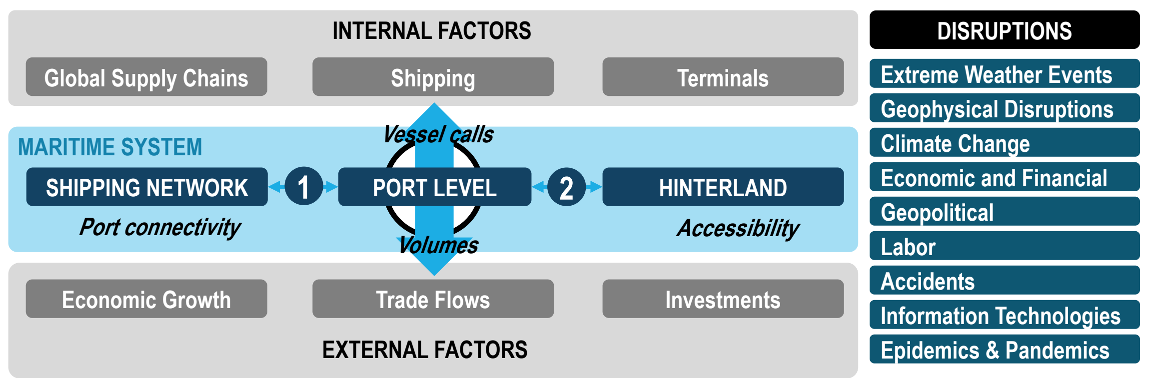
Several natural and anthropogenic disruptions **fall outside shipping and port control**. These include events, such as hurricanes, geopolitical crises, or economic recessions. Even if these elements are outside the realm of port interventions, they are drivers of change to which the port industry must adapt. The internal capability of ports to adapt to external forces is a fundamental element of their resilience.

Two port interfaces highlight the potential points of failure which could occur along a maritime transport chain:

1. **Ship/port interface:**
   This relates to the interactions between ports, terminal operators and ships/shipping carriers. The actions and strategies of shipping lines can support or undermine port resilience. For instance, the decision of a shipping line to select a port or terminal as a transshipment hub affects a port's resilience in a regional shipping network. A transshipment hub can have improved connectivity to global maritime shipping, but feeder ports may experience a decline of connectivity. Another example is the digitalization decision by shipping lines and ports to improve their interface, particularly by setting up a port community system (PCS). This information platform supports the resilience of the ship/port interface through an enhanced exchange of information between key port users, such as shipping lines, terminal operators, beneficiary cargo owners (BCOs) and carriers.

2. **Port/hinterland interface:**
   Relates to the interactions between ports, terminal operations and inland transport carriers. This includes infrastructure managers, logistics service providers, and the crucial relations with roads, rail, waterways, transport carriers, and their relations with dry ports, inland container depots, and port-related logistics facilities. The actions and strategies of hinterland actors can support or undermine port resilience. For instance, an improved inland transport infrastructure will increase hinterland connectivity of a port and, by extension, its resilience by ensuring that cargo continues to flow from/to the hinterland to/from the global market.

Figure 1: Ports in the maritime supply chain resilience landscape



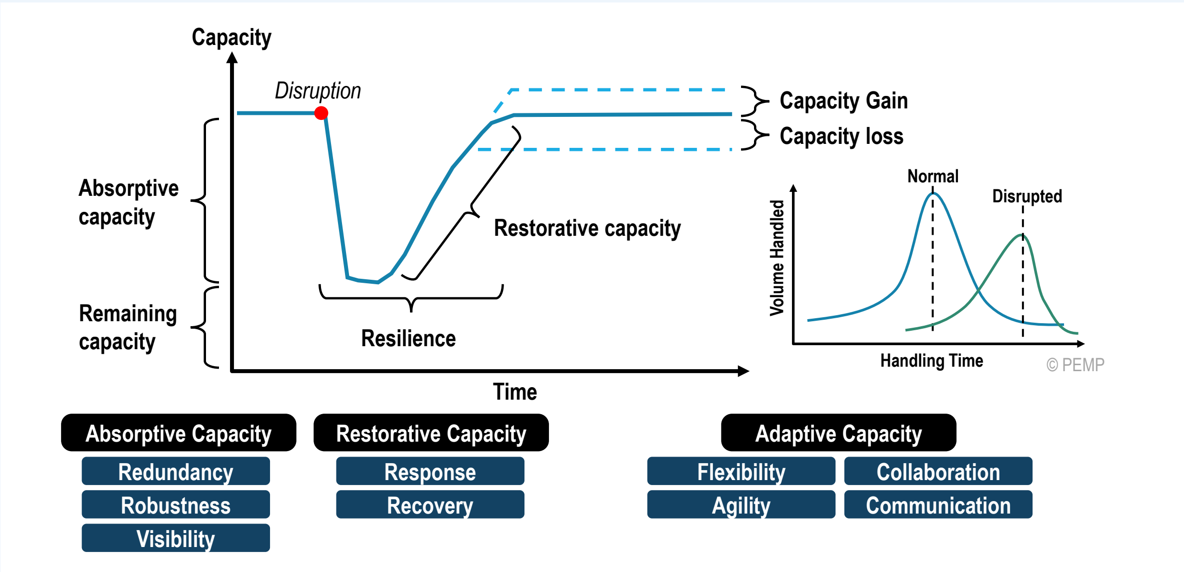
In some cases, and when not implemented properly, actions by stakeholders may have the unintended effect of causing or amplifying a port disruption and creating additional points of failure. These may not be directly and physically associated with the port interface and include: (i) shippers and cargo owners (providing the cargo); (ii) government agencies (overseeing regulatory aspects, customs, safety, security, and the environment); and (iii) the insurance, finance and banking sectors. For example, cargo owners could become a point of failure when they perform a major change in their procurement strategy, face labour shortages, or even bankruptcy. They may not be able to arrange for the removal of containers in a timely fashion resulting in terminal congestion. They may also delay the return of empty containers and constrain their ability to be used by exporters. Thus, shippers can also influence port resilience.

2.1 Defining port resilience

Port resilience is the ability to maintain an acceptable level of service in the face of disruptions (e.g. pandemics, natural disasters and cyber or terrorist attacks); this varies with port size, location and type of operations. Ports' resilience is largely determined by their ability to remain operational and offer services and infrastructure to ships, cargoes, and othercustomers during disruptions. In some of the existing literature on supply chain resilience, the concept is more narrowly defined to mean the time to recovery (TTR), as also illustrated in (figure 2).

Port resilience is linked to the port's **inherent properties** as it is a capacity and capability issue, regardless whether there is port activity and traffic. For instance, if a disruption were to impact a port's hinterland and reduce traffic and cargo flows, the port would be considered resilient if the disruption did not impair its capacity to handle an average traffic level and the corresponding revenue. A port's responsibility is to ensure that it is connected to the global shipping network and its hinterland, and to provide an expected level of infrastructure and services. Factors beyond these realms, such as a disruption at a large manufacturing facility using the port, cannot be effectively and directly addressed by the port. However, given the potential volatility in volumes they should not be considered elements of port resilience, even if they indirectly impact its operations. For example, if a demand surge is created after a manufacturing facility resumes its operations, a port's capability to handle this surge is considered an element of its resilience. This does not infer that resilience only involves temporary cargo surges; it could also involve a systematic decline in volumes handled by a port, implying the need to adapt to a commercial environment generating less demand, which could be mitigated by adopting relevant measures, e.g. cargo consolidation and the search for new opportunities and markets.

Figure 2: The concept of port resilience



Source: Linkov, I. and J.M. Palma-Oliviera (eds) (2017).

Resilience tests the capacity of ports in **three different manners** (figure 2)**:**

- **Absorptive capacity.** is the ability of a port or a terminal to absorb a disruption using existing infrastructure and services, while maintaining the same level of service. This implies attributes, such as robustness, redundancy and visibility. A robust system is said not to be impacted by some disruptions as it can withstand them. Ports have technical and engineering design characteristics allowing them to withstand geophysical disruptions, e.g. storms, for which they have a level of **robustness**. Through **"redundancy**", ports are also able to withstand disruptions by being able to accelerate and expand their operations, or by being able to store additional inventory at terminals. Ports have a technical buffer (how much additional throughput they can handle) and a storage buffer (how much extra cargo they can store). **Visibility** allows port users to access information supporting their operations and make appropriate decisions. Providing real-time information during a disruption reduces any impact on related supply chains as decisions can be taken to defer or divert cargoes.

- **Restorative capacity.** The ability of a port to recover from a specific disruption to a level of service similar, or even above, a baseline. First is the ability of a port to provide a response to a disruptive event, mainly through its preparedness and the resources that can be mobilized to contain and abate the disruption. Second is the ability of a port to **recover** and return to a normal operational state with its associated capacity. After recovery, an outcome can be a capacity loss, as recovery leads to lower levels of efficiency. Another possible outcome is that the disruption becomes a "learning event", allowing for a capacity gain and more efficient operations.

A resilient port can cope with shocks, absorb disruptions, quickly recover and restore operations to a level similar to – or even above – a baseline, as well as adapt to changing conditions, as it continues to develop and transform.

- **Adaptive capacity.** The ability of a port to change its operations and even its management, either in anticipation of, or as a reaction to, a disruption. It involves **flexibility**, whereby a port can adjust its operations to mitigate disruptions, such as changing its schedule and workflows. A port can also display a level of **agility** and be able to respond rapidly to disruptions, including having a workforce capable of performing tasks they do not usually perform. Through **collaboration**, cargo can be routed through different terminals within the same port, or through different ports. If a port is part of a port system with a well-connected hinterland, its adaptive capacity can be improved by temporarily using other ports through collaborative efforts. Lastly, a port can rely on **communication** to inform stakeholders of the changes they are implementing to allow them to adjust their own operations. A port can also receive and process information from third-party providers, such as carriers.

The most common outcome of a port disruption is a temporary **degradation of the cargo handling performance**. Under normal circumstances, a terminal (or port) is expected to provide a performance level in which a notable share of the cargo is handled within a designated timeframe. With a disruption, the degradation of the performance can result in substantially longer handling time coupled with a lower capability to handle the traffic. In extreme cases, the disruption is significant enough to force a shutdown of operations. Once operations resume, port labor and equipment must catch up with the accumulated cargo waiting to be handled on both the maritime and inland sides. Other measurable outcomes to port disruption include a **loss of revenue and customers**. Although a port can have long-term agreements with shipping lines which bind cargo flows, disruptions provide incentives to carriers to reassess their commitments. Auxiliary services and activity clusters gravitating around the port can also be considered, as their performance and activity levels are closely associated with those of the port.

Disruptions can have two types of impacts on ports:

- **Operational impacts.** Impair port operations and cause delays, but generally leave port infrastructure and equipment intact. Operational impacts affect all elements of the maritime transport chains with, for instance, ships being delayed, terminals losing revenue, and cargo owners facing inventory shortages. An event, such as a storm, may occur within the port terminal's design parameters but could nonetheless lead to a slowdown or cessation of port operations. Other notable disruptions can include power outages and labour movements, e.g. strikes. For example, the COVID-19 pandemic impacted port operations by creating labour availability issues due to sanitary measures. However, the most notable impacts were related to disruptions caused by a demand surge resulting from a rapid return in demand for containerized goods, which in turn were boosted by national stimulus policies and support for consumer spending. Several gateway ports and their hinterlands were not able to cope effectively. Yard capacity can be a significant operational constraint, as once a terminal reaches full capacity, it is unable to handle ships effectively. Shipping lines c decide to skip a port call, or alternatively wait until the facility resumes its operations.

- **Infrastructure impacts.** These relate to damage to, or even the destruction of, port infrastructure and equipment. The disruption takes place at a scale above the port's design parameters. Although some infrastructure and equipment may not have been damaged, those that were damaged would impair regular operations until repaired. Since infrastructure impacts are usually of much longer duration than operational impacts, the port would be impacted by a loss of revenue, reputation and repair costs. These impacts would extend to activities directly dependent on the port that would be forced to find alternatives or be forced to curtail their operations until port activity resumes. Some actors, e.g. shipping lines, have more flexibility as they can allocate their ships to other ports and shipping markets while the disruption endures.

Additional information about **Port Resilience** is available in **PART II** of this guidebook.

2.2 Actors and layers of intervention in port resilience-building

Various actors and stakeholders have jurisdiction over, and the potential to intervene on port resilience related issues. These form part of the **port resilience ecosystem** and include the following layers (figure 3):

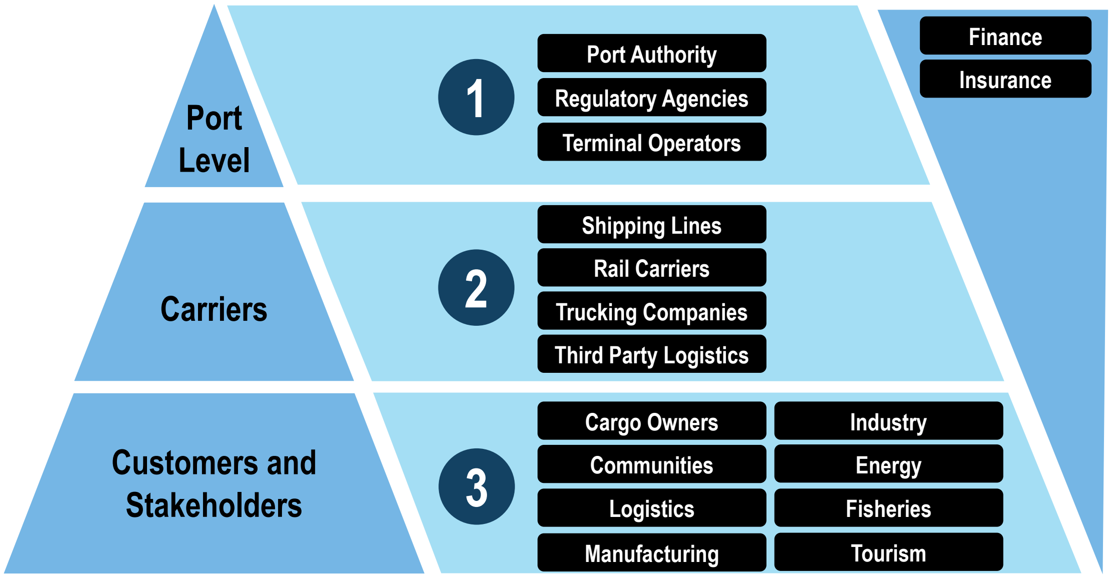
- **First layer.** Actors that are directly involved in a specific port through ownership, oversight, planning and operations. These include port authorities, government and regulatory agencies and terminal operators.

- **Second layer.** Actors that directly depend on a specific port for their carrying and handling cargo operations. These include shipping companies, ship operators, carriers, inland transport carriers, and third-party logistics service providers. Their actions have an impact on a port's resilience, and its ability to cope with disruptions as they control freight flows.

- **Third layer.** Actors that are indirectly impacted by the performance of a port and related carriers, including cargo owners, industrial and manufacturing activities. Their actions can have longer term implications for port resilience and can influence the location and the extent to which their port-related facilities are used. There is also a range of co-located activities depending on the port, such as energy generation facilities, logistics zones, local communities and tourist activities.

- **Meta-layer.** External actors that price port resilience through the valuation of risks. These mainly include stakeholders from the financial and insurance industries involved in covering risks related to capital investments and commercial loans and the operations of shippers, terminals and cargo.

Figure 3: Actors and layers of intervention in port resilience-building



3. THE PORT SYSTEM AND RELATED RISK FACTORS

3.1 The port interface

Ports are connectors within supply chains and the interface of two systems of circulation. The first is the shipping network and its trade connectivity; and the second is the port hinterland with its commercial accessibility. Port-centric logistics, energy production and manufacturing can be considered as the third element of the port interface (figure 4).

The port interface underlines the potential for propagation and back-propagation effects, which can also be referred to as a network contagion effect. The port is part of a complex network that includes information systems, workforce, supply chains, carrier services, financial transactions, and energy provision. The manner in which a port is embedded within these networks is an essential component of its resilience. A failure in one network can have substantial impacts on others networks and shape the feedback over a given port.

The logistics network, including shipping, ports and their hinterland interacts with other networks such as labour, energy and technology (figure 5). A failure of one network can have catastrophic implications for another. 'Risk propagation' associated with network and compound risks, as detailed further below in this guidebook, entail ripple effects within and across networks i.e. including not only up and down the logistics 'plane' (shipping network, port level, hinterland) but also on a cross-network basis.

Figure 4: The port interface: The hinterland and the foreland

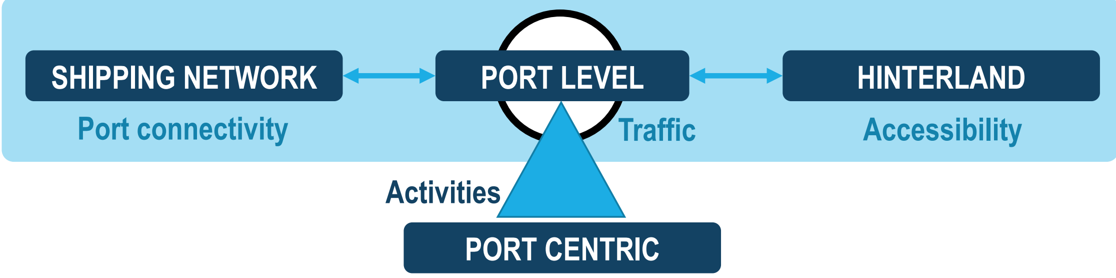
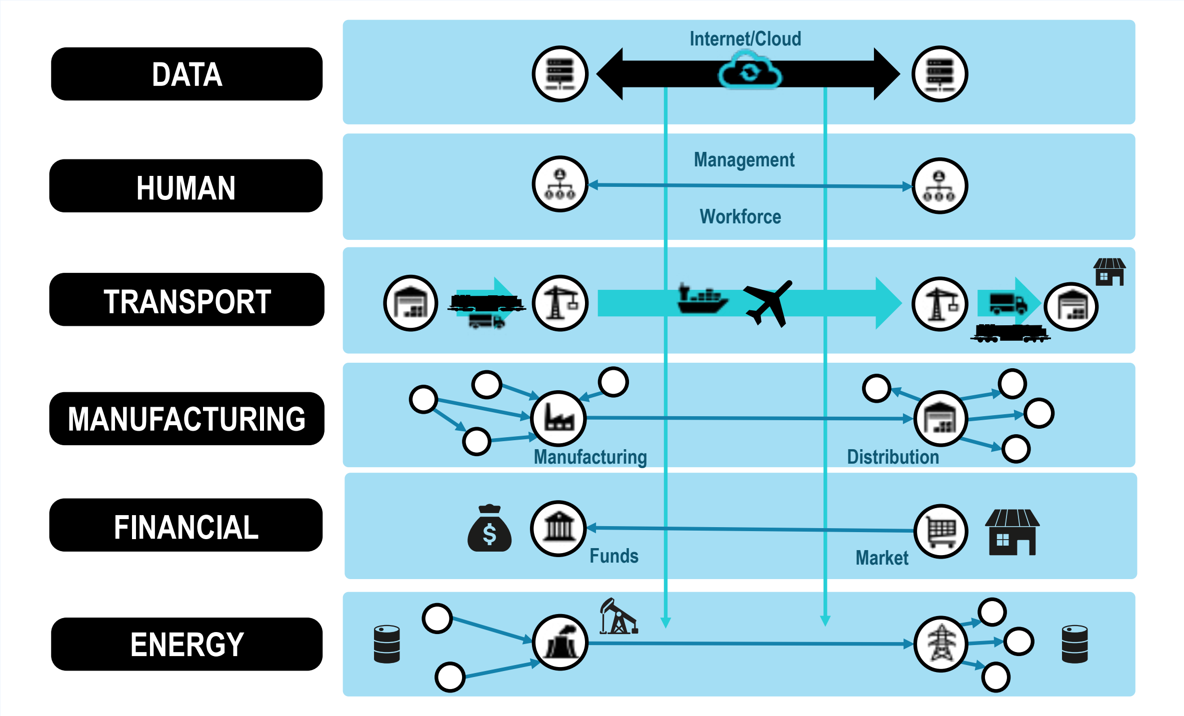


Figure 5: **Networks and related risks**



Source: Adapted from Manners-Bell J. (2022).

3.2 The shipping network

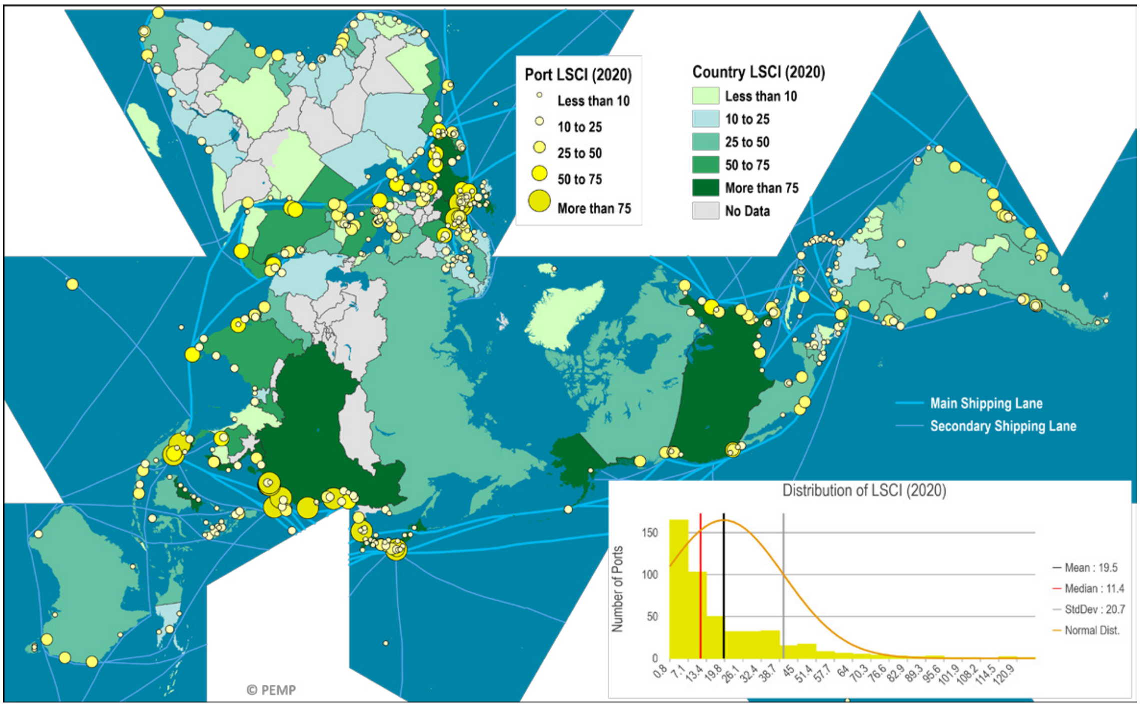
Since the 1990s, globalization has enabled the expansion of international trade, as well as the outsourcing and offshoring of manufacturing. Over this time, maritime supply chains, which include shipping networks, ports and hinterland transport operations, have expanded, largely due to the growth of container shipping services.

The configuration of the global liner shipping network can be represented through maritime connectivity, as measured by the Liner Shipping Connectivity Index (LSCI). It reveals a high concentration level among a small group of highly connected ports that act as gateways and hubs of global trade (figure 6). In 2020, 25 ports accounted for 17.7 per cent of the accumulated connectivity. Countries with the highest LSCI values are actively involved in international trade. The export-oriented economies of China and Hong Kong (China SAR), rank first, with the Singapore transshipment hub ranking third. Large traders, e.g. Japan, Germany, Republic of Korea, United Kingdom and United States, rank among the top 15. Countries such as Egypt, Malaysia, Oman, Spain, and the United Arab Emirates also rank high because of the major transshipment function of their ports. High concentration levels can expand the scale of disruptions, particularly when they involve ports or countries having high connectivity levels.

3.3 Container port handling and traffic

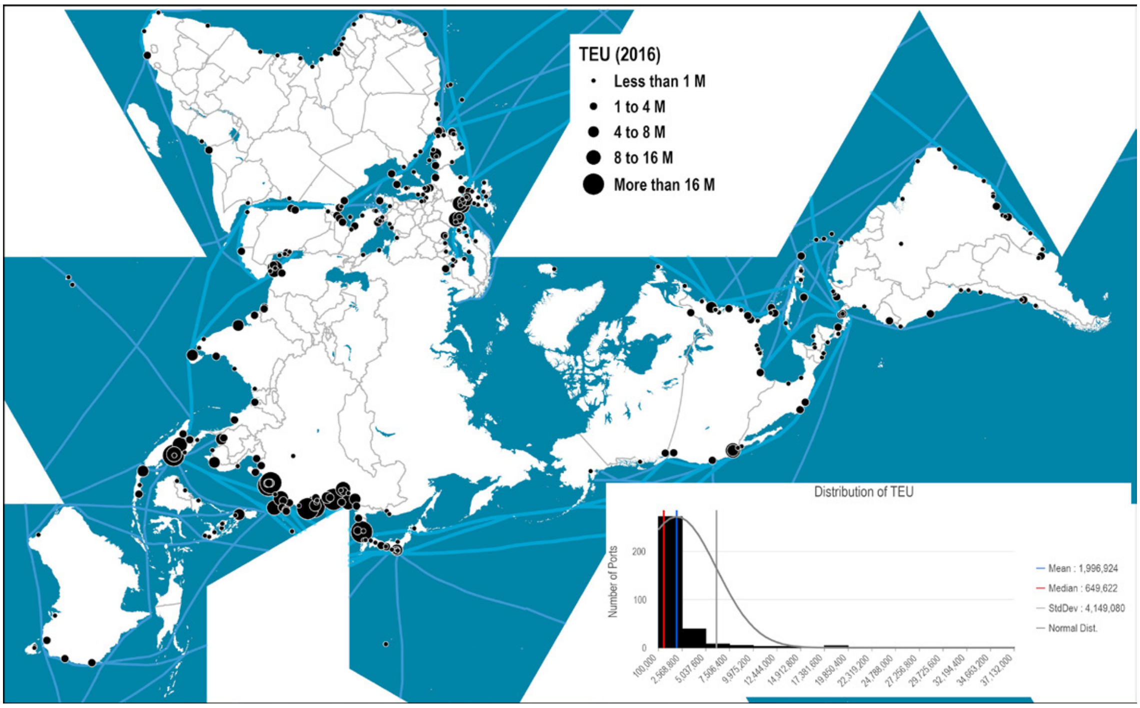
The level of **container port traffic** is reflective of the world's commercial geography and the handling of finished and intermediate goods (figure 7). Commodities, such as grain and lumber, are becoming more prevalent in container shipping but remain a niche market. Before the 1990s, the world's most important ports were North American (e.g. New York) and Western European (e.g. Rotterdam). Globalization, supported by containerization, changed the world's commercial geography with the emergence of new port locations, and reflected changes in the global geography of production, distribution and consumption. This new global geography indicates a high level of traffic concentration around large port facilities, notably Pacific Asian ports along the Tokyo-Singapore corridor. The 25 largest ports accounted for 49.8 per cent of twenty-foot equivalent unit (TEU) traffic, highlighting the vulnerability of global shipping focusing on a limited number of ports. Any significant disruption in the leading 25 container ports will have a ripple effect on other shipping networks through delays in services, which will cascade through other connected ports.

Figure 6: **Maritime container shipping connectivity**



Source: Based on data from MDST, https://www.mdst.co.uk.

Figure 7: **Container port traffic**



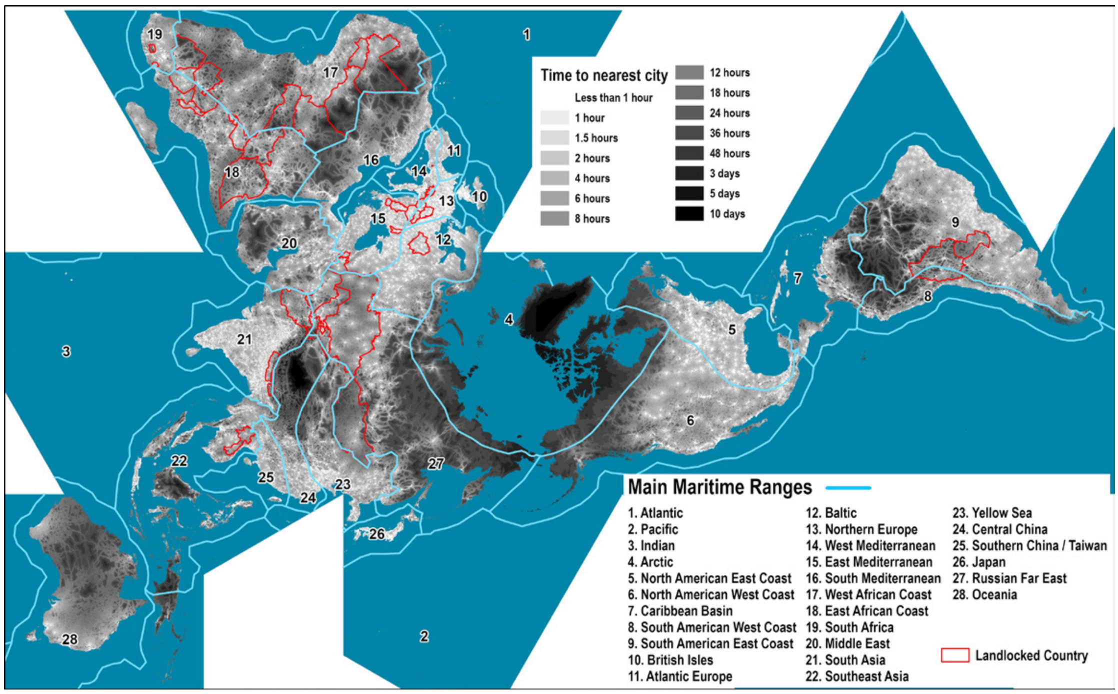
Source: Based on data from J.P. Rodrigue, Global Container Port Database.

3.4 Hinterland access

Maritime shipping services are commonly established to connect maritime ranges, which occasionally mark the extent of regional feeder services, such as the case in the Caribbean and the Baltic regions. Some maritime ranges and their hinterland have high levels of **access levels**, particularly when connected by high-capacity rail corridors, as in the case in the east and west coasts of North America (figure 8). Other maritime ranges are discontinuous and barely connected, as in the case of SIDS in the Caribbean, Pacific and Indian Ocean, or marginally connected, as in the east and west coasts of Africa.

For a given port, the hinterland contestability (i.e. the prospect for other ports to capture the cargo from/to the hinterland) affects its resilience. When a hinterland has a low or no contestability (i.e. not having more than one port option to route its cargo), it implies that the port handling trade from/to this hinterland, has access to a secure market base. This positively affects its resilience. However, such a port remains vulnerable to any significant downward change in demand.

Figure 8: Maritime ranges and hinterland accessibility



Source: Nelson A. (2008).

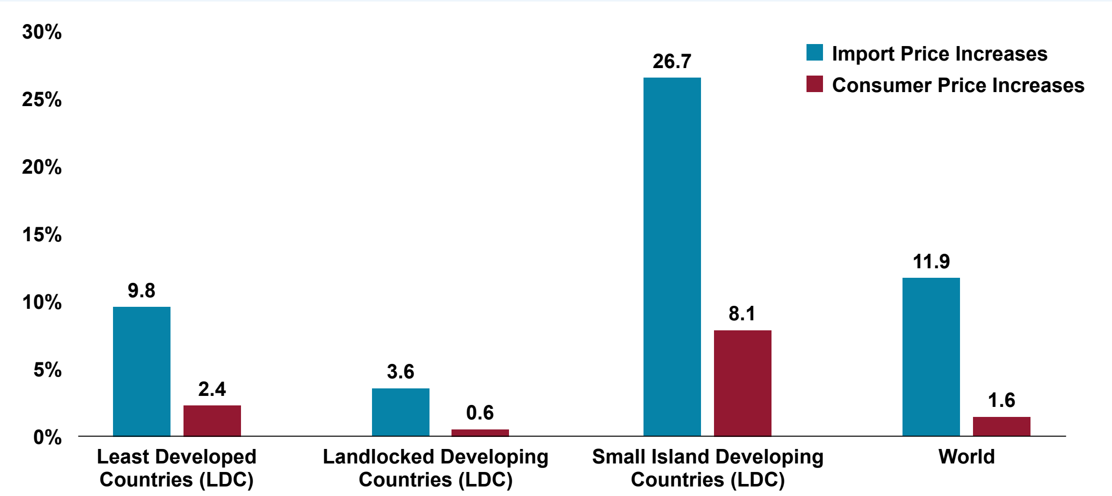
A hinterland (country) that does not have direct access to the ocean obliges it to use ports in a third country through a land (rail, road, internal waterways, or multimodal) corridor, and negotiating an access regime. This implies higher transport and trade costs impacting their economic competitiveness. If containerized imports are considered, landlocked countries have a cost structure that is about 85 per cent higher than the world average (World Bank, 2020). From a resilience perspective, these countries are particularly vulnerable because of the effects that higher transportation costs can have on their trade and costs (box 1).

Box 1. Impact of freight rate surges on import and consumer prices

According to UNCTAD analysis, the surge in container freight rates caused by COVID-19 disruptions, if sustained, could increase global import price levels by nearly 12 per cent and consumer price levels by 1.6 per cent (figure 9). Demand for goods surged in the second half of 2020 and into 2021, as consumers spent their money on goods rather than services during pandemic lockdowns and restrictions. Working from home, online shopping, and increased computer sales placed unprecedented demand on supply chains. This large swing in containerized trade flows was met with supply-side capacity constraints, including container ship carrying capacity, container shortages, labour shortages, ongoing COVID-19 restrictions across port regions, and congestion at ports.

This mismatch between surging demand and de facto reduced supply capacity led to record container freight rates on practically all container trade routes. Cargo owners faced delays, surcharges, and other costs, and still encountered difficulties in ensuring their containers were moved promptly. The impacts of the high freight charges are greater in SIDS, which could see import prices increase by 26.7 per cent and consumer prices by 8.1 per cent. In least developed countries (LDCs), consumer price and import price levels could increase by 2.4 per cent and 9.8 per cent, respectively. Low-value-added items produced in smaller economies could face serious erosion of their comparative advantages. A surge in container freight rates will add to production costs, rising consumer prices, and slowing national economies, particularly in SIDS and LDCs, where consumption and production are highly dependent on trade.

Figure 9: Simulated impact of soaring freight rates on consumer and import prices (Percentage change)



Source: UNCTAD (2021).

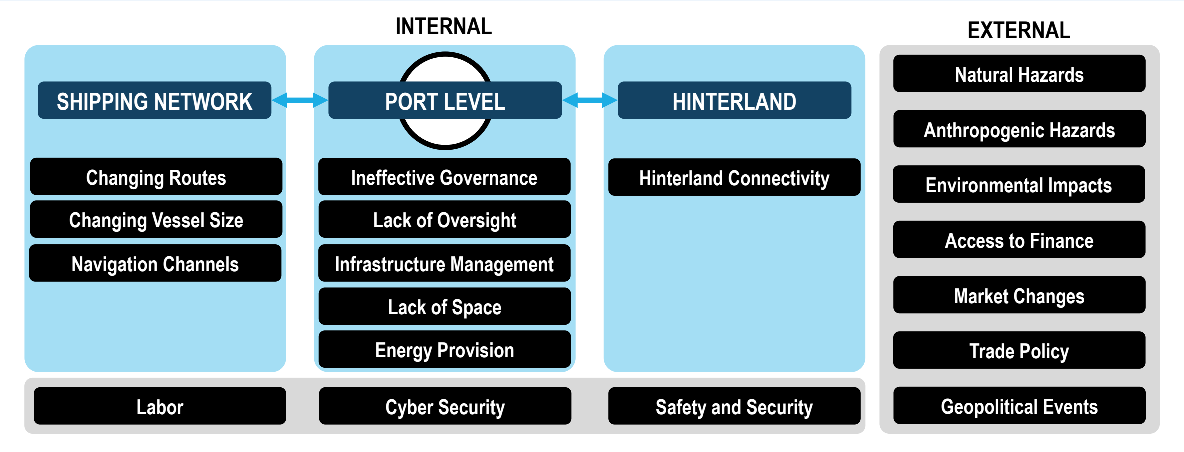
3.5 Port-centric activities

On a local scale, ports support an ecosystem of **activities** consisting of port users directly dependent on its capabilities. Such port clusters usually include: (i) logistics and warehousing; (ii) manufacturing; (iii) heavy industries (e.g. petrochemicals); (iv) energy production; and (v) transformation activities. This cluster is highly interdependent with port activities, implying that its resilience is based on the capability of the port to handle its cluster's inputs (coming as imports) and outputs (coming as exports). Under normal circumstances this **co-dependency** is a factor of efficiency, but can be a vulnerability in the event of a disruption.

3.6 Port risk factors and challenges to resilience

As previously noted, port resilience is regularly being challenged by disruptive events that can be internal, and under the control or influence of stakeholders, such as shipping lines, port authorities and inland carriers, or influenced by external causes of a natural or anthropogenic nature. Most disruptions tend to be local in scale and scope, but there are occasions when disruptions can become wide-ranging and affect a whole region, network segment, or in extreme cases, have global ramifications.

Figure 10: Port risk factors and challenges to resilience



Source: Adapted from Kim, Y., and L. Ross (2019).

Several internal and external **risk factors** to the maritime transport sector, or the port ecosystem, can become disruptive and test a ports' resilience (figure 10). Internally, these risk factors originate from within the three segments of the maritime supply chain:

- **Shipping network.** A change in a ship's routing, scheduling and service configuration can result in a decline or rise in volumes, which can negatively affect ports. A simple change in scheduling involves operational adjustments in terminal work hours and gate traffic. A port's capability to handle these changes can reflect its operational resilience. Economies of scale applied to maritime shipping have also tested the resilience of ports to adapt by upgrading their infrastructure and operations. Larger containerships, requiring channel and docking clearance, adequate terminal equipment, yard space and operational surges, can challenge a port's capabilities. The navigation channel approaching a port can also be subject to potential navigation disruptions because of depth and width limitations. Conflicts with different shipping services, e.g. ferries, cruises, barges and bulk and break-bulk ships, can create contested navigation channels, and limit the range of port activities, and the number and type of ships they can handle. An additional challenge is the on-going concentration of shipping lines, at both the individual shipping line level and through alliances.
- **Port level.** Governance could be ineffective at the port authority, or terminal level, and could lead to delayed decision-making and responses to disruptions, particularly if the hierarchical structure of the port authority relies on only a few key managers. There could also be a lack of regulatory oversight, implying that rules and regulations are not sufficiently monitored and enforced. This can pose a risk when hazardous materials are being handled and stored. Port infrastructure and equipment require a maintenance and upgrade cycle that must be monitored. Lapses can lead to failures, breakdowns and a decline in reliability. As the demand for container shipping has grown across the world, so has the demand on a port's footprint or extent. Several ports have faced a land scarcity issue, which has not only limited their expansion potential but has also become a source of conflict with local communities. Lack of space can become a challenge to port resilience as it limits a port's options for growth. When feasible, ports have responded to this challenge by relocating to new sites, resulting in an expanded footprint and related operational flexibility. Ports are large energy consumers and can face provision challenges, particularly in the context of on-going decarbonization efforts among the shipping and logistics industry. Changing port energy supply systems could be disruptive as new systems, e.g. wind energy, could be associated with new forms of vulnerability.

- **Hinterland.** Ports are generally integrated with their hinterland through transport corridors and inland facilities, such as dry ports and empty container depots. Maintaining and improving this connectivity can be complex and requires a collaborative framework involving: (i) cargo; (ii) land infrastructure managers, e.g. rail, highways, inland navigation; and (iii) cargo owners using the port, e.g. manufacturers, retailers. Lack of coordination between these actors could lead to capacity shortages or failures across segments of the inland transport system.

Additionally, the following internal risk factors are cross-cutting and common to the three maritime supply chain segments:

- **Labor.** The port industry requires an increasingly diverse set of labour skills to operate sophisticated equipment, manage operations and oversee complex information systems. Recruiting, training, and retaining this labour can be a challenge. Failure to do so impairs not only the operational capabilities of the port system but its ability to effectively recover from disruptions. The COVID-19 pandemic highlighted the crucial importance of maritime labour, ranging from seafarers, port terminal workforce to truck drivers.
- **Cybersecurity.** Maritime supply chains are increasingly relying on IT to manage operations and to transfer documentation (e.g. bills of lading). Digitalization along the maritime supply chain underlines the need to focus on cybersecurity to safeguard the integrity and availability of critical data, secure operations and to protect maritime infrastructure. A growing number of cybersecurity incidents have occurred in recent years, including the Maersk Petya attack of 2017, as highlighted in the Case Study on the Jawaharlal Nehru Port Trust and the 2021 South African port disruption.
- **Safety and security.** Theft, piracy and terrorism have come into sharp focus in recent years, especially after the events of 11 September 2001. This has led to the review and implementation of a range of port and maritime security measures, including through supply chain security-related instruments, such as the Framework of Standards to Secure and Facilitate Global Trade (SAFE Framework, 2005) adopted under the auspices of the World Customs Organization (WCO). Additionally, the Authorized Economic Operator (AEO) concept was introduced to allow certified entities, e.g. carriers and cargo owners, to be considered as a lower risk factor.

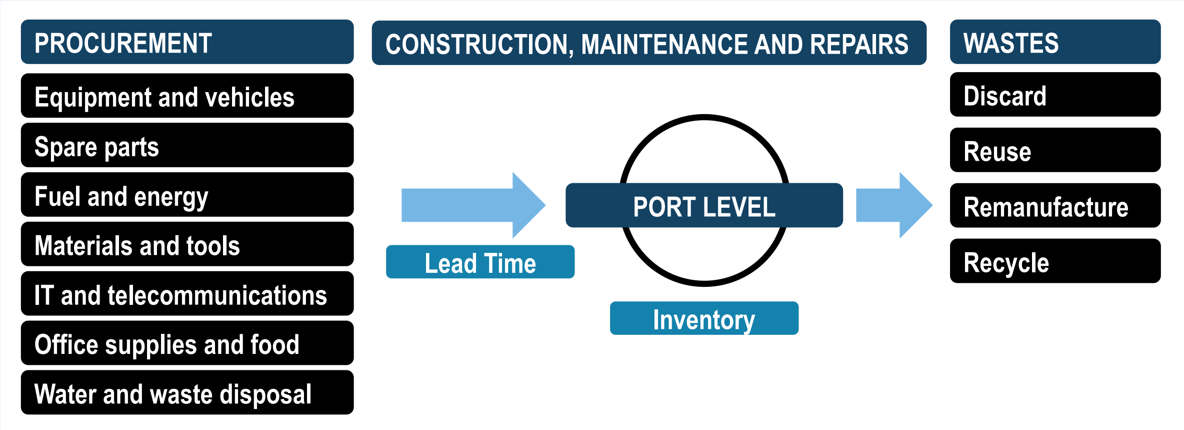
A series of other risk factors are external to the maritime transport ecosystem. These can have a significant impact on port resilience by directly affecting the port or its users, such as shipping lines and inland carriers:

- **Natural hazards.** Conventional natural forces, e.g. hurricanes and other extreme weather events, that can impact port and shipping activities.
- **Anthropogenic hazards.** Forces derived from human activities, intentional and unintentional, that can impact port and shipping activities. Examples include accidents and cyberattacks.
- **Market changes.** Sudden or gradual changes in supply or demand patterns which can impact global trade and supply chains. These include economic cycles, e.g. market crashes, recessions, and commodity and energy price shocks.
- **Access to finance.** A port's ability to access financial resources is critical to cover the cost of operations or for capital investment. Being unable to secure sufficient funding can be considered a risk factor undermining the capabilities of a port to cope with changes.
- **Environmental impacts.** Environmental conditions, such as pollutants, water contamination and noise that impair port activities and the health of the workforce. Efforts that aim to mitigate impacts or provide remedy can also result in additional burden.
- **Trade policy.** Policies and regulations implemented by governments to impede and restrict the importation and exportation of specific goods; they can also involve a change in regulatory status, such as the creation of a free zone, which can impact the comparative cost structure of the goods being handled by a port.
- **Geopolitical events.** Such as conflicts and civil unrest, are highly destabilizing events for port activity in impacted areas. These impacts can be unforeseen and have dramatic consequences on port activity. Russia's invasion of Ukraine in February 2022, and its blockade of Ukraine's Black Sea ports is an example of the unforeseen impacts of geopolitical events on ports.

3.7 Disruptions to third-party suppliers

Ports not only support supply chains but also need to ensure the smooth functioning of their own supply chains; the latter requires a **procurement process** which can supply ports and terminals with: (i) construction material; (ii) maintenance and repair of equipment; (iii) supply spare parts, energy; and (iv) other essential items to maintain operations (figure 11). These supply chains are provided by **third parties** and can be subject to disruptions, which would compound their impact and undermine port resilience. Port activities also generate **wastes** that need to be processed, recycled and discarded.

Figure 11: Third-party suppliers supporting port operations



Each element relating to third-party suppliers has a **lead time**, and procurement needs to allow for sufficient time to ensure access to required supplies (e.g. goods and services). For some procurement, the lead time can take years, whereas some utilities, e.g. electricity and water, can be supplied in real-time. For instance, once ordered from a manufacturer, a crane can take up to two years to be delivered. The port maintains an **inventory level** that should allow for the rapid repair or replacement of defective components, so that operations can be maintained. If a component is not available and has a long lead time, a disruption could endure for as long as the component has not been replenished.

The **financial strength of third parties**, such as port subcontractors and suppliers, can also be an indicator if they are solvent and robust, should a disruptive event occur. Relying on **multiple suppliers** and **sources** is a possible port resilience strategy, but every additional supplier brings additional negotiating and contracting costs. Another approach when a port is facing third-party risk or uncertainty is to **hold buffer or safety stocks** at the port, or at a convenient local storage facility. A buffer stock is the level of extra inventory maintained to mitigate risk due to uncertainties or events which may alter the demand for, or supply of, port operations. Third-party suppliers need to be **agile** and can contribute to resilience by, for example, offering procurement options and having a presence in a port's hinterland.

Finally, port activities **generate waste**, including discarded parts and equipment, that must be appropriately handled. Resilience can involve the capability of a port to discard, re-use, re-manufacture or recycle its waste.

4. BUILDING PORT RESILIENCE: A STEP-BY-STEP APPROACH

An overview of port-related supply chain disruptions, including the COVID-19 pandemic, emphasized the position of ports as **single points of failure** with significant ramifications upstream (i.e. a shipping network) and downstream (i.e. a port's hinterland). Depending on their nature, disruptions imply costs and delays for ports, port operators, port users (e.g. cargo owners), and inland carriers (e.g. railways, barges, trucking). Ports and their users make **decisions and take actions** that can enable or undermine its resilience. The cost implications of disruptions at a port are such that there is a substantial return to be made on appropriate resilience investments.

Port resilience starts with the **commitment of its management**. Several elements need to be considered by a port to create resilient practices, including its governance capabilities, which can minimize known risks and scan the horizon for emerging threats and opportunities.

An appropriate governance structure and relevant support is key to developing commitment and assigning ownership and accountability for port risk management. Emphasis should also be placed on the value of appropriate and controlled risk-taking, which is essential to developing a risk culture in ports. Further, responsibilities must be allocated and authority delegated.

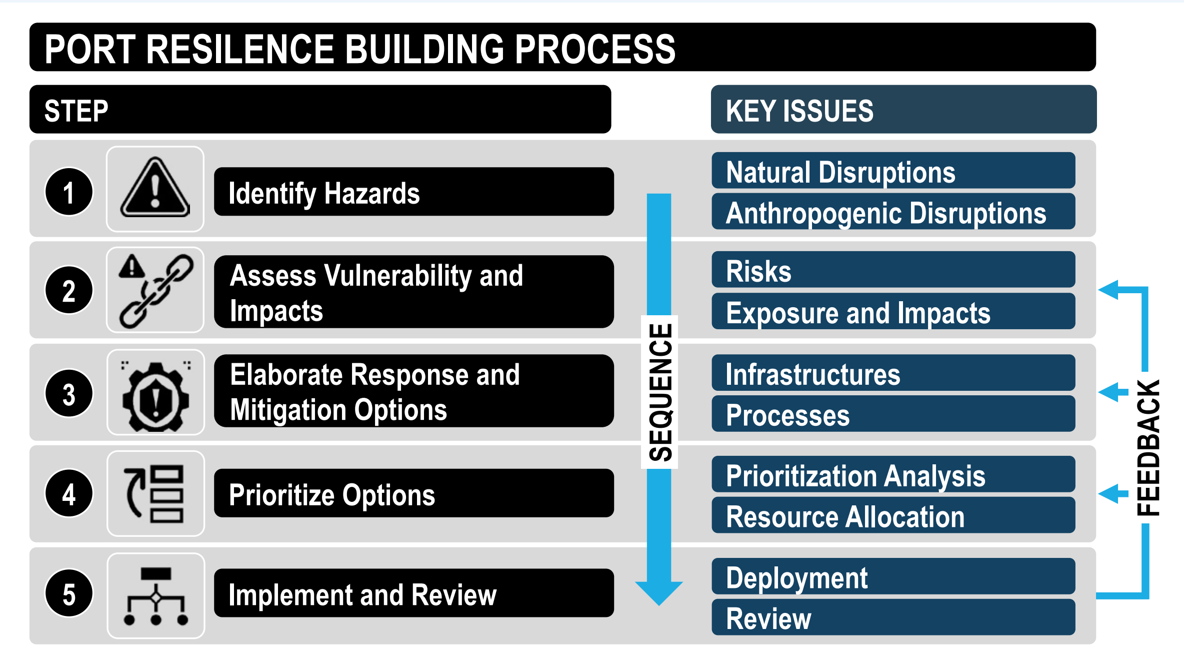
Most risk management frameworks and systems are only designed to manage "slow risk clock speed" risks. While information needed is sufficient and available before the extreme event, most extreme events, will not fit into this category. As a result, ports also need a "fast risk clock speed" perspective and understanding when managing risks. Ports need to be able to address the various types of risk problems and protect themselves from reputational damage.

Devising and implementing a strategy to enhance preparedness and port resilience in the face of disruptive events requires at least **five action-oriented steps**, involving (figure 12):

1. **The identification of hazards** from a wide range of natural and anthropogenic disruptions that are specific to the port being considered.
2. **Assessing vulnerability and potential impacts** by identifying port-specific risks, levels of exposure to risks, and the potential consequences of a hazard.
3. **Elaborating response and mitigation measures** involving port infrastructure and processes related to port management and operations. These measures can aim for prevention and preparedness (before the event), or be responsive and adaptive (after the event), with both aiming to speed up the port activity recovery.
4. **Prioritizing response and mitigation measures that had been elaborated** using prioritization analysis, such as cost-benefit analysis and resource allocation for finance, labour and other resources. This step will help to focus on the most important strategies.
5. **Implementing response and mitigation measures** that have been prioritized and elaborated through their deployment across the port ecosystem. Once these measures have been implemented, a review process should follow to assess their effectiveness and make any requisite adjustments that may be required.

These below-mentioned steps for port resilience building set out a generic framework that can be tailored and adapted to the existing context of ports, depending on the size and profile of the port and the development stage of the countries involved.

Figure 12: **Port resilience-building process: A stepwise approach**



Each port tends to have a different geographical, economic, political and managerial context, their risks categories and exposure as well as their ability to cope and respond to disruptions, are also likely to vary. The most common questions and concerns involve:

- Which **risks should be prioritized** from a port's perspective.
- Which stakeholder has **responsibility** for adopting response measures to mitigate impacts, adapt and recover from disruptions.
- Which **actor** should be involved in case of a specific disruptive event, this would allow for the implementation of stakeholder developed plans and strategies.
- What are the **costs of response and mitigation measures** and **implementation timelines**.
- How outcomes **reviewed**, and how are the lessons learned integrated into the resilience-building process.

Step 1 Identify the hazards impacting ports

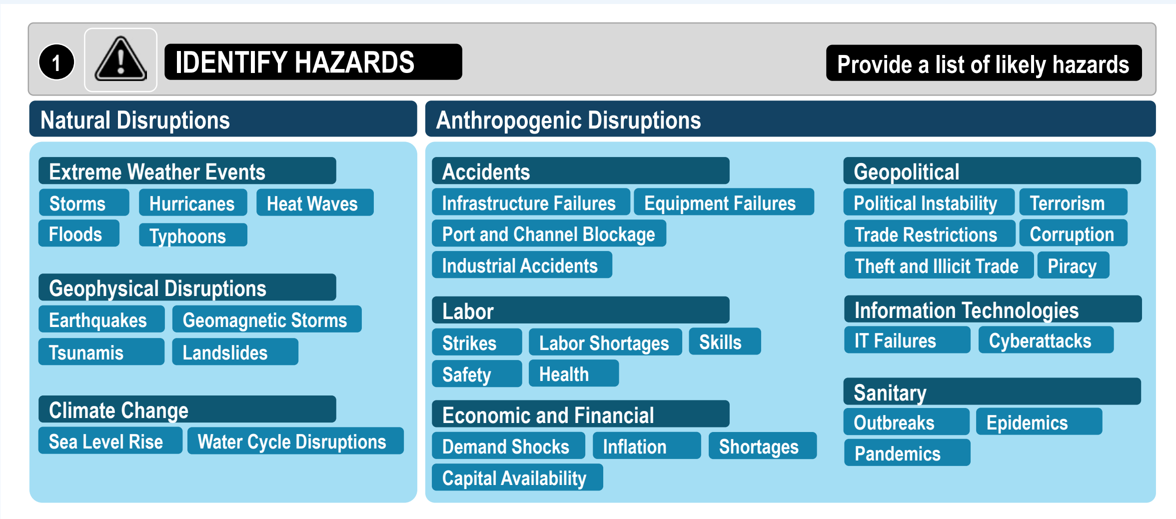
The term **hazard** refers to the source of disruption and how extensive or damaging this disruption could be. **Risk** refers to the likelihood that a hazard will occur within a specified timeframe. Figure 13: provides a comprehensive but non-exhaustive list of potential hazards or sources of port disruptions. The first essential step is to **establish a port resilience-building strategy**. The aim is to build awareness on the hazards that have already affected the port, or could potentially occur and identify their type.

One suitable approach to identifying hazards is to consider past experiences (the recurrence of hazards) and events that took place at similar or neighbouring ports. This helps to determine whether the port may be vulnerable, as well as to identify any future risks that may be expected, together with the likelihood for these events to occur, considering a port's characteristics and setting. This assists a port's management (i.e. its board and senior management) to identify the specific hazards that are the most likely to occur. In other words, port management determines the **hazards that present the highest risk**. Hazards that may disrupt ports can be grouped into two fundamental categories, namely **natural disruptions** due to:

- **Extreme weather events**, particularly storms, floods, typhoons and hurricanes.
- **Geophysical disruptions**, such as earthquakes, tsunamis and volcanic activity.
- **Climate change factors**, such as the compounding effect of natural and anthropogenic changes on weather systems, e.g. precipitation levels and drought. The risk of sea-level rise is particularly salient for the maritime industry.

Anthropogenic disruptions such as:

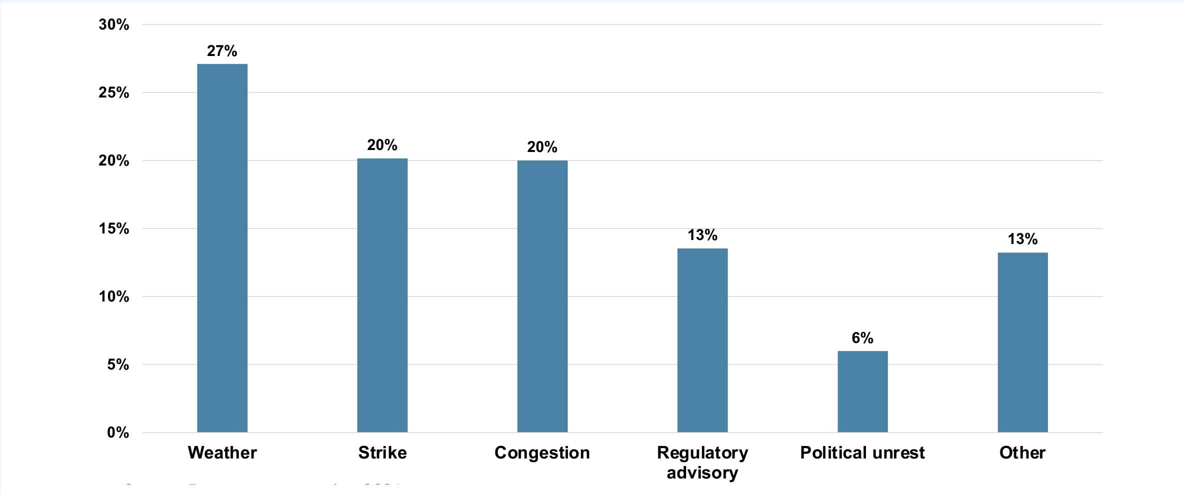
- **Accidents** include equipment failure, crane breaking, containers collapsing, channel blockage, chemical leakage, explosion or fire.
- **Geopolitical events**, including wars, civil unrest, military coups, and sanctions.
- **Labor-related** issues such as strikes, labour shortages, and the lack of skills.
- **Information technologies**, such as IT failure and cyber-security breaches.



- **Economic** and **financial** events, such as economic cycles, insolvency of third-party suppliers and financial crises.
- **Sanitary threats**, such as pandemics and virus outbreaks.[1]

Data from Everstream Analytics shows that the main source of disruption in developing countries' seaports are related to weather events. Figure 14: features the top six disruptions across developing countries in 2021 by share of incidents. See PART II for a more detailed description of each of these hazards.

Figure 14: Top six port disruption sources in developing counties, 2021 (percentage of incidents)

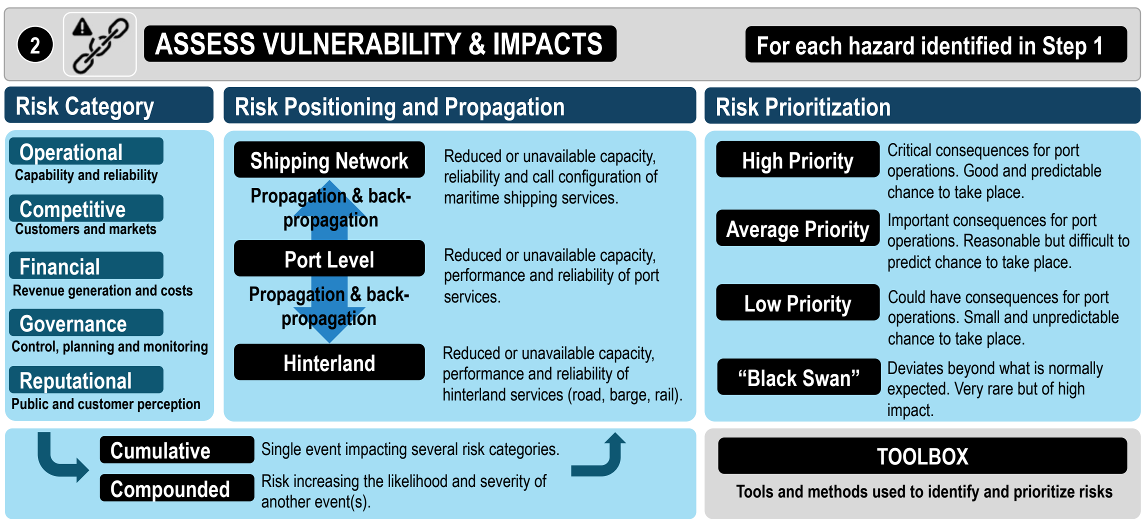


Source: Everstream Analytics, 2021.

Step 2 Assess the vulnerability of ports to disruptions and potential impacts

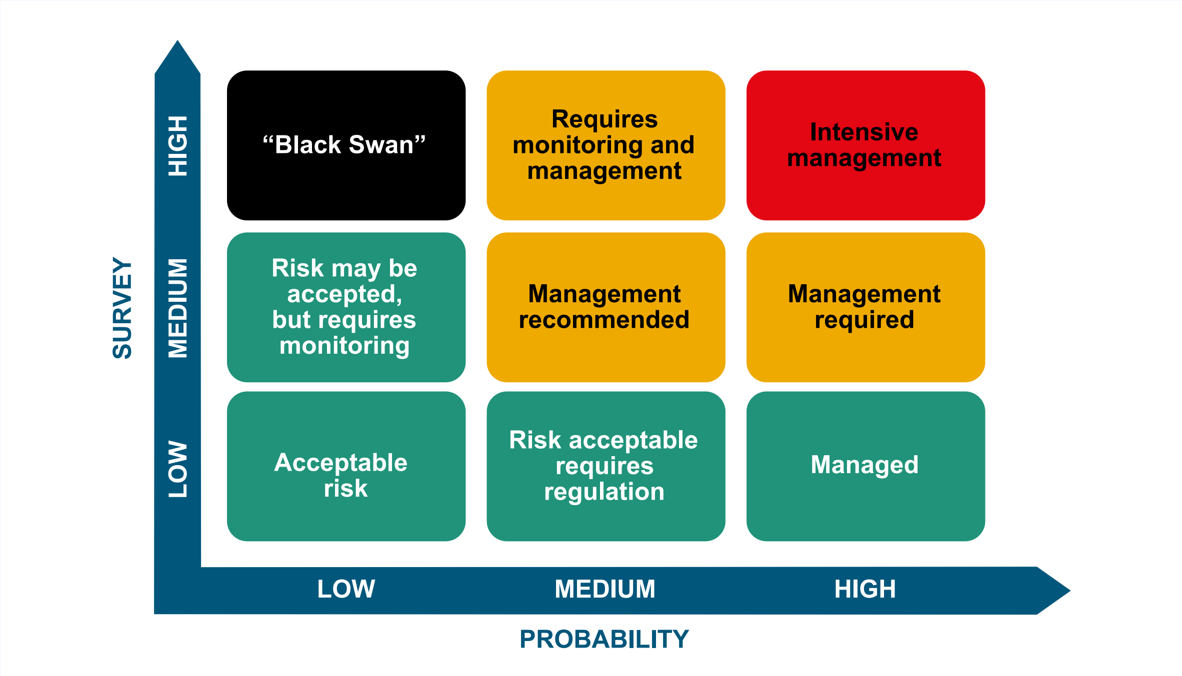
Once a list of the most important hazards potentially impacting a port has been established (see Step 1), the second step involves their **categorization** as risks. An explanation of the type and scope of the risk category needs to be provided, as well as their features, how they can occur and affect ports, and their resilience and the likelihood a disruption may occur (figure 15). Risks can be quantified using the risk=probability x severity method (figure 16).

Figure 15: Step 2 – Assessment of port vulnerability and potential impacts



[1] In 2021, UNCTAD deployed its TrainForTrade special course on "Building Port Resilience Against Pandemics" (BPR) to support the implementation of measures and to prepare for and alleviate contingencies related to a pandemic in a port, port terminals, and other seaport actors. For additional information, see https://unctad.org/meeting/trainfortrade-e-learning-course-building-port-resilience-against-pandemics-0.

Figure 16: **Quantifying risks**



Source: Adapted from Manners-Bell J. (2022).

Each hazard that may impact a port has an associated risk category. While the list identified in figure 15 is not exhaustive, it nonetheless reflects the various types of risks often associated with port disruptions. These include:

- **Operational risks.** To what extent does the hazard impact a port's or terminal's capacity to operate and offer services to ships, cargoes and other clients (e.g. clusters or activities in the proximity of the port). These indirectly impact global value chains which may be heavily dependent on well-functioning shipping and ports.
- **Competitive risks.** To what extent does the hazard impact a port's or terminal's competitiveness vis-à-vis its customers (e.g. shipping lines, cargo owners), and hinterland stakeholders.
- **Financial risks.** To what extent does the hazard impact a port's or terminal's revenue, operating costs, insurance rates and credit rating.
- **Governance risks.** To what extent does the hazard impact a port's or terminal's management and planning processes.
- **Reputational risks.** To what extent does the hazard impact a port's or terminal's public image, standing and customer perception.

These risks are **cumulative**, meaning that a single event could not only disrupt operations but also: (i) create reputational risks; (ii) generate a loss of business and revenue to the benefit of other ports or modes of transport; (iii) cause delays and congestion; (iv) labour shortages; or (v) result in a lack of storage areas.

Several risks are interconnected, with **compound risks** defined as risks that are non-independent. The compounding effects of one or more other risks could influence the probability and the severity of any other individual risk. For example, equipment failure can increase the risk of additional equipment failure as functioning equipment can become overburdened. A cyber-attack could impact IT systems related to payroll and equipment, compounding its deleterious effect across terminal operations.

Furthermore, **more than one hazard can occur at once**, and exacerbate the situation. For example, a port could be simultaneously impacted by a pandemic or a seasonal hurricane, while concurrently facing a labour shortage due to pandemic-related restrictions and constrained financial capacity.

The consequence of any given event could be greater than the sum of each individual risk. Since the maritime transport system is organized as an inter-connected network, with ports as core nodes, the compounding effects of risks serve as **propagation and back-propagation mechanisms.**

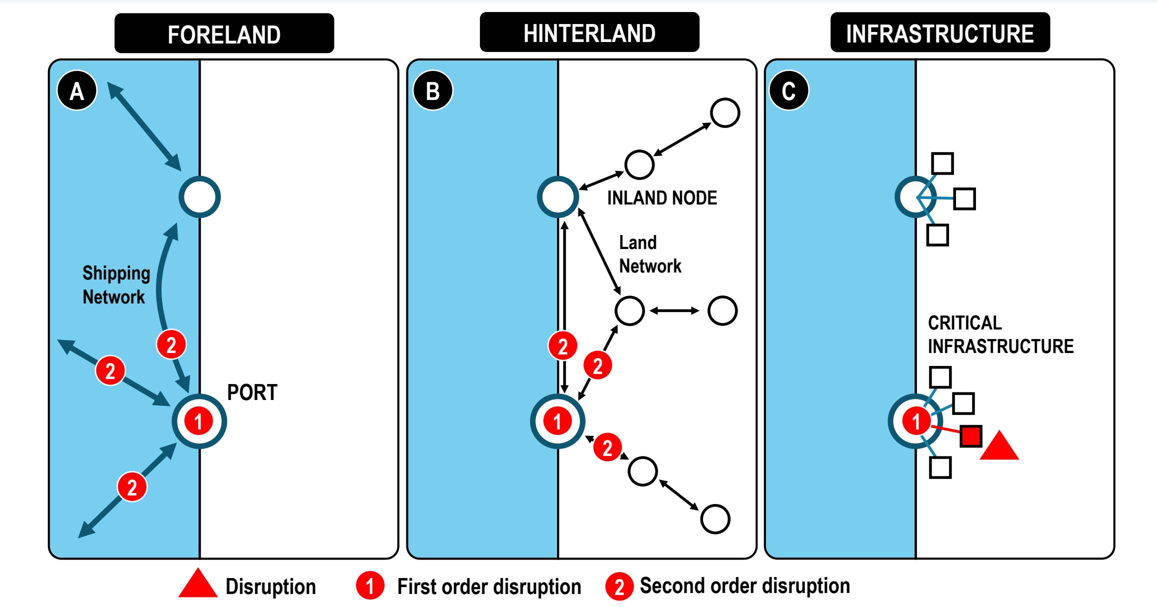
Risk positioning and propagation considers which elements of the maritime transportation chain may be impacted first, and how the disruption may propagate (or back-propagate) along the transport chain. This mechanism illustrates the compounding effect of risks in the maritime industry:

- **Shipping network.** The risks involved in a shipping network can lead to changes in – or to a reduction in or lack of – ships carrying to ship services capacity, shipping service reliability, or schedule reliability. The ship call configuration of maritime shipping services can also be modified, dropping a port, and reducing the frequency of port calls. Excess capacity can also be a risk, since it could result in the removal of shipping services and ports of call, thereby impacting the frequency of procurement for port-centric supply chains.
- **Port level.** Any change in risks – or to a reduction in or lack of – can affect the performance, reliability and costs of port services. As in the case of shipping lines, excess capacity can also be a risk for ports as it is associated with lower returns on investments and excess labour, which could lead to layoffs and undermine revenue.
- **Hinterland.** Risks involving changes in capacity (i.e. a reduction in or lack thereof) can affect performance and the reliability of hinterland services, including trucking, rail and barges. Excess capacity risks are less common over hinterland transportation, but building unnecessary infrastructure or services is a risk as it may not provide a sufficient return on investment.

Understanding the **potential disruptive propagation mechanisms along maritime transport chains** is important. For instance, a labour strike at a port may impact its capability to meet expected key performance indicators (KPIs), but could back-propagate over the shipping network as ships could spend more time at the port (e.g. waiting at anchor), which then impacts their schedule integrity. In such situations, the performance of other connected ports is also impacted. The disruption could also propagate through the hinterland connectivity with longer gate waiting times and slower yard operations.

The disruption of a critical infrastructure asset can lead to a port experiencing a **first-order disruption** (figure 17, Layer C). As any affected port is connected to other assets, as well as foreland and hinterland connectivity (layers A and B), **second-order disruptions** occur through propagation. The capability of the port to handle hinterland traffic and shipping services is impacted until the first order disruption is resolved. For instance, a power outage in critical infrastructure servicing a port could create a first-order disruption and impair operations (e.g. by relying on generators). If long-lasting, this disruption will then propagate to become a second-order disruption, which in this case will impact the hinterland and maritime connectivity of the port. Ships could be forced to wait at anchor or diverted to another port.

Figure 17: Disruption propagation in a port network



Source: Adapted from Verschuur, J., R. Pant, E. Koks, et al (2022).

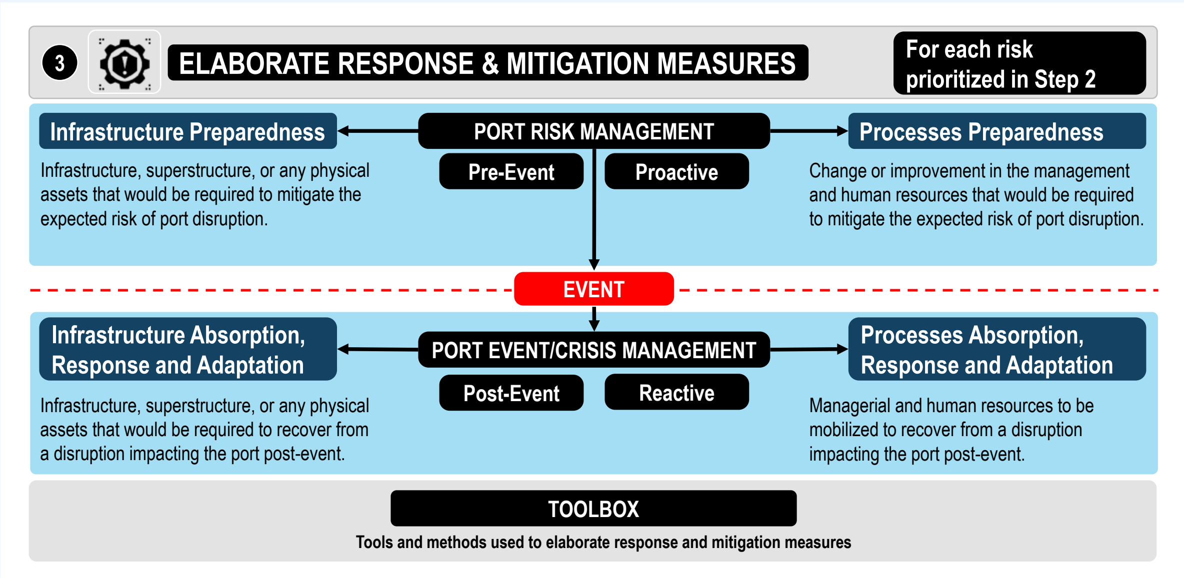
Once the vulnerabilities to each identified hazard are assessed as a risk, they can be ranked by levels of priority (**risk prioritization**). The lack of predictability limits the value of risk assessments for events with a low probability, but which could have severe consequences.

Furthermore, any resilience strategy must include considerations on unknown risks (Black Swan events).

- **High priority risk.** A hazard that is identified as high risk and could have critical consequences for port operations, including stopping operations, and has a good and predictable likelihood to take place. Ports in areas where there is a recurring risk of high impact natural hazards, e.g. extreme weather events, such as hurricanes in the Caribbean and typhoons in East Asia, are giving high priority to these risks.
- **Average priority risk.** This covers hazards that have been identified as having an average risk of occurring, but which could have significant consequences for port operations (e.g. disrupting operations) should they occur; these hazards are considered to have a reasonable but difficult to predict likelihood of taking place. Information technologies are an emerging risk that could have a notable impact on port operations in the event of a successful cyber-attack.
- **Low priority risk.** Hazards identified as having a low and unpredictable risk of occurring could have consequences for port operations and marginally disrupt operations. Accidents and equipment failures are usually disruptive but tend to have a limited impact.
- **Unknown risk (Black Swan events).** A hazard identified as a risk that deviates beyond what is normally expected, and which is extremely difficult to predict. These events are very rare, but their impacts can be substantial when they occur. This is the reason why they are usually referred to as "crises". While not "Black Swan" events per se, the COVID-19 pandemic and the financial crisis of 2008–2009, however, are two notable examples of a risk beyond what is normally expected. Preparing for such risks is difficult since their likelihood of occurring cannot be effectively assessed, and even the risk itself could remain unknown. However, adopting a sound risk management approach is still likely to have significant benefits.

The **prioritization of risks is often linked to a geographical context**. For natural hazards, risks can be associated with plate tectonics or subtropical convergence zones. For anthropogenic hazards, a lower level of economic development is usually associated with higher economic and geopolitical risks.

Figure 18: Step 3 – Elaboration of response and mitigation measures



Step 3 Elaborate response and mitigation measures

Response and mitigation measures promoting preparedness and strengthen absorptive, responsive and adaptive capacities must be elaborated once risks have been identified and prioritized (Step 2); these measures must be introduced throughout a port's infrastructure, processes and services (figure 18).

Two fundamental and complementary resilience-building/risk mitigation and impact alleviation strategies can be considered: the first is a **proactive strategy** (involving pre-event and promoting preparedness and readiness in the face of disruptions); and the second is a **reactive strategy** (comprising post-event and promoting mitigation of impacts, recovery, and adaptation).

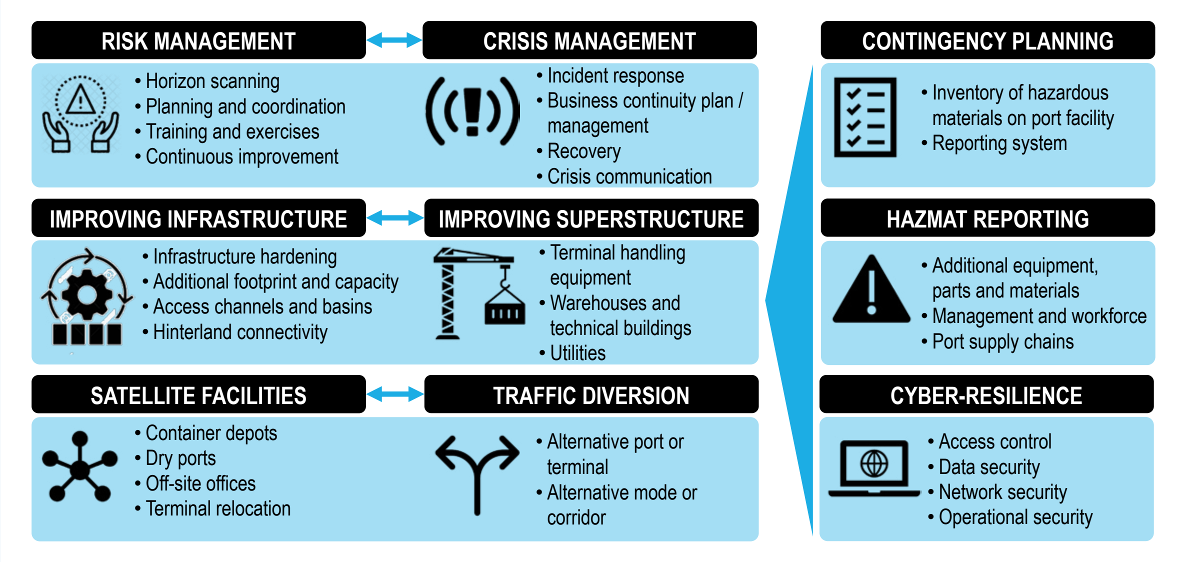
- **Proactive or pre-event (preparedness and port risk management).** This refers to risk management strategies that seek to identify, assess and mitigate risks, and address or mitigate risk before an event happens. It includes risk assessment, risk identification and vulnerability assessment. **Physical asset** or **infrastructure preparedness** focuses on the physical capabilities of the port, including infrastructure, superstructure, or any other physical assets that may be needed to mitigate an expected risk. **Process** and **people preparedness** focuses on a port's managerial capabilities, including the services, management and human resources, required to mitigate an expected risk, including collaborative measures with stakeholders, such as carriers and infrastructure managers.
- **Reactive or post-event (port crisis management, absorption of disruption and recovery).** This refers to an event/disruption, as well as crisis mitigation strategies aimed at responding to a crisis (a risk event) immediately after it has taken place, and which seek to reduce their negative impacts. **Infrastructure response** and adaptation focuses on the required infrastructure, superstructure, or the physical assets necessary to absorb the disruption, restore pre-existing conditions, or recover or bring them to a similar level, while at the same time as ensuring continuing growth. This mainly concerns repairs. **Process response** and adaptation focus on the required managerial and human resources to be mobilized to absorb the disruption, restore the pre-existing conditions or bring them to a similar level, recover from the disruption, and continue to grow. This mainly concerns operational adjustments, communications, collaboration and financial disbursements.

Port risk management and port event/disruption, or crisis management, can be implemented **jointly** or **independently**, depending on the risk. Adopting a proactive approach through pre-event preparedness could be judged as being too costly as some risks are unlikely to occur in some ports. In these circumstances, it may be more relevant to have a reactive approach or post-event response targeting specific risks, while concurrently maintaining the appropriate infrastructure and managerial capabilities.

An overview of the key elements forming part of a proactive (i.e. pre-event preparedness and state of readiness) and reactive (i.e. post-event response and mitigation) approaches to risk management and resilience building are presented below and featured in figure 19:

- Risk management includes the identification and assessment of potential impacts (e.g. enterprise risk management, risk registers, risk metrics).
- Crisis management (protocols).
- Improving infrastructure and Improving superstructure.
- Improving processes and operational efficiency.
- Satellite facilities.
- Traffic diversion and multi-sourcing (given third party supplier risks).
- Preparedness (pre-event focusing on preparing infrastructure and equipment, as well as processes such as business continuity plans).
- Hazmat reporting.
- Cyber-resilience.
- Training, awareness-raising, and building required skills among the labour force.

Figure 19: **Key mitigation and response measures to port disruptions**

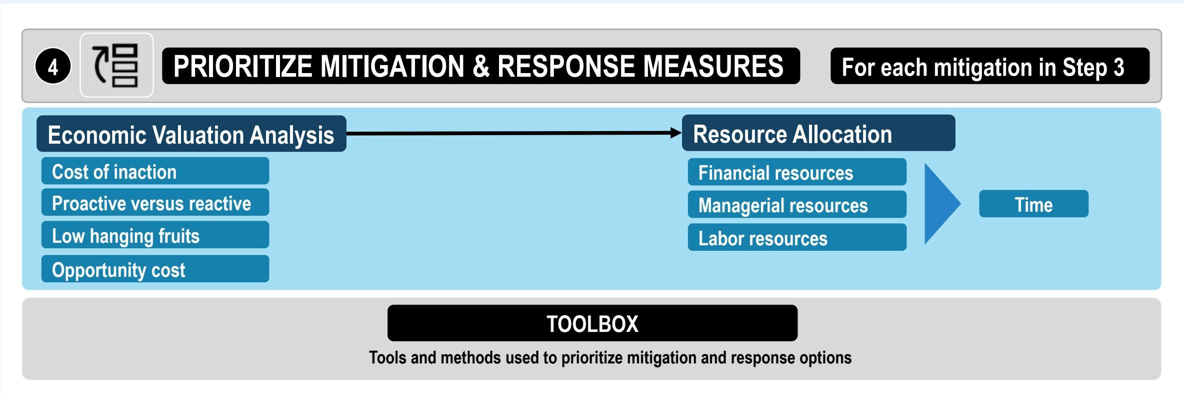


Step 4 Prioritize response and mitigation measures and allocate resources

Once mitigation and response measures have been elaborated (Step 3), each measure must be **prioritized** and the resources required for its implementation needs to be assessed, earmarked and mobilized (figure 20). When assigning an order of priority to the various response options and mitigation measures, it is important to distinguish between critical measures which could have dire consequences if left unaddressed, from those that are relevant but not essential. Their absence would not be detrimental to the port and its ability to cope and recover from the disruption.

The investments required for port infrastructure and superstructures are determined according to risks which can be ranked and prioritized. Cost-effectiveness analysis, stakeholder analysis and multi-criteria analysis are among a range of methods that can be used to conduct an **economic valuation**. Setting priorities or establishing a sequence of measures should be based on criteria, such as past experiences or current strategies being implemented by similar ports, as well as take into consideration other factors, such as affordability and the technical feasibility. Measures can be evaluated using a **cost-benefit analysis** to weigh the potential benefits of a response option or mitigation measure against its expected costs.

Figure 20: Step 4 **– Prioritization of response and mitigation measures and resource allocation**



Prioritization involves four fundamental issues:

- **Cost of inaction.** The default position concerning risk, and accompanying mitigation and response measures, could be to not take any tangible actions, particularly if the risk is not clearly identified, is of low probability, and requires expensive response and mitigation action. Inaction can appear to be an attractive proposition, and a conclusion may be reached that no resource allocation is required. This could also be related to the expectation that the costs associated with a disruptive event will, in part, be assumed by a third party, such as a terminal operator (e.g. it will need to clear any liability it may have), an insurer (with respect to coverage), or government entities (in the case of disaster relief).
- **Proactive versus reactive.** Each hazard risk can be mitigated, and its impacts alleviated proactively and reactively. Proactive measures (pre-event that promote preparedness and prevention) tend to be more expensive than reactive measures (post-event and focus on mitigating immediate impacts and concerns). Since most hazard events cannot be predicted accurately (unreliable risk assessment), reactive measures can be perceived to make more sense from a cost/benefit perspective.
- **"Low hanging fruit".** This usually involves a mitigation and response initiative that stands out from a cost/benefit perspective rather than more complex and expensive measures. In recent years, cybersecurity issues have emerged as one of the most salient risks to ports; this issue can be proactively mitigated, and its impact alleviated with a pre-event implementation of up-to-date software and staff training to avoid common threats, e.g. "fishing" emails containing malware. Paradoxically, a reactive post-event approach to cybersecurity can be much more costly.
- **Opportunity cost.** The time and resources allocated to risk mitigation (identification, potential impact assessment, and management), preparedness (pre-event measures), and response (post-event action and measures) is usually at the expense of other priorities and considerations. For example, the resources earmarked to increase port resilience against potential hazards could have been spent on expanding infrastructure, buying equipment, improving port marketing, or paying off a debt.

Each response and mitigation measure requires allocating often scarce resources, or constrained by other competing demands on the budget:

- **Financial resources** need to be earmarked to implement response and mitigation measures that have been prioritized and elaborated. Where will the funding come from? Can the port revenues and financial resources sustain the expenditure? Does it require contracting debt, such as issuing bonds? Are there grants available from national or international agencies?
- **Managerial resources** will be required to provide overall guidance and oversight when elaborating, implementing, monitoring, reporting and reviewing the effectiveness of response and mitigation measures deployed.
- **Labor resources**, including a skilled workforce will be required to elaborate, implement, monitor, report and review the effectiveness of any response and mitigation measures that may have been deployed. For smaller ports, particularly in developing countries, know-how, technical knowledge, expertise and technology are particularly important as these are less ubiquitous.

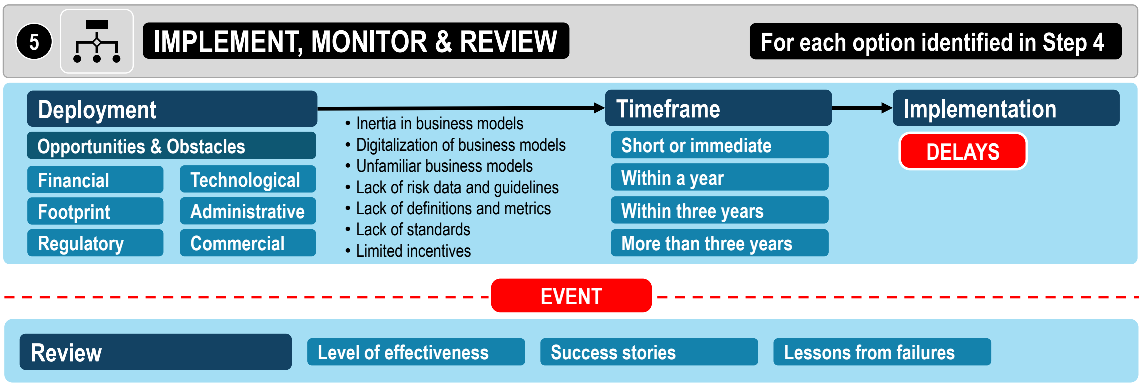
Step 5 Implement, monitor and review

The **implementation** phase immediately follows Step 4 and focuses on prioritizing response and mitigation measures and allocating resources accordingly.

The deployment and implementation of response and mitigation measures can face a variety of **opportunities** and **obstacles** (figure 21):

- **Financial.** Challenges may constrain the capacity to fund and pay for a resilience strategy. First, there could be financial opportunities, such as programmes, subsidies and tax abatements supporting resilience initiatives. Funds may only be partially available, or stakeholders with committed funds (e.g. a government agency) may delay, modify or rescind their commitment. Furthermore, response and mitigation measures could turn out to be more expensive than expected due to improper cost assessment, thereby impairing their implementation.

Figure 21: Step 5 – Implementation, monitoring and review



- **Technological.** This includes challenges relating to the implementation of infrastructure and superstructure remediation. New technologies commonly offer opportunities to invest in more resilient systems. Improved technologies often come with lower costs (acquisition and operations), and make it possible for ports with less financial capabilities to make such investments. However, the response and mitigation measures may be more technically complex to implement than expected, and the availability and capability of a technical fix could be overestimated. This is often referred to as the hype-cycle, i.e. the exaggeration of the capabilities of a new technology, leading to its abandonment and deferred implementation.
- **Footprint.** The physical capacity of some ports can hamper its capacity to implement needed mitigation. A port with access to additional land, including through reclamation, is presented with an opportunity to redesign some of its infrastructures and operations. This is also the case when a new terminal is constructed. Response and mitigation measures may create additional demands on the physical footprint available for port operations, as well as impair port activities, and compete with other uses. A port may not have a suitable amount of land to implement response and mitigation measures, which could restrict future expansion opportunities.
- **Administrative.** From a behavioural perspective, this challenges a port's managerial capacity to recognize the need for and subsequent design, implementation, monitoring and review of its resilience strategies. Policy changes present an opportunity for port governance and management to adapt; however, a port's governance structure may not be suitable to implement response and mitigation measures. A change in governance, such as new leadership, may create incentives to explore new approaches, and new roles and functions will need to be defined and adequate personnel recruited or trained.
- **Regulatory.** Challenges to the conditions and legality of resilience initiatives. Approval must be obtained from regulatory agencies when a port authority or terminal operator does not have the jurisdiction, or approval for implementing response and mitigation measures; obtaining this approval would take time, and require administrative and legal resources. Environmental impact assessments and reviews are among the most complex regulatory burdens faced by ports.
- **Commercial.** Challenges to remain competitive and satisfy the needs of its users and customers. The response and mitigation measures may impact port competition and its ability to attract or retain customers. It could impose additional costs or create changes in port operations that do not entirely meet customer expectations. However, port resilience strategies can lead to new commercial opportunities and attract customers.

Some response and mitigation measures can face **complex obstacles** which only become apparent in the latter stages of implementation (Kim, Y., and L. Ross, 2019).

- **Inertia in business models.** As a business, ports prioritize cost control, and focus on revenue. Port planning cycles usually have a 5 to 10-year horizon, and the life span of infrastructure is 30 to 50 years. Long-term leases make capital investment an essential risk for port development; all the while, other considerations, e.g. resilience, may be sidelined.

- **Digitalization of business models.** Automation and digitalization present opportunities to improve port resilience and risks.
- **Unfamiliar business models.** Ports require a better understanding of how resilience can enhance operational performance, profitability and competitiveness. As landlords, port authorities are reluctant to integrate resilience requirements in concessions and operational requirements as they may reduce the willingness of international terminal operators to bid for a concession.
- **Lack of risk data and guidelines.** Several risks are difficult to quantify and appraise in a suitable manner for decision-making. The lack of information and data on hazards, such as climate change makes them difficult to include in port planning and operations. Only well-defined risks could be enforceable. Furthermore, long-term risk data is lacking and not available in a manner that can inform planning and investment decisions.
- **Lack of definitions and metrics.** There is a lack of definitions and metrics challenges for resilience considerations in port investment projects from governments, lenders and investors. The concept of resilient investment remains elusive and potentially compromises the obtention of better financial and capital terms for more resilient projects.
- **Lack of standards for design and engineering.** Concepts and goals on resilience need to be translated into practical design and engineering standards for port infrastructure and superstructure. Hardening and threshold factors are mainly assumptions that can only be confirmed once disruption occurs.
- **Limited incentives for proactive actors.** Port and terminal operators may not see the benefits of proactively minimizing their risks, as costs are visible and benefits may be intangible. In addition, the insurance industry does not price resilience effectively; an improvement in insurance price differentials could become an incentive mechanism.

The **timeframe** is an integral part of the deployment and implementation of response and mitigation measures. The timeframe determines whether a resilience-building strategy will take place before (**pro-active and pre-event**), or after an event (**reactive and post-event**). Preparedness, response and mitigation measures that require investing in infrastructure and equipment will take more time than process or management-related measures. Four types of implementation or deployment timeframes can be distinguished:

- **Short-term/immediate implementation.** Measures that can rapidly implemented tend to be process-related or managerial, e.g. changes in managerial roles, new or upgraded software, training seminars, or the preparation of a business continuity plan (BCP).
- **Within a year.** The purchase of equipment and minor infrastructure improvements, e.g. IT upgrades and parts for maintenance and repair.
- **Within three years.** Significant infrastructure improvements, e.g. yard renovation and the acquisition of cranes.
- **More than three years.** Major port infrastructure projects, including yard expansion and hinterland connectivity (e.g. road construction, rail spurs and channel dredging).

Implementation **delays** are a common issue, and usually the outcome of obstacles, some of whom were underestimated or unforeseen. For instance, the dredging and expansion of the Elbe channel connecting the port of Hamburg to the North Sea was delayed by litigation for several years. Before becoming entangled in regulatory issues, the medium-term mitigation was projected to take about three years, but after litigation it was delayed by about five years.

A **review phase** can occur after a disruptive event and represents an opportunity to evaluate the effectiveness of a response, or a mitigation strategy and, if necessary, a subsequent revision. Success stories can become part of a port's promotional literature and evidence for other ports to learn from best practices. Failures, or ineffective strategies, should not be discarded but rather serve as valuable lessons.

Resilience strategies entail a **trade-off** between the potential risk of disruption and the cost of mitigating the risk and responding/mitigating its impact should it materialize. A fundamental issue is that each resilience-building strategy usually comes with an **additional cost** that must be shouldered by the stakeholders involved, particularly port users (e.g. carriers). A higher cost structure will ultimately be reflected in the final price paid by consumers, unless improvements in resilience are also associated with productivity improvement. These costs should be balanced against the benefits of reducing the likelihood, or impact of a disruption event.

5. PORT RISK MANAGEMENT AND RESILIENCE-BUILDING TOOLBOX

This section presents selected key tools and approaches that may be useful, whether individually or in combination, for improving port risk management and resilience-building.

Not every organization will need or be capable of implementing all of the processes offered here, but they should be aware of them and be able to develop a process that is appropriate for their size and maturity. This underlines the importance for organizations of having appropriately qualified and experienced risk management staff in place, to understand what is needed, and help the organization develop and implement a suitable risk management and resilience-building programme. Recognized training and qualifications in risk management and supply chain risk management can be obtained from internationally recognized bodies, such as the Institute of Risk Management, the Institute of Operational Risk and accredited universities. International standards on risk management, business continuity and other aspects to resilience-building are published by relevant international organizations, including the International Organization for Standardization (ISO).

An essential element for the successful management of port resilience is **learning from previous events**. These may be derived internally and externally from port organizational practices. Changes, such as new infrastructure investments, can be used to promote appropriate resilience improvements. Resilience can be instrumentalized to create value and competitive advantage through an improved service proposition, and not simply as a strategy to deal with a downside risk. Achieving these goals requires a **toolbox** which provides guidance to port stakeholders and actors to help them build port resilience in identifying, assessing and managing risks in a practical fashion, and devising coherent port risk assessment and management responses and mitigation strategies.

Port resilience-building efforts must be linked to a port's **core values and mission**. A combination of risk management and resilience-building tools enables ports to achieve an integrated understanding of organizational exposure, preparedness, absorption and responsiveness capacity to reduce the likelihood and magnitude of potential and actual impacts arising from disruptions.

Franken, A. et al (2014) referred to resilient organizations as having the following capabilities and attributes:

- They **prepare** and **anticipate problems** before they build up;
- They **build in structural flexibility** to respond to both adverse and beneficial changes;
- They **break down silos** to allow **risk information to flow freely** and prevent risk blindness;
- They implement **rapid response capabilities** to avoid incidents escalating into crises; and
- They learn from **previous mistakes** made by themselves and others.

Figure 22 features a ***Port Risk Management and Resilience-Building Toolbox***, which includes relevant risk assessment and management approaches, as well as tools and methods to enhance and build port resilience. Many come into play pre-event, during an event, or post-event. In some cases, these tools intervene at all stages of a disruption cycle (e.g. ERM and BCM).

5.1 Governance and risk management enabling framework

Ports will need to have an **appropriate level of organizational resilience** to cope with disruption and recover effectively. Having a proper governance structure and relevant support to drive resilience-building efforts is crucial, as is achieving a shift in perception in line with strategic objectives. Port organizational resilience needs to be part of its **culture**, and need to be driven by management actions.

Port resilience-building efforts require an enabling framework. These efforts should be led and supported by top management with appropriate governance measures.

Such efforts enhance an organization's resilience value proposition and its integration in multiple hierarchies and departments (figure 23). Learning from both sucesses and failures is important, whether derived from external events or within an organization.

Figure 22: **Port Risk Management and Resilience-Building Toolbox**

TOOLBOX	TIMING OF ACTION	
1 Governance Enabling Framework	Pre-Event, EVENT, Post-Event	Port resilience efforts led and supported by top management with appropriate governance measures.
2 Enterprise Risk Management	Pre-Event, EVENT, Post-Event	Integrated and coordinated approach to all the risks faced by the port.
3 Horizon Scanning	Pre-Event	Systematic examination of information to identify potential threats, risks, emerging issues, and opportunities allowing for better preparedness around risk mitigation and policy setting.
4 Business Impact Analysis	Pre-Event	Systematic process to determine and evaluate the potential effects of an interruption to port operations as a result of a disaster, accident or emergency.
5 Scenario Planning	Pre-Event	Assert control over uncertainty by identifying future assumptions and determining how the port will respond.
6 Business Continuity Management	Pre-Event, EVENT, Post-Event	Identify risks threatening the port, analyze their potential consequences, and support efforts to prepare for and recover from disruptive incidents when they occur.
7 Risk Registry and Metrics	Pre-Event, EVENT, Post-Event	Risk registry: Record of the risks faced by a port, including controls currently in place, additional controls, and responsibility for control activities. Metrics: Appropriate measures to track progress on driving resilience.
8 Incident and Crisis Management	EVENT, Post-Event	Application of strategies designed to help a port deal with a sudden and significant negative event.
9 Third Party Risk Tools	Pre-Event, EVENT, Post-Event	Tools that can be used to improve a port's resilience in respect of third-party risks (procurement).
10 Insurance Risk	Pre-Event, EVENT, Post-Event	Insurance industry offers the opportunity for a port to transfer some of its risks and often provide relevant risk advisory services.

This approach can take the form of a **mission statement** issued by management underlining a commitment to improving resilience and identifying the key dimensions that should be prioritized. This directive can then drive more specific initiatives, beginning with ERM.

Additional information about the importance of a supportive governance and enabling framework is available HERE.

Figure 23 : Key actors driving port risk management governance

Senior management
- Provide leadership and commitment to the program.
- Allocate sufficient resources.

Steering group
- Supervise, manage, and guide the program.
- "Eyes and ears" of top management.
- Ensures cross-departmental buy-in.

Risk/Business continuity plan
- Ensure that the business continuity (risk management) plan is aligned with the capabilities and resources of the port organization.

Enterprise risk management
- Coordinate program activities.
- Facilitate and support program activities.

Departmental heads
- Alert the steering group of changes in their department that can affect the program.
- Gather Business Impact Analysis information.
- Develop and maintain Business Continuity Plans.
- Conduct and participate in exercises.

Staff
- Understand role in a crisis/business continuity.
- Understand lines of communication in a crisis/business continuity incident.
- Contribute to activities as needed during an event.

Other port stakeholders
- Cooperate with the port steering group and Enterprise Risk Management team to ensure plans are aligned and integrated.

5.2 Enterprise risk management (ERM)

Risk management is part of organizational resilience, with ERM playing a vital integrating function. The latter allows for the determination of ports risk and **resilience thresholds**, assessment of exposures and **impacts**, and setting of **priority areas**. It incorporates different risk perspectives, such as financial and reputational and ensures that resilience-building efforts keep the actual port organizational resilience capabilities within their risk appetite and risk tolerance. Applied in the context of a port the ERM approach aims to:

- **Identify areas of port exposure to risk** (financial, operational, reporting, compliance, strategic, governance and reputational);
- **Prioritize** port risks and exposure and **manage** these as an **interrelated risk portfolio** rather than as individual risk silos;
- **Evaluate the risk portfolio** by considering **internal and external contexts**, systems, circumstances and stakeholders;
- **Recognize** that individual risks across the port are interrelated and can create a **combined exposure** that differs from the sum of individual risks;
- **Provide** a **structured process for risk management**, whether those risks are primarily quantitative or qualitative;
- **Mainstream risk management** as a component in critical decisions throughout the port;
- **Identify** the **risks it is willing to take** to achieve strategic objectives;
- **Make available** the **means of communicating** on risk issues to foster a common understanding of the risks faced by the port and their importance;
- Support **internal audit activities** through a structure which provides risk assurance to the Board and Audit Committee. Further guidance on how to carry out audits (internally or by a third party) to assess resilience is available from the Chartered Institute of Internal Auditors; and
- Ensure that an effective management of risks is viewed as a **potential competitive advantage**, and that it contributes to achieving business and strategic objectives.

Enterprise Risk Management is an integrated and coordinated approach to port risks. It integrates different risks and ensures that a port's organizational resilience capabilities are within its risk appetite and tolerance levels.

Implementing a fully functioning ERM programme is a significant undertaking in which all relevant port stakeholders, including third parties, should participate.

Additional information about ERM is available HERE.

5.3 Horizon scanning (HS)

The COVID-19 pandemic and other recent disruptions caused by interconnected risks, e.g. geopolitical and trade tensions, are a stark reminder of how organizations, including ports, can be **exposed to wide-ranging risks**. Ports can use Horizon Scanning (HS) **to monitor and identify potential threats**, as well as **opportunities and issues that may be reshaping** the short and the longer-term operating landscapes. Its value is that it makes it possible to **consider the complexity of a threat**, challenge assumptions a nd review how risk events could occur. HS helps identify emerging issues through **early warning signs** and provide insights into how to organize and explore these signals. It is essential to obtain appropriate input from sources (e.g. experts and organizations) involved in risk assessments and is widely used by governments and large corporations as part of their overall planning processes.

Horizon Scanning is a systematic examination of information to identify potential threats, risks, emerging issues, and opportunities allowing for better preparedness. It is an organized and formal process of gathering, analyzing, and disseminating value-added information to support decision-making.

Information and tools are widely available, allowing smaller entities, such as ports, to undertake a HS scan and support developments by:

- Deepening the understanding of the **driving forces** affecting the future development of a policy or a strategic area;
- Identifying **knowledge gaps** and bring into focus new areas of research required to understand driving forces better;
- **Building consensus** among stakeholders about the issues and how to tackle them.
- Identify and make explicit some of the **difficult policy choices and trade-offs** that may need to be made;
- Creating a **new resilient strategy** more reflective of changing external conditions; and
- **Mobilizing port stakeholders** to act in respect of identified risk areas.

A HS can be used to **inform strategy** and **feed into port planning**. The exercise around the most likely future events and ensure continuous update as the situation evolves with new potential disruptions identified and existing risks abated. The port authority should be the core driver of a HS exercise, with key stakeholders (e.g. terminal operators or hinterland carriers) included to provide a more comprehensive picture. Key steps in a HS process include:

- **Identifying key stakeholders.** Gather relevant port-related individuals and organizations to work with to obtain a diversity of views;
- **Kicking-off.** Explain the objective of HS, how it will be conducted, and how results will be used;
- **Researching.** Setting a timeframe for research, assigning single issues to specific individuals/teams to be researched, reviewing the literature and best practices, and identifying potential risks;
- **Preparing outputs.** Stakeholders to document their research and submit viewpoints;
- **Combining.** Collate the various relevant viewpoints and present them to the group for discussion;
- **Monitoring and reviewing.** Decide which key risks would require further investigation and conduct an in-depth analysis; and
- **Engaging.** Stakeholders should be engaged around outputs and provide feedback. All port stakeholders beyond the select group that was involved in the HS exercise should be involved.

Additional information about HS is available HERE.

5.4 Business impact analysis (BIA)

Business Impact Analysis (BIA) helps identify a port's most **critical business functions**, and the role of and actions of stakeholders that may be required to promptly recover activities once a disruption occurs. It can be run as part of a HS activity in terms of the impact assessment or a separate risk technique. Given the strategic role of ports as national gateways to the global marketplace, engines of growth and employer generator, BIA, in the case of ports should also consider broader implications of a disruptive event for the local and national economy and trade.

A BIA requires assigning a **business continuity manager** (or assigned point person). If such a person has not yet been assigned, port management needs to select an individual (internally or externally) with prior knowledge and an understanding of risk management and business continuity approaches. A BIA process involves the following key steps:

- Meeting with port department leaders for an overview exercise involving a **BIA** to identify the key potential business interruption events. Inputs from a HS process can help identify some of the major risks that need to be considered;
- Scheduling individual BIA interviews with port department leaders and subject matter experts to **validate potential risk events** and their potential impact and probability;
- **Analyzing the results** of interviews and discussions held with departments;
- Providing each relevant manager with results for their **review and approval**. These results need to include appropriate financial impacts and probability; and
- Creating a **report for review** and consider **engaging relevant stakeholders** on the BIA in other processes to provide relevant input.

Business Impact Analysis is a systematic process that determines and evaluates the potential effects of a disruption on port operations.

Scenario planning is a technique that uses probabilistic models to build explicitly uncertainty into the analysis.

It is important that ports understand and present the risks they face in a manner that can be readily understood by relevant stakeholders to facilitate the appropriate risk management process. Several approaches support risk identification and assessment, and ports may either choose from among these approaches or devise their own approach. While information about the relative impact of a given risk and the probability of its occurrence is implicitly integrated into a BIA, a risk severity and probability matrix is another useful tool that can help ports inform stakeholders about the risks they face. If a port has already carried out a BIA, a risk severity and probability matrix will become one of the outputs generated by the BIA.

Additional information about BIA and risk mapping is available HERE.

5.5 Scenario planning

Scenario planning starts by building a **dynamic flow model**, including a digital flow model for the entire port and related supply chains as a network with inputs, outputs and processing times. Users populate the model with data from existing systems, including historical behaviour and uncertainty factors, such as lead times, capacities, demand, production, vessel and terminal requirements.

"**What-if" scenarios** are developed considering changes in demand, lead times, market share, supplier disruptions, port equipment disruptions, competitive pricing changes and geopolitical changes. Users can then run simulations across the entire port operational network for the different scenarios. The outcomes normally take the shape of histograms, sensitivity curves with confidence intervals, and probabilities of occurrence, along with risk assessments for each scenario. Scenario outcomes are prioritized based on the probability of occurrence and their associated risk index. The final step is to develop a **Risk Response Plan** (RPP) for the critical scenarios for a port's strategic, tactical or operational horizons.

By combining tools, such as **probabilistic methods**, modeling, and discrete-event simulation, couple with risk assessments for every scenario, these techniques provide a better understanding and managing risk. This approach to port supply chain risk management can have significant benefits, which have become more accessible with the falling cost of information technologies and data availability. However, the quality of these models is highly dependent on the **quality of the data used**.

Additional information about scenario planning is available HERE.

5.6 Business continuity management (BCM)

The first step of a BCM plan is to obtain a **clear understanding of the business requirements** of port operations. The following should be considered:

- Are there any port regulatory or compliance **BCM requirements**?
- Are there any **port user demands or expectations** relating to the BCM?
- Do the port's **charter or insurance policies** require a BCM?
- Are there any **new developments** that may oblige a port to design, review and implement a BCM?
- What are the **capital requirements** that are needed to protect a port from financial challenges caused by a disruption?

There are many benefits to having an effective BCM programme. One benefit is that ports are assured that they will be better positioned to **keep their business operations running** during and after an incident. Other benefits include:

- Ability to **resume operations more quickly** due to clear plans being available.
- **Lower disruption costs** due to quicker or reduced recovery costs.
- **Greater trust** from port users and stakeholders.
- **Safeguard a port's reputation** by having a good record of maintaining operations in the face of disruptions.
- **Better insurance terms**, coverage and benefits.
- Potentially **save lives and reduce injuries** in the event of hazardous incidents.

Business Continuity Management is the management capability that identifies risks that threaten the port, analyses their potential consequences if they were to materialize, and supports efforts to prepare for and recover from the impact.

A Business Continuity Plan aims to ensure continuity of business operations when an event disrupts a port and impacts its operations and activity.

Effective BCM requires collaboration across an entire port's organization and its multiple stakeholders across the maritime supply chain, including with respect to shipping and hinterland operations. The participation of all port business units and departments is required, and employees should be well-trained and equipped to respond to an emergency. An effective BCM programme also requires continued maintenance and testing as well as investment.

BCM is about **keeping critical activities available** in case of an interruption to port operations. As this risk management strategy is deployed and tested, it enables a port to become more resilient to a wide variety of incidents which could impact its infrastructure, equipment, personnel, superstructures, information technologies and suppliers.

Additional information about BCM is available HERE.

5.7 Business continuity planning (BCP)

Once the BIA and the overarching BCM strategy have been completed and documented, the port should prepare its Business Continuity Plan (BCP).

A BCP is generally developed based on the **priorities and requirements that evolved from the BIA process**. The BCP should be a go-to, **practical guide** and be regularly maintained in anticipation of an unexpected disruption. Port personnel will use it to ensure that critical business operations, functions, processes and IT applications can **quickly resume operations during and after a disruption**. BCPs **should include all the information the relevant people and teams in the port** will need to assess and resume operations quickly and affordably. The plan is generally developed based on the priorities and requirements that evolved from the BIA process.

A typical port BCP should consider and potentially contain the following information on:

- **Roles, responsibilities**, rules and structures to document/approve the plan;
- **Emergency procedures** to ensure the safety of port employees, clients, customers, etc. present at the port;
- **Response procedures** to bring the port back to a functional state and **recovery procedures** to bring the port back to its pre-incident state;
- **Activation and de-activation procedures**, notably when the BCP should be put into action;
- **Coordination procedures** with public authorities and other third parties, as appropriate;

- **Communication procedures** and call trees (a telecommunications notification chain regarding the incident);
- **Contact information for the team** responsible for enacting the BCP, port personnel, customers, suppliers, key third parties, etc.;
- **Linkage to critical IT application** programmes;
- **Off-site storage of critical back-up media** (IT data storage), documentation and other pertinent resources; and
- **Meeting locations for BCP or incident** response teams and required software. Teleconferencing was particularly important during the pandemic.

These key areas must be appropriately covered in the BCP documentation.

Additional information about BCP is available HERE.

5.8 Business continuity management testing and improvement (BCM Validation)

The danger for any BCM system is that BIAs and BCPs can be stored away and not subjected to any later testing or updated. Another concern is that the relevant port workforce, especially newly recruited staff, lacks the necessary training relating to BCM. When a port only uses its BCP when an incident occurs, gauging the effectiveness of this plan becomes difficult. Therefore, with BCPs being an important component of a port's BCM, the system needs to be tested before an event occurs. It also needs to be updated as deemed necessary. A port's BCPs should be regularly tested, at least annually, with varying options for testing, including the following:

> *Business Continuity Management Validation aims to ensure that relevant business continuity solutions and responses reflect the size, complexity, and type of port organization and that the plans are current, accurate, effective, and complete.*

- **Exercises and drills** involving reviewing documented procedures with those responsible for executing the BCP and checking for overall plan viability.
- **Tabletop exercises** and drills discussing roles during an emergency and responses to a particular emergency case.
- **Physically testing of the BCP**, such as relocating services or equipment to alternative sites at the port or elsewhere. While the most comprehensive approach, this exercise can be costly and time-consuming.

Additional information about BCM validation is available HERE.

5.9 Risk registry

A **risk registry** is a record of risks, current controls, additional required controls, and responsibility for control activities. It should be a **continuous process**, with port staff logging risks that have been observed, including the actions taken. To appropriately respond to a risk, a risk manager may need to bring in experts to understand the steps that can be taken to reduce the likelihood of the risk occurring, or to mitigate the impact of a risk if it occurs.

> *A risk registry is a formal tool used to document port risks along with the actions to manage each risk. The registry features all results of risk analyses carried out and information as to where response plans are recorded.*

A risk **registry** generally contains a **Risk ID** that is a unique identifier for the risk and the **date raised**, i.e., the date the risk was identified. The risk register also features: (i) the **risk description**, including indicating what might happen if the risk occurs; (ii) the **likelihood that a risk** will occur; (iii) the **impact or magnitude, overall rating, which is measured by multiplying** the likelihood by impact; and (iv) the risk owner or the person who will be responsible for managing the risk. The risk register will also mention **mitigating action** and includes actions that can be taken to reduce the likelihood of the risk occurring again. This may also include acceptance of the risk or its transfer, e.g. insurance. Thus, these actions tend to take place before an event happens by way of anticipation, preparedness and prevention. **Contingent action refers** to efforts aimed at: (i) reducing and mitigating the impact on the operation and feedback on lessons learned; (ii) **progress on activities that** provides a regular update on the progress of the mitigating actions; and (iii) **status of the identified risk event**, i.e. whether the event is considered to be open, closed, in process, or accepted within tolerance, etc.

5.10 Resilience-related metrics

Existing indicators used to assess port performances, whether financial, economic, social or environmental sustainability, can be relied upon to infer preparedness to withstand disruptions and keep port activity flowing during and after events. While keeping track of resilience performance through indicators and data is important for resilience-building is important, a common challenge associated with assessing, monitoring, and tracking port resilience and its performance relates to the relates to the **variables/ aspects** and **indicators** (metrics) that need to be developed, quantified and compiled (figure 24).

Figure 24 : Resilience-related variable and metrics

ROBUSTNESS	REDUNDANCY	VISIBILITY
Deviation from normal throughput	Reserve capacity (equip. and workforce)	IT to track operations
Continuation of operations	Energy and utilities backup	IT to track equipment and workforce
Stability of operations	Reserve capacity for demand surges	Business data intelligence
Effect of multiple disruptions		

FLEXIBILITY	COLLABORATION	AGILITY
Adjust delivery schedules to disruptions	Interact with key stakeholders	Respond to uncommon customer requests
Adjust workforce to disruptions	Develop objectives with key stakeholders	Respond to changes
Port users can adjust capacity	Develop synergies with key stakeholders	Workforce able to perform diverse tasks

INFORMATION SHARING	RESPONSE	RECOVERY
Relevant information with stakeholders	Quick response to disruptions	Financial ability to recover
Timely information with stakeholders	Effective response to disruptions	Lessen the cost of disruption
Accurate information with stakeholders	Available contingency plan	Lessen the cost of recovery

Source: Adapted from Kim, S., S. Choi and C. Kim (2021).

Variable that could serve as metrics can be grouped by resilience categories:

- **Robustness.** The expectation is that port performance should **not deviate** significantly from a standard representing an expected throughput and should be able to carry out a **continuity of operations** when faced with a disruption. Robustness can also s measured by the **stability of operations** and a port's ability to **handle multiple possible disruptions**.
- **Redundancy.** A port can maintain a **reserve capacity of equipment and workforce** that can be brought in case of a disruption. This also involves **backup energy and utility supplies** to maintain operations if regular supplies are compromised. The port can also have **reserve capacity to handle unexpected demand surges**.
- **Visibility.** The port has an information system that accurately **tracks its operations**, can **track equipment and workforce** in real-time, and has an effective **business intelligence** programme for data analysis and horizon scanning.
- The port can **adjust its delivery schedules** to mitigate disruptions, particularly its yard and gate operations. This may also require **adjusting workforce capacity** in response to disturbances. On both the maritime (e.g. shipping lines) and hinterland sides (e.g. truck, rail, cargo owners), port users must be able to adjust capacity to mitigate disruptions.
- **Collaboration.** A port can **interact with key stakeholders** to mitigate disruptions. This implies the **development of strategic objectives** that can be addressed jointly and finding issues where stakeholders could obtain mutual benefits and create synergies.
- **Agility.** A port can respond to **unusual requests** by partners, including specialized and project cargo. Port operations can **react to changes**, such as new regulations, market and demand changes, and new technologies. A port's workforce can **handle various tasks** and switch tasks according to the demand.

- **Information sharing.** A port can exchange **relevant information** with stakeholders in a **timely manner**, and ensure that this information is **accurate**.
- **Response.** A port can **quickly respond to disruptions** as it can do so. These responses are also **effective**. The **availability of contingency plans** allows resources to be put forward to respond to a disruption.
- **Recovery.** A port has the **financial capacity** to absorb significant losses through existing reserves and financial support from third parties, such as banks and public funds. A port should have the resources to lower the **cost of disruption and recovery**.

5.11 Incident and crisis management

Incident and Crisis Management refers to steps that ports need to take to prevent crises from occurring, and prepare to deal with a crisis when it occurs and respond.

It is essential to understand **what distinguishes a crisis from an incident or disruption event**. A crisis will significantly impact port operations; once a crisis unfolds, it becomes too late to prepare for it. From a port perspective, a crisis may be defined as an event impacting a wide range of port activities, which undermines or removes its customers' expectations. Most customers will be visibly affected by delays and even cargo loss. An **incident** relates to an event impacting a limited range of port activities and, if properly managed, may not be noticed by customers or only be noticed by a few of them.

Crisis management provides a **framework** for risk management, business continuity and crisis response. A crisis could significantly impact port operation, and unlike incidents which are generally seen as **disruptive events** with a higher frequency but lower severity, a crisis can have a more severe impact on a port. Because business continuity is concerned with the maintenance of business functions and services in the face of such foreseeable disruptions, it generally **focuses on incidents**. The objective of a ports' business continuity is to ensure that incidents do not spiral out of control. Some events can be so severe and have dire consequences that business continuity measures are overwhelmed and immediately give rise to a crisis.

For ports, crisis preparation entails several actions, including:

- **The identification** of what may potentially cause **problems for port operations**.
- The establishment of **business continuity arrangements**.
- The development of **crisis management capabilities** by setting priorities, definition of roles and responsibilities, and drafting a plan.
- **The validation** of arrangements through **testing**.

Developing a port crisis **management capability** will require the port to, among others: (i) establish an appropriate leadership in terms of setting the overall direction for the crisis management; and (ii) communicating and motivating people to achieve the overall objectives. It is advisable to appoint an executive sponsor for overall oversight and directional support. This person should be a member of the port's senior management team, with the appropriate training, particularly in crisis communication as he or she is likely to be the port spokesperson. Roles and responsibilities in the crisis management team should be clearly defined, and a brief and flexible crisis plan should be created, and should reflect the inherent unpredictability of events.

Some **golden rules for a successful crisis response**, include the following:

- Facilitate early notification (culture and processes);
- Activate the team without delay;
- Follow the plan;
- Exert team and meeting discipline;
- Set the strategic goal;
- Determine the main effort;
- Ensure clarity of roles and responsibilities;
- Engage in scenario planning;
- Make timely decisions; and
- Align with the port's values.

Additional information about incident and crisis management is available HERE.

5.12 Third-party risks, supplier assessment and audits

Ports should identify and prioritize critical suppliers of goods and services that fundamentally support their core functioning. They can also devise their own strategies for determining who their critical suppliers or third parties might be. If the impact of a failure by a third party or a supplier is felt by the port, these can be deemed critical for the port and may entail risks for its business continuity. Critical third parties or suppliers can be identified and categorized by: (i) type; (ii) services rendered; (iii) goods supplied; (iv) volumes; (v) service levels; (vi) predictability of demand; and (vii) elasticity of supply.

A ports' BCP should be integrated with that of third parties/suppliers operating within the port or its hinterland, together with critical third-party suppliers, such as those providing supplies to the port (e.g. cargo handling equipment or services). Ports also need to assess the adequacy of the business continuity processes of third-party providers or suppliers.

These should be considered as part of any contracting process by the port with a new supplier or a revised contract with an existing supplier, particularly when they are key to port operations. In all cases the maintenance of adequate business continuity procedures should be included within the contract, as well as the port's right of to test them appropriately, either independently or as part of an overall port business continuity testing.

Risks due to failure to deliver by third parties such as suppliers.

A third party could fail to **provide equipment, parts, supplies or services** for which it is under contract to procure. This can occur for several reasons, such as strikes by key contractors, regulatory closure of a supplier, or the inability of a supplier to maintain their supply and production capabilities. However, financial **failures** remain a common source of third-party risk.

An important step is to identify the most critical suppliers, particularly with respect to essential assets (e.g. cranes, IT systems), the expected level of service, and the frequency of third-party demand. Understanding the **financial health** of a third party is critical. It helps protect the port from a potential disruption and operational failure, as well as from a loss of revenue or the loss of a key third-party support service which could have a negative effect on the port being able to provide a service.

Should an event occur, the financial strength of third parties, e.g. subcontractors and suppliers, can also be an indicator of their **robustness**. Having substantial cash reserves enables these third parties to absorb the impact of a disruption event. In addition, they are also more likely to enhance the services they offer and support a port's development through innovation.

Bankruptcy predictors can help assess the financial performance of existing and new suppliers or customers. One of the most widely used bankruptcy predictors is the Altman Z-Score. The Z-Score provides a well-established approach for assessing the financial health of suppliers and customers and requires only a moderate level of financial data. The Z-Score combines a series of weighted ratios for public and private firms to predict the likelihood of financial insolvency. There are several other financial ratios and approaches that ports may want to use to assess the financial viability of third-party suppliers. They could also use international service providers, such as DNB, Rapid Ratings and Creditsafe, to determine the financial viability of these suppliers.

These service providers tend to provide good cost-effective coverage around international public companies but have more limited insights for national private companies without supplementary service activity. A list of potential providers is set out in the section titled "Useful Resources" in the Annex to this guidebook. Furthermore, ports could have regional financial viability service providers to support the financial analysis and help obtain relevant data. For small ports and when resources are limited, a third-party provider is likely to be the best approach.

A **third-party supplier audit or assessment** should be conducted for critical suppliers and third-party providers before the start of the contract. For existing critical suppliers, these audits and assessments should be annual, or when significant concerns are raised. This is to ensure that members of a port's supply chain adhere to sound business and legally compliant practices, as well conform with relevant requirements, including those relating to ethics, regulations, laws, business continuity and standards. In the case of ports, this would include relevant freight forwarders and transport partners, among others. Other instruments such as **supplier strategies, supplier and third-party portfolio matrix, commodity or category strategies/risk plans, multiple supply sourcing, buffer or safety stocks** are also useful in preparing for and mitigating potential disruptions arising from third-party or supplier failures.

Additional information about managing port supplier and third-party risks is available HERE.

5.13 Risk transfer and insurance

One resilience option available to a port is to **transfer selected risks** to the insurance industry. Insurance companies typically assess the risks of port operations and offer a variety of covers, particularly for damage events through **property and liability covers**.

Transferring defined risks to an insurance company.

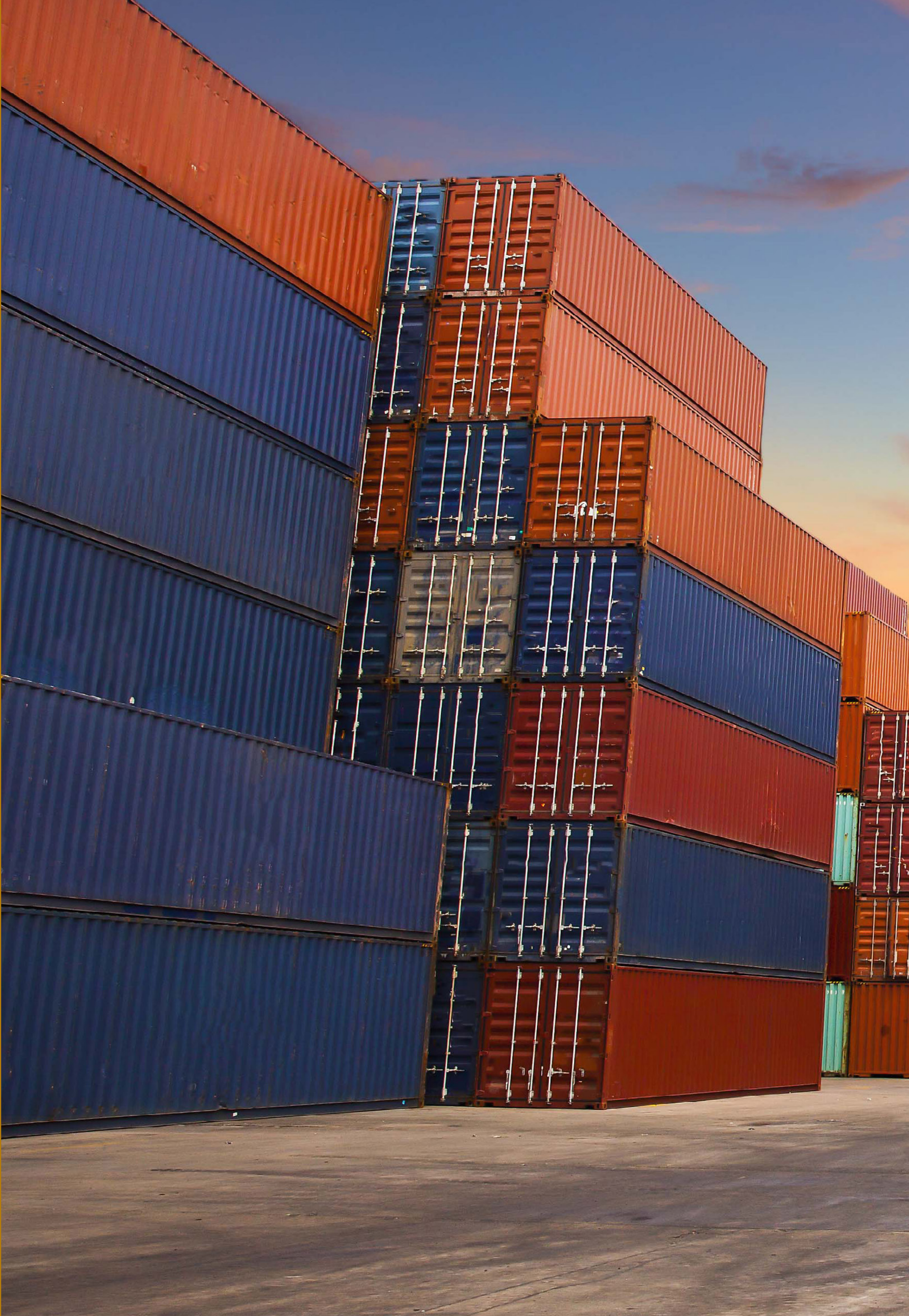
The types of insurance coverage available to ports are best accessed through an insurance broker. The cover that is offered and the price or premium that is charged depends on how the insurance company assesses covered risks.

As a risk transfer tool, insurance primarily comes into use because **other risk mitigation techniques have failed**.

Insurers examine several port-related risk factors, including:

- Nautical services;
- Natural hazards;
- Property fire;
- Management and leadership;
- Maintenance;
- Contractor management;
- Environmental exposures and controls;
- Health and safety management;
- Contract management;
- Security;
- Ship-to-shore operations;
- Road and rail infrastructure; and
- Cargo handling and business interruption.

Additional information about insurance risk transfer and insurance is available HERE.



PART II

PORT DISRUPTION AND RESILIENCE: **A CLOSER LOOK**

1. HAZARDS AND PORT RISK FACTORS

1.1 Contemporary challenges to port resilience

Since the beginning of the 21st century, a series of events have tested the resilience of ports and maritime supply chains (figure 25). Each disruption represents an opportunity for the logistics and freight distribution system to adapt to a new reality and associated constraints. For instance, the resilience of ports and maritime supply chains was tested after the events of 11 September 2001; thereafter, security measures became a core focus as ports were considered as potentially vulnerable targets for attack. Security measures and standards were introduced across the industry, e.g. cargo scanning and advance manifest notification, resulting in increasingly secure ports. As a result, security measures and standards now form an integral part of shipping practices, and have consequently led to a substantial reduction in security concerns.

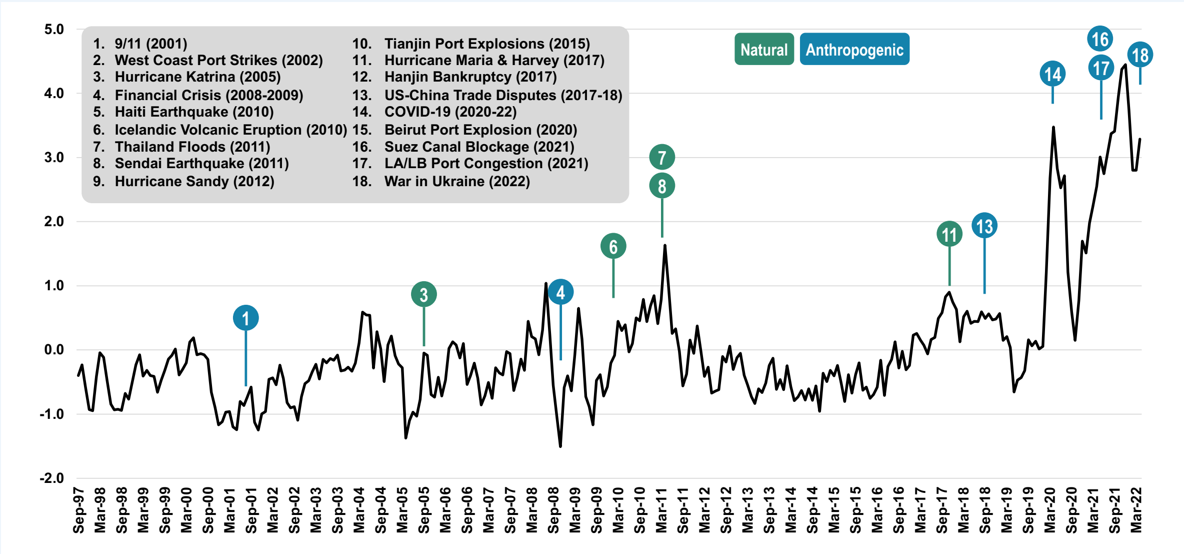
Figure 25: Main natural and anthropogenic supply chain disruptions in the 21st century

Source: Based on data from J.P. Rodrigue, Global Container Port Database.

Assessing the severity of a supply chain disruption is challenging as it can involve the price of raw materials and issues along the multimodal transport chain, e.g. strikes disrupting a port's operations, or natural disasters disrupting manufacturing clusters. The Global Supply Chain Pressure Index (GSCPI) was developed by the Federal Reserve Bank of New York and includes 27 monthly variables reflecting events within supply chains and transportation costs in the maritime and air cargo sectors.[2] The index is normalized so that zero indicates an average value, and any deviation is related to a stress level. Positive values represent how many standard deviations the index is above the average, implying that supply chains are under pressure. Negative values are shown when supply chains are functioning well and experiencing limited disruptions or pressure (figure 26).

[2] These variables include the three country-specific supply chain variables: (i) PMI for the Euro area, China, Japan, the Republic of Korea, Taiwan, Province of China, the United Kingdom and the United States; (ii) two global shipping rates (BDI and Harpex); and (iii) the four price indices summarizing airfreight costs between the United States, Asia and Europe.

Figure 26: **Global Supply Chain Pressure Index (GSCPI) and major supply chain disruptions**



Source: Data from G. Benigno et al (2022).

The variability of the GSCPI, particularly when it surges above 0, can be associated with specific events. For instance, the index surged significantly in 2011 following the Sendai earthquake and resulting tsunami; the latter impacted Japanese car manufacturing and its exports to foreign markets.The same year, flooding around Bangkok, Thailand, disrupted global supply chains in the automotive and electronics sectors, particularly hard drives, leading to shortages among global computer manufacturers. The index rose again in 2017 and 2018 following United States-China trade disputes, inciting several large manufacturers and retailers to revise their manufacturing and procurement strategies. Some events, particularly the onset of a recession, e.g. the financial crisis of 2008–2009, can remove substantial pressure on supply chains as demand declines. A part of the resilience challenge relates to the geographic scale and complexity of maritime supply chains, where a singular event can have profound ramifications. The following sections present the most significant hazards and risk factors impacting port resilience.

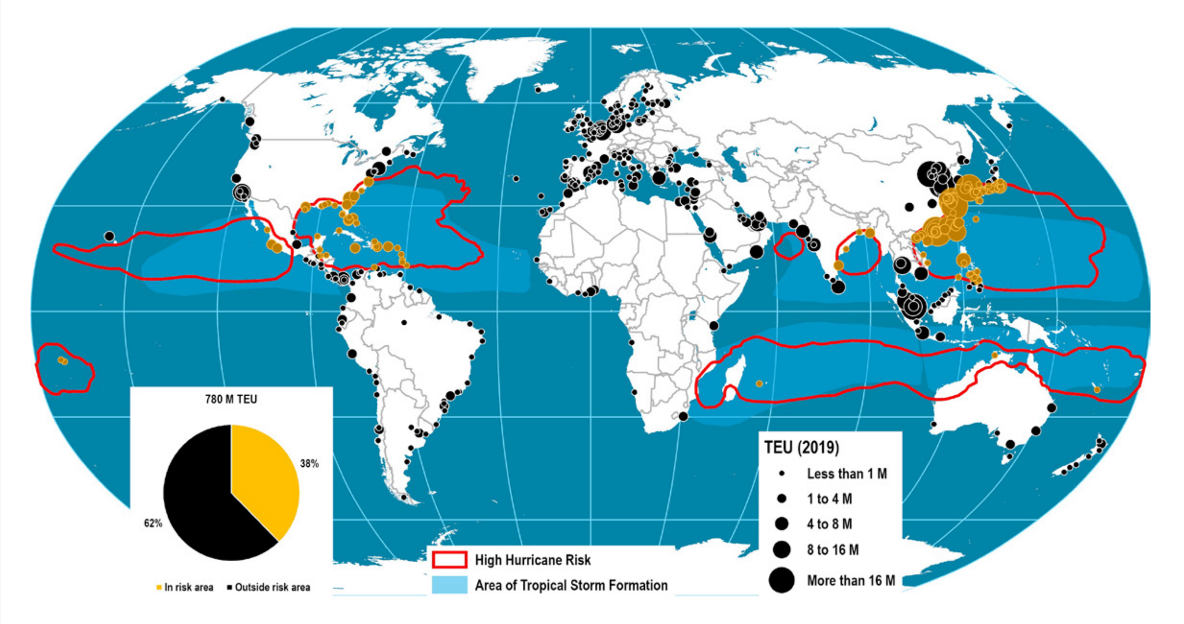
1.2 Extreme weather events

The most common extreme weather events impacting ports are **storms, hurricanes, heat waves** and **floods**. Storms, including snowstorms and sandstorms, can be intense but of short duration (less than a day), and only affect a defined geographic area. Floods are a common type of weather hazard and can cause significant damage to infrastructure. Floods often occur following heavy rain, snowstorms, coastal storms, storm surges, and the overflow of dams and other water systems, particularly in delta areas.

Hurricanes represent a significant potential disruption to maritime shipping and port operations, and their impacts on ports are subject to a distinct geographical concentration of risks. Tropical storms emerge in intertropical convergence zones which are located just north of the equator for the Atlantic Ocean, and on both sides of the equator for the Pacific Ocean. A tropical storm may develop into a hurricane (or typhoon in Asia) with sustained winds above 100 km/hr, and can move beyond the formation areas and make landfall. High winds with the associated precipitations and tidal effects can substantially disrupt and damage coastal activities, including ports and their terminals. Another important characteristic of hurricanes is their seasonality, with peak activity usually occurring between June and October. The cycle is more acute in East Asia, which experiences a greater number of typhoons, which can occur year-round (figure 27).

About 38 per cent of global container port activity occurs in areas subject to high hurricane risk. With their high container port activity levels, the American Eastern Seaboard, coastal China, Japan and the Republic of Korea, are the areas facing higher levels of potentially disrupted areas.

Figure 27: Risk of hurricanes for global container ports, 2019

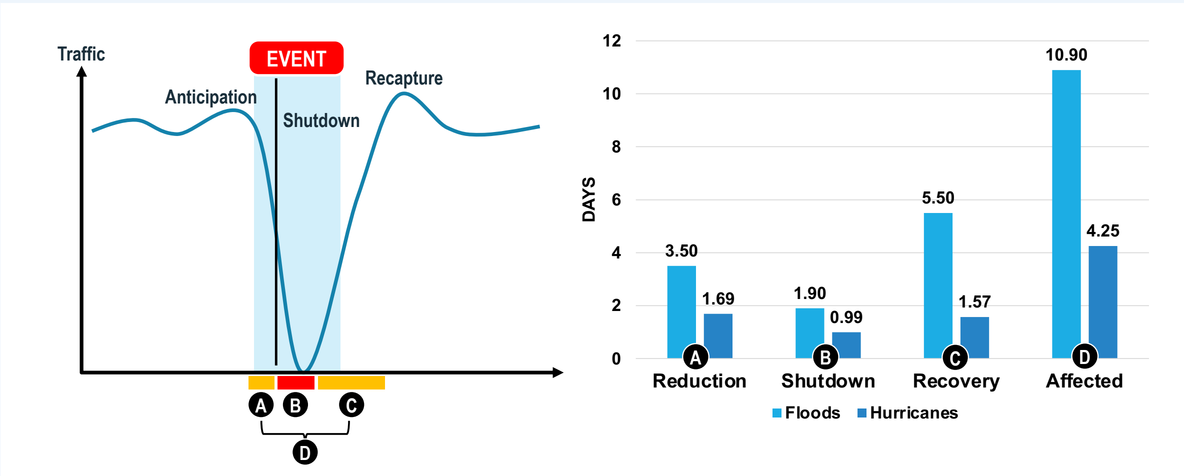


In addition to disrupting and halting port activity, hurricanes can damage port equipment and superstructure. Yard activity can be disrupted by toppled containers and flooder areas, damaging cargo and equipment. Connections with the hinterland can also be damaged, such as flooded road and rail connectors. On some acute occasions, port infrastructure, e.g. piers, can be damaged.

Evidence from a sample of hurricanes and floods in two areas prone to hurricanes with a high density of port facilities – North and Central America and East Asia – depicts a typical impact sequence on port activity (figure 28).

The path and intensity of hurricanes and the risk of floods can be predicted several days in advance, enabling ports to anticipate the event by rushing the handling of expected ships. As the weather event begins to be felt, a port may experience a reduction of activity as ships begin to divert to an unaffected port nearby or skip the port call altogether. Evidence shows that activity reduction spans over an average of 1.7 days for hurricanes and 3.5 days for floods. If the event is significant enough, the port will be forced to shut down, usually one day for hurricanes and close to two days for floods.

Figure 28: Typical impact of hurricanes and flood events on port activity



Source: J. Verschuur et al (2020).

A container port usually takes one to two days to resume full operations (recovery) after a Category 1 hurricane. If a container port is a transshipment hub, the disruptions caused by a hurricane can be extensive for the schedule integrity of maritime shipping networks, and could convince shipping lines to use alternative hubs. Once able to re-open, and recovery begins to take place, port activity will resume its normal activities. There is likely to be a post-recovery surge where the port is trying to recapture the traffic that has been lost during the event (figure 28).

Evidence shows that floods have the most substantial impacts on port operations, with the average number of affected days close to 11, compared with 4.25 days for hurricanes. Longer disruptions are associated with damage to hinterland infrastructure, preventing the port from being connected with its customers (See Case Study 14: Port of Houston, United States).

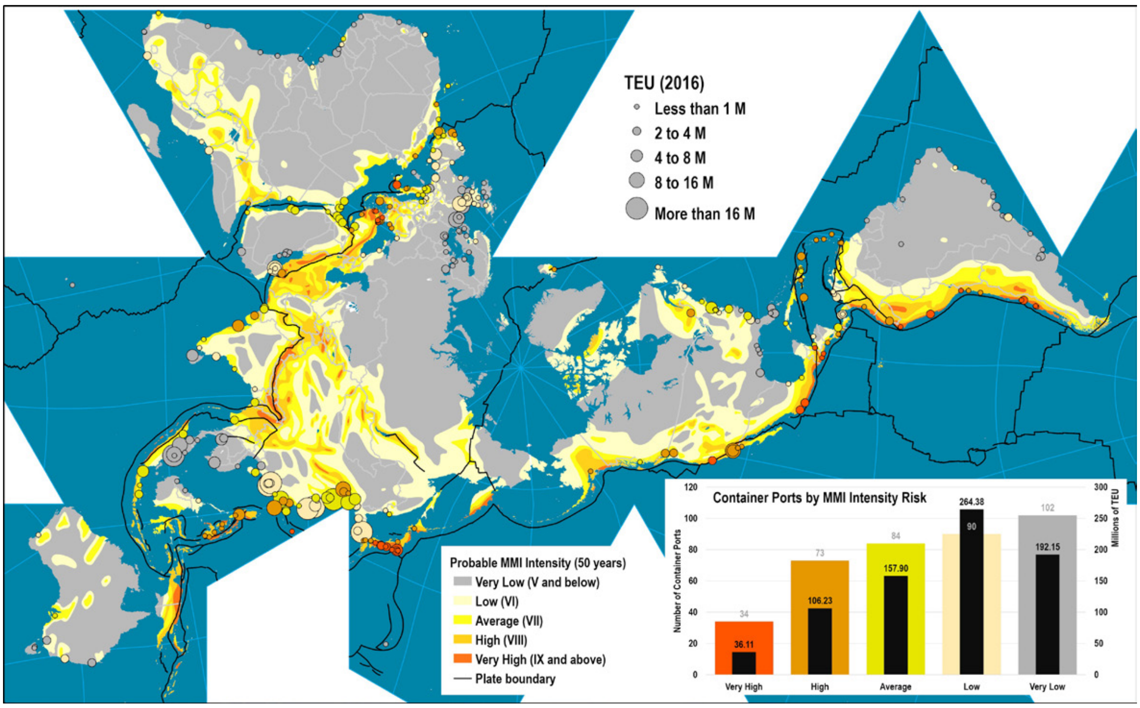
1.3 Geophysical disruptions

Due to the positioning of tectonic plates, ports are exposed to a significant geographical risk distribution (figure 29). As container ports have a life span of at least 50 years, it is almost certain that all container ports will be exposed to an earthquake event. What will differ is the intensity of this event. Some areas face a high risk of a high-intensity earthquakes will occur over a period of half a century, while in others only a low-intensity earthquake can be expected over the same period. Ports bordering the Pacific Plate, also known as the "Pacific Ring of Fire", are at a particularly high risk as most of the largest earthquake events of the last century took place in that region.

Areas of high tectonic risk are associated with lower economic and port activity levels. For instance, 34 container ports (19 per cent of all ports) in very high MMI (Modified Mercalli intensity scale) risk areas (IX scale and above) account for only 4.7 per cent of the total TEU handled. Japan and the Pacific Coast of the Americas are areas of high risk. Other areas of high port activity have a very low risk, such as around Australia, the Baltic and northern Europe, the American Eastern Seaboard, the Gulf Coast, and the Straits of Malacca. Ports in these areas are almost certain to experience a notable earthquake event that could potentially damage their infrastructure and superstructure.

Even if a port may not be in a high-risk area, or not directly impacted by a specific earthquake event, tsunamis may cause alerts and interruptions in operations.

Figure 29: Risk of earthquakes for global container ports



1.4 Climate change

Additional natural risks to port activity fall under the **multidimensional impacts of climate** change, many of which will potentially take place in the long term and difficult to evaluate. In addition to the risk of hurricanes, with which it may be associated, sea-level rise is of direct concern to port activity. However, port terminals are resilient facilities designed to handle tidal ranges. Any expected sea-level rise will likely impact surrounding infrastructure, such as access roads, before disrupting port infrastructure. Elements associated with climate change have an array of potential impacts on transport operations and infrastructure (figure 30):

- **Heat waves.** These impair the construction and maintenance of port infrastructure by shortening and restricting work conditions. The cooling equipment of reefer transport is subject to additional loads on the electric grid and supporting power generation systems. Heat stress can negatively impact port infrastructure, such as the softening of pavement, which can then be substantially damaged by yard equipment, such as straddle carriers.
- **Rising sea levels.** In areas near ports, transport operations can be impaired by the temporary flooding of infrastructures accessing port facilities. Port terminals can also be flooded, damaging equipment and disrupting operations.
- **Increase in intense precipitation events.** These can damage transport infrastructure through flooding, disrupt maritime shipping operations, and cause delays.
- **Increasing hurricane intensity.** Due to higher humidity, the expectation is that hurricanes will release more rainfall and that their average intensity will increase. However, these expectations have not materialized, and the frequency and intensity of hurricanes have decreased since 1990 (Klotzbach, P. J. et al, 2022). Hurricanes impose substantial disruptions on port operations, including maritime shipping. The impacts are not confined to a single port but may affect a series of ports along the path of a hurricane, which varies in intensity as it evolves. For cruise operations in the Caribbean and elsewhere, hurricanes result in itineraries being changed. Very strong winds can topple container stacks and port equipment, such as cranes. The accumulation of debris can delay operations and add to maintenance costs.
- **Increase in Arctic temperatures.** The receding ice cover over the Arctic may extend the shipping season in the region. There is also the potential to use shorter Arctic shipping routes, shortening maritime shipping distances within the Northern Hemisphere.

Figure 30: Climate change potential impacts on maritime transport

	Operations	Infrastructures
Heat waves	• Limits on periods of construction activity. • More energy for reefer transportation and storage.	• Thermal expansion of piers. • Pavement integrity and softening. • Deformation of rail tracks.
Rising sea levels	• Frequent interruptions of coastal low-lying road and rail due to storm surges. • Flooding of terminal areas.	• More frequent flooding of infrastructure (and potential damage) in low lying areas. • Erosion of infrastructure support. • Changes in harbor facilities to accommodate higher tides and surges.
Intensity of precipitation	• Increase in weather related delays and disruptions.	
Increasing hurricane intensity	• Topple of container stacks and port equipment. • Debris on port infrastructure.	• Greater probability of infrastructure failure. • Greater damage to port infrastructures. • More significant flooding on hinterland infrastructures.
Increase in arctic temperatures	• Longer shipping season. • More ice-free ports in northern regions. • Availability of trans-arctic shipping routes.	• Damage to infrastructure because of the thawing of the permafrost.

Source: Adapted from National Research Council (2008).

Climate change can also affect the hinterland connectivity of ports. For example, climate change is expected to result in significant water level fluctuations on key inland waterways, e.g. the Rhine in Europe or the Yangtze in China. Extended periods of extremely low water levels jeopardize the continuity of inland barge service operations and negatively affect the utilization of inland vessels. In such cases, vessels have to sail below their actual loading capacity to restrict their draft. A similar risk has been observed in the Great Lakes system with a potential trend of higher levels of water fluctuation, with periods of lower-than-average water levels intermixed with periods of higher-than-average water levels. Navigation and shipping capacity become more challenging to plan which, in turn, has a knock-on effect on investments on new ships and equipment investments.

1.5 Accidents

Anthropogenic disruptions are related to human activities, particularly managerial and operational errors and labour-related disruptions. Accidents at terminal facilities can be disruptive, but the large majority have a limited impact on total capacity. For instance, a container could be mishandled in a yard, and its contents could be damaged, as can the equipment handling it, such as a reach stacker. **Ship maneuvering** errors have damaged piers and even toppled cranes, resulting in the loss of terminal capacity and costly repairs. Infrastructure and equipment failures can create sporadic disruptions but can be mitigated with predictive maintenance and operational safety.

Another risk concerns **accidents in the access channel** that could result in a partial or complete blockage of the port terminal facilities or transoceanic passages. The blockage of transoceanic passages is rare but can have important ramifications due to the cascading effects it creates along supply chains. For instance, the closure of the Suez Canal between 1967 and 1975 because of the conflicts between Israel and Egypt led to substantial disruptions in the shipping industry due to deviations via the Cape Route. In 2021, the Suez Canal was blocked for one week when the ultra-large containership Ever Given ran aground, causing disruptions on Europe-Asia trade routes and associated supply chains. Unintentional vessel groundings can have a wide range of causes, but navigation errors remain the most important.

Ports with a long and relatively **narrow access channel** are particularly at risk of blockage. In the worst-case scenario, an accident or incident on the access route can result in a full or partial **port blockage**. The potential impact of a port blockage varies from port to port as options may be available. The direct effect of a blocked entrance is that maritime traffic cannot enter the port for the duration of the blockage is removed or the lock repaired. This would mean that normal maritime-related activities would halt for at least a couple of days, and perhaps months. A significant share of all directly employed personnel involved in dock labour would become technically unemployed. Logistics companies located in the port would suffer as their main modal transfer point would no longer be available, forcing them to secure more costly transportation options. Relocation could become an option in such cases.

As the size of ships continues to increase, pilots have less margin for errors. Nautical authorities have worked out stringent conditions for large ships entering a port or navigation channels to avoid any accident risk as much as possible. Ship simulators can evaluate the risks associated with accommodating specific ship sizes in navigation channels and ports. A **trial call** of a ship provides empirical verification of the simulation results, and a basis for clearance of the respective ship size and class. The occurrence of a risk is substantially reduced through the observance of traffic rules and separation schemes, port traffic control, and the use of experienced pilots. However, a catastrophic failure always remains a possibility, even if the chance of it occurring is slim. The risk of accidents and port blockage can further be reduced by providing multiple access ways, such as more locks.

The most disruptive events are linked with the use of the port as a **storage facility for hazardous goods**, such as chemicals and explosives. The Tianjin and Beirut port explosions of 2015 and 2020, respectively, illustrate the massive damage, loss of life and disruptions a port industrial accident can generate. Both events resulted from a fire that set off an explosion in stockpiled explosives and chemicals. While Tianjin was able to quickly resume operations because the explosion took place in the backport area, the Beirut explosion destroyed and severely damaged multiple piers and storage facilities.

Many ports across the world are home to a range of industrial activities, such as chemical and petrochemical clusters, steel plants and automotive assembly plants. These industrial clusters can be the source of **major industrial disasters** ranging from a local fire, accident or explosion to a large chemical spill affecting the entire port. A remote possibility exists for nuclear contamination as many nuclear plants are located in or near port areas. The impact of an industrial disaster depends on its nature. For example, an isolated fire could lay waste to a chemical plant and cause temporary problems for surrounding companies but would have no major effect on port operations (See case studies on Suez Canal Blockage and Tianjin Explosion in PART III).

1.6 Geopolitical events

Geopolitical events, particularly conflicts, represent acute disruptions for the ports involved. As a result of conflicts, port infrastructure can be damaged, pillaged and unmaintained; this would undermine its capacity to support basic demand for essential goods. A facility could become inoperable because of **security considerations** for the cargo and the workforce. Managers and workers could have fled and shipping lines could refuse to call on a facility. Following the Arab Spring of 2011, several countries in North Africa and the Middle East faced social turmoil and, in some cases, degenerated into civil war. Port activity in Libyan ports (Tripoli and Benghazi), Syria (Tartus, Latakia) and Yemen (Aden) has collapsed and barely recovered since then. In the case of civil unrest, ports can become the focus of relief efforts where international aid arrives, which creates a unique set of challenges as populations converge towards port facilities.

Economic embargos can equally have adverse effects on port activity in both the country subject to sanctions and the ports of its trade partners. Iranian ports have been impacted by successive waves of sanctions set in the wake of the Iranian Revolution in 1979. The case of Venezuela is also illustrative as economic policy and associated massive decline in economic activity since 2015 have undermined port volumes, as occurred in the leading national ports of Puerto Cabello and La Guaira. In 2022, the Russian invasion of Ukraine resulted in international sanctions curtailing its port activities, and seversal strategic resources, such as energy (petroleum and natural gas), fertilizers and wheat.

1.7 Labour issues

Labour disputes resulting in strikes can hamper port and terminal operations and even result in de facto port or terminal blockages. Labour unions are typically very visible in port contexts, although major differences in union power can be observed across seaports and countries. Labor unions (representing dockworkers and pilots) initiate most port strikes, often disagreeing with: (i) planned port reform schemes; (ii) nautical service provision reforms; (iii) wage levels and remuneration; and (iv) overall working conditions and arrangements forming part of collective bargaining agreement negotiations. The 2002 port strikes involving 29 ports on the American West Coast, were highly disruptive events for transpacific trade and a key contributing factor for the further expansion of all-water routes to the East Coast through the Panama Canal by maritime shipping lines. This shift was an important factor in the decision to expand the Panama Canal, which was finally achieved in 2016.

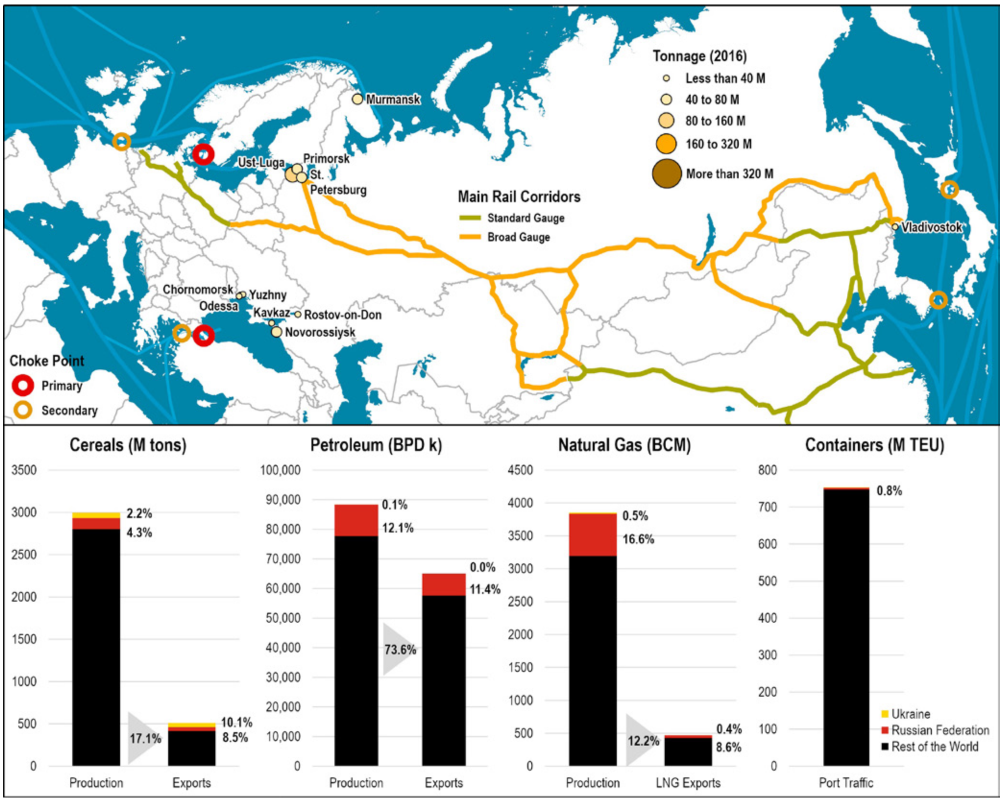
Terminal automation can also be a source of labour unrest. For example, the new APM terminal development at Maasvlakte 2 in Rotterdam faced strong opposition from local labour unions as they feared the possible loss of jobs and lower wages as the work conducted by quay crane drivers was transferred to remote operators of automated quay cranes.

When a strike lasts several days or even weeks, the disruptions can spread to neighbouring ports as many ships head to other terminals. Ports affected by regular and extended strikes can incur major **reputational damage** and a **loss of trust** among market players. The impacts can be far-reaching and can lead to, for example, structural shifts of cargo volumes to rival ports, as well as sharp decline in port investments by international companies. The risk of strikes can be reduced by structures allowing a **social dialogue** between workers and management, and effective management of stakeholder relations. Social dialogue through effective joint consultation bodies is considered key to a sustainable relationship between employers and labour unions. When industrial relations are good, labour unions can contribute to enhancing the service provision process and labour productivity. Unions can help dock workers and nautical staff participate effectively in improving performance by critiquing existing work methods, resulting in a safer working environment. A climate of constructive dialogue enhances social peace in ports.

Box 2. Conflict in the Black Sea

The Russian Federation-Ukraine conflict has further exposed the vulnerability of the global maritime supply chain to shocks and disruptions. While Russia and Ukraine account for relatively small shares of world trade and output, they are important suppliers of food and energy, among other inputs, into industrial value chains (figure 31). The conflict has complex and difficult to predict ramifications on global supply chains, as it is often only possible to determine which supply chains had been the most impacted after the event.

Figure 31: Russian Federation and Ukraine – Transport networks and contribution to global trade



Source: Based on data from FAO, the BP Statistical Review of World Energy July 2021, and J.P. Rodrigue, Global Container Port Database.

Maritime grains export from Ukraine dipped by 95 per cent in March 2022, while exports from Russia declined by over 10 per cent. Major grain importers have been trying to secure alternative sources, which involves new import routes. For example, while Egypt's maritime grain imports from Ukraine slumped by 97 per cent between February and March 2022, their imports from the United States increased by over nine times during this period.[3] This can have an impact on both the deployment of bulk ships and the capacity of the shipping industry to handle these sudden shifts. Existing grain supplies from Ukraine could not be exported as the country's ports are closed due to the war. Vessel calls at Ukrainian ports fell by more than 90 per cent immediately after the start of the war. A 20 per cent fall was recorded in vessel calls at Russian ports. Already expensive and over-stretched maritime trade will find it difficult to substitute for the unviable land and air routes. In 2021, 1.5 million ocean containers of cargo were shipped by rail west from China to Europe. If volumes currently using the container rail would be added to the Asia-Europe ocean freight demand this would mean an increase in an already congested trade. The implications for freight rates are significant due to higher fuel costs, re-routing efforts and limited capacity in maritime logistics. By raising food and fuel prices, the conflict is already accelerating inflation in many countries, with adverse distributional impacts among the poorest segments of populations who tend to spend a disproportionately high share of their income on food and energy. At the same time, fuel and food-import dependent countries will experience deteriorations in their balance of payments and exchange rate pressure.

Source: UNCTAD (2022).

[3] UNCTAD calculation based on Sea/analytics data, www.sea.live

1.8 Information technologies

The diffusion of IT for communication, managerial and operational considerations has pervaded the maritime industry. Even if the industry tended to be paper-intensive, the COVID-19 pandemic presented an urgent opportunity to digitalize transactions. However, the concurrent growing level of digitization and reliance on information systems has opened **opportunities for cyber-related disruptions at ports**.

Ports and the maritime industry have been increasingly targeted, with cyberattacks growth rates in triple digits since 2017. The causes of cybersecurity breaches can be intentional or unintentional, such as employee error (e.g. losing a laptop or a storage device retrieved by others, see (figure 32). The consequences of such developments are multidimensional and range from data theft to operational disruptions impacting carriers and cargo owners.

Cyberattacks are undertaken by a variety of agents guided by their own motivations and objectives. The core motivation remains **financial gains** and increasingly undertaken by specialized criminal groups.

The use of ransomware is on the rise (box 3); this involves emails which aim to trick at least one recipient within an organization to open an attachment or an embedded link. Once this happens, the malware is activated and propagates through the internal network and infects as many computers as possible. In the case of ransomware, files on infected computers are encrypted, leaving the system unable to function; a message then appears that offers decryption if a payment is made to a specific cryptocurrency wallet.

Other emerging forms of cyberattacks are by activist groups trying to disrupt the IT system of a target organization. This can involve denial of service (DoS) attacks in which a server is overwhelmed with multiple requests. In this case, the motivations are not solely financial, but also aim to damage an organization's reputation and disrupt its operations. Since cyberattacks continue to evolve in nature, an organization must continuously adapt to new threats, train personnel, and upgrade its IT systems.

Figure 32: Main sources of cyberattacks

	Motivations	Objectives
Nation States	• Political gain. • Financial and commercial gain. • Commercial and industrial espionage. • Smuggling.	• Gaining intelligence and information. • Economic and infrastructure disruptions. • Market advantage to national firms.
Criminal Groups	• Financial gain. • Commercial and industrial espionage. • Fraud. • Smuggling.	• Selling or ransoming stolen data. • Ransoming system operability. • Arranging fraudulent transactions. • Gathering intelligence for crimes.
Insiders	• Revenge. • Unintentional.	• Seek retribution through harm. • While performing work.
Activists	• Reputational damage. • Disrupting of operations.	• Media and public attention. • Denial of service.
Terrorist Groups	• Ideological motivations. • Political goals.	• Disruption or destruction. • Media attention and political influence. • Financial gains to support activities.

Source: Adapted from IAPH (2021).

Box 3. Petya ransomware cyber-attack on Maersk

In the Summer of 2017, a cyber-attack using "Petya" ransomware affected the Maersk group. Maersk contained the attack but had to shut down multiple systems to prevent the malware from spreading. For a short while, Maersk Line was unable to accept new electronic bookings on its own systems. Its APM terminals division suffered from the effects of the attack at 17 port terminals worldwide, including shutdowns or severe slowdowns for cargo operations at Nhava Sheva (JNPT), Rotterdam, Mobile, Alabama, Port Elizabeth and the Port of Los Angeles. Some terminals had to reserve extra storage space for export containers that were temporarily stranded by APM's inability to access booking data. The event sent shock waves through the supply chain, causing all parties to re-evaluate their cybersecurity defenses.

Source: Notteboom T. et al (2022).

1.9 Economic and financial

A category of disruptions is associated with the multiple demands made on ports, implying that port activity is largely reliant on **external demand factors** largely outside its control. **Economic and political shocks** can indirectly disrupt port activities by impacting cargo demand. For instance, the financial crisis of 2008–2009 was associated with substantial declines in port activity in several regions of the world. Ports at Los Angeles and Long Beach took almost a decade for the traffic to recover to pre-crisis levels. For large ports, such economic disruptions can result in reduced traffic that can reach millions of TEUs over the years. If infrastructure investments were made years prior to the economic disruption, a port could face enduring overcapacity that may test its **financial resilience**.

Since future traffic expectations are important factors in terminal concessions and infrastructure investments, the **lack of return on investments** can undermine the viability of ports and maritime shipping. For instance, in 2016 the world's seventh-largest carrier, Hanjin, was forced which was forced to cease operations as it went into bankruptcy; this occurred at a time when the market was already in a situation of overcapacity, with most shipping lines posting negative returns.

Ports evolving in highly volatile markets are subject to constant and random traffic fluctuations. For example, some ports, e.g. the Argentinian port of Buenos Aires, have seen limited growth over the last 20 years, and fluctuations in the traffic they handle. More recently, inflationary trends, particularly in energy and commodity prices, are threatening global economic and political stability.

1.10 Sanitary threats

Ports have a long history of sanitary threats as they represent gateways to the intercontinental flows of people. As passengers can spend several days on a ship, there is ample time for a disease to be transmitted and noticed. If many cases are present on a ship, **quarantine measures** are implemented, effectively isolating the ship until the infection would run its course. The growth of international air travel from the 1960s, particularly jet planes, has shifted concerns about sanitary threats away from ports.

However, local sanitary risks have been recurrent in ports, and have disrupted their workforce. Port workers were also impacted each time an epidemic or pandemic occurred. New threats have emerged with the **growth of cruise shipping** and the growing number of passengers spending time at ports and on cruise ships. The most frequently reported cruise ship outbreaks involve respiratory infections (e.g. influenza), gastrointestinal infections (e.g. norovirus), and vaccine-preventable diseases (e.g. varicella, measles, chickenpox).[4]

When the COVID-19 pandemic began in early 2020, the first cases of infection reported outside China were on cruise ships calling at Chinese ports. In February 2020, the Diamond Princess, operated by Princess Cruises, was reported to be the first cruise ship to be impacted by the COVID-19 pandemic. Quarantine measures were implemented at ports where ships were allowed to dock. Later, as the cruise industry was shut down, concerns rapidly shifted to port workers who judged to be **essential workers** and needed to maintain supply chains. Sanitary measures, such as protective equipment, were implemented to keep the workforce operating in safe conditions.

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4 Center for Disease Control (CDC). Cruise Ship Travel. https://wwwnc.cdc.gov/travel/page/cruise-ship.

2. KEY MITIGATION AND RESPONSE MEASURES TO PORT DISRUPTIONS

Nine general realms of engagement can be considered to improve port resilience to a wide range of disruptions (figure 33).

2.1 Port risk and crisis management

From a managerial perspective, port resilience mitigation comes in two categories; those related to **port risk management** (pre-event) and those related to **port disruption/crisis management** (post-event) (figure 34).

Port risk management is proactive and tries to prepare for the eventuality of a risk before an event happens. It adopts a dynamic, integrated and value-driven approach to build resilience in organizations, which goes beyond identifying, assessing, and evaluating threats or even opportunities. It also enhances the organizational resilience value proposition and integration in multiple hierarchies and departments, learning from successes and failures.

According to the Institute of Risk Management, the main components include:

- Horizon scanning (HS);
- Information security;
- Communications and liaison;
- Planning and coordination;
- Training and exercises; and
- Continuous improvement.

Port disruption/crisis management is reactive and implemented at the onset of a disruption where the managerial, labour and physical resources are mobilized. The main components include:

- Incident response;
- Business continuity;
- Recovery; and
- Crisis communication.

Production recapture is the ultimate goal of port crisis management, as it aims to ensure that operational capabilities are able resume according to pre-event standards. To clear the accumulated backlog from a disruption, ports can make up by handling more cargo once they become operational after the event, which is possible if the event is of short duration (hours to a few days). Port crisis management may require substantial labour and managerial effort, and coordination with hinterland transportation.

2.2 Contingency planning

Preparedness involves the positioning of equipment, parts and material to replace or repair damaged facilities (due to breakdowns, accidents or natural hazards). It represents a **buffer stock** of a whole range of inputs used for port operation. It also identifies **essential personnel** that need to be available to operate the terminal and repair damaged infrastructure and equipment.

Figure 33: Key mitigation and response measures to port disruptions

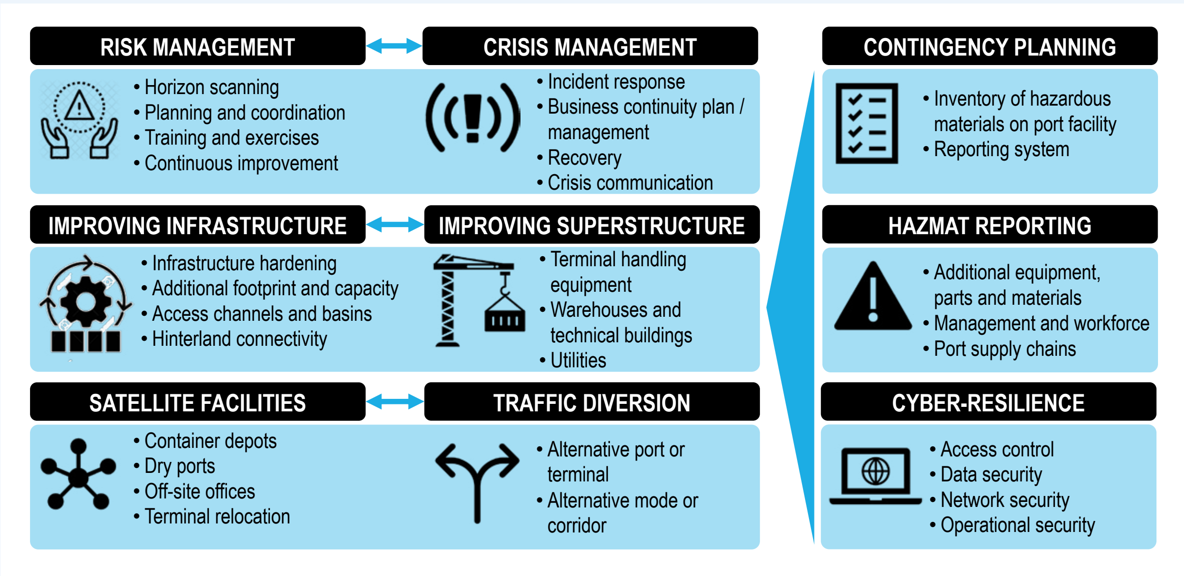
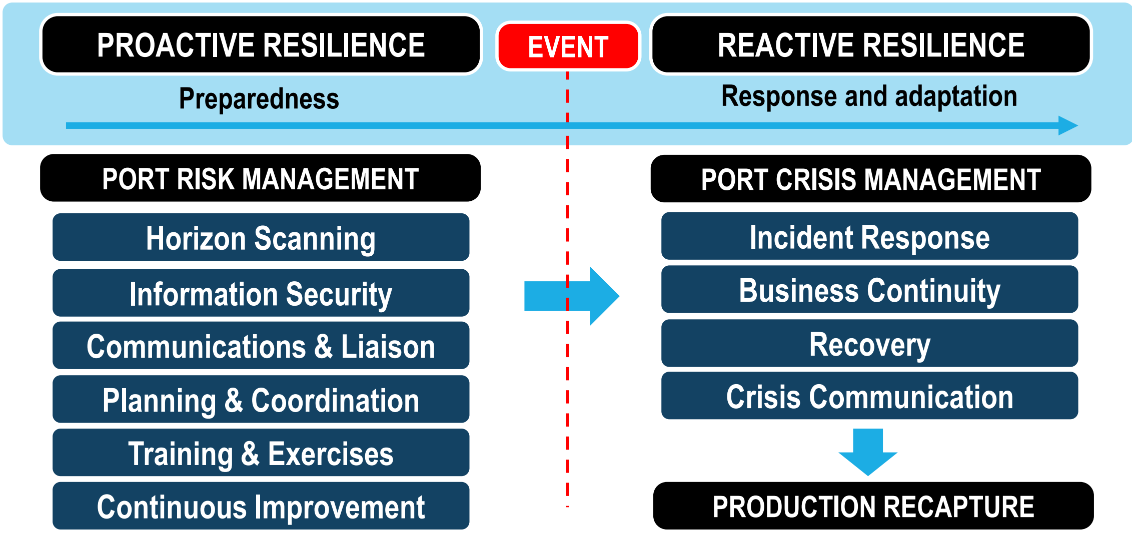


Figure 34: Proactive and reactive approaches to port risk mitigation and resilience-building



Source: Adapted from the Institute of Risk Management (2020).

Preparedness improves the restorative capacity of a port terminal at the cost of duplication (i.e. more parts and equipment are available than necessary for standard operations) and higher inventory costs. The critical challenge is to assess the quantity of buffer stocks to store in case of potential risks and disruptions, and to build redundancy in operations and infrastructure.

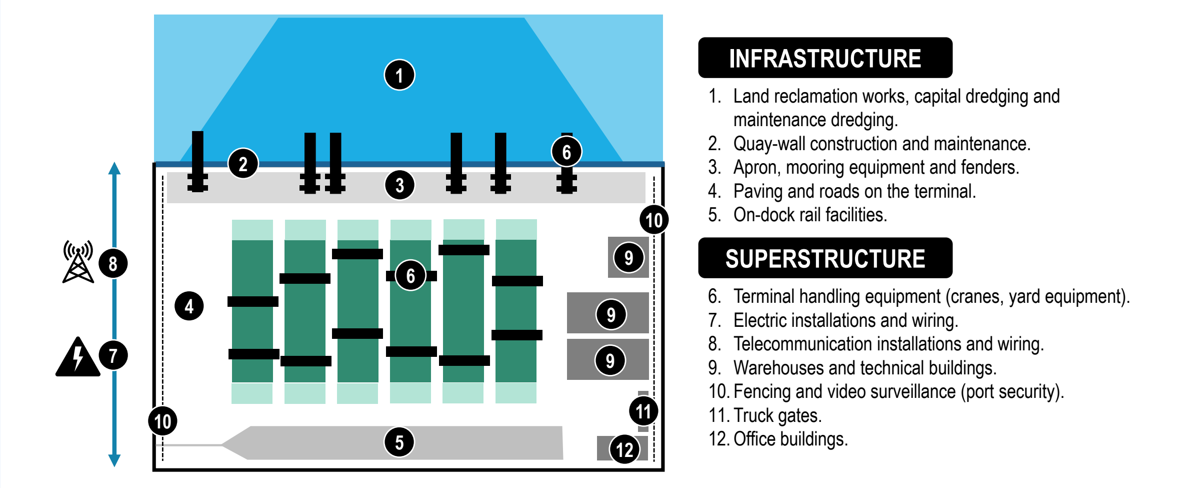
2.3 Improving port infrastructure and superstructure

Physical port resilience allows withstanding natural hazards, e.g. earthquakes and anthropogenic risks, from accidents or hazardous materials. Existing infrastructure and superstructure can be **hardened** with design features capable of withstanding physical damage resulting from natural hazards, e.g. extreme weather events and earthquakes (figure 35).

The main infrastructure and superstructure components that can be hardened include:

- **Land reclamation works.** Ensuring that the terminal facility is on stable foundations that are less vulnerable to erosion and landslides. This includes breakwaters able to protect the port from current and tidal effects.
- **Dredging of access channels and basins.** Ensuring that the nautical profile of the port can accommodate a diversity of ship sizes and classes. Having an access channel less vulnerable to blockage.
- **Quay-wall construction and maintenance.** Ensuring that quay walls can handle additional tidal, seismic stresses and small collisions.
- **Apron, mooring equipment and fenders.** Ensuring that the dock can moor and secure ships under stressful conditions (e.g. high wind, tides).
- **Terminal handling equipment.** Ensuring that terminal equipment, such as ship-to-shore cranes, gantry cranes, and yard equipment, can withstand expected natural hazards and can be repaired quickly in case of damage, breakage or failure. Availability of equipment (and work shifts) to handle demand surges.
- **Electric installations and wiring.** Strengthening of the electric distribution system, particularly towards crucial equipment and facilities. Setting auxiliary power generation.
- **Telecommunication installations and wiring.** Strengthening of the wired and wireless telecommunication system. Installation of a backup telecommunication system.
- **Paving of the terminal.** Ensuring a hardened well-drained terminal surface, particularly yard areas.
- **On-terminal rail facilities** (if present). Ensure rail yards and spurs can withstand expected natural hazards.

Figure 35: **Strengthening of port terminal infrastructure and superstructure**



Source: T. Notteboom et al (2022).

- **Roads on the terminal.** Ensuring that areas across the terminal remain accessible and that alternate routes are available.
- **Warehouses and technical buildings.** Ensuring that buildings can withstand a range of expected natural hazards.
- **Fencing and video surveillance.** Ensuring that the port perimeter remains a secure facility with controlled access.
- **Truck gates and inspection.** Ensuring that terminal access for drayage, supplies and the workforce remains available, including alternate access points.
- **Office buildings.** Ensuring that buildings can withstand a range of expected natural hazards and that they are able to provide on-site business continuity for management and the workforce.

As an outcome, **robustness** is improved, and infrastructure and superstructure are less susceptible to damage from high winds, flooding, storm surges, flying debris or tremors. Existing infrastructure and superstructure need to be **stress-tested** to see if they can withstand stress levels associated with a range of expected natural hazards. This can also include simulations where the facility and its equipment are submitted to exceptional circumstances. These results would shed light on the condition of a particular infrastructure (or superstructure) if it were to experience stress, particularly if it remains operational. As some infrastructure and superstructures are already designed to meet industry and regulatory standards, it is necessary to ensure that this remains the case, particularly as they age.

2.4 Satellite facilities

Ports can on occasion be subject to demand surges or pressures to increase their throughput by handling more cargo during a port call. This is particularly the case when a new container ship class is introduced along a route, obliging ports to adjust to the changes created from the greater volumes of cargo handled per port call. **Container depots** and **inland terminals** support port operations, relieve congestion, and offer a buffer to accommodate volatility. They also provide a real estate footprint that partially transfers selected port operations, particularly storage and some logistical activities (e.g. stuffing and de-stuffing), to another site.

The **relocation of terminal facilities** to lower-risk areas represents the most drastic mitigation strategy. It can be done preemptively when there are capacity restrictions, and an existing site is assessed to be of high risk. It can also occur when a terminal has been damaged to the extent that repairs are not cost-effective, so shutting a terminal down becomes an alternative. A new site is selected at a location that is assessed as more resilient and less prone to disruptions.

Satellite facilities can also involve administrative functions. Off-site office facilities can be set to accommodate an additional managerial workforce; they can also offer a work space for management to operate if the on-terminal office facilities are forced to close temporarily.

2.5 Traffic diversion

Mitigation strategies can also incorporate traffic diversion strategies which take into account the closure of certain parts of a port, e.g. a specific terminal or an access corridor. This can involve **contingencies** to use different terminals within the port if a disruption is only partial. For hinterland access, this can involve an **alternative mode or corridor**. This could result in higher transport costs and delays, but offers an alternative to route supplies.

The ultimate strategy is to consider a **complete traffic diversion** if the port is forced to close for a period because of severe disruptions and infrastructure damage. Short-lived disruptions can, on occasion, mean that a few ships will need to be diverted to an alternative port. Cargo can be diverted to other port(s) if the disruption is more extensive and lasts longer (i.e. more than a week). This will require the re-organization of shipping schedules and hinterland services. However, this comes with the risk that the diversion will promote a competing port that could retain the traffic once the disruption is over.

This approach may require more collaboration between port authorities and terminal operators. For instance, in case of disruption a share of a terminal's capacity could be made available to another terminal on a reciprocal basis. Collaboration between terminal operators within the same port and in neighbouring countries could also support resilience-building. For example, by adopting mutual support agreements among terminals. Encouraging regional port cooperation across countries can also help port resilience. When an individual port is down, the solution could be the use of regional port and/or overland transport networks.

2.6 Hazmat reporting

To avoid industrial accidents, regulations covering hazardous materials need to be rigorously enforced. However, **industrial accidents** often occur not because regulations are not followed but because authorities are unaware of the nature, extent and conditions in which hazardous materials are stored within port facilities. Therefore, such regulations cannot be effective without a reporting and accounting system.

2.7 Cyber-resilience

Cyber-resilience represents a separate category of mitigation strategies due to the unique nature of the potential disruption, affecting the IT layer of port management and operations (box 4). Information technologies and related security risks raise significant risks for ports and their partners in the logistics chain, particularly as they have extensive exposure to these technologies and have increasingly moving towards digitalization.

The integrity of an organization's information system is supported by the following cyber-resilience concepts (figure 36):

- **Access control.** The range of strategies controlling and regulating access to an organization's IT network. The most fundamental relates to how the network is accessed by using credentials, e.g. usernames and passwords. In addition, the roles and what information users can access are subject to close management to ensure that privileges are removed if a user leaves the organization or is assigned another function. Stricter conventions on the selection of passwords are now required; these now need to be more complex and include special characters to avoid brute force password attacks. For highly sensitive information, or if a user accesses the system from a new (remote) location, two-factor authentication is becoming the norm.
- **Data security.** The range of strategies used to regulate the integrity of the information stored by an organization. Encrypting data and its transmission has become the norm to avoid breaches. Furthermore, corporate data needs to be classified by level of importance and sensitivity and stored accordingly. Key strategic information should be stored in systems only accessible through internal networks and through highly secure connections. Removable media, such as UBS storage drives, but also laptops and portable devices, needs to be restricted as they represent security risks if lost or stolen. Additionally, old IT equipment, particularly the hard disk drives of computers, need to be disposed of appropriately. A common practice is to wipe or physically destroy any storage device that has been earmarked for disposal. The software and the hardware processing the data can also be tampered with, implying that their integrity needs to be verified on a regular basis.

- **Network security.** Involves the deployment of a range of strategies to protect the integrity of an organizational IT network. An IT network can be segmented in such a manner that the administrative network is separated from the network supporting operations. Network redundancy can improve cyber resilience. Firewalls have become standards and allow monitoring of all inbound and outbound traffic between a network and the outside; virtual private networks (VPN) can also be used for outside access. IT systems also require a form of physical protection that can range from locked access for servers and network hubs, and must include a form of protection from hazards, e.g. floods and power outages. An IT network must be protected from malware attacks, which could be used as a propagation tool within an organization's IT infrastructure. Furthermore, the physical components of the network, such as cables and switch boxes, must be hardened against physical damage.
- **Operational security.** The range of strategies to ensure that daily IT operations do not contribute to risks. Software upgrades and patches must be monitored to ensure that each network component has the latest up-to-date version. Information technology networks are constantly probed by hackers, which will require the network to be continuously monitored for vulnerabilities. As an organization's finances can be accessed online, hackers have a strong incentive to make unauthorized transactions. An organization's IT has also to be aware of cultural and intelligence developments in the sector to enable new risks to be identified and mitigated, and ensure that lessons can be learned from events taking place elsewhere.

Box 4. The port of Los Angeles' cyber-resilience centre

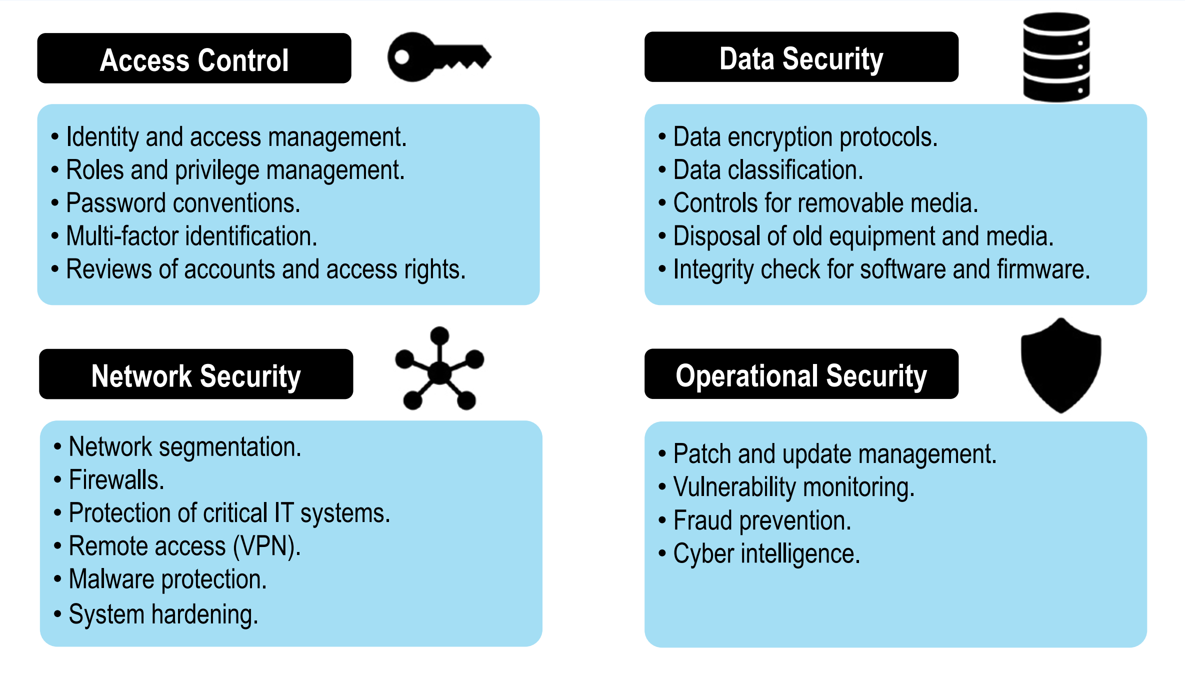
As cybersecurity becomes a more salient threat to the integrity of information systems, port authorities are setting up forms of organizational support. In 2022, the Port of Los Angeles Authority established a Cyber-Resilience Centre (CRC) to act as a "system of systems," whereby port stakeholders using the Port Community System will automatically share cyber threat indicators and deploy common defensive measures. Cyber-threat information is centralized so that there is a lower risk that an attack could be successful. The goal is to create a supply chain of IT integrity through stakeholders handling cargo, e.g. terminal operators, shipping lines, motor carriers and rail carriers (See Case Study 1: Ports of Los Angeles and Long Beach, United States).

Third-party contractors or port suppliers can also be the source of cyber-attacks. Ports need to be aware of these when considering the integration of relevant digital services such as Maritime Single Windows, which offer more efficient and paperless compliance processes at ports but increase cyber exposure.

The industry organization BIMCO issued Guidelines on Cyber Security onboard Ships – fourth version (BIMCO et al, 2021). According to the BIMCO guidelines, enterprises should:

- Identify cybersecurity threats – to the ship, both external and internal, including those posed by inappropriate use and poor cybersecurity practices;
- Identify vulnerabilities of assets within the company;
- Develop inventories of onboard systems with direct and indirect communications links;
- Assess risk exposure and vulnerabilities;
- Develop protection and detection measures;
- Establish response plans, including contingency plans to respond to cyber-risks and tackle the effects of potential attacks on ship safety and security; and
- Respond and recover – from any cyber security incidents using the contingency plan, then report on the effectiveness of the response plan, update it, and reassess threats and vulnerabilities.

Figure 36: **Cyber-resiliency measures for information technologies**



Source: Adapted from IAPH (2021).

BIMCO and other maritime non-governmental organizations (NGOs) have invited public and private stakeholders to help create global digital ISO standards to facilitate the digital exchange of data, particularly given the new urgency of the COVID-19 pandemic and increasing demand.

Other available guidelines include the Digital Container Shipping Association's Implementation Guide for Cyber Security on Vessels v1.0); the recommendation by the International Association for Classification Societies (IACS), and which applies to newbuild ships only but can also serve as guidance for existing ships (IACS, 2020); and the United States National Institute of Standards and Technology (NIST, 2018). While their target audience is the container industry, other shipping segments may also find them helpful. Taking account of IMO guidelines and the United States NIST framework, the guidance specifies, for example, that company plans and procedures for cyber-risk management should be incorporated into the existing security and safety risk management requirements contained in the International Safety Management Code (ISM) Code and International Ship and Port Facility Security (ISPS) Code. The British Port Association have issued a national level guide on managing cyber risks (British Ports Association, 2020).

3. PORTS, SHIPPING AND THE COVID-19 PANDEMIC

3.1 The ultimate stress test

A series of divergences between supply and demand was observed during the COVID-19 pandemic, placing maritime shipping and port operations under stress. In the initial stages of the pandemic in 2020, a reduction in demand was mitigated by capacity management in maritime shipping, such as blank sailings and dropping port calls. Shipping lines apply blank sailing or cancel a scheduled port call or a shipping service, mainly due to a lack of demand or to maintain schedule integrity.

The Global Supply Chain Pressure Index (GSCPI) surged in early 2020 and fell back in the Autumn of the same year as China resumed its manufacturing in the second semester of 2020. This return to normality created a divergence as the shipping and port industry could not cope with the surge across several trade lanes. An important driver was a **shift in consumption patterns** in key import markets, particularly in the United States.

While consumers usually spend about 69 per cent of their personal consumption expenditures on services, the pandemic resulted in a drop to around 65 per cent by the second half of 2020, the extra spending going on goods consumption, notably durable goods. This shift was substantial enough to put significant pressure on supply chains. By late 2020, increasing port congestion resulted in the GSCPI surging again, particularly for Los Angeles/Long Beach – a surge aggravated by the blockage of the Suez Canal in March 2021.

The COVID-19 pandemic underlined the crucial importance of maritime shipping as a divergence took place between passenger and freight transport systems. For the port industry, the pandemic created a "perfect storm" of unforeseen consequences in a far-ranging array of sectors. In contrast to conventional disruption in supply and transport chains, the event was **global in scope**, lasted **more than two years**, and comprised a **series of waves and associated disruptions** across **multiple components**, such as demand patterns, manufacturing, maritime and terminal operations and freight distribution. In the port and maritime shipping industry, a series of COVID-19-induced vertical and lateral impacts took place, particularly in the second semester of 2020. A series of propagation and backpropagation mechanisms were set in motion with compounding effects. These were felt differently across the main elements of the maritime shipping system (figure 37).

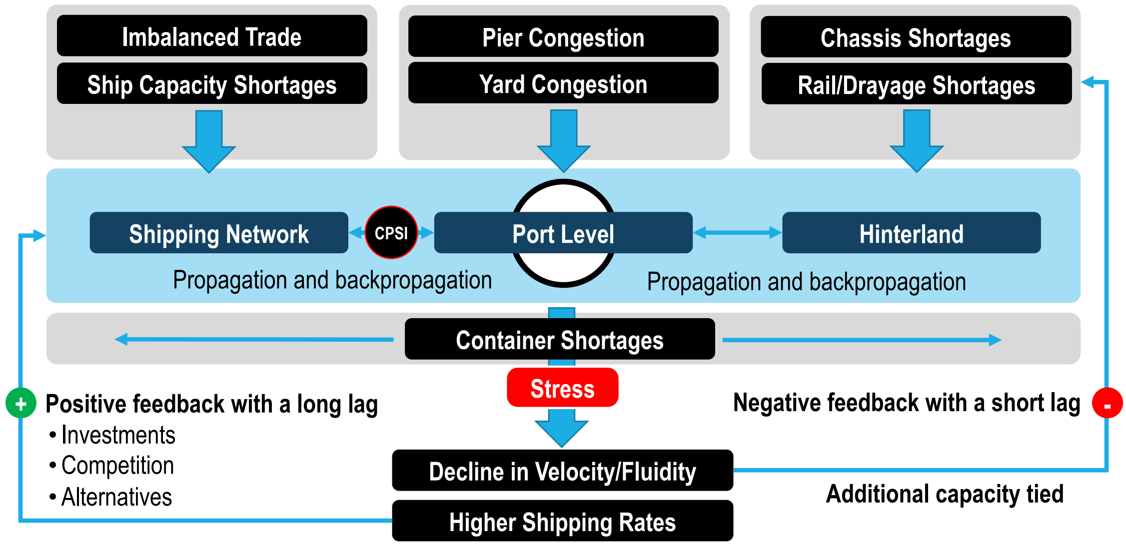
The stress related to the decline in the velocity of container movements gave rise to a **negative feedback** loop occurring over a short time lag. As containers had to spend more time being carried at terminals or inland due to a lack of capacity, whole elements of the transport chain had a reduced velocity and fluidity. More assets were then required to perform the same level of service, which further exacerbated congestion. If a container yard is congested, it restrains a terminal's capacity to handle ships as they cannot be unloaded due to a lack of yard space. Starting in late 2020 until 2022, the case of Los Angeles/Long Beach is illustrative of these mechanisms at play (See Case Study).

The stress imposed on the shipping capacity resulted in a market response through higher rates, providing a **positive feedback loop** that will take more time to realize (i.e. month or years).

These lagging effects, some of which have yet to materialize, include:

- **Improved added value** of the shipping and logistics sectors, leading to better profitability, visibility, capital investment and wages. The COVID-19 pandemic underlined the strategic importance of global supply chains with ports as key nodes. Disruptions were associated with higher rates, resulting in increased profitability for several key ports and maritime shipping lines.
- **Increased competition and innovation** in modes, terminals, distribution centres, processes and ITs. This could involve new entrants with substantial financial capabilities making the strategic decision to invest in own-account maritime shipping. Large retailers, such as Costco, are now chartering ships to transport containers between Asia and North America, and account for 20 per cent of the volume they generate. The purpose is to allow transportation and port infrastructure to continue to maintain a level of service that is better able to handle disruptions.
- **More resilient** supply chains will address the vulnerabilities that became apparent during the COVID-19 pandemic, such as an over-reliance on outsourcing and offshoring. This may lead to a shift in the location where the final product is assembled, also known as "semi knock-down". Parts are sourced to regular suppliers but are carried in higher density (i.e. they are not packaged) to a new assembly point closer to markets. Additional automation levels in manufacturing and material handling are also to be expected, reducing labour inputs, and improving locational flexibility.
- **Investments in transport infrastructure** to expand the capacity, performance, and resilience of supply chains, including ports. Disruptions tend to underline the critical bottlenecks of a transportation system, often providing a renewed focus on improvements and investments.

Figure 37: **Vertical and lateral impacts of disruptions in maritime shipping during the Covid-19 pandemic**



3.2 Shipping network stress

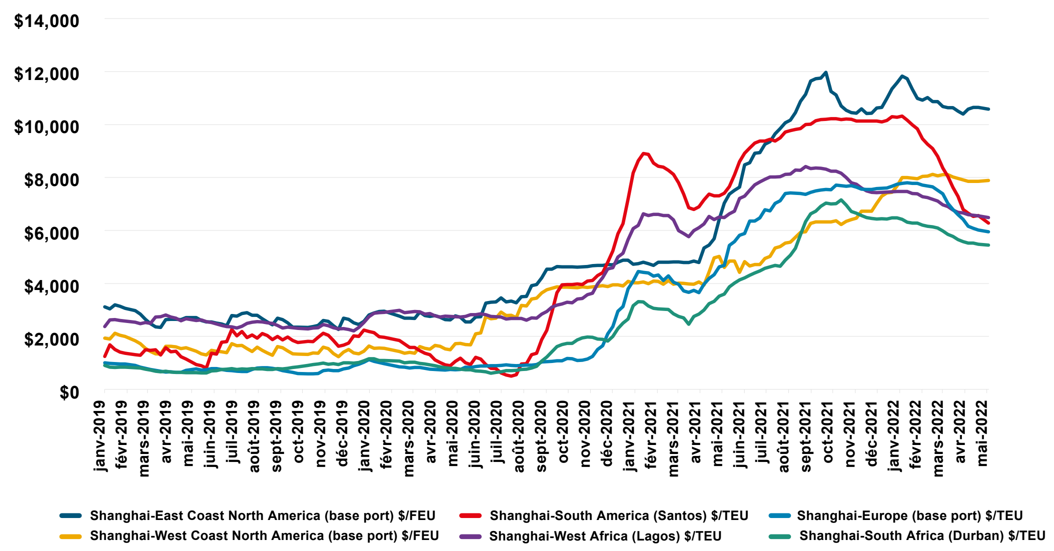
For decades, container shipping has been characterized by imbalanced trade patterns resulting in imbalanced container flows. This implies that about 20 per cent of the containers carried by maritime shipping are being repositioned empty. When COVID-19 lockdowns were being implemented in March 2020, the sudden drop in demand forced shipping lines to curtail capacity with blank sailings. Later in 2020, there was a surge in global demand as Chinese factories were brought back online. Demand patterns in North America and Europe subsequently shifted towards higher quantities of durable household goods.

The shipping industry, which had curtailed capacity, was ill-prepared to keep up with the demand surge, and a delayed response. Even as shipping capacity was fully restored, a decline in velocity due to overshooting demand and port delays resulted in ship capacity shortages contributing to shipping rates surges and empty container shortages.

Figure 38 underlines the stress that maritime shipping has absorbed across the main China/Europe/North America trade routes, in particular with rates surging since the second semester of 2020.

Limited additional shipping and container capacity converged to incite a surge in container shipping rates to historical highs by mid-2021. Under normal circumstances, high shipping rates would provide a strong incentive to create additional capacity and remove marginal demand. However, about 50 per cent of all shipping contracts are long-term rates set below the spot rate, which are often offered to large customers, e.g. retailers, leaving large cargo owners to ship their cargo at a different (lower) rate. The sharp increase in shipping rates prompted shipping lines to renegotiate their contracts and set rates reflecting current market conditions.

Figure 38: Container freight rates between Shanghai and selected markets, 2019–2022



Source: UNCTAD based on Clarkson Research data (2022).

3.3 Port-level stress

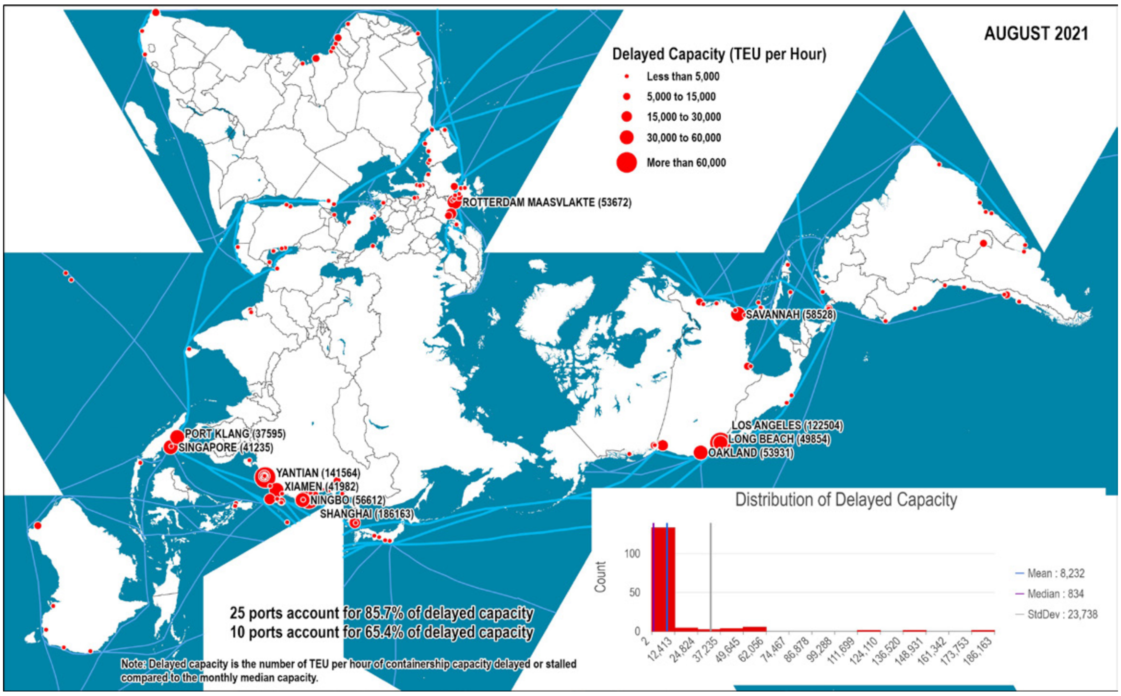
The World Bank is developing a more focused **port-centric stress index**, which considers stalled shipping capacity, and measures the total number of TEU of shipping capacity delayed at ports, resulting from containerships of Panamax size and above operating on main deep-sea services. Under normal circumstances, shipping services have consistent lead times between port calls and turnaround times at port. Notable deviations, resulting in stalled capacity at ports, can then be established through periodic observations of the benchmark of normal performance (figure 39).

Schedule integrity and reliability were substantially impacted by a surge in port delays. COVID-19 lockdowns in a manufacturing area near a port can create substantial disruptions as cargo gets backed up, leading to a destabilizing surge when the lockdown is lifted. By late 2020, pier and yard congestion became more prevalent along the world's main gateway, further reducing the numbers of available containers and the capacity of shipping lines to move containerized cargo. This congestion resulted from a concentration of delays in a limited number of ports.

As of August 2021, 25 ports, mainly located in China and on the West Coast of the United States, accounted for 85.7 per cent of delayed container capacity. Ten ports, including Los Angeles/Long Beach, Ningbo, Savannah, Shanghai and Yantian, and accounted for 65.4 per cent of the delayed capacity, underlining their excessive concentration.

Several container yards were filled at capacity, slowing the processing of ships that could not be unloaded until yard storage space became available. These delays have a strong backpropagation impact on shipping networks as vessels waiting at anchor have cascading effects by removing their capacity while waiting, resulting in additional container shortages and shipping rate surges. This had a bullwhip effect on supply chains. Because of the growing unpredictability of delivery times, elements of the supply chain attempted to increase supplies and the buffer (safety) inventories, which contributed to a demand surge.

Figure 39: Containership delayed capacity in TEU, per hour at port, August 2021



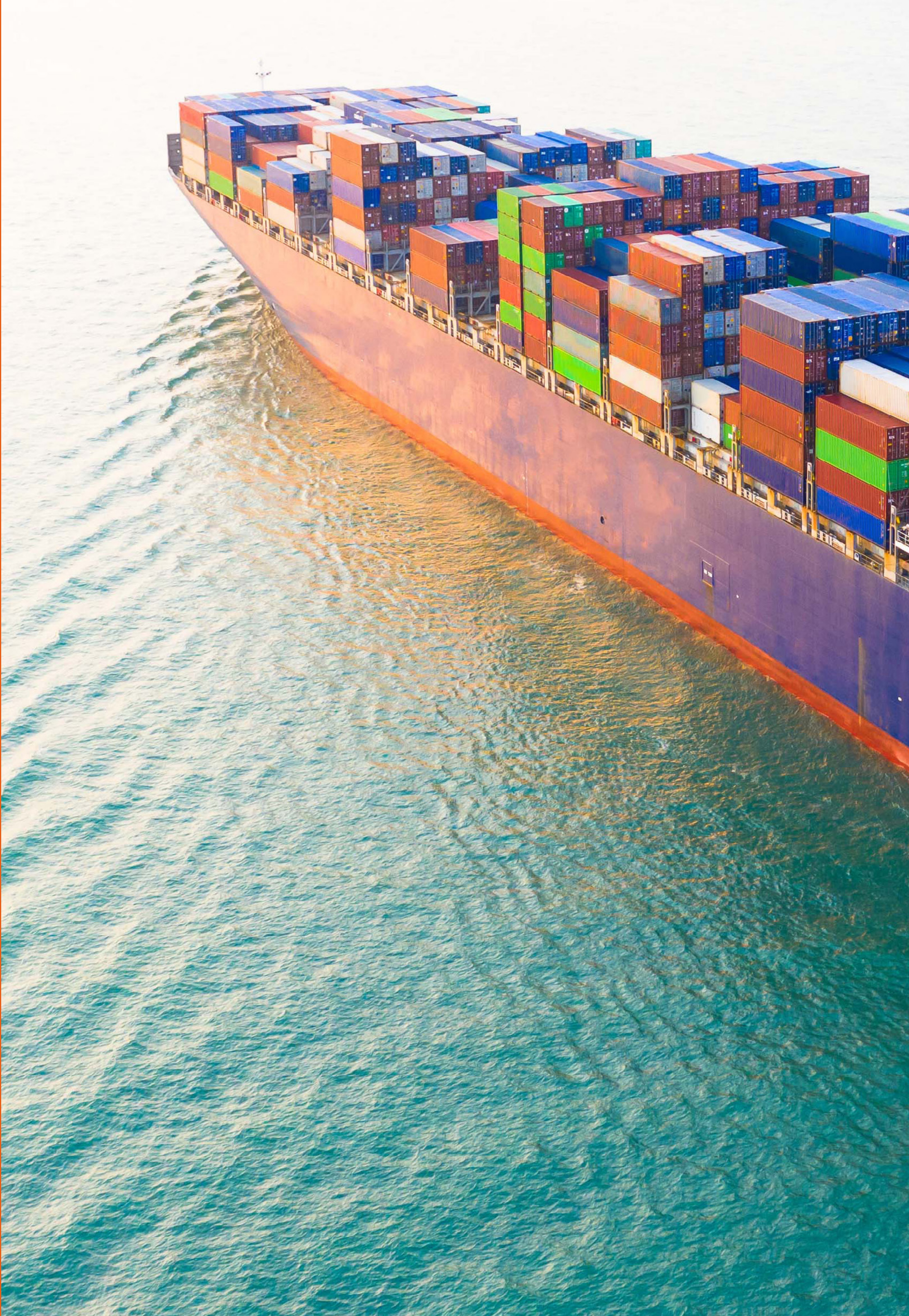
Source: World Bank "Container Port Stress Index" (unpublished).

3.4 Hinterland stress

A port depends extensively on the capacity of its hinterland connections to handle cargo volumes. Port congestion impacts the **availability of hinterland transport assets**, such as drayage and rail. Furthermore, the availability of chassis to transport containers by road could face shortages and reduce capacity, as occurred on the West Coast of the United States. Chassis are also used for container storage at some rail yards and distribution facilities; a shortage of these chassis negatively impacted wheeled intermodal rail yard operations. A decline in the velocity of hinterland transportation ties up chassis assets, further impairing inland transport capacity.

Divergence was also observed between the increasing punctual and flexible requirements of supply chains, such as e-commerce, and the rigidity of a maritime shipping system driven by the economies of scale offered by post-Panamax ships.

Often, the response to this situation has been to increase stocks and order additional quantities as a safeguard; in turn, this creates a backpropagating effect along supply chains, commonly known as the "bullwhip effect". The demand surge effect, in part driven by actual demand, but also the outcome of artificial buffer stocking, stressed shipping resources, particularly containers. Container availability and shortages became the primary propagation and backpropagation mechanism along the maritime transport chain. In this context, containers were spending 20 per cent more time in the transport system with their immobilization on ships, chassis and container yards.



PART III

CASE STUDIES
GOOD PRACTICES AND LESSONS LEARNED

Lessons can be drawn from past events, such as pandemics earthquakes, tsunamis, weather events, floods, accidents, oil spills, fire, storm surges, labour strikes, social unrest, economic disruptions, security incidents, cybersecurity breaches, blockage of maritime passages (e.g. canals), congestions, low water levels and high water levels, etc. This section will identify best practices and potential lessons to be learnt through selected case studies in port disruption, and will do so by focusing on the nature of the event, its causes and impacts and the response provided.

1. PORT DISRUPTIONS ACROSS REGIONS

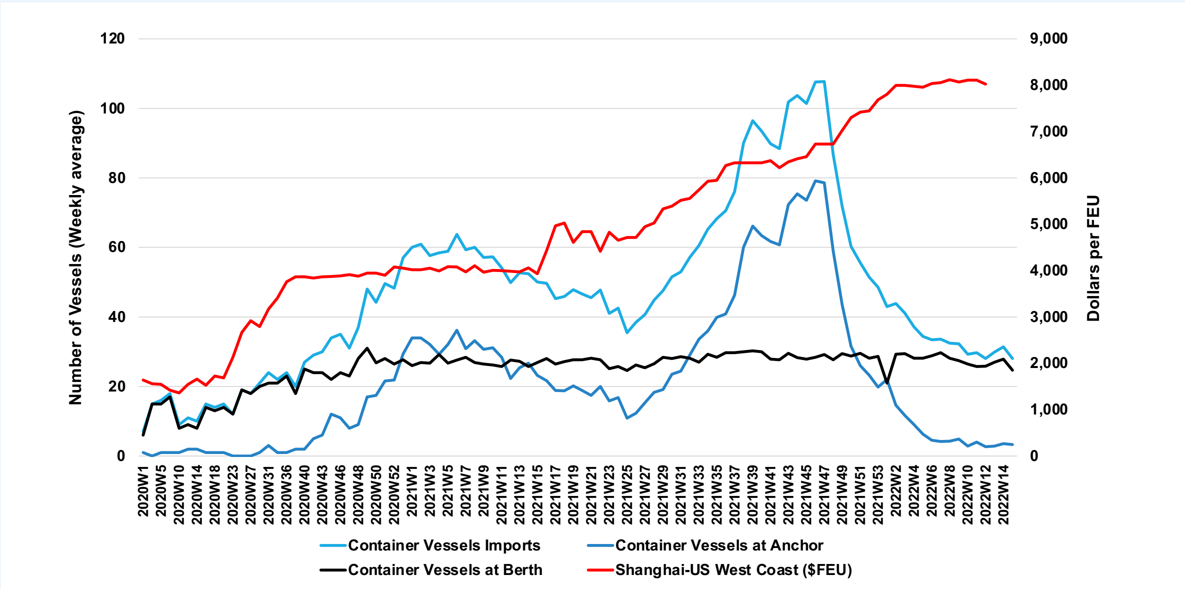
CASE STUDY 1
Ports of Los Angeles and Long Beach, United States

Event: COVID-19 pandemic, 2020–2022

Since the onset of the COVID-19 pandemic in 2020, the ports of Los Angeles and Long Beach have faced severe disruption. From mid-2021, the ports experienced massive logjams of container vessels at anchor, with an average of 30 vessels waiting at any given time (figure 40). The crisis abated slightly between mid-April and the end of July 2021 when the average number of vessels anchored dropped to about ten. In August 2021, this number surged to record levels (60-80 vessels) as congestion resumed, mainly due to the peak import season of the late summer and early Autumn. By the first half 2022, there were signs of a material easing of the congestion and a drop in the average number of days during which vessels remained anchored.[5]

The associated decline in the velocity of containers due to port congestion and the unavailability of containers and chassis compounded propagation and led to a global shortage of containers (Henry P., 2021). Relatively small increases in the traffic resulted in a disproportionate decline in the velocity of containers, resulting in additional rate surges. Workforce shortages and the capacity of inland transport systems, including rail and drayage, also played a significant backpropagation effect. The repositioning of empty containers back to Asia – a priority for shipping lines – had a negative impact on exports.

Figure 40: Containerships inside 25 Miles of Los Angeles/Long Beach (weekly average), 2020–2022



Source: Marine Exchange of Southern California. Freight rates data based on Clarkson Research 2022.

[5] See https://www.portoflosangeles.org/business/supply-chain/ships.

Causes and impact

The disruptive nature of the COVID-19 pandemic is the main factor behind the congestion that occurred in the Port of Los Angeles. The backlog of ships be ginning in mid-October 2020 was amplified by: (i) large fluctuations in import demand supported by stimulus policies which boosted imports and e-commerce demand (Goodman J., 2021); (ii) a rush to replenish stocks and meet demand peaks, reflecting seasonal trends in American retail cycles; (iii) a shortage of skilled employees at the port complex and its hinterland induced by the pandemic and related restrictions (Foroohar R., 2021); (iv) limited spare structural capacity at container terminals; and (v) hinterland bottlenecks with limited railway connections and no-short-sea shipping options (Kundu A., 2021).

With San Pedro Bay handling 40 per cent of the American containerized traffic, the impact on global supply chains progressively cascaded, with ripple effects on next-destination ports and interconnected transport modes. Peak activity period is usually between August and November, and the period of low activity is between January and March. Delays in delivery times were observed across the board. Cost increases, rate increases, extended delays along supply chains, canceled port calls, mostly in developing economies, and goods shortages have also been reported. There was also a negative environmental impact and air quality degradation/pollution due to emissions in port areas. Ships at anchor damaged a pipeline and caused a large oil spill. Subsequently, calls were made for greater regulatory oversight of container shipping and their pricing practices.

Response and mitigation measures[6]

- Expanded port operations hours; strengthened port cooperation (Brunton L., 2021).
- Raised the container stacking height limit on facilities outside the port.
- Large cargo owners chartered their own ships to move goods across the Pacific.
- Government legislation aimed at investing in transport infrastructures, including ports, roads and railroads (Peterson E., 2021).
- Regulatory intervention to ensure fair and transparent shipping practices and rate/charge setting.
- Incentives and deterrents were put in place to reduce the dwelling of containers at port terminals.

Lessons learned and good practice

- **Aligning hinterland capacity** with port capacity and demand peaks can help minimize congestion. This may involve improving short-line rail infrastructure and rail service to the port and promoting collaboration between the public and the private sector owning the rail infrastructure.
- **Short-sea services should be considered,** as deemed appropriate and applicable, to enhance hinterland connectivity.
- **Additional warehousing capacity** should be developed to help solve inland congestion and lack of storage space.
- Speeding up the **flow of containers and chassis** may help to avoid extended dwell times and inefficiencies. For example, apart from providing incentives and deterrents, ports and ocean carriers can agree on a joint strategy to deal with empty containers and ensure their availability to exporters.
- **Efforts** should aim **to enable digitally facilitated real-time coordination** between port and hinterland operators.

CASE STUDY 2
Port of Djibouti, Djibouti

Event: COVID-19 pandemic, 2020–2022

Since 2022, the Port of Djibouti has been facing severe disruption due to the COVID-19 pandemic. The port is key for oil and gas routes and container transshipment towards inland Africa; 95 per cent of foreign trade for Ethiopia and most cargo for Yemen moves through Djibouti. Despite strict social distancing and sanitary measures, the COVID-19 pandemic severely impacted the country and exacerbated: (i) the lack of an available workforce at ports; (ii) hinterland key connecting points; (iii) limited preparedness in health emergencies; and (iv) a general shortage of primary goods.

[6] This section also draws upon Swanson A. (2021).

Causes and impact

The COVID-19 pandemic is the main factor causing the disruption, with several concurrent trends amplifying the problem. These include: (i) torrential rains and flash floods in Spring 2020, aggravating water and sanitation conditions; (ii) limited access to electricity; (iii) a migrant crisis caused by the deportation of Ethiopian citizens from the Arabian Peninsula, transiting through Djibouti, generating social tensions at the port; (iv) Complex port governance resulting from a legal dispute between the port operator and the Government of Djibouti since 2018; and (v) Inefficient hinterland connectivity and lack of infrastructure redundancy, with only one functioning railway line and limited road networks connecting the port to inland destinations.

With the port representing the only access point to primary food and medical goods imports, the impact on regional supply chains has been severe. The COVID-19 pandemic has caused unemployment, inflation and fiscal pressures to increase and investments to decline. Landlocked Ethiopia was also affected. In 2021, the Ethiopian Shipping & Logistics Services Enterprise increased shipping rates by a factor of four compared to the previous year. As a result, goods imports declined, and the economies of both Djibouti and Ethiopia suffered economic losses (Bogale S., 2021).

Response and mitigation measures[7]

Intervention by the United Nations supported the situation by: (i) establishing a Humanitarian Logistics Base with a large storage capacity of food and primary goods (with dry warehousing, temperature-controlled warehousing, cold-chain, silos and a container freight station to facilitate onward movement to further destinations (United Nations, 2020); (ii) facilitation of regional access to crucial logistics services for emergency operations through a UN network of strategically located hubs (Shanghai, Liege, Dubai and Atlanta) and establishing partnerships to fast-track supply chain pipelines (Xu L, 2018); (iii) providing help to local authorities in the field of digital governance to enhance medical goods supply chains; (iv) enhancement of cross-border administrative duties and clearance processes to ensure business continuity; and (v) strengthening of hygiene measures and guidelines across supply chains.

Lessons learned and good practice

- Promote more **efficient terminal design** at the port to help alleviate logistical bottlenecks at ports. An example are the changes to the design of the DP World Doraleh container terminal design, originally built in 2008 and the expansion of the port's infrastructure capacity and yard space. The new configuration allowed for different port access between large vessels and feeders.
- Ensure a **simplified and stable port governance**, reduced bureaucracy, and seek to achieve agreements that can facilitate coordination and collaboration (e.g., agreement between Ethiopia and Djibouti).
- Aim to **cut customs clearance processing** time including by adopting digital solutions.

CASE STUDY 3
Port of Port Said, Egypt

Event: Operational accident/ Canal obstruction, 2021

In March 2021, Port Said faced a one-week disruption caused by the blockage of a large container vessel in the Suez Canal.[8] A Japanese-owned container vessel (Ever Given) with a capacity of over 21,000 TEU blocked the Suez Canal for seven days.

Causes and impact

The large vessel size, as well as a fully loaded ship (high profile to wind), was the main cause of the incident. However, several factors (Safety4Sea, 2021), amplified the disruption, included: (i) poor visibility and high winds due to a sandstorm; (ii) the complexity of rescue operations involving a large vessel in a narrow channel (Yee V., 2021); and (iii) the limited size of the canal, even though it had been widened in 2015.

Maritime traffic passing through the Suez Canal was severely interrupted, with 367 vessels blocked in the canal by the end of the rescue phase (Leonard M., 2021). Not only was the impact on global supply chains significant but Allianz estimated that the container ship blocking the Suez Canal could cost global trade $6-10 billion a week (Gladstone R., 2021).

[7] This section also draws upon UNCTAD (2015).

[8] See Port Said's website at https://www.apmterminals.com/en/port-said/media/news.

Port Said continued to experience congestion for days after the rescue and further congestions were seen in next-destination European ports, mostly Rotterdam and Antwerp, for an additional three months. The shipping industry increased its blank sailings, and some vessels were re-routed via the Cape of Good Hope. As a result, lead times and container shortages increased, while delays in the delivery of goods, especially for semiconductors, worsened. The cost of the rescue operations faced by the state-owned Suez Canal authority totaled $1 billion.

Response and mitigation measures[9]

The prompt cooperation between the government, the canal authority and the shipping industry enabled the rescue operations to last just over a week. Responses to the event included: (i) the re-opening an older section of the Suez Canal to ease the traffic jam in the waterway while rescue operations were on-going; (ii) promptly engaging skilled firms and equipment for salvage operations, in close cooperation with the Canal Authority; and (iii) avoiding further congestions with proper communication with major carriers, which temporarily modified their routes.

Lessons learned and good practice

- Develop and implement **strategic plans to adapt infrastructure and superstructure** capacity so that ports and maritime passages are better prepared to handle the shipping and logistics of today and the future (e.g. ultra-large vessels, autonomous vessels).
- Expand **gate handling capacity** and establish stronger partnerships between ports and carriers to prevent and mitigate risks.
- Investment in **digital solutions**, such as: (i) remote robotic controlling and mooring systems; (ii) automated container operations management; (iii) early warning systems; and (iv) enhanced planning of vessel schedules moving through the Canal.

CASE STUDY 4
Port of Tianjin, China

Event: Safety accident/explosion, 2015

In 2015, the port of Tianjin suffered an explosion that occurred at a warehouse located in the port area. The warehouse building was owned by a privately held company established in 2011, which was authorized by the Tianjin Maritime Safety Administration to handle hazardous chemicals at the port. Its operating licence was renewed only two months before the explosions.

Causes and impact

The presence of 700 tons of highly toxic materials – at least 70 times more than the legal limit – is the main factor behind the accident (Huang P., 2015). Safety regulations requiring that public buildings and facilities should be at least one kilometer away were not respected. Hazardous and toxic materials and gases provoked two initial explosions, which resulted in 2.9 magnitude seismic shockwave, leading to many casualties and injuries. Several concurrent factors amplified the disruption, including: (i) heavy rains right after the accident created harmful chemical foam and pollution, which gave rise to an additional health hazard; and (ii) lack of control and legal enforcement of basic safety regulations stating that hazardous operations had to be located at least one kilometer away from public buildings.

Given the size and importance of the port of Tianjin, the impact of the disruption was severe for both regional and global supply chains. The port and its hinterland were congested for months after the explosion, with the main road accessing the port being temporarily unavailable. Several key port buildings were either destroyed or damaged, public transportation facilities stopped functioning order, and most administrative functions, such as customs and inspection offices, were interrupted. Port operations were disrupted, and 7,500 intermodal containers piled up. The oil and gas industries, LNG imports and steel and iron ore trades were particularly affected. Containerized trade was mostly redirected via air freight, and significant damage to local biodiversity was observed.

[9] This section also draws upon Labrut M. (2021).

Response and mitigation measures[10]

Immediately after the explosion, dangerous cargo operations (mainly liquid bulk and petrol-chemical cargoes) were temporarily banned. Vessels were temporarily allowed to leave but not to enter, and stringent checks of movements in and out of the port were imposed. The overall port planning was also revised, and unaffected sections of the port continued operations. Responses included: (i) stringent checks of movements in and out of the port; (ii) regular risk assessment processes; and (iii) regulatory changes, such as forbidding the use of incinerators in Tianjin port and requiring carriers of hazardous materials to use sealing or other protective measures and ensure that fuel quality is monitored and regularly tested (Japan P&I club, 2018).

Lessons learned and good practice[11]

- Strengthen **port coordination** and transparent communications among business partners and the local community to minimise the negative impact of an incident and backpropagation.
- Enhance **transparency and data availability** to better monitor cargo, including hazardous materials within port facilities.
- Carry out **regular risk assessments** and implications for port activities and the other port-centric industries and services.
- Ensure that **clearer regulations** are in place to prevent and control maritime pollution.

CASE STUDY 5
Port of Ho Chi Minh, Viet Nam

Event: Operational accident, 2019

In October 2019, the Port of Ho Chi Minh faced a disruption caused by an operational accident involving a domestic container vessel carrying about 300 containers that capsized on the Long Tau River. The rescue phase lasted one month.

Causes and impact

An engine malfunction was the main factor causing the accident. Several factors amplified the disruption and associated congestion, including: (i) recurrent severe congestion on the inland routes as the 74 terminals in the delta are all located in the city, causing traffic jams and bottlenecks (Nguyen Hoang P., 2019); (ii) large vessels could not access the port through the estuary area because of water depth, sedimentation and tides restrictions; and (iii) an imbalance in port capacity, with Cat Lai port operating at more than 80 per cent of capacity, with the remaining ports having low utilization rates (OOCL Logistics, 2019).

The main terminal at Cat Lai remained severely congested for over a month as large vessels could not pass through, and feeder services were severely delayed, leading to missed connections to feeder vessels. No loss of life was deplored but most of the containers that had been initially carried were lost (OOCL Logistics, *Ibid*).

Response and mitigation measures

Responses put in place by the Maritime Administration of Ho Chi Minh City included: (i) the mobilization of an emergency team (human resources and vehicles); (ii) setting the prevention of oil or toxic materials' dispersion as a main priority; (iii) limiting the numbers of transiting ships and blocking the passage during the rescue phases; (iv) limiting the weight of containers, for both inbound and outbound vessels; (v) differentiating throughways between the flow of goods on the southwest or southeast routes; (vi) identifying an alternative route to the blocked canal (Soai Rap channel), which could only handle a few vessels at a time because of its limited water depth; and (vii) and developing Cai Mep port complex, increasing waterway barge connection services, diversifying the service offer between import and export goods, reforming se aport operations and administrative procedure (Ministry of Transport of Viet Nam, 2019).

[10] This section also draws on Fu G. (2016).
[11] See also, Bahtic F. (2021).

Lessons learned and good practice

- **Invest in infrastructure and capacity adaptation** to ensure that ports and their hinterland connections can service larger vessels, while at the same time ensuring operational agility and minimizes accident risks. For example, in the case of the Port of Ho Chi Minh, an investment plan to further expand the container capacity to meet the demand surge that occurred during the COVID-19 pandemic was validated in 2020 (Speedmark, 2021).
- **Plan efficiently the arrival and departure of vessels** and regulate traffic, especially in the case of ports such as Ho Chi Minh where the topographic conditions of access channels impose specific criteria and limitations on traffic fluidity.
- **Strengthen cooperation** between public and private stakeholders involved in port activities.
- Promote **digital connectivity**.

CASE STUDY 6
Port of Gothenburg, Sweden

Event: Labour strike, 2016–2017

In conflict with the global port operator, APM Terminals, the Swedish dockworkers union began to strike in April 2016. The dispute only ended in December 2017 (Bergsten H., 2018).

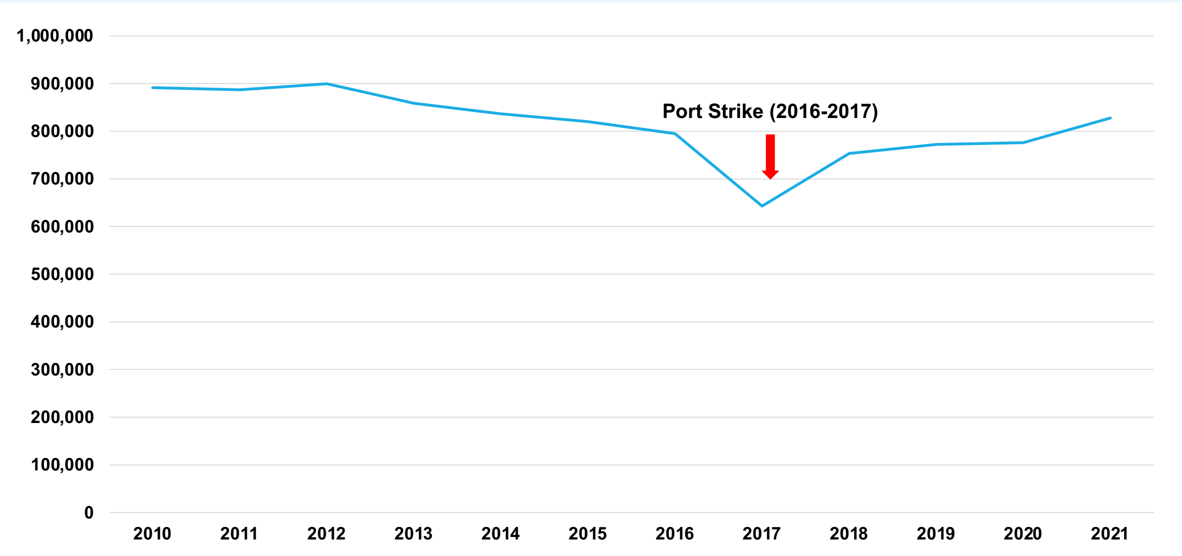
Causes and impact

The strike was the main factor behind the disruption, which was sparked by: (i) a long-lasting political debate on whether the Swedish government should modify the underpinning labour law; (ii) APM's investments on new technology and innovations, which impacted labour requirements in terminal activities; (iii) the lack of sufficient alternative connectivity within the region (besides rail transport); and (iv) the compounding effects of the 2017 cyber-attack on Maersk. (Svanberg M., 2021).

The strike created congestion and disrupted operations. The volumes handled by the container terminal decreased by 20 per cent between 2016 and 2017, and port calls fell significantly, especially calls by large vessels. The port limited the import of containers to dispatch export cargo (figure 41).

The port experienced reputational damage, with several customers shifting from Gothenburg to rival ports nearby in Sweden or Northern Europe (e.g. Rotterdam, Antwerp and Hamburg), or rail and road transport. Many Swedish firms were affected, with significant consequences on import-dependent sectors, such as the retail industry, which accounts for the largest share of Swedish imports (Lindroth E., 2020). Logistic costs increased across the board after the event (Gonzalez-Aregall M., 2018), social tensions in the wider Swedish labour market heightened, and environmental concerns amplified with greater use of land transport.

Figure 41: Container traffic handled by the Port of Gothenburg, 2010–2021



Source: UNCTAD secretariat based on Port of Gothenburg data.

Response and mitigation measures

The labour strike reflected a country-wide legal and political conflict. There was limited scope for the port of Gothenburg to take mitigation actions or find ways to end the strike. However, the port took measures to manage cargo flows by prioritizing export cargo, despite the overall negative effect on port throughput.

Lessons learned and good practice

- **Differentiate a port's value proposition** and **offer container storage services** to mitigate a temporary supply/demand imbalance. For example, learning from the 2017 disruption, the Port of Gothenburg launched the "Empty Container Initiative" in the winter of 2020 to mitigate the effects of the COVID-19 pandemic. The port has also tightened its cooperation with Railport partners to offer container storage of imported goods during the holiday season.
- **Ensure effective hinterland connections** for last-mile transport through rail shuttles and agreement with hinterland transport operators. For example, since the strike, the port pf Gothenburg tightened its **connectivity agreements with regional hub and feeder ports** and invested in a short-sea terminal in 2021.[12]
- Establish transloading facilities within terminal facilities.

CASE STUDY 7
Port of Valparaiso, Chile

Event: Labour strike, 2019

In November 2019, the Port of Valparaiso faced disruption due to a nationwide strike. The strike involved many sectors and industries, with protesters calling for economic and political reforms and a higher minimum wage. Tensions continued to flare between stevedores and truck drivers until January 2020 (The Maritime Executive, 2019).

Causes and impact[13]

The strike is the main factor causing the disruption, which led to reduced port and hinterland accessibility. Several factors amplified the disruption, namely: (i) The lack of a national legal framework to sustain port specialization and cooperation; (ii) the rapid upsizing of container vessels and consequent pressure in infrastructure investments; and (iii) the high reliance on road transport as the only connection to inland destinations (Merck O., 2016).

The combined effect of recurrent strikes in the transport chain (the fact that stevedores and trucks drivers were both on strike) meant that port operations were severely affected.[14] As the port depends entirely on road transport for hinterland access, road congestion directly affected the port. In addition to congestion, other ripple effects include air pollution and disruption of Chile's fruit exporting industry.

Response and mitigation measures

The Port of Valparaiso had limited scope to mitigate the effects of labour strike, or the congestion that was caused, including overland activities.

However, experience derived from the COVID-19 pandemic provided measures to address the disruption and associated bottlenecks. The port implemented health and safety protocols for protecting both employees and people interacting with the terminal to ensure business continuity (OECD, 2019). The remote document endorsement was put in place to enable customers and customs to operate remotely and maintain social distancing. The port also supported suppliers by providing early invoice payments. (Terminal Pacifico sur Valparaiso, 2020).

Lessons learned and good practice[15]

- Invest in and implement digital solutions and technological advancements, including **Port Community System** (PCS).
- **Enable hinterland digital connectivity**, including by implementing solutions that monitor the trucks and cargo to/from ports.
- **Avoid** traffic through the city and facilitate real-time visibility over road networks.

[12] See Port of Gothenburg website at https://www.portofgothenburg.com/news-room.
[13] This section also draws upon CRISIS24 (2018).
[14] See Port of Valparaiso website at https://www.puertovalparaiso.cl.
[15] This section draws also upon UNEP, Port of Valparaíso.

- Establish **long-term partnerships with key freight forwarding stakeholders** and create shared value across local communities (e.g. early invoice payment) (AIVP.ORG, 2021).
- Promote **long-term port labour agreements** and improve basic working conditions.
- **Diversify transport options** connecting ports to their hinterland.
- Adopt a **unified port and logistics strategy** at the national level to avoid ports' fragmentation (IKONS ATN, 2020).
- Ensure **transparency when setting port tariffs** and avoid discriminatory practices.

CASE STUDY 8
Ports of Rotterdam and Antwerp, Netherlands and Belgium

Event: Capacity constraints, 2014–2017

In 2020, the Port of Rotterdam handled over 14 million TEUs, while the Port of Antwerp handled 12 million TEUs. Both ports faced recurrent congestion over recent years (Knowler G., 2018). The capacity of these two ports was often challenged by the increasing vessel sizes and related implications for port and inland operations (Knowler G., *Ibid*). Up to five 20,000 TEUs mega-ships can call simultaneously in Antwerp and Rotterdam, generating massive workload peaks and pressuring container operations.

Causes and impact

Increased vessel sizes and limited hinterland capacity to absorb mega-ships, delays and sudden workload peaks, were the main factors behind the disruption and the congestion at the ports of Rotterdam and Antwerp. Amplifying factors included: (i) the poor schedule reliability of large vessels; (ii) the limited barge capacity for inland connections; (iii) barge handling capacity was not defined upfront, and instead scheduled in between deep-sea vessels, often undermining coordination and demand visibility; (iv) barge and feeder terminals limited operating times causing bottlenecks out of rush hours; (v) seasonal peaks during the summer; and (vi) ongoing concentration in Rotterdam and Antwerp of most of the traffic moving through the Europe-Far East shipping corridor.

The five-month congestion which occurred in 2014 triggered surcharges and led to carriers diverting their business to other ports. Barges had to wait between 72 hours and 92 hours to process cargoes at both ports (The Meditelegraph.com, 2015).

Response and mitigation measures

Infrastructure adjustments and port upgrades were made to handle barge demand have been steadily monitored, adjusted and finetuned to meet expected demand.

The Port of Rotterdam focused on enhancing both digital cooperation and hinterland connectivity (Sterling T., 2021). Such measures proved highly effective as the port has gained competitiveness despite disruptions, such as the COVID-19 pandemic. Some examples of physical and digital connectivity concretely improved or employed at the Port of Rotterdam include: (i) data sharing across the containerized supply chain; (ii) enhanced scheduled barge capacity through Nextlogic, making it easier for terminal and barge operators to draw up schedules and be aware of the status of the handling process (Port Technology); (iii) Road network and barge shuttle service to connect terminals within the port area (Waters W., 2018); (iv) cargo bundling services, with barges carrying 150 to 200 containers to shuttle directly between deep-sea port and inland terminals; (v) dedicated barge berths in the port; (vi) fixed barge windows and automation (a new app called Pronto, reduced the waiting time by 20 per cent) (Hochfelder B., 2018); and (vii) effective information systems to support inland barge traffic (waterway inland network of Rhine Ports and Upper Rhine Information system).

Along with similar efforts to promote digitization, Antwerp also opened a new barge terminal in 2019 (Louppova J., 2018), and promoted enhanced barge cargo bundling. Minimum call size criteria for barges to access the deep-sea terminals (30 moves) were also introduced.

Lessons learned and good practice

- **Digitalization** (Witschge L., 2019) can promote transparency and data sharing of shipping processes (notifications for pilots, Maritime Declarations of Health, etc.). It can also mitigate hinterland connection capacity constraints and lack of coordination (e.g. waterway inland vessels).
- Develop a **chain performance dashboard** to provide insights into the logistics chain and make it easier for participating parties to identify the source of congestion and jointly work towards a solution.
- Favour upstream locations and side to build on the **inland waterway connectivity services**, develop dock systems connected to the river via large sea locks, and simultaneously serve large deep-sea vessels.
- Strengthen **cooperation with downstream ports** (domestic, coastal or estuarine rivals), and further upstream ports to strengthen logistics cluster and maritime networks.

CASE STUDY 9
Port of Hamburg, Germany

Event: Capacity constraints, 2013–2014

The Port of Hamburg experienced a disruption in 2013 and 2014 due to capacity constraints created by the size of ships calling at the port and related increase in the number of port calls. This capacity constraint, coupled with a series of storms, caused delays for vessels calling at the port and generated bottlenecks at container yards.

Causes and impact

The disruption at the Port of Hamburg was due to its operation at full capacity, leading to congestion (Port News, 2016). Factors amplified the bottlenecks included: (i) storms and bad winter weather conditions impairing navigation; (ii) a high concentration of local exports serviced by big ships that can only operate within specific timeframes and which are non-divertible to other ports; (iii) large vessels schedule delays of 3-4 days on average and up to 6 days, leading to complex operational planning; (iv) ultra-large container vessels could only berth during specific high-tide windows; (v) calls by trucks mainly occur between 1 p.m. and 5 p.m., with consequent road congestions at peak hours; and (vi) rush hour congestion also occurred for feeder services as they were unable to dock, creating further delays across the transport chain (Van Marle G., 2014).

Over the first months of 2014, one-quarter of the port's storage capacity for export containers was unavailable as large volumes of export containers accumulated while waiting for the arrival of incoming vessels. The average dwell time for a container doubled and container terminal capacity reached saturation, preventing vessels from berth and feeder lines to operate whenever mega-ships were at port.

Response and mitigation measures

The Port of Hamburg considered using an alternative terminal to load/discharge containers at an extra cost for the shipping companies. However, this solution was never implemented as weather conditions improved. The port used additional yards and equipment to expand storage capacity and put in place immediate actions to enhance the coordination with truckers (Beermann N., 2014). Additional empty container areas in the immediate proximity of terminals were created to reduce the volume of truck-based transshipment within the port. Forwarders and haulers expanded the time of their operations beyond peak hours (at night/weekends). Moreover, technological projects were accelerated to promote real-time visibility and coordination across all port stakeholders (Härtel J., 2016), including: (i) rolling out the Port River Information System Elbe (PRISE) in 2014, which optimized waterway traffic; (ii) the implementation of the truck appointment/slot system and trucks parking space management application, using transparent telematic support; (iii) deployment of a port road management information system to gather real-time traffic information across the hinterland; and (iv) the introduction of tablets or smartphones to exchange information quickly.

Lessons learned and good practice

- **Hinterland connectivity** (Biermann F., 2016) is critical and should be improved to ensure greater port resilience.
- **Enhance technology** to sustain better communication among port stakeholders, optimize arrivals and departures of vessels and ensure early warnings regarding bottlenecks.
- **IoT and Blockchain technologies** can help diversify freight forwarding services by providing real-time visibility, enhanced interactions and early warnings (Notteboom T., 2016).
- **Reframe the concept competition** and favor coopetition and shared value creation thinking, including with hinterland transport operators (Kasiske F., 2019).

CASE STUDY 10
Port of Seattle, United States

Event: Climatic factors/sea-level rise, 2021

The Port of Seattle has regularly been disrupted by flooding and erosion, which has resulted in a shrinking shoreline in recent years. Significant disruption at the port and its hinterland access occurred during the most recent flooding event, which followed a new daily rainfall record was set in October 2021.

Causes and impact

Weather disruptions, including severe flooding, were the main factor for the disruption (Skagit Climate Science Consortium, 2015). Other amplifying factors included: (i) the COVID-19 pandemic and its ripple effects on container shortages and the availability of the port's workforce and truck drivers; (ii) topography, with the port area bounded by the Pacific Ocean and Puget Sound in the west and the Cascade Mountains which form a barrier to the east. The port is crammed within a narrow corridor with very limited north-south road and rail connectivity; and (iii) surge buying and bullwhip effects along the supply chain, immediately before the weather events.

The impact on the ecosystem around the Port of Seattle was severe, and affected low coastal lands, farmland, coastal septic systems, and hinterland infrastructure. The impact on sea biodiversity was also important. Vessels waiting at anchorage raised safety concerns when high wind speeds threatened to unmoor them.

Response and mitigation measures

The Port of Seattle, in close collaboration with the neighbouring residential communities, took a set of emergency measures, namely: (i) use of digital tools shared across port stakeholders; (ii) implementation of weather forecast and risk assessment procedures to detect potential population clusters with no access to food sources and other priority threats across the port surroundings; and (iii) adapt Puget Sound as a highway for the transportation of primary goods, equipment and people during and after the disruption.

Lessons learned and good practice

- **Implement preventive risk assessment processes** and organize coordinated trials and rehearsals with key port and community stakeholders prior to the event. This has proven useful and enabled the Port of Seattle, for example, to deploy emergency plans during the 2021 flood-led congestion (Holdeman E., 2021).
- Take proactive and creative actions that **leverage local accessibility and mobility options during a disruption**. For example, the Puget Sound waterway was adapted as a highway to transport supplies, equipment and people during and after the disruption.
- **Implement digital solutions that enable continuous risk assessment** before and during a disruption. For example, these have helped the Port of Seattle to continuously adapt its strategy and operational plans.
- Ensure **infrastructure improvements** dedicated to minimizing damages from disruption including flooding. These may include wharves improvements, the relocation of buildings, rail yard expansion, apron upgrades, and slope stabilization measures.

CASE STUDY 11
Port of Gulfport, United States

Event: Hurricane Katrina, 2005

In August 2005, the Port of Gulfport faced a severe disruption caused by Hurricane Katrina. While the hurricane event only lasted a few days, the overall disruption to coastal Mississippi lasted at least six months.

Causes and impact[16]

Hurricane Katrina was associated with storm surges and high winds, and significantly impacted the states of Mississippi and Louisiana, especially along the coastline. The worst property damage from Katrina occurred in coastal Mississippi, and resulted in extensive flooding and property damage. The U.S. Coast Guard Gulfport station was rendered inoperable, causing moderate to severe impacts to local supply chains.

[16] This section also draws upon Eyerdam R. (2018).

The port is Mississippi's largest and the third busiest container port on the U.S. Gulf Coast. It is specialized in importing fruit from Central and South America, which is then distributed throughout the southeastern United States. One of the impacts of the port's inoperability is that it led to a (temporary) regional shortage of tropical fruits and job losses across the fruit supply chain.

Hinterland and coastline infrastructure, boats and offshore oil rigs were damaged. Roadways and railways were put out of service by excessive amounts of debris and occasional collapse. Until major roadways could be cleared, deliverers of supplies and other emergency relief were forced to detour through local roads, causing significant hinterland congestion. The damage to Mississippi State Port Authority facilities, e.g. warehouses, offices, piers, wharves, railways, catwalks, fender systems, high mast lighting systems, and small craft harbour, exceeded $100 million. The disruption at the Port of Gulfport resulted in $51 million in damages, a decline in 69 per cent decline in tonnage in the following year, and a 70 per cent fall in revenues.

Response and mitigation measures

The Port of Gulfport Restoration Programme (PGRP), initiated in 2008, included the development of new container terminals, road and rail facilities to allow for expansion. The development plan included deepening the port channel, doubling its acreage, and elevating the entire platform to face extreme weather conditions Jacobs (2008-2018). The new multi-mission port platform was designed and constructed to withstand Category 4 hurricane winds and storm surges of 18 feet above high tide. A regulatory response was also taken to provide for higher/elevated emergency command centres.

Lessons learned and good practice

- **Clustering of the port community stakeholders** and enhancing their cooperation can improve resilience.
- **Create a shared value for the entire port community** and port ecosystem helps longer term recovery. In the aftermath of Hurricane Katrina, the Port of Gulfport struggled to rebuild its facilities and cargo base. At the same time, the surrounding local community and state government aimed to reuse the port area for urban renewal of the waterfront. The state renewal plan conflicted with the Port Master Plan and port access plans, which limited port operations.

  The port has, nevertheless, balanced competing interests as it included: (i) container terminals; (ii) hotel/commercial land uses; (iii) marinas; (iv) shrimp fleet operations; (v) elevated highway connector roadways; (vi) rail access; and (vii) an off-dock intermodal yard.
- **Promote publicly funded large-scale flood mitigation projects**, such as levees or flood gates, together with context-specific construction solutions to reduce exposure to disruptive events, while concurrently servicing trade in an effective manner.

CASE STUDY 12
Port of New York, United States

Event: Superstorm Sandy, 2012

In 2012, the Port of New York was hit by superstorm Sandy, which inundated most of the port area and surroundings.

Causes and impact[17]

The main factor in the disruption at the Port of New York was superstorm Sandy. The storm caused 280 deaths (out of the port community) and major damages to the port, its surrounding areas, and related supply chains. The Port Authority Trans-Hudson railway system was completely inundated and threatened by saltwater corrosion. The storm caused severe damage to port operations and facilities. A total of 25,000 shipping containers were diverted to other ports. The port remained closed for a week. Freezing temperatures during the event compounded the impact of the superstorm Sandy. Operations resumed eight days after the storm. The severity of the disruption extended beyond the length of the storm as it was followed by fuel shortages, extended power outages, and the persistence and amplification of inland congestion.

Response and mitigation measures

Pre-disaster preparation and emergency plans trials, with the engagement of the entire port community and stakeholders, enabling an effective, prompt deployment of emergency interventions in the immediate aftermath of the storm. Longer-term mitigation efforts to minimize the damage from future storms included a $59 million package for about 200 flood-reduction projects (e.g. building barriers, stockpiling of sandbags, and moving equipment to higher ground).

[17] This section also draws upon Smythe T. (2013).

Lessons learned and good practice[18]

- **Promote effective coordination between port stakeholders** (Ryan-Henry J. and Becker A., 2020) to ensure prompt recovery and resilience. In the case of the Port of New York, this was facilitated by a network of relationships and trust between port partners built over many years in committees as well as on lessons learned from past experiences (e.g. Hurricane Irene in 2011).
- **Aim to cluster stakeholders and define their roles** through joint pre-event preparation, e.g. prior planning and rehearsing/drills/exercises. This can speed up joint actions (Verschuur J. et al 2020).
- **Establish clear communication systems** (known codes and decision-making criteria) to be used by all parties and facilitate collective operational agility.
- Strengthen **institutional relationships**.

CASE STUDY 13
Port of Lagos, Nigeria

Event: Post-civil war, 1975

In 1975, the Port of Lagos faced a severe disruption. While the situation improved with the port reforms introduced in the early 2000s, it continued to face ongoing congestion (UNCTAD, 2014). The port congestion reported during the COVID-19 pandemic is a case in point (UNCTAD, 2020).

Causes and impact[19]

The Nigerian civil war (1967–1970) caused damage to most the country's ports and port infrastructure. After the war, improved economic conditions resulted in more trade and port activity, resulting in severe port congestion (Oguche H., 2018). Among the factors amplifying the disruption were: (i) ineffective cargo handling operations; (ii) lengthy procedures and documentation work; (iii) unskilled dock workers; (iv) lack of cargo handling equipment; and (v) lack of proper hinterland transportation systems (Raballand G. et al, 2012).

Response and mitigation measures

Extensive port rehabilitation efforts were made in the post-war period. By the mid-2000s, the Nigerian government introduced private port concession as part of the port reform model. It retained ownership of the infrastructure and, for a specified period, contracted out facility operations to the private sector, such as terminal operators. These reforms resulted in the Port of Lagos achieving operational efficiency gains owing to the concession, with vessel turnaround time falling by more than half between 2006 and 2017. Infrastructure modernization, process optimization, and simplification of administrative procedures largely contributed to improving port performance and minimizing congestion risk.

Lessons learned and good practice

- Ports must obtain the **strategic tools** to identify the causes of recurrent congestion and determine relevant actions to tackle these causes, including from a governance and infrastructure perspectives.
- Address (i) infrastructural deficiency; (ii) undeveloped intermodal facilities; and (iii) poor hinterland connection.
- **Establishing standards** to **benchmark operational performance** and productivity.
- **Consider Port reforms and port governance aspects**, including the landlord model that incorporates public-private partnership schemes that attract investors, know-how, and modern port management practices (Ogochukwu U. & Kayode O., 2021).
- **Strengthen cooperation** among port community stakeholders and partners across the transport chain when aiming to address bottlenecks and manage risks (Ogochukwu U. & Kayode O. *Ibid*).
- Promote **efficient hinterland connections** and diversify modal options to alleviate inland transport bottlenecks.
- **Invest in digital solutions** to improve operational efficiency, and simplify administrative and regulatory procedures and documentation.

[18] This section also draws upon University Transportation Research Center (2013).
[19] This section also draws upon Bogale S. (2021).

CASE STUDY 14
Port of Houston, United States

Event: Hurricane Harvey, 2017

The Port of Houston suffered a disruption caused by Category 4 Hurricane Harvey in August 2017. The event lasted about two weeks because of ripple effects after re-opening (Bonney J., 2017). Related reconstruction projects lasted 3-5 years (Witthaus J., 2017).

Causes and impact

Hurricane Harvey was the main factor causing the disruption. Texan seaports often experience the recurrent threats of hurricanes, storm surges, sea-level rise and tornadoes (Mohamed A. A. et al, 2020).

Over 40 per cent of the population in the State of Texas was affected by damages to buildings and material losses (Mohamed A. A. et al, Ibid). According to the National Hurricane Center, Hurricane Harvey caused $125 billion in damage, at a cost that exceeded any other natural disaster in American history, except for Hurricane Katrina. Freight transportation across modes was interrupted for over a month (Mohamed A. A. et al, Ibid). Warehouses, refineries and petrochemical plants remained closed over the same period. On 25 August, the United States Coast Guard closed multiple ports along the Gulf Coast, including Houston, Galveston, Texas City, Freeport and Corpus Christi.

By one estimate, the closure of a major port, such as the one in Houston, for one week can cause financial losses of up to $2.5 billion from delayed or canceled business transactions. While the Port of Houston reopened after one week, access restrictions continued due to flooded roads (Odyssey, 2017). The silt carried by floodwaters created shoaling in mission-critical areas (Marine Log, 2017), including at the entrances of the port's three major terminals. The port needed to perform dredging work in its access channel and inland connections continued to be challenged (Elenaor L., 2017). Freight carriers were reported to be adjusting routes and faced heavy congestion due to flooded roadways and a shortage of drivers (Odyssey, *Ibid*).

Response and mitigation measures

The port developed a hurricane procedure manual, which gives detailed instructions on the gradual securing and shutdown of terminal facilities as a hurricane event gets nearer (figure 42). After Hurricane Harvey, public authorities were directly involved in the recovery and emergency intervention measures (Marine Log, 2017). On 8 September 2017, President Trump signed a bill approving $15.25 billion in storm aid, and the United States Army Corps of Engineers deployed personnel, worked with local and state agencies and the Coast Guard to clear navigation channels, enabling critical ports to resume operations. Engineers performed generator inspections and installations to provide temporary emergency power at critical locations and provided technical assistance for debris and temporary housing.

SUPERSTRUCTURES

- Lash down cranes, gear, and equipment.
- Fill fueling rigs and store additional fuel, lubricant, and water drums.
- Fill up all terminal vehicles.

YARD

- Secure yard and warehousing areas of loose items.
- Verify and secure empty container doors.
- Stack loaded containers in safe positions.
- Stack down empty piles.

FACILITIES

- Verify inventory of emergency equipment and supplies (rope, plywood, tape, batteries, fuel).
- Purchase goods (food) for potential employees staying at the terminal.
- Office equipment moved away from uncovered windows.
- Secure electrical power sources not required for minimum operations.

Source: Port of Houston (2020

The Port of Houston allocated up to $2 million to the Corps of Engineers for terminal-related dredging expenses. It also awarded contracts to harden communication capabilities for telephones, data centres and inter-terminal connectivity. Meanwhile, some partial and non-exhaustive responses were implemented by regional oil and gas industry players. Exxon was publicly held responsible for climate-change led disruptions (Harvard Business School, 2017), and thereafter worked on: (i) creating alternative supply routes (using non-US based oil suppliers); (ii) establishing long-term back-up contracts in case of a crisis; and (iii) increasing the safety stock of oil in warehouses and distribution centres before the hurricane season.

Lessons learned and good practice

- Develop **clear instructions and guidelines** to assist in port preparation when a hurricane event is on the horizon.
- **Promote technological modernization and digitization** to provide real-time visibility of vessel movements and port operations and allow ports and other stakeholders to share data and conduct predictive analytics.
- Steadily **monitor, maintain and upgrade** infrastructure.
- **Early-warning digital tools** are crucial, especially in the case of storms and extreme weather events (Duram Bathgate K., 2021).
- **Improve waterway systems**, namely access channels due to the destabilizing impacts of hurricanes (flooding and tide surges).
- When improving infrastructure, a **port should be considered as part of an interface** with the goal of improving its continuity (Schulze A., 2017).
- Response and recovery measures should seek a return to pre-event operations and seize the **opportunity to make improvements** to generate additional value including by enhancing efficiency and resilience.

CASE STUDY 15
Port of Meulaboh, Indonesia

Event: Tsunami, 2004

The Port of Meulaboh and the surrounding area were devastated by a tsunami in December 2004. The small-scale port located in Aceh, Indonesia, handles general cargo, and has just two docks and a limited capacity due to its shallow water depth of 5.5 meters. (UNCTAD, 2020)

Causes and impact

A tsunami was the main factor causing the disruption. Amplifying factors included: (i) poor hinterland connectivity; and (ii) heavy reliance on maritime transport for access and mobility. The Port of Meulaboh is located 200 kilometers away from the earthquake epicenter and was heavily damaged by the tsunami. The disruption caused damage to the ferry terminal but also destroyed the terminal building and access way, and led to the removal of berth fenders. The berthing area was only relatively damaged.

Response and mitigation measures[20]

Temporary measures of up to 12 months were introduced to ensure port business continuity. These included the construction of a new T-shaped wharf with deepened water depth at low tide, which was completed one year after the event. Two accessible ports in North Sumatra were identified for the purposes of international cargo and transshipment routes. Small reconstruction measures allowed small ferries to moor at Meulaboh's old wharf six months after the event. Longer-term measures focused on creating short-sea shipping lanes connecting Meulaboh with other ports in Sumatra and nearby islands.

Lessons learned and good practice

- Invest in **early warning systems**.
- For small ports in developing economies, **international aid can be critical** in the early stages of a crisis and reconstruction efforts due to the lack of access to capital. These funds should be channeled to ensure the long-term sustainability of the projects and the solutions provided. This will also ensure preparedness in case of future similar disruptions
- **Monitor and follow up**, as deemed appropriate, on the initial efforts to verify progress and ascertain effectiveness.

[20] This section also draws upon UNDP (2005).

CASE STUDY 16
Jawaharlal Nehru Port Trust (JNPT), India

Event: Cyberattack, 2017

In June 2017, operations at one of the three terminals of the Jawaharlal Nehru Port Trust (JNPT) were disrupted by a global cyberattack on its port operator, the Danish AP Moller-Maersk. JNPT is a major transshipment hub in South Asia (Jadhav R., & Rocha E., 2017).

Causes and impact

A global cyberattack using the NotPetya malware created a major security breach and had a severe and global impact on AP Moller-Maersk operations, and affected all of Maersk's ports and partners. The JNOT terminal temporarily closed, while containers piled up outside the port due to technical delays in loading and unloading. Congestion also involved trucks in the hinterland.

Response and mitigation measures

A substitute port, Gujarat Pipavav Port, also operated by APM Terminals, was identified to limit the disruption. Disaster management was led directly by Maersk, as the whole company's IT system was down and severely threatened. Meanwhile, JNPT port brought in cyber experts to prevent further damages from the security breach. It also made alternative arrangements to divert container traffic. Planning for congestion, the JNPT worked with local authorities to identify more storage areas for containers being stranded. Traffic control teams were deployed to address anticipated road congestion.

Lessons learned and good practice

- A digital transition should be accompanied by measures and tools to **protect data and systems security**.
- Prevention alone is not sufficient. **Automated detection and response systems** are necessary, as is limiting the number of privileged accounts.
- Cyberattacks are a **business and commercial problem**, and not only a technology problem. Therefore, partnerships between managementand IT are crucial for handling cybersecurity threats.
- **Collaborate among ports and stakeholders**, including competing ports to ensure that flexible arrangements can be found amid crises and disruptions (e.g. e-route traffic and plan for reducing congestion).

CASE STUDY 17
Port of Durban, South Africa

Event: Cyberattack, 2021

In July 2021, a cyber-attack against Transnet, which operates major South African ports and most of its railway networks, disrupted container operations at the ports of Cape Town and Durban (Heiberg T. & Blair E., 2021).

Causes and impact[21]

The cyberattack targeted Transnet, the local port operator, and caused the disruption (Shabalala Z. & Heiberg T., 2021). One amplifying factor consisted of country-wide civil unrest and violence, which occurred the week before the cyberattack.

Transnet was forced to declare *force majeure* after the cyber-attack. Port workers were obliged to manually track ship movements and use a paper-based clearance process for cargo at ports, including Durban. Processing time for imports increased significantly at the Port of Durban, which accounts for 60 per cent of Southern Africa's containerized trade.

A significant build-up in containerized cargo was observed after the port resumed operations a week (Africa News, 2021). Refrigerated container cargo was most affected as the ports ran low on reefer plugs to store backlogged cold chain cargo. One of the effects of the riots following the cyber-attack in mid-July is that importers of chilled and frozen products lost 40,000 tons of cold storage capacity in the wake of the riots. Manual processing of shipments led to grain carriers experiencing delays and to the re-routing of some bulk and container vessels, resulting in longer transit times and delays. Other privately operated port terminals not directly affected by the cyber-attacks also faced congestion and the diversion of some ships away from South African ports. Copper and cobalt from the Democratic Republic of Congo and Zambia; import flows of the southern African region were also negatively impacted, but hinterland operations remained mostly unaffected.

[21] This section also draws upon USDA (2021).

Response and mitigation measures

The port public operator, Transnet, led the crisis management (Goddard E., 2021). The Incident response team oversaw the rebuilding of the active directory server, and the deployment of the Microsoft E5 security stack was fast-tracked. All older operating systems have been upgraded and fully patched before being brought back online. A web access firewall, reverse proxy and anti-distributed denial of service system (DoS) for all public web sites was deployed by the ICT team.

In 2020, Transnet adopted measures to address congestion and inefficiencies at port/hinterland connections. These included acquiring new equipment and increasing the number of gangs working to ease the flow of both vessels and trucks. These measures were taken to help clear any backlogs that may have resulted from the disruption, as well as improve cargo handling performance and mitigate congestion (Transnet, 2021).

Lessons learned and good practice

- **Recruit employees** with the necessary skills to counter cybersecurity threats and provide **training** in the field of threat awareness and prevention of risks (Reva D., 2020).
- **Long-term cyberthreats mitigation measures** must rely on industry-wide digital cooperation, strong public support, and regional financial investments in IT infrastructure (Raballand G. et al, 2012). For example, Interpol's African Cybercrime Operations Desk, in partnership with the African Union, Afripol, law enforcement communities and private stakeholders, developed a joint strategy to set up a **cybercrime intelligence unit** and promote good cybersecurity practices. African Union member states need to agree on a joint security plan and adopt relevant national laws, to ensure compliance with the latest IMO guidelines for cybersecurity for vessels (BusinessTech, 2021).
- Avoid the **compounding effects of a cyber-attack** on IT-dependent equipment, business processes, Human Resources and terminal gate.

CASE STUDY 18
Port of Freeport, Bahamas

Event: Hurricane Matthew, 2016

In 2016, Category 4 Hurricane Matthew hit the Bahamas and disrupted the Port of Freeport, a key transshipment hub in the Caribbean (UNECLAC and IDB, 2020).

Causes and impact

Hurricane Matthew caused a disruption, which led to the port congestion. Factors exacerbating the disruption include: (i) poor infrastructure with deficient structural construction standards; (ii) insufficient use of steel, stone reinforcement and gravel in the aggregate material; and (iii) deficient infrastructure maintenance (AON Benfield, 2017).

The Bahamas lost 1.1 per cent of its total gross domestic product (GDP), with its two largest sectors, tourism and fisheries, being heavily affected. Restoration of power took several weeks, especially on the Grand Bahama island. The lack of electricity severely impacted water and sanitation, health and education services, and wired services, including landline phones, fixed internet and cable television systems.

Damage to the transportation infrastructure was estimated at $13 million. The port's structural pillars and loading areas were damaged, but the docks were less affected. The storm knocked out the power supply of terminal equipment and several ship-to-shore (STS) cranes. Freeport terminal halted operations to repair cranes, and container carriers were forced to re-route vessels to other ports. Unlike other ports in the Bahamas, the Port of Freeport remained closed until mid-November due to extensive damage to local infrastructure and businesses. Roads on the island were damaged by Hurricane Matthew, but this had a limited impact on the port's transshipment operations.

Response and mitigation measures

Responses included a coordinated emergency plan from the International Federation of Red Cross and Red Crescent Societies (IFRC, 2016), the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC), the Inter-American Development Bank (IDB), as well as private sector stakeholders, such as the logistics emergency team, which formed by the World Economic Forum in 2005 to assist the United Nations during large-scale natural disasters, and which comprises four global logistics and transportation companies (UPS, Agility, Moeller Maersk and DP World) (Canty M., 2016).

Lessons learned and good practice

- Carry out **risk assessment and risk management planning**.
- **Establish regional partnerships** to jointly face common challenges and provide early warning signals, especially through shared technology investments.
- Further **collaboration**, promote joint efforts, seek experience sharing and **optimize resource use** (OCHA-PDC Global, 2021).
- Elaborate methodological assessment and guides that help **identify the most likely natural hazards and map these against the most vulnerable assets** and priority areas requiring mitigation measures.
- Existing **vulnerability and impact assessments** and experiences from other areas or sectors in terms of response and adaptation to disruptions can provide lessons on how to build resilience in ports.
- **Ensure long-term investment and planning** to reduce vulnerability to disruptions, including natural disasters and promote adaptation action in ports (Freetown Container Port, 2022).

CASE STUDY 19
Port of Port-au-Prince, Haiti

Event: Hurricane Matthew, 2016

In 2016, the Port of Haiti was hit by Category 4 Hurricane Matthew. Although small, the port is a vital gateway for the country.

Causes and impact

Hurricane Mathew was the main cause of the disruption and the congestion that followed. Amplifying factors included: (i) Poor infrastructure and construction standards; (ii) insufficient infrastructure maintenance; (iii) limited redundancy such as alternative routes and hinterland connections; and (iv) slow reconstruction progress after the 2010 earthquake. The impact was felt nationally and not just by the transport and trade sectors. Hurricane Matthew brought in its wake large-scale flooding and mudslides, collapsed bridges, widespread crop damage, and destruction of residential, schools, and health facilities, as well as widespread lack of electrical power. In the immediate aftermath of the hurricane, infrastructure-deprived Haiti saw a rise in food insecurity, lack of clean water, and cholera cases. Death tolls and damage reports rose rapidly in the days immediately following the hurricane, making Hurricane Matthew the most significant humanitarian emergency in Haiti since the earthquake of 2010. Overall damage to transport infrastructure were estimated at $1.9 million. The flood-related damages and debris and overall power outages in Port-au-Prince disrupted port operations.

Response and mitigation measures

In cooperation with international organizations, such as IFRC and the United Nations, the government responded to the crisis by adopting a coordinated emergency plan, including prompt intervention logistical support for food and non-food primary items, agricultural recovery, shelter, and health measures, especially after the ongoing cholera outbreak worsening after Matthew. A logistics working group was created to work with the government (Logistics Cluster, 2018). Coordination units with dedicated staff in the major logistic hubs, above all at the Port of Port-au-Prince, provided logistics coordination and information management support and facilitated the handling of incoming cargo. A logistics coordination hub in Port-au-Prince was set up, with the primary objective of assessing the requirements, coordinating and facilitating access to common logistics services, including GIS/mapping services and cargo tracking.

To support the response efforts, private sector actors, such as the logistics emergency team (comprised of four global logistics and transportation companies: UPS, Agility, Moeller Maersk and DP World) made available logistics capacities on a *pro bono* arrangement, and provided upstream supply through airlifts and international ocean freight to Port-au-Prince. Inland logistics, such as warehousing space, forklifts and trucks were made available to receive aid and transport it within the country.

In 2018, the port established plans to expand its capacity by: (i) constructing a new wharf (PROPARCO, 2018); (ii) developing new storage areas, buildings and offices; (iii) dredging; (iv) acquisition of new port equipment; and (v) constructing a larger container yard to ensure better physical connectivity. It also intended to improve maintenance works through, among others, improved lighting, upgraded perimeter security and fire systems, better sanitary facilities and potable water supply at the port, as well as achieve higher operational efficiency (USAID, 2019).

Lessons learned and good practice

- In terms of pre-event preparedness, **mapping, engaging with and expanding suppliers, partners and logistics stakeholders around the port's wider interface** can enable an agile participation in the response.
- **Improve understanding** and shared awareness of the logistical bottlenecks and transport assets in and around the port.
- **Strengthen international support and cooperation**. International support should not, however, inhibit local stakeholders and prevent the formulation and implementation of longer-term strategies.
- **Elaborate risk assessment and risk management plans** to minimizing the risks.
- **Set up regional partnerships** to jointly face common challenges and provide early warning systems, especially through shared technology investments.
- Elaborate methodological assessment and guides that help **identify the most likely natural hazards and map these against the most vulnerable assets** and priority areas requiring mitigation measures.
- **Ensure long-term investment and planning** to reduce vulnerability to disruptions, including natural disasters and promote adaptation action in ports.

CASE STUDY 20
Port of Vila, Vanuatu

Event: Cyclone Pam, 2015

In 2015, the Port of Port Vila was hit by Tropical Cyclone Pam. It was the second-most intense tropical cyclone in the South Pacific Ocean in terms of sustained winds, and is regarded as one of the worst natural disasters in Vanuatu's history.

Causes and impact

Cyclone Pam was the main factor disrupting Port Vila. Poor infrastructure and construction standards amplified the disruption, which lasted over two weeks.

Damages to transportation infrastructure were estimated at $0.3 billion. Communication across the archipelago was crippled. Only one cellular tower in Port Vila remained operational, and 60 inhabited islands were cut-off from the outside world. Some 90 per cent of the buildings in Vanuatu were affected, and hospitals, schools and the water supply were either compromised or destroyed. A combination of large flood flows and debris accumulation caused wash-outs and extensive damage to bridges, approach roads, piers, abutments, riverbanks and service connections. The debris accumulation at bridges, coupled with water pressure from floodwaters, disconnected bridges from approach roads, and washed out many major bridge components. Damage to airports, wharves and jetties in the affected areas was minimal. Transportation was disrupted for weeks because of fallen trees and damage to connecting roads. Cruise liners, international cargo ships, and domestic vessels and ferries resumed sailing one day after the cyclone.

Response and mitigation measures

An emergency plan was implemented by the National Disaster Management Office in Vanuatu, with the support of international organizations. Port Vila served as the logistical hub for relief efforts.

The government conducted a rapid post-disaster needs assessment. Transport, recovery and reconstruction needs have been estimated at $34 million (Government of Vanuatu, 2020). It was recognized that the sector would require short- to long-term efforts and resources for its reconstruction and to ensure more disaster-resilient infrastructure.

Short-term (up to 12 months) needs included measures to: (i) resume delivering transport services in the affected areas until the reconstruction or replacement of damaged structures; (ii) restoration works to provide access and connectivity to road users; (iii) de-silting blocked drains; and (iv) provision of remedial measures or blocking water from entering landslide areas. The government undertook much of this work, but engineering and equipment assistance was made available by Australian and New Zealand Defense Forces who were instrumental in opening access to the outer islands. Medium to long-term needs (up to 48 months) measures included rehabilitation, reconstruction, or upgrading of transport infrastructure and roads works. The reconstruction promoted engineering designs that included disaster-resilient and climate-proof elements (for seismic activity, cyclones, and floods). Financing from the Asian Development Bank (financing grant agreement signed in 2016) started the implementation process, which involved reconstructing damaged road infrastructure and climate and disaster-proofing them (Asian Development Bank, 2017).

With a view to the longer term, the Government of Vanuatu, in conjunction with the Ports Authority, embarked upon a $100 million project to build a new international container terminal and wharf, which provided additional freight capacity and separated international cargo vessels from cruise ships. The project was completed in 2018 (Fletcher, 2018). The government has also called for special insurance schemes adapted to SIDS-climate change-led risks (SPC, 2015).

Lessons learned and good practice[22]

- **Promote regional collaboration to improve the port's adaptive capacity**. For example, the Australian Government Department of Foreign Affairs and Trade-funded Pacific iCLIM project have worked with the Governments of Fiji, Tonga and Vanuatu to identify regional and national-level barriers to climate change data and information management in the Pacific.
- **Elaborate risk assessment and risk management planning** to minimizing risks.
- **Set up regional partnerships** to jointly face common challenges and provide early warning systems, especially through shared technology investments.
- Elaborate methodological assessment and guides that help **identify** the most likely **natural hazards and map these against the most vulnerable assets** and priority areas requiring mitigation measures.
- **Invest in preventive measures**, ensure community preparedness and rapid response, enable infrastructure reconstruction and building-up local capacity and knowledge.
- Build **local resilience and reduce dependency on external agencies** as part of a long-term exit strategy (Ensor J., 2016).

CASE STUDY 21
Port of Malé, Maldives

Event: Tsunami, 2004

The Port of Malé is a vital entry door for primary goods to the Maldives. The December 2004 tsunami, which followed an earthquake in the Indian Ocean, caused the disruption to the port.

Causes and impact

The tsunami caused the disruption and amplifying factors included: (i) the loss of communication and connectivity capability among islands and with other countries; (ii) the limited preparedness and planning for natural disasters; and (iii) the lack of early warning systems.

Nearly a third of Maldives' population suffered from loss or damage of homes and livelihoods, which was estimated at $0.5 billion, which is 62 per cent of its GDP (World Bank Group, 2005). A quarter of the islands experienced major damage to essential infrastructures such as jetties and harbours, which provide crucial links between the islands and the outside world. Severe environmental effects included coastal erosion, solid and hazardous materials waste dispersion, contamination of water sanitation systems and floods (Marchant N., 2021).

[22] This section also draws upon Brown, R.A. et al (2015).

Response and mitigation measures

The government established a special task force to provide prompt aid and supplies. Communications were restored to 11 atolls within 24 hours (Keating B. & Helsley C., 2005). A National Disaster Management Centre (NDMC) was created to enact preventive assessments and preparation (Ministry of Planning and National Development, 2005). The Ministry of Defense and National Security (MDNS) coordinated the overall relief effort (donor assistance, long-term response, and planning). It initiated a project to collect the necessary funding/collective support to reconstruct the port. UNEP intervention focused on assessing environmental impacts and drawing recommendations for long-term reconstruction efforts. The port planned to tailor and adapt its physical lay-out and infrastructure.

The government planned to invest in coastal engineering defenses to protect against storm waves and promote the Safe Island Programme, which foresees communities living on smaller, less inhabited, and potentially more vulnerable islands, will be settled on five host larger islands, with enhanced coastal defenses. It also developed conceptual urban designs for enhanced mitigation features on the proposed host islands, including elevated areas or buildings to enable evacuation if needed.

Lessons learned and good practice[23]

- Prioritize the design of **transport infrastructure to withstand disasters**, especially in countries highly exposed to extreme weather conditions. For example, being ringed by a seawall, Malé was better protected from tsunamis, compared to other atolls (Hieber Girardet L., 2019).
- Invest in **strategic regional short-sea inter-island services** and strengthen the connections linking smaller ports to the main ports (Maritime Gateway, 2021).
- Invest in local environmental protection and **domestic renewable energy resources**.
- Invest in **risk management systems** documenting the range of risks and the likelihood of their occurrence, as well the identification of mitigation measures, including soft and hard measures. Soft measures include adapting legal and regulatory system, land-use planning and building codes, and hard measures foresee the building of sea defense works, adapted road and water networks, and identification of shelters.
- **Share and spread risks among relevant stakeholders** to promote preparedness and raise awareness among the government, private sector, transport industry and insurers.
- **Integrate disaster and climate risks into public and private sector investment decisions** and infrastructure developments (LaRocque I. & Steiner A., 2017).

CASE STUDY 22
Port of Chittagong, Bangladesh

Event: Seasonal demand surge and capacity constraints, 2020

The Port of Chittagong faces recurrent seasonal congestion between the months of April and October. Ships often wait for over a week to unload/load cargo, with no viable immediate alternative transport option (JOC.com, 2018).

Causes and impact

Capacity constraints (also work holidays) in the face of seasonal demand surges have created the recurrent congestion in the Port of Chittagong. Factors exacerbating the situation included: (i) upsizing of vessels resulting in volume peaks, which put pressure on existing yard capacity; (ii) the port only had six berths to handle primary in cargo operations with an outer anchorage space being used to load cargo onto inland waterways vessels; (iii) Insufficient container handling capacity to meet seasonal demand, both at the yard and inland container depots (ICDs); (iv) a lack of alternative ports for cargo handling operations. The second seaport, Mongla, is of limited capacity; (v) Lack of bilateral agreements with neighbouring countries (e.g. India), such agreements could allow for alternative routes; and (vi) port yard power outages constrain the capacity to service reefer containers.

Since 2017, ships have had to wait more than a week to unload/load cargo between April and October. By mid-April 2020, 49,000 containers were waiting in the port yard, and 30 vessels were waiting to anchor (Chowdhury S. H., 2020). As of July 2020, feeder vessels were anchored for 20 days (Lennane A., 2020). Although the end of the seasonal peak, vessels were still waiting five days to berth (Islam S., 2020), while feeder vessels cumulated delays at other regional ports (Colombo and Singapore). Recurrent congestion undermines Bangladesh's economy as Chittagong handles 90 per cent of its seaborne trade.

[23] This section also draws upon UNDP (2020).

Response and mitigation measures

The National Board of Revenue (NBR) intervened in early 2020 with a political directive to solve the chronic congestion. The plan provided a temporary transfer of six specific types of containers held at the port towards private ICDs. Container types were differentiated by cargo carried (e.g. seeds, fiber, products listed by the drug administration, imported yarn for the production sectors, tire cord, and insecticides). This measure was ineffective because the specified containers only accounted for 5 per cent of the total, and the differentiation added further operational complexity to the port. Measures also included sending containers to a private company (Summit Alliance) offering off-dock services, via inland waterways, rather than via the usually congested rail, which was only partially effective, again because of the lack of container storage capacity across inland waterways. The Port Authority also re-introduced demurrage charges to keep imported containers in the port yard. In 2020, the Government of Bangladesh and the Chittagong Port Authority jointly defined an expansion plan for the port to be completed in one year. The expansion would include: (i) a new container terminal, expanded yard facilities; (ii) a new mooring yard; (iii) the adoption of a port community system; and (iv) agreements with alternative terminals to support the separate trade of raw materials (Alam M. Z., 2021). Meanwhile, congestion was cleared by August 2021, with median times in ports down to the standard maximum of 72 hours and no waiting time before berthing.[24]

Lessons learned and good practice

- Ports should **collaborate** with ICDs and inland terminals.
- Establish **regional collaboration strategies with other ports and adjacent countries** and invest in the infrastructure required to optimize operations.
- Promote **competition among private ICDs service providers** to increase capacity and performance.
- Invest in port infrastructure to ensure **continuous improvement and operational efficiency**.
- **Adopt a regionalized strategic approach**. In this respect, Chittagong's regionalized approach was good practice. The port launched a direct shipping service with Ranong Port (Thailand), lowering bilateral shipping time from 15 to 4 days and enabling short-sea services.

CASE STUDY 23
Port of Laem Chabang, Thailand

Event: Floods, 2011

In July 2011, the Port of Laem Chabang faced a disruption caused by flooding which occurred at the confluence of the two downstream rivers that flow into the Chao Phraya River. The flooding reached the Bangkok area in October 2011 and persisted in some areas until mid-January 2012 (OCHA, 2011).

Causes and impact[25]

The flooding was mainly caused by an intense monsoon season characterized by seasonal flash-flooding, typical of tropical climate, which regularly occurs in northern Thailand and spread down the rivers flowing into the Mekong. Other amplifying factors exacerbated the disruption, including: (i) the continuously expanding infrastructure and construction standards (clay foundation rather than bedrock) are causing the Bangkok metropolitan area to progressively sink at a pace of up to three centimeters annually; (ii) sea-level rise; (iii) mismanagement of the dams upstream, the capability to take advantage of gentle slopes to control flooding of the Chao Phraya River was usually regarded as a good practice; (iv) bottlenecks on hinterland connections; and (v) higher tide levels in the Bay of Thailand in November, which prevented floodwaters to quickly flow out to sea.

The 2011 flooding in Thailand was described as one of the world's costliest disasters (BBC, 2011), with the World Bank estimating economic damages and losses at $46.5 billion. In addition to the loss of life, several major industrial estates were inundated, causing a global shortage of rice, car parts and electronics, which disrupted various global value chains. Thailand was the second-largest producer of hard disk drives after China, which the computer industry is heavily dependent on as they serve as storage devices for computers and servers. Several factories were closed for more than a month, creating a scarcity of hard drives. In the inbound segment, many supply chains rely on a just-in-time principle, particularly since they are part of the same cluster. With short transport distances, inventory levels can be maintained at a low level with short cycle times. On the outbound segment, computer manufacturers usually have between 4–6 weeks of hard drive inventory.

[24] For additional news about Chittagong port, see https://www.maritimegateway.com/tag/chittagong-port.
[25] This section also draws upon World Bank Group (2012).

The area is an important car assembly and part manufacturing cluster, particularly for Japanese manufacturers attracted to the lower labour costs and available energy supplies to be found in Thailand.

Local manufacturing industries closed, which impacted port traffic. Hinterland infrastructure, including dry ports and transport links to the main ports, in particular roads, were disrupted. Railway embankments and inland waterways reported more limited damage. Meanwhile, the Port of Bangkok stopped receiving inbound containers due to yard congestion and container ships being rerouted to Laem Chabang. Thus, the latter suffered congestion due to the ripple effects of the Bangkok flood. The shortage of containers occurred as many of the inundated container terminals and ICDs had to stow laden containers above empties to avoid cargo damage.

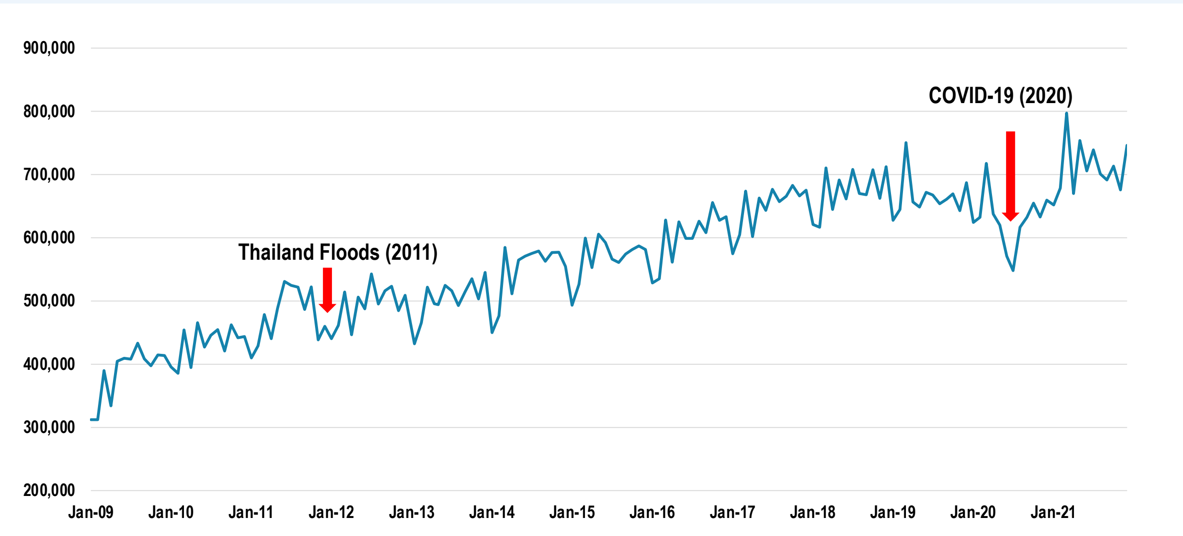
The impacts of the floods on port traffic were noticeable (figure 43). Laem Chabang is the main port facility for Thailand and is situation about 125 km from Bangkok. Although the floods did not directly impact the port itself, it experienced a notable drop in traffic in November and December 2011. While January is the month of lowest activity; in the 2011 cycle November was the lowest month. On the positive side, the event took place at the onset of a period of low activity, giving the port room to handle the post-event demand surge. The expected low activity month (in January 2012) did not occur (AON Benfield, 2011).

Response and mitigation measures

Centralized flood monitoring and coordination began in mid-August. Public emergency intervention by the Thai government and Army, in cooperation with the Thai Red Cross and support from China, Japan, New Zealand and the United States. A 24/7 emergency operations centre was set up to coordinate warning and relief efforts. Inland water traffic was suspended for about 33 days at the peak of the flood.

Pre-event flood mitigation strategies included both structural (e.g. dikes and storage areas) and non-structural measures, such as diversion schemes and flood retarding areas. In many cases, structural solutions failed as flood walls broke in the prolonged flood. The case of Thailand underlines that for well-established logistics clusters, it takes substantial disruptions to incite mitigation measures involving relocation outside the cluster. Disruption inertia, a form of resilience, occurred. The preferred option is to improve the resilience of the cluster was through a series of strategic investments (APEC, 2011). In this case, the return on investment was facilitated by the fact that hard drives maintained their price for more than a year after the event. Port traffic was affected by the disruption but the main port's infrastructure was not substantially impacted.

Figure 43: Monthly traffic at the Port of Laem Chabang, 2009–2021



Source: Based on data from Bangkok Ship Owners and Agents Association (BSAA) http://www.thaibsaa.com/index.php/statistics.

The Government of Thailand sought the support of Japan Disaster Relief for its drainage efforts (ten drain pump vehicles arrived at Laem Chabang at end of November). The Port of Laem Chabang responded by: (i) formulating longer-term strategic measures aimed at establishing better connectivity and regionalization; (ii) ensuring that it be directly and more densely connected with Singapore and other Asian economies, especially China; and (iii) increasing its market share of short-sea transport to reduce reliance on road transport, whose networks are often confronted by bottlenecks (JICA, *Ibid*).

Lessons learned and good practice[26]

- **Monitor and assessment** progress in terms of reconstruction efforts.
- Invest in a **more climate-resilient infrastructure**, including in relation to: (i) disaster risk management related to droughts, floods, and tropical storms; (ii) drainage capacity; (iii) maintenance of assets to improve efficiency and lifetime design; (iv) effective early warning systems; and (v) the review of critical flood embankments and dam safety.
- **Strengthen port infrastructure through continuous improvement and maintenance**.
- **Enhance hinterland connectivity** and ensure diverse transport connectivity options (Director, C. & Francois Bafoil).
- Implement **digital solutions** to cut the burden of bureaucratic and cross-border procedures.

2. LESSONS LEARNED AND GOOD PRACTICES

The COVID-19 pandemic provides lessons to learn from when addressing future disruptions. These include the following:

- Ports should aim to formulate an **integrated resilience and business continuity approach** that includes relevant stakeholders (e.g. shipping lines, terminal operators, third-party logistics service providers, inland carriers, etc.), as well relevant suppliers, e.g. port equipment provision.
- The **availability of personal protective equipment** (PPE) for relevant staff members is vital for port operational continuity and should be managed as a strategic resource.
- A pandemic can be accompanied by other significant risk events, such as typhoons or hurricanes. Therefore, resilience-building strategies need to consider the **potential for compounded events**.
- Pandemics can have **impacts beyond a short time scale** extending beyond two years. Port resilience planning should consider the potential for a disruption to take more time to clear than expected.
- The pandemic accelerated the **diffusion of new technologies**, including digitalization, such as e-bills of lading, blockchains and smart logistics hubs, to drive efficiencies and overcome human contact required by sanitary controls and protocols. These measures have been useful in ensuring business continuity and keeping ports open and the maritime supply chain working.
- **Synergies and co-benefits** can be generated by combining port resilience building and sustainable maritime transport strategies (e.g. digitalization).
- The value of improved **data-driven decision-making** for ports has been emphasized. For example, data insights and analytics can help ports understand their various levels of dependency on other stakeholders in the supply chain.
- **Collaboration** is crucial for stakeholders in the maritime supply chain, including carriers, ports, inland transport providers and shippers. This particularly enhances communications and data-sharing to ensure that maritime transport and ports remain reliable, predictable and efficient.

[26] This section also draws upon Carpenter G. (2012).

- The importance of a better understanding of the **network effects of disruptive events**. For example, the queueing of container vessels at a port can impact on related global trade routes due to a reduced ship carrying capacity and lack of container availability.
- The importance of having **resilience-building and risk management processes and structures**, including collaboration and communication within ports, as well as between ports and relevant third-party port hierarchies.
- Pandemics create conditions that are complex, dynamic, ambiguous and volatile. **Human resources are crucial to resilience** efforts, and need to be appropriately supported with improved education and training.
- Many risk management frameworks and systems are designed to manage risks for which information needed is sufficient and available before the event occurs. However, ports need to learn to **make decisions with imperfect information**.
- Improving **awareness of emerging risks** is critical and horizon scanning and scenario planning can help anticipate future challenges to port resilience.
- Ports and terminal operators need to **better manage yard and gate operations**, such as the management of container stacking and satellite yard facilities.

In the case of broader disruptions that may be caused by factors other than pandemics, the various case studies reviewed, including small ports (box 5), indicate that the impacts were severe in most cases. In addition to the initial trigger, the disruption was amplified by **various local or contextual factors**, including: (i) poor hinterland connectivity and lack of effective coordination with freight forwarders and hinterland transport operators; (ii) limited technology and insufficient digitalization; (iii) delays associated with increasing ship sizes; and (iv) severe weather conditions.

Immediate responses usually involve the formulation of **emergency plans**, which were coordinated locally or with international support (especially in developing regions affected by severe natural disasters), optimization of operations, and temporary restrictions. **International cooperation and public support** are instrumental, especially in the early stages when significant modifications or restrictions to normal operations are required.

Over the medium and long term, most mitigation measures tend to focus on: (i) investments in port infrastructure and equipment; (ii) modernizing existing technology; (iii) enhancing cooperation across key actors (shipping lines, terminal operators, cargo owners); (iv) engaging with relevant stakeholders; and (v) diversifying freight forwarding options and service offering. The goal is to ensure **sufficient agility** in case of disruptions and **avoid cumulating bottleneck effects**. In some instances, the ability of a port to effectively cooperate with partners across the supply chain (e.g. Antwerp, Rotterdam, Seattle, Gothenburg and Mumbai) played a role in mitigating the disruption. A business culture that favours cooperation among port stakeholders, and shared risk awareness and preparedness plays an essential role as risk and disruption mitigating tools.

A review of 23 cases revealed that, among others, the ports of Antwerp, Los Angeles and Hamburg, accelerated digital coordination with the hinterland, continuously optimizing operations, and ensuring spare capacity based on enhanced risk awareness and forecasting. Another cluster of ports, such as Rotterdam, Ho Chi Minh, Tianjin and Laem Chabang, are more exposed to natural disasters and vulnerability to climate change. They tend to carry out pre-event risk assessments, establish engagement and communication with stakeholders, accelerate shared digitization, invest in and adapt infrastructure to the identified risks, and diversify hinterland connectivity options. Another set of ports, such as Freeport, Gothenburg and Gulfport, tend to respond to disruptions by tightening their regional bonds, investing in digital connectivity, and cooperating with their ecosystem to offer attractive and competitive services. Coopetition with rival ports, rather than market competition, can be a resilience enabler for smaller ports.

Measures that promote robustness, redundancy, visibility, flexibility, collaboration, agility, information sharing and technology, all enable greater port resilience. Some good practices identified from the case studies include the following:

- Setting up **regular risk assessments** and disaster prevention management framework.
- Strengthening **collaboration among hinterland stakeholders and partners**.
- Reinforcing **cooperation with local and international agencies**.
- Enhancing **communication and information sharing**.
- Improving **maritime and hinterland connectivity**.
- Investing in **technology and infrastructure**.
- Ensuring **digital readiness and connectivity**.

Internal operations and process optimization emerged as the most straightforward response and mitigation measure. As generally, other measures involve other partners and stakeholders, their effective implementation is not directly within the sphere of influence of a port.

Proactive strategies seem to be more prevalent when facing **recurrent risks**. Such risks can be associated with: (i) capacity constraints arising from the delay in mega-ships schedules; (ii) workload peaks creating bottlenecks for hinterland transport operators; (iii) unexpected demand surges; and (iv) expected disruptive events (e.g. natural disasters). The cases reviewed have shown that **preparedness**, i.e. planning for the disruption before its occurrence, contributes to the effectiveness of the response measures and reduces the disruption's duration.

Diversifying **hinterland connectivity** options and modal choices linking the port to its hinterland can mitigate risks and disruptions to ports. **Digital connectivity** is equally important, especially when the pandemic underscored the need for better, quicker and more transparent information-sharing across various supply chains. Greater use of digital means and solutions across the hinterland has become a necessary requirement for port connectivity. Digital connectivity provides an opportunity to reduce transaction and coordination costs needed to cope with conventional bottlenecks, such as customs clearance. When a disruption occurs, digital tools help reduce the operational disturbance, while also facilitating the participation of smaller and more marginal players.

Box 5. Small ports: key resilience-building actions

Smaller ports can face a paradoxical situation: 1) they can be more agile as they have a smaller organizational structure and more direct lines of communication, and at the same time, 2) have limited resources and skills available to drive resilience-building activities. That said, the tools and approaches set out in this guidebook remain valid for consideration and appropriate for adoption even for a small port.

Some relevant steps and actions that small ports may wish to consider to strengthen their resilience and improve preparedness in the face of disruptions, whether from pandemics or any other risk factor, are set out below:

- Identify the intended benefits of the Enterprise Risk Management (ERM) resilience-building initiatives and seek to obtain the support of the board and senior management.
- Plan the scope of the ERM initiative and develop a common language relating to risks and their management. Relevant key concepts are defined in the guidebook.
- Establish the resilience-building and risk management strategy and define roles and responsibilities. One may need to assume more than one role, and the selective use of specialist third parties should also be considered. Ensure that the port workforce benefits from relevant training and awareness-raising activities about risks and their management.
- Adopt suitable risk assessment tools and an agreed risk classification system. As a minimum, it is suggested that a port looks at horizon scanning (HS), early warning systems, such as those around weather events, business continuity plans, and financial, infrastructure, reputational and market approaches to assess impacts. Establish risk benchmarks and undertake risk assessments. Determine risk appetite and risk tolerance levels and evaluate existing controls.
- Evaluate the effectiveness of existing controls and introduce improvements on an annual basis.
- Mainstream a risk-aware culture and align resilience-building and risk management with other activities in the port by linking staff health and safety training to resilience and risk management.
- Monitor and review risk performance indicators to measure ERM contribution.
- Report risk performance in line with regulatory obligations and monitor improvements

WAY FORWARD

Resilience: An emerging paradigm

Shipping and ports are essential for global trade and supply chain continuity both during and outside crises. The COVID-19 pandemic and the heightened disruptions to global maritime logistics observed over recent years have underscored the critical importance of risk management and emergency response preparedness and the need to build ever more agile and resilient maritime transportation systems.

Although the strategic importance of ports for maritime shipping, trade and interrelated economic activities is widely acknowledged, ports and their stakeholders – shipping lines, cargo owners and terminal operators, among others – can still face disruptions that undermine their ability to effectively support global trade and interlinked supply chains. Maintaining the integrity of these complex supply chains requires continuous efforts, with port resilience being a critical element. Many ports are unable to assess which disruption is likely to occur; however, many also know that a future disruption remains a certainty.

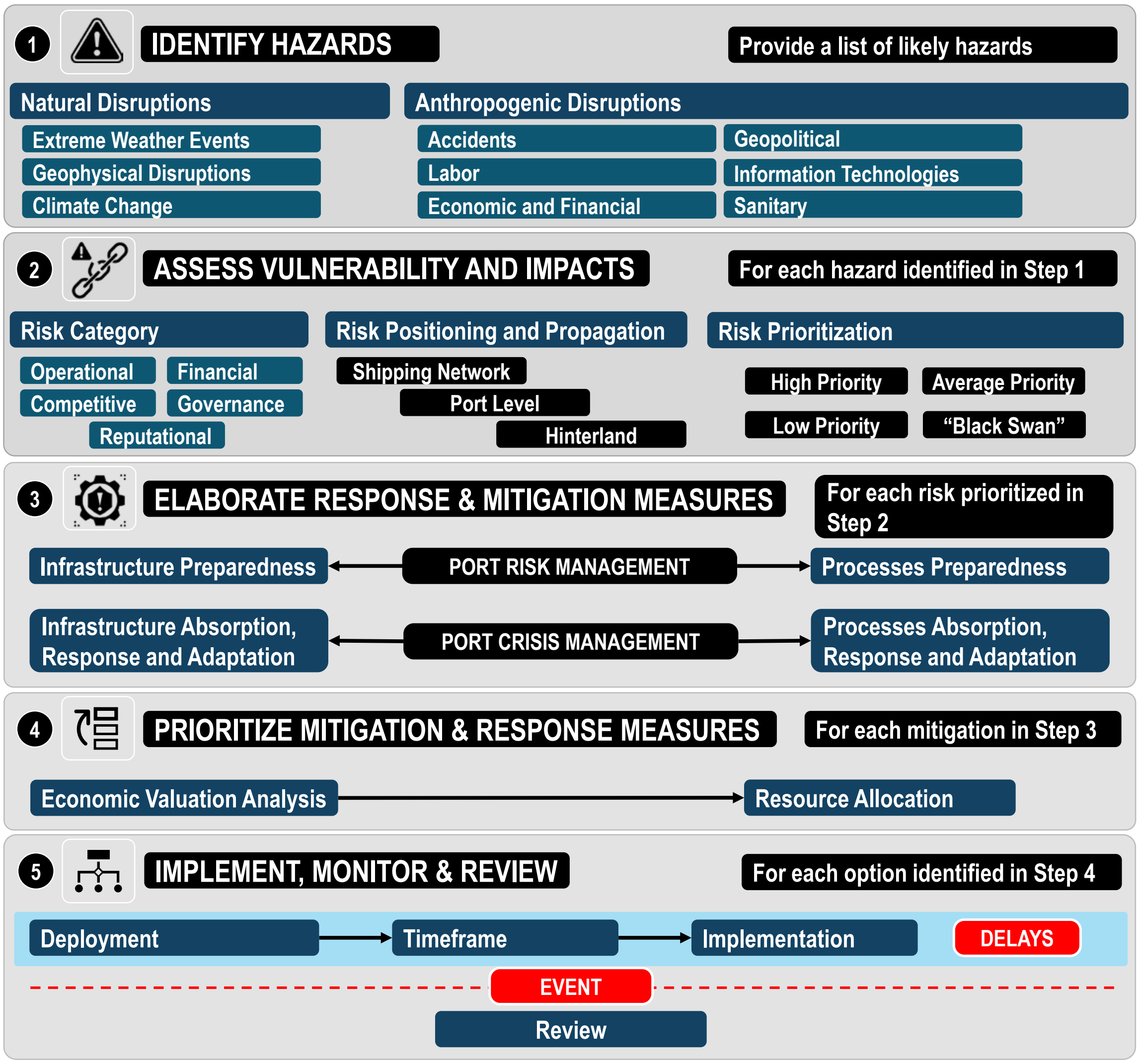
Building and enhancing port resilience remains a challenge with obstacles, delays and sometimes unclear financial trade-offs. To the extent that port resilience, or a part of it, is perceived as a **cost centre**, inertia is a likely outcome, and **reactive post-event approaches** would remain the norm. A port is likely to be compelled to revise its strategy only after a disruptive event, particularly if the financial and commercial impacts were significant. Resilience is better promoted when perceived as a **competitiveness and business continuity factor**. Difficulties faced as part of efforts to mainstream environmental sustainability principles into commercial and business practices illustrate the complexity of some of these issues and the magnitude of the challenge in resilience building efforts.

Over the years, however, and in the context of growing sustainability momentum, sustainability and environmental protection issues are increasingly seen as a competitiveness factor. Perception and policy changes, such as the push towards decarbonization, have played an important role in this respect. A similar outcome is likely to result from resilience, which can become a “default” feature of ports and maritime supply chains of the future and emerge as a core element of port operations and management. This new paradigm would put more **emphasis on preventive and proactive strategies**, such as pre-event planning.

This guidebook aims to guide and assist stakeholders acting in the field of maritime transport, especially ports that handle container traffic in their efforts to build their capacity to enhance preparedness in the face of disruptions and strengthen their ability to absorb shocks, maintain business continuity, recover and even thrive.

Figure 44 synthesizes a proposed approach to port resilience-building. The approach is articulated around five key steps. While not exhaustive, a list of relevant tools, instruments, resources and standards supporting risk management and resilience-building objectives have also been identified (Port Risk Management and Resilience-Building Toolbox and Annex IV, Section A). By adapting and tailoring many of the existing tools and solutions to a port context, stakeholders in the sector can better foresee and prevent adverse events, ensure a timely response and build back better.

Figure 44: Synthesis of port resilience-building process



The **five steps** to port risk management and resilience-building are as follows:

1. **Identify hazards.**
   Provide a list of the most likely natural and anthropogenic hazards that have historically and could potentially impact a port.
2. **Assess vulnerability and impacts.**
   For each of these hazards, provide a categorization of the type of risks, for example: (i) are they operational, financial, competitive, governance and reputational risks; (ii) how could they likely propagate along the supply chains supported by the port; and (iii) what is their priority (low to high).
3. **Elaborate response and mitigation measures.**
   Two major approaches, one related to **port risk management**, proactively identifies and prepares a port to mitigate likely disruptive events. The second is **port disruption/crisis management**, which reactively sets response strategies once an event has occurred.
4. **Prioritize mitigation and response measures.**
   Economic valuation analysis, such as cost/benefit analysis, can be performed to evaluate the cost of selected mitigation measures, including the potential costs of inaction and opportunity costs. It is then possible to prioritize the measures considering the availability and scarcity of resources.
5. **Implement, monitor and review.**
   The deployment of response measures and mitigation options can face a series of opportunities and obstacles, resulting in delays common in large infrastructure projects. The occurrence of a disruption event represents an opportunity to review the effectiveness (or the lack of) of existing measures and revise options.

The port as a resilience-building platform

A proposed perspective is to consider a port as a **resilience platform** that allows for the continuation of supply chains and the availability of transport capacities. This perspective includes four fundamental infrastructure and operational aspects (figure 45):

- **Strategic asset.** As a transport facility, a port provides access and distribution capabilities to global and national markets. Ports should be recognized as strategic assets of national importance and receive appropriate regulatory and financial support. They support the resilience of their hinterlands by maintaining inbound and outbound supply chains. This also includes power generation facilities, essential to maintaining electric power supply, many of which can be found in the vicinity of a port.
- **Secure facility area.** The port facility must be secured to promote safe access, which involves a perimeter and checkpoints. The core purpose is to maintain the operational capabilities of the port, which requires the presence of key personnel and equipment.
- **Inventory management.** Ports commonly have co-located logistical facilities (e.g. warehouses and distribution centres) that should be considered part of the secure perimeter. These logistical facilities support critical supply chains by ensuring the procurement of energy, parts, goods, food and medical supplies. During a disruption, these facilities are expected to continue their operations and provide storage of critical inventory.
- **Connectivity and accessibility.** Mainstreaming digital solutions and electronic processes in ports are needed to maintain their physical connectivity to the shipping network and accessibility to their hinterland.

A resilient port is a port that has:

- Identified, reviewed and prioritized any **potential risks** that could impair its operations and market position;
- Strengthened its **adaptability and responsiveness** to disruptions related to its most probable risks;
- Identified **internal and external support structures** that can be accessed to address unforeseen and rare disruptions; and
- Created an iterative process involving the **reviewed and improvement of a resilience strategy**, taking into account events, as well as new and emerging risks.

Resilience can be implemented proactively or reactively:

- **Pre-event (resilience-by-design**). Pre-event measures build the capacity of a system to recover and resume critical functions after an expected disruption, which is within the design parameters of the system, namely its infrastructure, operations and management; and what the port can do proactively.

- **Post-event/during event (resilience-by-intervention)**. This includes post-event measures that react to the disruption, either on a planned or an ad-hoc basis, and what the port can do reactively when faced with a disruption. It assumes that internal and external resources will be available to stakeholders, as needed, to support system resilience. In addition to the resources available to the port, many governments have agencies designed to intervene and manage large-scale emergencies by offering supplies, relief and equipment to repair local infrastructure. This represents the support structure that the port can draw from. However, depending on the nature and the scale of the event, a support agency may be overwhelmed or have other priorities, such as providing relief to the population.

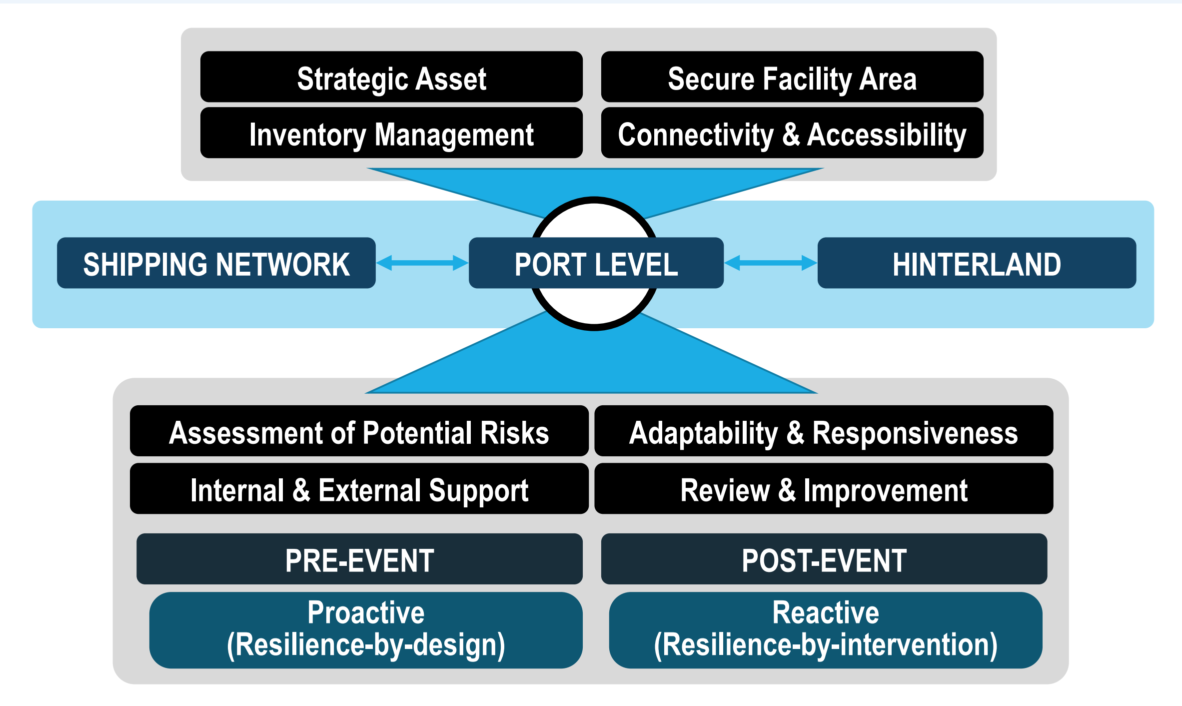
A review of the case studies shows that most ports have a post-event **reactive approach** and response to disruptive events, even when these events have a level of predictability (e.g. hurricanes and extreme weather events). Ports have a complex and capital-intensive infrastructure, which help explain inertia and the existence of default "resilience-by-intervention" approaches. However, this approach to risks and disruption is increasingly inadequate considering the growing importance of ports as trade, logistical and energy platforms.

Therefore, a transition towards a more proactive view of resilience is important and is likely to have accelerated in the context of COVID-19 pandemic and recent geopolitical and climatic risks, and disruptions.

Port resilience-building should not be seen as a one-off solution but as a **strategy and an ongoing process** that can be gradually implemented and revised. It must be adapted and fine-tuned to the unique situational, governance, managerial, commercial, and infrastructural context that each port faces.

The success of port resilience-building measures depends on effective collaboration among all players, at the national and international levels, especially for transborder trade. Concerted efforts and coordinated action are crucially important, especially when tackling bottlenecks not only at the port and ship/port interface level but also along the hinterland, including landlocked, transit and coastal countries. In facing the challenges ahead, policymakers should ensure that financial support, technical cooperation and capacity-building are provided to developing countries, in particular the most vulnerable economies in LLDCs, LDCs and SIDS.

Figure 45: The port as a resilience-building platform

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PART IV
ANNEX

A. RISK MANAGEMENT AND PORT RESILIENCE-BUILDING TOOLBOX: ADDITIONAL INFORMATION

1. PORT RESILIENCE

The term "**operational resilience**" incorporates traditional risk identification and detection tools, e.g. as business impact assessment (BIA), horizon scanning (HS), scenario planning, risk management, and mitigation techniques, such as business continuity planning (BCP) and crisis management. These techniques are implemented in various ways and can each be of greater relevance before, during or after a disruption. "Operational resilience" needs to be combined with "strategic resilience," which entails value-adding activities, and a well-entrenched culture that supports risk management and resilience objectives. "Strategic resilience" also requires effective communications, including among decision-makers at the port level.

Thus, **operational resilience** relates to the port's capabilities, while **strategic resilience** relates to the **culture** in which it thrives. 'Pro-resilience' organizational cultures, including operational and strategic activities, are best set top-down and led by clear examples.

Two elements are crucial for successful organizational cultures that promote resilience:

1. Whether the risk management capability is in the hands of individuals reporting directly to the senior port management, and whether there are sufficient and appropriately trained and competent staff, or advisors in risk management techniques.
2. Whether performance measurement systems, such as key performance indicators (KPIs) (e.g. vessel time spent at ports), and key risk indicators (KRIs) (e.g. availability of the port's main operational IT system) are in place.

2. RISK CULTURE AND APPETITE

A risk culture describes the values, beliefs, knowledge, attitudes and understanding about risk shared by a group of people with a common purpose (Institute of Risk Management, 2012). This applies to private companies, public bodies, governments and not-for-profit entities.

Although there is no single method of 'measuring' risk culture, several diagnostic tools are available and can be used to assess and track an organization's risk culture. The mix of tools and the order of their deployment will depend on the organization's risk management maturity level. The Institute of Risk Management has articulated a Risk Culture Framework around which to analyse, plan and act to influence risk culture within any organization (Institute of Risk Management, 2012).

A port's risk culture determines its ability to balance risk and opportunities as they emerge. An appropriate risk culture ensures that ports recognize the importance of effective risk management, and that their actions are consistent with their operational risk policies, procedures and appetite. Inappropriate risk culture can lead to increased operational risks and amplify impacts.

Risk culture is concerned with risk-taking, as well as risk control. All ports must take risks to achieve their objectives, including having to accept a degree of operational risk exposure. A port's risk culture will influence whether people perceive an operational risk as beneficial (e.g. associated with pursuing a potential opportunity) or a threat. A port can use surveys to gather the views of staff, interviews, or employee panel sessions to ascertain its risk culture. An example of a risk culture questionnaire can be found in Appendix A of the Institute of Operational Risks Risk Culture Guidance.

A survey questionnaire alone will not be sufficient to fully capture a port's risk culture; however, the key elements to be addressed as part of this exercise include:

- Whether staff share the risk management objectives outlined in the policy;
- Attitudes towards the risk function or specific operational risk tools and procedures (e.g. HS);
- The presence of subcultures, e.g. differences in responses based on functions and location or levels of seniority;
- Whether staff believe that the port is taking too much or too little risk; and
- Whether staff have adequate knowledge and understanding of risks and risk awareness

Surveyed staff should represent a port's workforce, with contract and other third-party staff operating in relevant locations across the port also included in the survey. Changing the risk culture takes time and is typically best achieved in small incremental stages. A risk culture should not be measured as a one-off and should be reviewed at least once a year. Several metrics can inform a port's risk culture, such as staff turnover, staff conduct (fall or rise in staff grievances), risk policy compliance, losses and near misses.

Port leaders and managers can influence their ports' risk culture through the following actions:

- Being visible and consistent in terms of what they say and do. This requires them to act in a way that supports the values of the organization as well as its policies and procedures;
- Sending out clear messages regarding their expectations about risk management and decision-making. Including having a clear risk appetite statement and risk management policy;
- Making it clear that all areas of risk management, including operational risk management, are important value-adding activities, not simply 'cost-centres'; and
- Being open to challenges and avoiding becoming blind to or against new information about their risk exposures and risk management strategy.

Human resources (HR) processes and management techniques can influence a risk culture, including recruitment and performance management approaches. Clear communication channels are required to escalate potential concerns as quickly as possible.

Port workers should trust that management listens to their concerns on operational risk and how they are managed. It is important to establish a 'just' culture, which encourages open and no-blame reporting, while ensuring that accountability is maintained. The establishment of an effective whistleblowing procedure is also important.

Risk appetite is the amount and type of risk that a port is willing to retain to meet its strategic objective, and mainly involves decision-making. Every action or decision within a port involves an element of risk. Therefore, the port must distinguish between risks that are likely to result in value-creating opportunities, such as profit, a positive reputation and improved services, as opposed to those that may undermine value. By determining an appropriate appetite for risk and implementing a framework to ensure that this appetite is maintained, decision-makers avoid exposing their ports to either too much or too little risk.

The benefits of implementing a framework to determine and manage a port's risk appetite involves, among others:

- Enabling senior management to exercise appropriate oversight and corporate governance by defining the nature and level of risks it considers acceptable (and unacceptable), and setting appropriate boundaries for business activities and behaviours;
- Providing a means of expressing the attitude of senior management towards risks, which can then be communicated throughout the port to help promote a risk-aware culture;
- Establishing a framework for risk decision-making to help determine which risks can be accepted/retained, as opposed those that should be prevented or mitigated;
- Improving the allocation of risk management resources by moving these into sharp focus;
- Helping to prioritize issues, specifically risk exposures or control weaknesses outside a determined "risk appetite" or "risk tolerance";
- Ensuring that the cost of risk management does not exceed the benefits; and
- Balancing development/growth/returns and the associated inherent risks.

Mainstreaming "**risk appetite**" in a port requires looking at the "**risk tolerance**", which is typically used for a specific benchmark for the acceptability of a given risk exposure or metric. In other words, a port may decide that it is prepared to tolerate a particular number of operational errors or control weaknesses because their elimination would not be cost-effective.

Risk tolerance is often expressed by using a colour scale:

- **Green**: Acceptable and no immediate action required, except for routine monitoring.
- **Amber**: Tolerable and investigate to verify and understand the underlying causes and consider ways to mitigate within a specified time.
- **Red**: Unacceptable and take immediate steps to mitigate or avoid it.

The thresholds determining shifts in how risk exposure is labeled or perceived (red, amber, green flags) reflect the level of risk tolerance at the port. The wider these thresholds, the greater the degree of tolerance. No port should take on risks with a high probability of causing death or injury, a breach of applicable laws and/or regulations or financial distress, and bankruptcy. When setting out the appropriate "risk appetite" and "risk tolerance," an agreement is needed on who will be responsible for determining risk appetite and risk tolerance, as well how to express risk appetite and risk tolerance. Figure 1 sets out the linkages between risk appetite, tolerance and capacity.

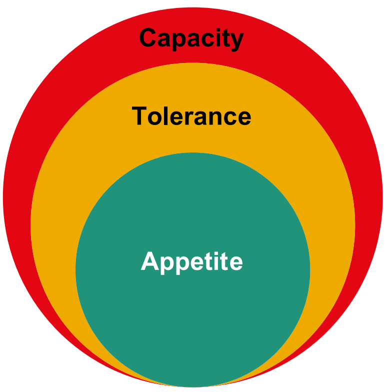
Port senior management should be responsible for setting the relevant risk appetite and risk tolerance levels which can be expressed in qualitative or quantitative terms. Examples on the qualitative side include some unpreventable operational rissks, such as global pandemics and natural disasters. On the quantitative side, examples include measures related to the port's IT system or key crane availability (e.g. set levels so that no more than a given percentage of any business-critical system or equipment becomes unavailable for more than one week in any given year).

Senior management should consider three primary factors when deciding on the port's risk appetite level:

1. **Port strategic objectives.** For example, a port looking to grow may choose to accept a greater level of risk, taking into account health and safety and legality objectives.
2. **Risk preferences of key port stakeholders.** Where stakeholders are more averse to risk, a lower level of risk appetite will be appropriate, and vice-versa.
3. **Port financial stance.** Ports in a solid financial position are expected to have the funds necessary to finance the costs associated with managing risks.

Figure 1: Risk appetite, risk tolerance and risk capacity

Risk appetite	The amount and type of risk that an organisation is **willing** to pursue or retain.
Risk tolerance	The acceptable degree of variability, or deviation from the expected level of risk that an organisation is **prepared to withstand**, in order to achieve its objectives.
Risk capacity	The **maximum level** of risk to which the organisation should/can be exposed.



Source: Elaborated by the authors based on various sources including the Institute of Risk management and Business Continuity Institute.

The risk tolerance thresholds are established based on the agreed risk appetite. For example, red and amber thresholds need to be set for a new port IT system. Although extensive testing suggests that the system is very reliable, no historical data exists regarding the system's stability in regular daily use. Managers at the port decided to set red and amber limits based on their experience with other IT systems and user reactions to failures. Evidence suggests that a non-availability rate of less than 1 per cent is tolerable, but 2 per cent or more can significantly disrupt operations. Hence the amber threshold is set at 99 per cent availability and red at 98 per cent.

A port may communicate its overall risk appetite by using a range of methods, including staff induction and training sessions, staff meetings, intranet resources and performance reviews. It is recommended that multiple channels be used to ensure that the message is well received and understood. Risk tolerance thresholds for specific operational risks and controls should be communicated to all staff involved in the management of these risks and controls.

Procedures are required to ensure that the port remains within its chosen risk appetite and tolerance levels and uses its risk management resources most efficiently while preventing and mitigating risks.

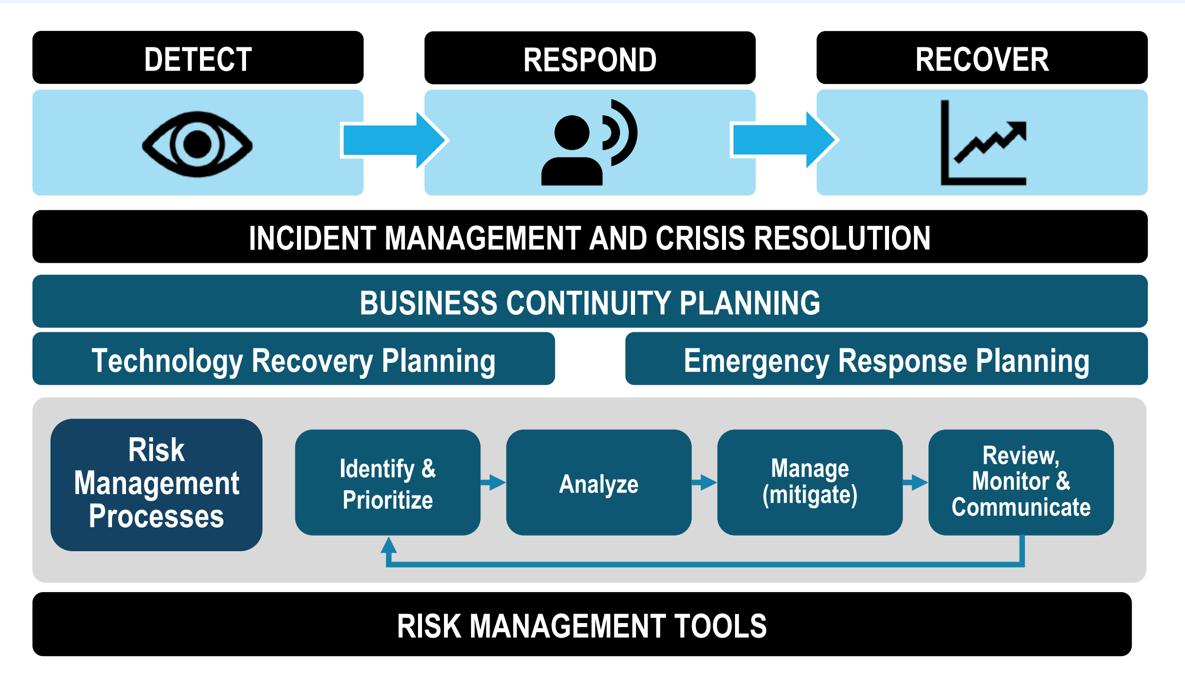
Designing and implementing these measures involve:

1. Arranging for the required data on port risks to be reported by the appropriate port individual responsible for managing the risk at an agreed frequency. All reasonable steps should be taken to ensure that data is complete, accurate and timely. Risk appetite and tolerance levels should be built into existing risk reports to save time producing new reports and prevent overloading management.
2. Converting data to information by adding context and interpretation (e.g. how the data compares with business performance metrics, whether the data suggests the emergence of increased or reduced risk). This entails the identification and investigation of adverse variances and trends and analyzing the underlying causes.

3. RISK MANAGEMENT TOOLS

Beyond minimizing and managing risks, resilience-building efforts can create value and competitive advantage through an improved service proposition. Figure 2 sets out relevant risk management tools and approaches.

Figure 2: Risk management and resilience-building tools and approaches



Source: Elaborated by the authors based on various sources including the Institute of Risk management and Business Continuity Institute.

3.1. Governance and risk management enabling framework

Enterprise Risk Management (ERM) plays a vital function in bringing together the various resilience-building approaches and tools, including business continuity planning (BCP), horizon scanning (HS). To ensure that risk management principles are mainstreamed, port authorities and executives at higher levels need to commit and assign ownership and accountability for risk management and resilience. A helpful approach to achieve this is the widely used "RACI matrix" approach, setting out clearly who is *Responsible, Accountable, Consulted and Informed*.

A starting point is to fully understand the port's current business strategy and operational capabilities and its strengths and weaknesses. To ensure that the port or its situation is well understood from the start, it is important to establish a collaborative team and include experts from within and outside the port ecosystem (e.g. epidemiologists in the case of a pandemic).

A function of port corporate governance is to ensure that appropriate risk management procedures are in place.

Elements required to develop a port risk management programme include the following:

- Clearly defined scope for the programme, including the appropriate involvement of representatives from the hinterland, regional and national governments:
- The governance and the review process around the programme;
- Defined detailed roles and responsibilities; and
- Clear activity phases.

Determining the scope of port risk management activities involves:

- Forming a steering group to coordinate efforts;
- Considering, among other factors, which port services/areas to focus on, e.g. a specific terminal operation, or other;
- Identifying processes supporting relevant port service/area. e.g. IT systems, vessel scheduling;
- Coordinating and integrating with other port activities.

Setting up a risk governance structure involves:

- Determining the status of port operations and risk management to ensure the proposed approach is feasible, and considering the financial, staff and other resources available;
- Establishing a review, ownership and execution process;
- Identifying specific success criteria;
- Defining who needs to know what and when;
- Setting up the reporting streams; and
- Clarifying how the programme interacts with the rest of the port operations. For example, how the terminal operator interacts with hinterland operators.

When assigning responsibility and distributing tasks, the following considerations may be helpful. Ports need to agree on the risk tools that will be used and by whom. For example, whether the HS activity is to be conducted by the port and who should be involved. The Steering Group should ensure that all activities are appropriately coordinated and prioritized, and that appropriate reporting on progress is provided to senior management.

3.2. Enterprise risk management

For ports, "**resilience**" can be achieved by formulating, implementing, and monitoring a well-executed **Enterprise Risk Management** (ERM) strategy and procedure. ERM allows for resilience-building to be viewed as a strategic desired outcome for the port; it is framed as an opportunity for ports and an enabler for competitiveness, re-shaping, growth and strength (Bell G., 2020). It determines thresholds for resilience-building measures, while concurrently assessing extreme exposures and impacts and determining priority areas. ERM ensures consistency in decision-making processes, enabling organizations to understand better the acceptable level of vulnerability and options relating to preventive and corrective treatments and controls.

Port resilience-building efforts must be linked to the port's core values and mission. A combination of risk management and resilience-building tools enables ports to achieve a fully integrated understanding of organizational exposure, preparedness, absorption and the response capacity required to reduce the likelihood and impact of potential and actual disruptions. In this context, ERM acts as a common ground and integrator for other tools and instruments, e.g. business continuity and scenario planning.

Ports should not take false assurance from aspirational response plans that (often) do not specify how suitable arrangements will be implemented. For example, a response plan can be disconnected from relevant risks, risk appetite and tolerances, and crisis management arrangements do not adequately handle processes related to required information flow and decision-making. In other cases, the workforce is not sufficiently well trained and has limited practice, and therefore is not crisis ready. Thus, often the management system required to sustain and provide relevant human and financial resources for resilience-building can be inadequate. With appropriate response plans, disruption impacts can be minimized. This requires, however, a well-trained workforce and teams operating via connected and well-thought-through plans.

Inadequate communications across a coordinated resilience framework have compromised the actions of many organizations, causing them to ditch poorly prepared plans. Furthermore, collaboration is crucial to overcoming silo perspectives among business continuity, crisis management, and other risk management practices.

As a result, disruption impacts can be minimized when a major disruption event, e.g. the COVID-19 pandemic, occurs. This can only be addressed by a well-trained workforce and teams operating via connected and well-thought-through plans. Inadequate communications across a coordinated resilience framework have compromised the actions of many organizations, causing them to ditch poorly prepared plans. Furthermore, collaboration is crucial to overcoming silo perspectives among business continuity, crisis management, and other risk management practices.

ERM integrates different risks (e.g. financial, reputational, etc.) and ensures that resilience-building activities keep port organizational resilience capabilities within its risk appetite and tolerance levels. Hopkin, P. (2018) described ERM as encompassing the following activities:

- Prioritize port risks and exposure and manage these as interrelated risk portfolios rather than individual "silos" of risk.
- Assess the risk portfolio and consider internal and external contextual factors and stakeholders.
- Analyze individual risks across the port and recognizing their interlinkages. Recognize that these can create a combined exposure that differs from the sum of the individual risks.
- Pursue a structured process for the management of all risks.
- Mainstream risk management in the port's critical decisions.
- Identify acceptable risks to achieve the port's strategic objectives.
- Ensure communications to foster a common understanding of risks and their importance.
- Support internal audit activities, when applicable, and provide a structure for the provision of risk assurance to the Board and the Audit Committee.
- Consider effective management of risks as a competitive advantage that contributes to achieving business and strategic objectives.

Implementing a fully functioning ERM programme is a significant undertaking involving all relevant port stakeholders, including third parties. The time required to implement an ERM programme depends on various factors, including:

- Existing risk management efforts upon which to build.
- Commitment on the part of senior management. The greater its commitment and involvement, the more likely it will give prioritize the programme.
- Size and complexity of the port, including its terminals, hinterland and seaside connections
- Available resources, including financial and human resources.

HINT[27]

💡	Engage senior management and the Board to provide organizational support and resources.
💡	Establish an independent ERM function reporting directly to the Board/authority.
💡	Set up the risk governance structure at senior management/Board levels, supported by internal audit, as deemed appropriate.
💡	Develop the ERM framework that incorporates an appropriate risk classification system.
💡	Promote a risk awareness culture fostered by a common language, training and education.
💡	Provide written procedures with a clear statement of the port's risk appetite.
💡	Agree on a monitoring and reporting mechanism against established objectives for risk management.
💡	Undertake risk assessments to identify accumulations and interdependencies of risk.
💡	Integrate ERM into relevant strategic planning, business processes, and operational success.
💡	Track and measure benefits achieved by ERM.

3.3. Horizon scanning

The aim of a **horizon scanning** (HS) is not to predict the future but to improve understanding and review potential options and course of actions and ensure more informed decisions, which ultimately can help enhance resilience and preparedness in the face of uncertainty and change. HS is defined in various ways, including as:

- An organized and formal process of gathering, analyzing, and disseminating value-added information to support decision-making.
- A systematic examination of potential threats, risks, emerging issues, and opportunities, enables better preparedness.

Governments and large corporations frequently use HS as part of their overall planning processes. Smaller ports can also use HS and adapt it to reflect resources and capabilities. A HS can inform port strategic planning while keeping the scan relevant and updated. The HS process is illustrated in figure 3.[28]

A port HS can cover issues, such as climate change mitigation and adaptation, cyber-risks, energy transition, changes in global trade patterns, and related implications for port calls and vessel routing. These issues entail both upside and downside risks that can be transformational and affect ports operations, business continuity, reputation, profitability, sustainability and resilience.

Risks can then be assessed in terms of the time horizon of their likely impacts by addressing the question of whether certain risks are likely to materialize and if so, when their effect is to be expected, i.e. over a short period, within 12 months; a medium period, (1–3 years); or a longer term, more than 3 years.

It is important to develop a framework for categorizing both risks and opportunities. It is also important to assess the potential impact of these risks on a port business, and the port's risk appetite. This will help determine the need to respond and the timeframe in which a response will be required. Figure 4 illustrates HS results.

The impact rating (high, medium and low) should reflect the specific context of each port. For example, a port with assets of only $1 million, a disruption causing an economic impact of $500,000 would be considered high as opposed to a port with assets worth $200 million. Determining the likelihood of occurrence can make use of relevant historical frequency data as available.

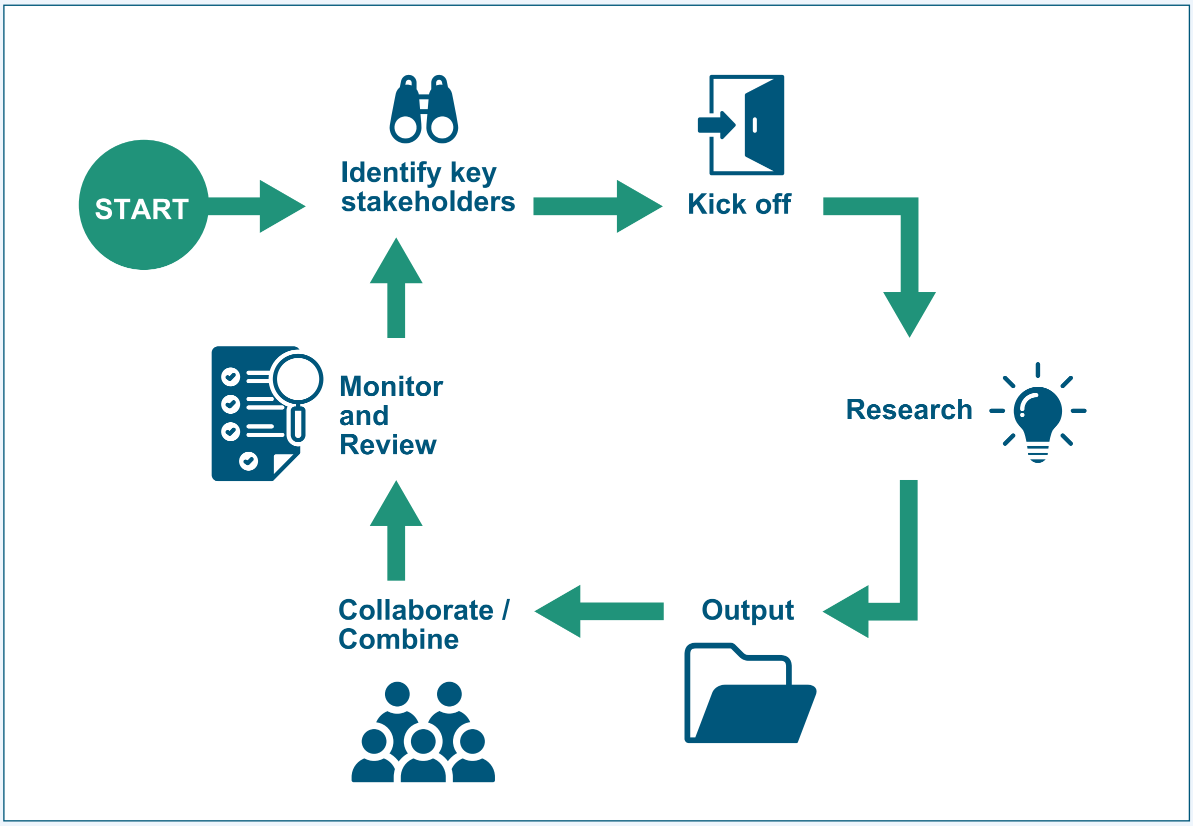
The rate at which information becomes available (i.e. the risk clock speed) is more important from a risk management perspective than the velocity or the speed at which the risks will occur. (Smith, 2010). When information needed to manage risk is available pre-event, detailed management steps can be implemented, including port plans for the arrival of mega vessels associated with collisions/accidents.

[27] See Hopkin, P. 2018.
[28] See IRM Horizon Scanning: A Practitioner's Guide. https://www.theirm.org/media/7423/horizon-scanning_final2-1.pdf.

Detailed information and related plans on common types of risk can be found in risk registers. These cases are known as "slow risk clock speed". This means ports have sufficient time to process, discuss and plan for action and response. An example of such risks would be limited water depth for ship docking. While the ship may not arrive until some months in the future, the tidal pattern is known well in advance. The port can therefore manage the risk that the ship may run aground through adequate planning. There are also instances where the information required to manage a given risk arrives in quick succession or close to real-time resulting in "fast risk clock speed risks".

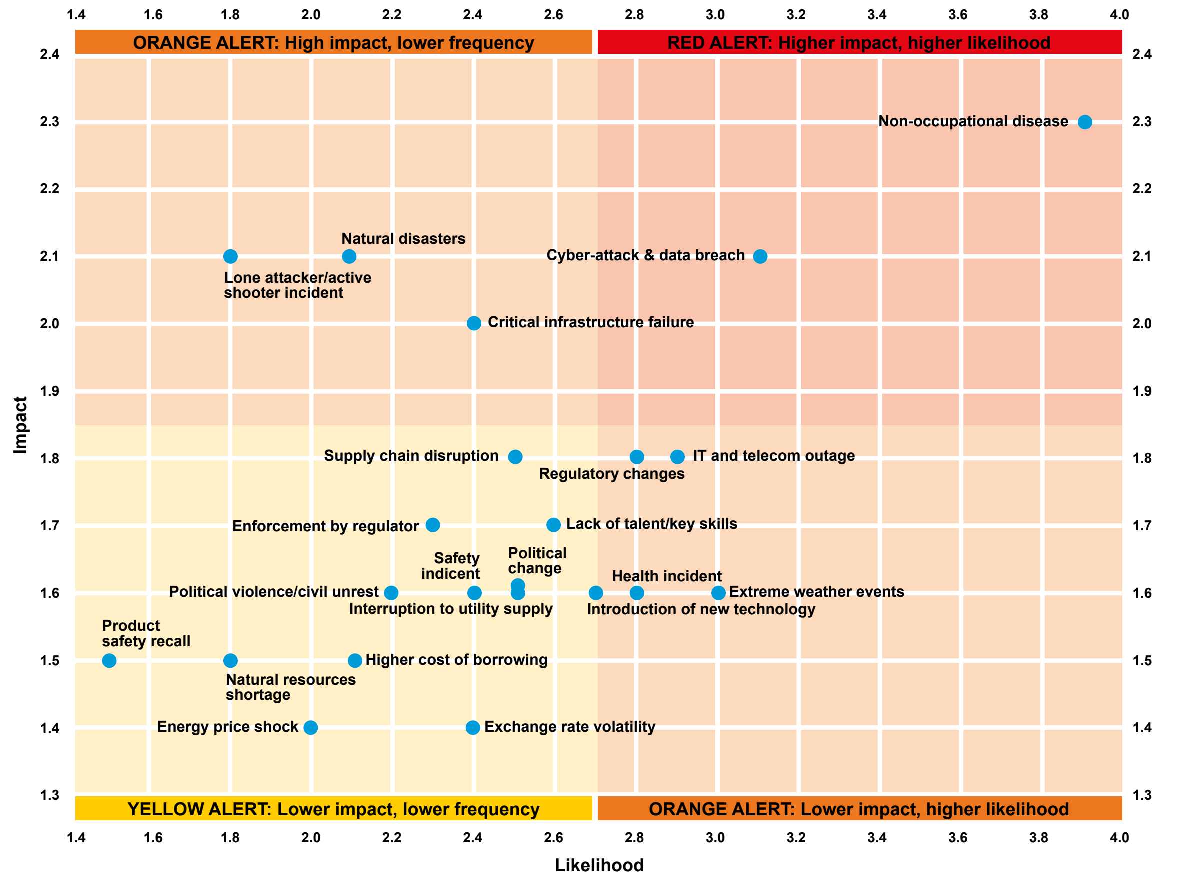
It is crucial that any new material risks or significant changes to existing risks be communicated in an appropriate format to port senior management/ Board. Stress-testing and scenario planning to assess the robustness of the port, in particular a port's financial situation, could be relied upon. The port's financial position is key to withstanding a risk event, e.g. having $100 million in cash resources, instead of $1 million (see scenario planning).

Figure 3: Horizon scanning process



Source: Institute of Risk Management (2018).

Figure 4: Example of horizon scanning results



Source: BSI (2021).

Horizon scanning should be carried out on an annual basis or appropriately updated where there is a known significant change in the risk environment; it can be completed relatively quickly in smaller port operations. Such HS can be achieved while using information, data and resources within the public domain. Only internal resources are required in many cases, but external expertise can be leveraged, if needed.

An effective HS will need to take into consideration existing biases and perspectives, namely:

- The heightened uncertainty – in terms of its impact and likelihood of risk/opportunity occurrence – associated with longer term timeframes and horizons.
- Over-focus on historical trends analysis and overlooking new trends and developments.
- Over-reliance on previous assessments and under-rating or ignoring weaker signals.
- Mis-rating of risks by over-rating the standard, known and understandable risks, while under-rating risks that are more complex and difficult to fully understand.

HINT

- Set up the risk governance structure at senior management/Board levels, supported by internal audit, as deemed appropriate.
- Engage multiple stakeholders across disciplines and departments.
- Lessons learned from leading HS by the Government of the United Kingdom and Northern Ireland (Carney J., 2018) include the following:
  - **DON'T think that HS is about predicting the future** – this is a common misconception. The value of HS is to change mindsets, challenge assumptions, and provide more options.
  - **DON'T look for 'what you know or want'** – scanning is not the same as searching. This may seem contradictory, but it is one of the hardest commandments to get your mind around as a practitioner or a client. HS is about asking the 'unasked questions', or identifying the "unknown unknowns" (after Donald Rumsfeld).
  - **DON'T negate the need for a champion or dedicated clien**t – the major challenge for a HS analysis is in overcoming cultural resistance. A supportive and influential stakeholder is a great help – but choose wisely (if you can) and manage expectations accordingly.
  - **DON'T forget to sustain the evidence base** – a systematic and comprehensive scanning process provides a degree of (scientific) robustness, which is important for credibility.
  - **DON'T think that there is any consistent understanding of what HS is about** – there is a lack of a common understanding within the HS and futures community. The various disciplines that have contributed to HS have resulted in various views of what it is. Furthermore, the inconsistency of application means the term Horizon Scanning is widely used and, in many cases, misused. You should define your own terms and meanings.
  - **DON'T be afraid to challenge your way of doing things** – there is no magic (or agreed) recipe for how to do HS but watch out for thinking that the way you do it is the best and only way. Asking other teams to review your work is a great way to introduce new approaches and views to your HS activities.
  - **DON'T forget 'the team'** – use a dedicated cadre of 'generalists,' ideally recruited from different academic backgrounds (including the arts and the sciences). Consider the wider team too. Externals to your own area or consultants can often present an uncomfortable conclusion more effectively.
  - **DON'T negate the need for impact** – Focus on describing the implications of your analysis (the 'so what') rather than the process or detailed content. Also, remember that uncertainty and risk (or opportunity) are not the same thing.
  - **DON'T expect to be thanked or enjoy it too much** – HS is a challenging function, and at times you may feel like you are in the front line of a war zone. The most important contribution a futures project makes is likely to be an invisible one.
  - **DON'T give up the day job** – for some, HS may become a full-time or even life-long profession, but for most, it can be a useful adjunct to a more mainstream activity. Be wary that HS can seem like a cult at times but treat it not as a single bullet but rather another useful tool.

3.4. Business impact analysis and risk mapping

Business Impact Analysis (BIA) is a fundamental first step in developing a port **Business Continuity Management (BCM)** system. It focuses on identifying the critical parts of port assets and operations that could be impacted and prioritizing BCM to protect these critical parts.

In addition to a general BIA which incorporates all its assets and operations, a port can also focus attention on specific services, processes, and activities supporting areas of key revenue flows. Risks need to be prioritized as not all risks can be tackled simultaneously, and for some risks, it would not be cost effective.

Ports should conduct a BIA, among others, to:

- Quantify the impact a disruption will have on a port's ability to function over time;
- Enable informed prioritization of port recovery in the event of a disruption;
- Justify current and future resilience-building investments as well as expenditure on recovery strategies; and
- Enable the identification of critical dependencies (e.g. departments, suppliers, processes, applications, infrastructure, etc.)

When conducting a BIA, ports should consider the following elements:

- Interdependencies between operations, functions, and processes (both internally and externally).
- Business functions and operations, processes and IT applications that need to be recovered, and in which order of priority.
- Key personnel required to help the port recover and resume operations and activity.
- Standard operating procedures, or manual workarounds.
- Alternate sites or technology requirements for support staff (e.g. the ability to work remotely during a pandemic).
- Compliance requirements or regulatory obligations.
- Location of essential records for relevant activity and operations and potential backup records and files.
- Consideration of external vendors and other third parties, including hinterland operators.
- The time during which the port can sustain without a key service such as IT, known as recovery time objective.
- Security of locations where IT servers are operating.

As part of the process, creating a central repository of infrastructure information can be useful, and may include: (i) location data – latitude and longitude of the port, height above sea level, and linkages with other infrastructure; (ii) data on remaining useful life; (iii) relevant structured finance indicators from project finance documents (e.g. capital expenditures, maintenance, and operations costs); and (iv) a survey of damages resulting from past events and the associated costs. Information about key hinterland stakeholders such as logistics hubs and critical locations of key third-party providers is also important to gather as part of this process.

BIA outputs and results are generally presented as written reports and diagrams, which include:

- A list of interdependencies (both internal and external) between functions, operations, and processes within the port, as well as in connection with hinterland and terminal operations.
- A list of business operations, functions, processes, and IT applications by recovery priority.
- Key metrics are provided, such as maximum tolerable period of disruption (MTPD), recovery time objective (RTO), recovery point objective (RPO), for each critical operation/process/activity.
- Documentation relating to critical operations and processes. Printing out physical copies of the most critical documents should also be envisaged. Contact information for critical personnel should also be included. Software solutions can help in making this data available more quickly and automating some of the processes. However, they themselves need assessing for resilience.
- Documentation regarding compliance, financial and regulatory concerns, and reporting requirements.
- Documentation regarding, for example, manual workarounds, alternate sites, and technology needs.
- Critical contracts and service level agreements (SLAs) with suppliers and key port subcontractors.
- For critical IT applications, recovery time objectives (i.e. how long the port can be without the application), recovery point objectives (i.e. how much data the port is willing to lose), and backups of the port's vital electronic records.
- Lists of key personnel and planning for cross-training relating to critical functions and operations.

After port senior management and leadership endorse the BIA results, the port can start developing a port-wide Business Continuity Management (BCM) system. This requires the involvement of relevant port stakeholders and functional departments and operational units, including terminal operators, hinterland operators, local authorities and the government.

Some questions that need to be addressed as part of the BIA implementation process include whether the port can perform certain critical business processes and operations from an alternative location (or remotely) when the existing location becomes unavailable, and whether it should divide functional teams and allocate them to various port buildings to ensure that when one facility becomes unavailable, it does not also bring an entire function down, i.e. be situated in multiple smaller office buildings over one larger one).

The implementation process also requires addressing offsite requirements, cloud back-ups, or secondary data centres for crucial electronic data or paper records and whether the port can procure "on-demand" space or technology capacity in advance. Another issue to consider is whether the port faces risks that are too costly to mitigate effectively. A "do nothing" approach is not always advisable, but in certain circumstances, it may be the least worst option.

The BIA should be updated at least annually. Updates will also be required if a port has experienced new or altered operations or facilities, new key business processes or functions, turnover in key staff members (e.g. core business continuity team members), major IT application changes, or supplier changes. These changes can expose the port to new risks, including financial risks. Ideally, this update and maintenance process should be embedded in other relevant processes. For example, suppose a port has a checklist relating to the setting up of a new IT system. A note could be added to the list recommending or instructing to contact the port's business continuity team before deploying the system.

HINT

BIA must be appropriately sized and targeted for the port before it is initiated. It should not be overly complex or overwhelming. If it cannot be carried out efficiently, stakeholders may lose interest in the exercise.

Port services generating the largest share of revenue or which disruption could result in significant negative impacts are likely to be the critical services that the port needs to prioritize. These priority services should be integrated while considering several disruption perspectives such as financial, operational, reputational, customer and supplier, environmental, and employee impacts. It may also be appropriate to consider a broader economic impact model, such as the country or hinterland that depends on the port.

BIA can also be considered from the risk attachment theory angle. Risks are generally defined in relation to the effect of uncertainty on objectives set. Risks can have an impact on a port's corporate objectives as well as on key dependencies, core processes, and stakeholder expectations. This is called "attachment of risk", and ports can map out how risks are attached to each of these elements to fully analyze their impact. "**Risk attachment**" comprises:

- **Key dependencies:** Internal or external elements required for achieving ports' objectives.
- **Core processes:** A collection of activities that deliver a specific stakeholder expectation, e.g. a successful operation of the ship-to-shore cranes.
- **Stakeholders:** Groups of individuals with a stake in the port, or are affected by the port's actions and decisions (e.g. port authority, terminal operators, port employees, investors, suppliers, carriers, shippers, public authorities and the broader community).

In addition to a BIA, risks can also be mapped using a risk severity and probability matrix. It benefits from a consensus approach involving individuals who are knowledgeable about the risks. It is important to note that this approach can also be extended to cover suppliers and other relevant third parties. The aim is to develop appropriate responses based on the probability and severity of the risk event. In addition, it helps ensure that risks receive differentiated management attention, and allocated resources according to their relative resilience importance.

Four risk areas are set out in the matrix below (figure 5):

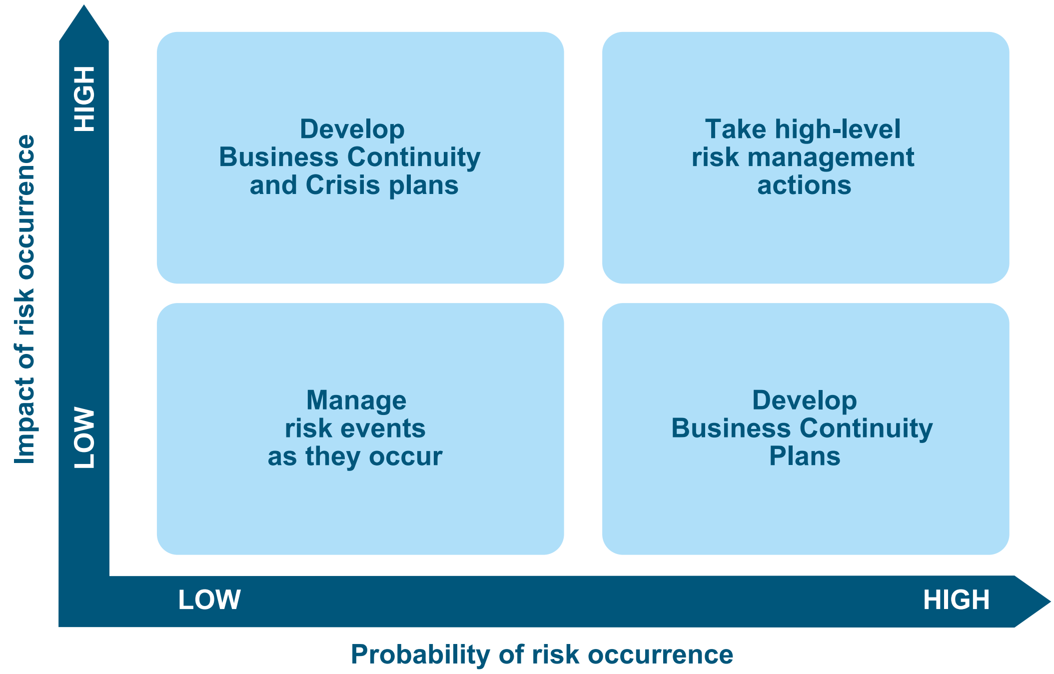
- **Low severity/low probability risk:** These do not necessarily require BCP. They can be addressed during normal day-to-day operations.
- **Low severity/high probability risks:** These have a strong likelihood of occurring. The appropriate action here is to have a BCP to mitigate these risks.
- **High probability/high severity risks:** These require detailed business continuity and crisis management plans. These plans should focus on reducing the severity or probability.
- **High severity/low probability risks:** These occur rarely but have serious consequences when they do. This scenario also requires business continuity and crisis management planning.

Heat maps, along with the mapping matrix, have formed part of risk management for many years. There are many derivations of heat maps, but they generally follow a common approach, as featured in figure 6. BIA helps determine where risk sits on this chart. The port determines the parameters for defining the severity of the impact and likelihood of a risk to occur, bearing in mind its risk appetite and risk tolerance.

Severity is usually measured in terms of the financial impact and other impacts to, among others, loss of life and damage to infrastructure or the environment. The financial measure provides a common measure that can be used as a basis to justify any risk management efforts. Likelihood refers to the probability that a disruptive event might occur.

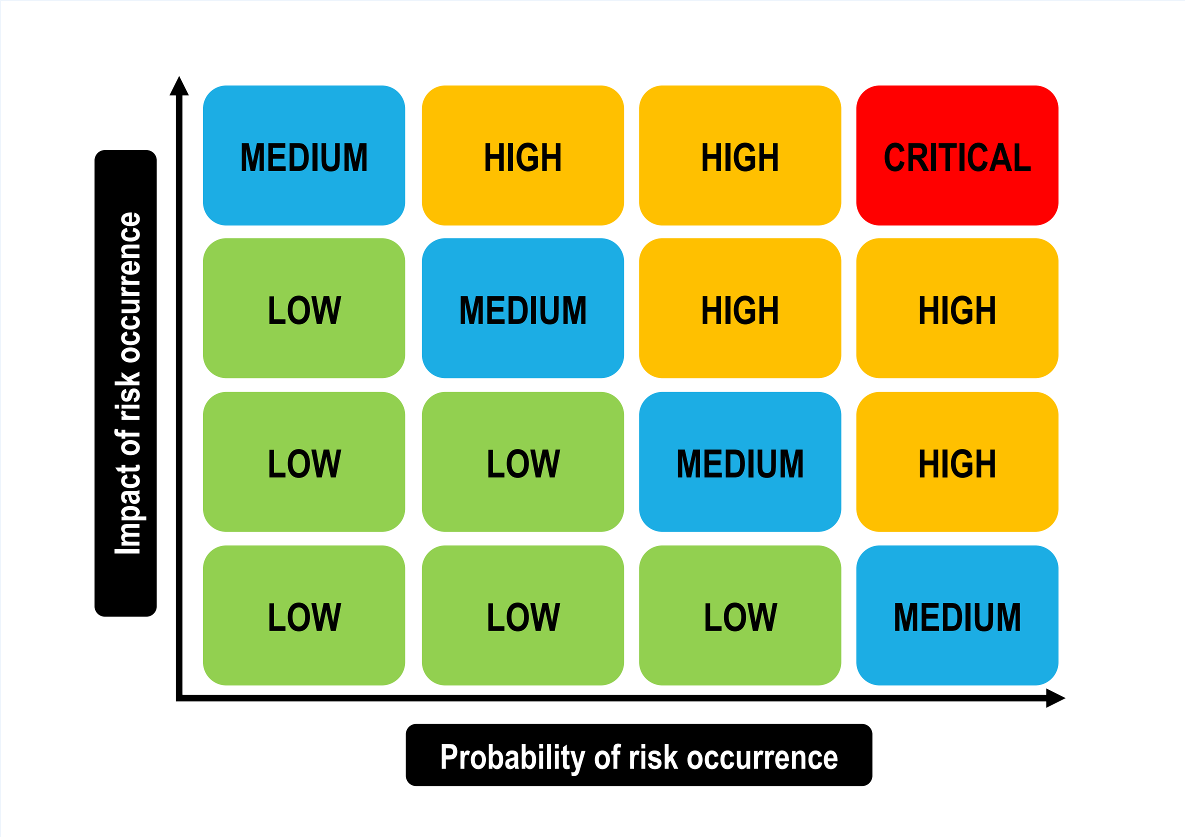
Both the heat map and severity matrix present outputs that provide alternatives and options on how to visualize risks, their likelihood, as well as potential impacts. They can help ports to determine where they should focus their risk management efforts, strengthen their resilience, and champion greater preparedness in the face of shocks and disruptions.

Figure 5: Severity and probability matrix



Source: Elaborated by the authors based on various sources including the Institute of Risk management and Business Continuity Institute.

Figure 6: Heat map



Source: Elaborated by the authors based on various sources including the Institute of Risk management and Business Continuity Institute.

HINT

Each approach involving the identification and assessment of risks will provide results and insights that can be presented in an output/document and serve as important guidance. In some cases, such outputs of risk assessment or identification process may not always **be valid or reliable**, especially when it comes to predicting risk events – the probability or likelihood of the event can be underestimated.

Validity refers to an indicator or model fulfils its intended objective. In risk management, validity addresses whether the tool is fit for purpose.

Reliability refers to how a tool, technique or methodology is consistent across its application and usage. A watch could measure time (it has validity), but it could become inaccurate as its battery wears down (it is no longer reliable). Something that is reliable means that we have confidence in its use across time. Over or under specifying the variables to include in a risk model can also be problematic. If port risk measures or indexes are too sensitive, they may raise a flag when no unusual risks exist. By contrast, if the risk measure is not sensitive enough to detect changes, or if the model excludes the right factors, it may not notice the fact there is a likely risk event. When considering the best approaches for ports to employ when identifying and assessing risks, this should be kept in mind.

3.5 Scenario planning

By combining powerful tools, such as probabilistic methods, digital modeling, discrete-event simulation and risk assessments for every **scenario**, ports can better understand and manage risks. This approach to risk management has become more widely used due to the falling cost of IT processing and the increasing digitization of supply chains. However, the quality of models applied is highly dependent on the quality of inputted data as well as the model data.

Simulations can be carried out across the entire port operational network to obtain different scenarios. Outcomes typically take the shape of histograms, sensitivity curves with confidence intervals, and probabilities of occurrence, along with risk assessments for each scenario. Each scenario may require several hundred iterations until the outcomes are considered statistically significant.

Outcomes of the scenarios are prioritized based on the probability of occurrence and their associated risk. The final step is to develop a risk response plan (RPP) for the scenarios deemed critical, covering the port's strategic, tactical, or operational horizons.

3.6 Business continuity management

Business Continuity Management (BCM) is part of a broader ERM programme. On the one hand, the risk assessment required under the risk management process and the BIA required under the Business Continuity Management are closely related and can effectively be combined. BCM aims to identify actions that should be taken after the risk has materialized to minimize impacts, limit damages, and contain costs and losses. A successful BCM programme allows a port to respond to disruptions and realize its strategy and safeguard the interests of its key stakeholders, reputation, and value-creating activities.

There is no one "right way" to build a BCM for ports, but it should be tailored to match a port's needs and conditions. Senior management at the port should identify the person or entity driving the process and ensure that they have the appropriate skills to deliver on the task. This requires a clear understanding of the port's business requirements and context.

*The **BCM lifecycle** comprises the following stages:*

- **Analysis and design:** Establish a port business continuity policy, objectives, targets, controls and procedures relevant to managing risk and improving business continuity.
- **Implementation:** Implement and operate the elements set out in the business continuity policy, controls, processes, and procedures. In general, bringing the BCM lifecycle to life involves identifying critical activities as part of the BIA, performing a BIA and a risk assessment, and designing and implementing a business continuity plan (BCP). Some of these steps, such as the BIA and identification of critical activities, can be carried out in tandem.
- **Validation:** Monitor and review performance and effectiveness against business continuity policy, objectives, and practical experience, and report the results to management for review. Also, determine and authorize actions for remediation and improvement.
- **Continue to adjust and maintain:** Maintain and adjust the BCM by taking corrective and preventive actions based on the results of the management review and reappraise the scope of the BCM and business continuity policy and objectives.

An effective BCM should be inclusive and involve port personnel from departments, e.g. finance, operations, communications, legal, IT and other key functional units. Input from key third parties relating to the port's operations should also be considered. An experienced team member with a good understanding of port organizational functions and ERM should lead the BCM and be given the operational responsibility and accountability.

The team responsible for the BCM should carry out, among other functions:

- BCM planning, development, testing and revision.
- Map and assign a cross-functional team (CFT) to each identified potential risk and threat. In doing so, clear roles, responsibilities and deliverables can be set to ensure the rapid return of operations.

- Bringing back operations to the “normal” state, as defined in the BCP. An action could, for example, be the replacement of an insolvent crane maintenance company. The team brings together subject matter experts (commonly functionally assigned) to address issues related to their expertise. For example, in a pandemic situation, multiple teams might be identified and asked to address the following:
  - **Human resources and administration:** (i) address the health concerns at the location of operations; (ii) monitor the situation internally (personnel) and externally (the families of the workforce); (iii) apply government/regulatory body directives; and (iv) administer basic safety protocols in response to the incident.
  - **Logistics/supply chain management:** Monitor the situation with suppliers, contractors/service providers, hinterland and logistic providers, through frequent communications and risk management.
  - **Operations:** Ensure enforcement of “new” regulations, protocols, and adaptations to the working environment and situation. Assess the port operational impact of the situation based on available information.
  - **Customer management:** Clear and frequent situational awareness communications to the customer. Set up appropriate engagement forums to enable information flow.
  - **Legal Counsel:** Contract clauses and mitigations to be understood and applied as required.
  - **Communications:** Serve as the primary communication channel with internal and external stakeholders, e.g. government authorities, on issues relating to the port’s response to the incident.
  - **Third parties** as required, such as arrangements for vessels crew.

The following high-level BCM related aspects must, as a minimum, appear in any written documentation:

- Scope and purpose of the BCM system;
- Governance and programme leadership;
- How often are key documents, e.g. BIAs and BCPs, updated in the context of BCM;
- Trials and testing approaches; and
- Business continuity training considerations.

Once the supporting BCM documentation has been drafted, it should be presented to its senior management team for review and approval.

HINT[29]

An effective BCM programme can help ports learn more about their operations. For example, the port may discover that many “hidden”, or not very visible business areas and processes, also need documentation, additional capacity, or improvement.

Broader list of stakeholders outside the port ecosystem and beyond geographical neighbours who may be key to the success of the port’s BCM should be considered.

3.7 Business continuity plan

Once the BIA and the port’s overarching business continuity strategy have been completed and documented, the port should prepare its business continuity plan (BCP). The port should decide whether to have one single centralized BCP for the whole port or smaller, and more targeted BCPs for its most critical business activities or processes. The smaller the port and its operations, the more likely a single BCP will suffice. If a port has multiple distinct and geographically dispersed operations, it is recommended that each operation has its own BCP. This may mean the port does not need to cover the full extent of its operations. Port BCPs should be filed in a centralized repository.

[29] For additional information, see the Good Practice Guidelines (GPG) 2018 Edition published by the Business Continuity Institute. Available at: https://www.thebci.org/product/good-practice-guidelines-2018-edition---download.html. The Good Practice Guidelines draw on the knowledge of practitioners from all over the world, as well as international standards. As a result, the GPG is globally recognized as the go-to publication for good practice. See also ISO’ s Business Continuity Standard 22301, a useful reference document, even if a port is not looking to achieve certification. Available at: https://www.iso.org/publication/PUB100442.html.

When not covered by the overall BCM programme, ports should ensure that their BCPs address the following elements:

- Critical disruption criteria focus on the disruption level required for the BCP to be enacted. This is especially critical if the port has a centralized incident monitoring entity, e.g. a security operations centre. Disruption levels triggering the BCP could relate to the recovery of a critical terminal, following a severe weather event.
- The frequency at which BCP should be updated (annually).
- The location where the port intends to store copies of its BCPs and supporting documentation. This will enable easy access and retrieval when needed.
- The immediate consequences of a disruption, such as the welfare of individuals and other key stakeholders, the prevention of further loss, and whether there has been any environmental impact. These are important for the port's reputation as stakeholders expect ports to do the right thing.

HINT

When in doubt about the right level of detail to include in a BCP, ports should aim to provide more detail and reliably document any aspect or issue that would be useful in a crisis.

3.8 Business continuity management testing and improvement (Validation)

A port's BCP should be regularly tested, at least annually, with varying options for testing. At the end of a significant incident, the port, led by its core business continuity team, should conduct an after-action review (AAR). An AAR is a structured approach for obtaining feedback, lessons learned and identifying areas for improvement.

An AAR presents an opportunity to fine-tune the BCP or overall ERM process. An AAR helps ports to understand what was expected to happen rather than what occurred. It also helps clarify , how the port responded, what went well and not so well, and whether things could be improved.

The AAR should be completed as soon as possible after the port has fully returned to normal operations. Ports should encourage candid feedback from those involved in the process, and discussion insights should be documented.

A port should pay special attention to how its BCM system or programme interacts with its HR department and staff onboarding activities to ensure greater port awareness on its BCM and ERM-related activities and programmes in periods of staff turnover. Ports should strongly consider embedding knowledge that can benefit port workers/employees on some issues, such as best practices in cybersecurity, within their training programmes, especially for new employees. Visual guides or videos can facilitate this process and make it more scalable. Similarly, if a port has an annual training programme on, for example, health and safety or compliance training, it can incorporate training modules for staff directly engaged in working on the port's BCM system and responsible for its implementation and execution. Leveraging training and knowledge sharing is a straightforward, cost-effective way to enhance the port's readiness in the face of future disruptions.

When available, a ports' internal or external audit resources can help determine whether:

- BCM system plans are updated.
- All critical business operations, functions, and systems have been covered and considered, for example, the new critical IT application or the new port terminal.
- Plans are based on the identified risks and their potential impact.
- Plans under the BCM programme are fully documented.
- Functional responsibilities have been assigned.
- The port is capable of and prepared to implement the BCPs.
- BCPs are tested and revised accordingly.
- Plans under the BCM programme are correctly and safely stored, and the storage location is known.
- The location of alternate facilities (back-up sites) is known to the ports' employees.
- Plans, which call for coordination with local emergency services and other third parties, contain appropriate contacts and details.

3.9 Incident and crisis management

Some incidents and events can be severe in scale and impact and escalate to become a full-fledged crisis. A crisis is not precisely the same as an incident as it is expected to significantly impact port operations.

A crisis management plan will be required and needs to be relatively short and flexible, reflecting the inherent unpredictability of events and address the following issues:

- **The people involved:** By identifying who, for example, is authorized to determine whether the port is facing a crisis and who has the function of activating the plans. It also needs to include practical information (e.g. contact details and relevant building and IT access requirements). Members of the crisis management team should be familiar with the plans, and gain confidence in carrying out their assigned roles during a crisis.
- **Getting started:** By setting out what is expected from the designated staff and ensuring that the appropriate level of resources is made available.
- **Information management:** Information is a critical part of crisis management. The port must carefully consider all potential information requirements in various crisis scenarios, setting out how the port might find the information likely to be needed, obtain the actual information, collate the information into the various briefing documents, and remain aware of how the situation evolves.
- **Agreed objectives and means:** By deciding on the goals and the options for achieving these and the resources available. Therefore, one of the priorities of a crisis management team is to produce a statement that defines, agrees with and communicates the desired end state that everybody is working to achieve.
- **Coordination** of action among the entire crisis management team, including senior management, operations and communications. This should be checked regularly, mainly as everyone will be operating under stress.
- **Protection of the workforce:** By balancing workloads amid the crisis to ensure that the crisis does not affect the health and well-being of port employees.

Validating pre-prepared crisis plans, including through scenarios, is also an important part of building a port's crisis management capability. A scenario can be chosen to test the level of preparedness and consider reasonably foreseeable worst-case situations.

Scenario planning during a crisis could be envisaged by assigning a few people to consider: (i) what could happen next; (ii) how the situation could deteriorate; and (iii) what would be the worst-case scenario. They should report their conclusions back to the crisis management team. This exercise can be repeated regularly throughout the crisis. The crisis management team should identify and agree on the measures that would reduce the likelihood of a worst-case scenario occurring and agree on contingencies to be prepared should a worst-case scenario materialize.

Responding to a crisis will require ports to focus on:

- Situational awareness through a good understanding of what is going on, including: (i) what are the factual developments; (ii) what are the implications and impacts on the port; and (iii) what may happen in terms of potential worst cases and looking at how the risk it could be mitigated.
- Decision-making regarding what to do about the crisis. Not all relevant information will be available during a crisis or an emergency; the port will be making decisions based on the latest information available. It will need to confirm the facts behind the decision-making and move quickly as "doing nothing" is usually more damaging, especially in terms of the port's reputation and meeting customers' expectations. It will also need to continuously validate the facts even under the pressure of the crisis to mitigate potential mistakes.
- Clear communication with all relevant parties. When the crisis hits, the port should set out its strategic objectives and what it aims to achieve. Communication amid a crisis is crucial for a port's credibility, reputation, and protection of its position in the marketplace.

The strategic objectives set out in earlier communications can be relied upon to guide decision-making and prioritization throughout the crisis. The port will need to indicate where the primary efforts are focused and prioritized in terms of resources. While the strategic objectives are not likely to change during the crisis, the main areas of focus, however, are likely to evolve as the crisis unfolds. It is important at the end of a crisis that feedback is obtained from relevant stakeholders, e.g. customers, staff, government authorities, parties operating in the hinterland to the port and suppliers. From their perspective, the crisis may not be over. It is also critical that lessons identified and learned during the crisis are captured and shared appropriately across the organization.

HINT

- Just because a port has a particular perception of the current situation, it does not mean that this is shared by other stakeholders. The port should accept that other stakeholders can challenge its views.

- Across the industry, some common issues arising as part of crisis response include: (i) inaction/freezing rather than dealing with the crisis; (ii) the impact on the port shaping the response, rather than the impact on the port stakeholders/customers; (iii) absence of communication and lack of clear direction; (iv) acting without thinking and getting the priorities wrong; (v) focusing on tactical/operational matters rather than the need to be strategic; (vi) decisions may be being made too late or not at all; and (vii) confusion leading to mistakes and miscommunications.

- Conducting scenario planning amid a crisis has many benefits, including: (i) providing visibility of how a crisis might evolve; (ii) facilitating considered decision-making and planning; (iii) enabling the production of well-conceived communication materials; (iv) enhancing the port's ability to respond to a crisis promptly; and (v) allowing ports to better shape events rather than react to them.

- The following can help create a crisis resistant culture: (i) recognizing that, as with any other organization, ports can be vulnerable in the face of a crisis; (ii) committing to planning, training, and exercising; (iii) encouraging behaviours that reduce risk; (iv) welcoming challenges; (v) empowering staff to deal with frontline issues; (vi) identifying and addressing early crisis indicators; and (vii) learning from incidents and near misses to avoid their escalation.

3.10 Port third party/supplier risk assessment and management techniques

This section presents cases of risks which occur due to the failure of third parties to deliver services or goods to the port.

Suppliers are the most obvious third-party dependency, but operators could also be impacted by the activities of other third parties such as governments, customers, neighbouring businesses or pressure groups. Further information about understanding and managing complex risk across an "extended enterprise" can be found in the IRM's publication 'Risks in the Extended Enterprise' (Institute of Risk Management, 2014).

Understanding the breadth and the depth of supplier is critical and while supplier risk entails much more than financial risks, a good example of a third-party risk is a **financial failure**, but other failures may affect third-party partners, customers and suppliers. Other failures may include strikes by key contractors, the closure of a supplier by government authorities, or the inability of a supplier to maintain crucial equipment.

Understanding the **financial health of a third-party supplier**, such as a piloting service supplier, is critical. The financial failure of third-party suppliers can be disruptive and cause operational challenges and lead to a loss of revenue. Losing an essential support service provided by a supplier can significantly hinder port operations. If a supplier or a subcontractor has substantial cash reserves, they will be better positioned to absorb the impact of a disruptive event. They are also more likely to be able to enhance their service offering and support the port's development.

Based on their financial importance to the port, a financial assessment of existing and new suppliers or customers should be carried out. Bankruptcy predictors can be used in this respect. One of the widely used bankruptcy predictors is the Altman Z-Score.[30] The Z-Score provides a well-established approach for assessing financial health and only requires a moderate level of financial data. The Z-Score combines a series of weighted ratios for public and private firms to predict the likelihood of financial insolvency. Over time the Z-Score has demonstrated almost 90 per cent accuracy in predicting bankruptcy one year in advance, and 75 per cent accuracy over two years. The Z-Score has several features that make it popular.

[30] For additional information on the Altman Z-score, see the Corporate Finance Institute at: https://corporatefinanceinstitute.com/resources/knowledge/credit/altmans-z-score-model.

The Z-Score provides a numerical value related to the level of financial risk: a higher score is better than a lower score. Only four ratios are needed to calculate the Z-Score for private firms and five for public firms. The challenge with private companies is in obtaining the data to populate the model. Z-Score can be interpreted with a red, yellow and green scoring format. There are several other financial ratios and approaches that ports may want to use to assess the financial viability of third-party suppliers. They could also use international third-party service providers to help in this analysis, such as DNB, Rapid Ratings, and Creditsafe. They provide good cost-effective coverage around international public companies but more limited insight for private national companies without supplementary service activity.

Furthermore, ports could have regional financial viability service providers to support the financial analysis and help obtain relevant data. For small ports and when resources are limited, a third-party provider is likely to be the best approach.

HINT

Backward-looking financial ratios can overlook signals of financial distress, which could be more visible when looking at qualitative measures, such as a supplier failing to meet its delivery dates required, or the declining quality of their service. A port relies on many third-party suppliers and customers.

A port should have a sound understanding of the status of all its critical third parties and suppliers/subcontractors, as any failure of any of these critical parts can significantly impact a port's operations and its business continuity and financial viability. A port cannot just make use of financial assessments that are quantitative. **The best risk management approaches will feature a combination of quantitative and qualitative assessments.** While ratio analysis can be a powerful tool, the technique still relies on infrequently updated historical data, challenging to obtain data, or sometimes even unreliable data.

Qualitative measures can be used to understand the status of a critical third-party supplier. Many indications of a supplier or other third-party provider's financial situation can be seen ahead of time. The following are potential warning signs that a supplier or other third-party provider may be at risk of failure or default:

- Overly dependent on: (i) sales to a single industry or just the port itself; (ii) sales to customers in declining industries; or (iii) sales to other ports that are financially distressed or reducing operations.
- Unable to meet agreed lead times because of problems placing a purchase order for materials to its suppliers.
- Shipping early due to a lack of business.
- A key executive becomes ill, or there are significant changes in senior management.
- Significant disruptions to operations because of reduced staff availability (e.g. pandemic).
- Hints at or announces facility shutdowns, closings, and/or layoffs.
- Reduction in R&D investment, IT, equipment or resources.
- Taking more time to pay own suppliers.
- Deterioration in the quality of service.
- Suppliers offer additional discounts for timely payment, or payments are required in advance.
- Becomes subject of an investigation due to accounting irregularities.
- Rumors of problems begin to emerge around the port community or on social media.
- Loss of a substantial customer contract.

While qualitative indicators are usually not modeled quantitatively, they can still provide valuable insights. The challenge becomes one of obtaining intelligence systematically rather than receiving it on an *ad-hoc* basis. One way to make some qualitative assessments more systematic is to establish internet alerts that forward information about companies as soon as it enters the public domain. Qualitative techniques in assessing supplier and customer financial health can be a valuable addition to using just a historical quantitative approach.

HINT

Consider using appropriate news alerting service providers, including those who specialize in supply chains, to provide customized news alerts on critical third parties. Having the appropriate data at hand can help the port develop the agility required to ensure the resilience of operations.

A third-party supplier **audit or assessment** should be conducted for critical suppliers/third-party providers before starting the contract. These audits and appraisals should be annual for existing critical suppliers or where significant concerns are raised. Audits are performed to ensure that the port supply chain members adhere to sound business and legally compliant practices. Such audits involve an objective examination and evaluation by a port of a supplier's performance and practices to ensure they align with relevant requirements, including those relating to ethics, regulations, laws, business continuity and standards. For ports, this would include relevant freight forwarders and transport partners.

Audits of suppliers or third-party providers traditionally focus on costs, quality and delivery. More and more, these audits need to consider suppliers' commitment to standards and legal requirements related to ethics, labour practices, health and safety, environment, as well as cyber and data security. In addition, these audits need to consider whether supplier shave business continuity and emergency plans in place and whether these plans address port risk scenarios.

In addition, it is also useful to have their business continuity and contingency plans, if any, and whether they address port risk scenarios and environmental concerns. The auditor, either as a port employee or a third-party designated by the port, understands that supplier issues place the port at risk from various perspectives, including reputational risk. Some supplier audits focus on topics beyond the scope of supplier performance scorecards, such as a supplier's adherence to social and regulatory requirements, for example, in respect of fair labour and environmental practices.

It is difficult to have any standard port template for supplier audits because ports often have different reasons for performing the audit and are likely to have additional legal and regulatory requirements. However, a framework can be created and be tailored to meet the port's requirements.

HINT

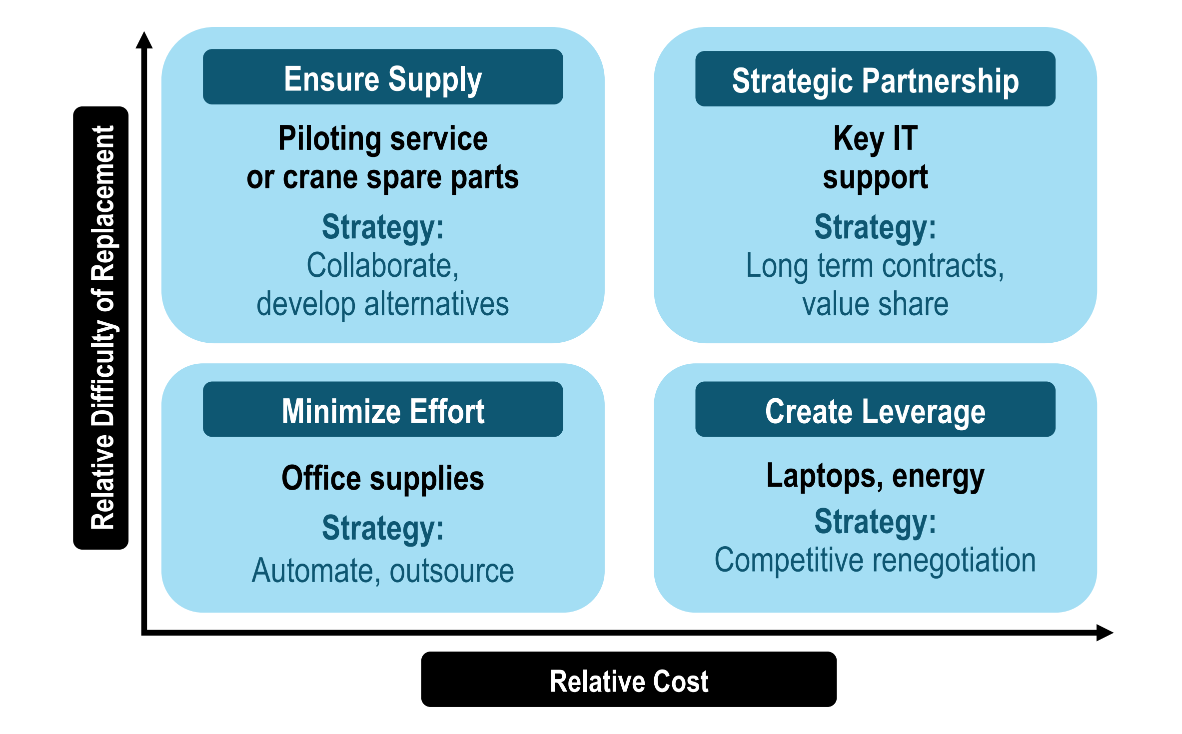
Ensure that the underlying contracts for relevant suppliers and third-party providers give the port access to relevant data and personnel, and allow audits or ongoing assessments to be performed.

Ports must **understand the extent of their reliance on suppliers and third-party providers**. An important part of supplier management involves the **development of appropriate supplier strategies**. A failure to develop strategies presents a severe risk to effective port resilience. A tool called the portfolio matrix (Kraljic) (figure 7) is one that port staff managing suppliers should understand and routinely apply when developing supply and supplier strategies.

Poorly developed supplier/supply chain strategies create a wide array of risks – the portfolio matrix is designed to ensure this is not the case.

Using the supplier portfolio matrix as a positioning tool helps: (i) identify the type of supplier relationship to pursue; (ii) whether to engage in a win-lose or win-win negotiation and relationship; (iii) whether to take a price or cost analytic approach when managing the commodity or item; (iv) the types of supply strategies and approaches that should work best; (v) how to measure supplier performance including the port risk exposure; and (vi) how best to create value across different purchase requirements.

Figure 7: **Supplier and third-party portfolio matrix**



Source: Elaborated by the authors based on various sources including the Institute of Risk management and Business Continuity Institute.

The matrix segments the purchases and supplies from third parties across two dimensions articulated around risks and impact. **Risk (Y-axis)** captures the number of active suppliers in the marketplace (such as suppliers of port equipment like cranes or vessel scheduling IT solutions) that provide services or the relevant product/components to the port. **Impact (X-axis)** features the cost or value of the good or the service to the port. A supplier manager quantifies how much the port spends for a category of product or service (i.e. the value at risk to the port from the failure of this category). The product or service is sourced from a supplier will be positioned within the most appropriate area of the portfolio matrix. Depending on where the supplier stands in the matrix layout, four situations can result, calling for different responses and strategies by the port, including:

- **Minimize effort/transaction:** The goods and services have a low total value and impact. Reducing the transaction cost of a purchase is the primary way for the port to create value, usually through electronic purchasing systems. Even when a requirement has many possible suppliers, the cost of comparing these options outweighs the value of searching for suppliers. Any price or risk analysis is cursory due to the low value of the good or service and the limited impact they would have on the port if they failed. As per the diagram, this would include office paper and other stationery supplies for the port.
- **Create leverage/market quadrant:** Items purchases include standard items or services with lower to total medium value. Many suppliers can provide substitutable products and services, and hence limited disruption impact on the port, well-defined specifications and lower supplier switching costs. The port should rely on market forces to determine the most efficient service provider or producer. When obtaining these services or items, competitive bidding or price comparisons, spot buys, shorter-term contracting, and reverse auctions are often used. Relationships with the providers of market items are typically competitive (i.e. win-lose) and price-focused. Ports should use the power of the marketplace to have suppliers actively compete for their business.
- **Ensure supply or bottleneck:** This situation includes services and purchase items, which, although not very costly, would create a significant impact on the port's operations if they stop being available (e.g. smaller spare parts for critical port equipment). The port needs to focus on ensuring the relevant good or service supply.

- **Strategic partnership/critical situation:** This includes goods and services that have high costs or value impact and are essential to a port's operation. This situation also features fewer suppliers that can satisfy a port's requirements, which often involves customization rather than standardization. The port creates value when managing necessary items and services by pursuing collaborative and alliance-type relationships with suppliers/third parties, e.g. piloting services or ship to shore cranes. Items that are critical with relatively few suppliers also mean suppliers have significant power. Using a portfolio risk approach helps ensure that the port strategies concerning its supplies and risk requirements are aligned. An example would be the piloting services or specialist dredging operations, where the availability of alternative suppliers is limited. Still, the failure of the process could have a significant impact on the port.

A useful **strategy in supplier management** involves the **development of commodity or category strategies**. A category is a logical group of related items or services from a supply market sector where suppliers operate in a similar supply chain. e.g. the supply of piloting services in the port. A category is named after the item or service provided and not the names of the supply companies involved. A category that accounts for more than 5 per cent of the total supply spend is probably too large and should be divided into two or smaller groups, e.g. IT would be too big a category on its own, either because its supply chains go back to different sources (hardware manufacturers or software engineers), or because total IT expenditure exceeds the 5 per cent threshold. Examples of categories might include ship-to-shore cranes, temporary labour services, and IT service providers. Commodity or category sourcing teams should include commodity or category risk assessment plans in their purchase strategy development process. This forces ports to assume the responsibility for risk management rather than shifting it to another party. It also helps embed risk management thinking into the corporate culture.

A commodity or category risk plan may include the following sections:

- Market analysis involves an intelligence report that describes the supply market for the commodity/material. It asks: (i) who are the major suppliers, and where are they located?; (ii) who are the primary customers?; (iii) what are the supply trends?; (iv) are there specific supply and demand price drivers?; (v) what is the overall competitive environment of the market for this commodity?; and (vi) what is the available market capacity relevant to my location?
- Risk identification involves identifying and categorizing risk(s), including a detailed description of each risk (i.e. not a generalization, such as "potential supply disruption" or bad weather, but that this critical supplier's leading production site is in a flood risk zone).
- Risk scenario mapping requires the development of a risk scenario map with each risk plotted on the map.
- Risk management plans involve a comprehensive risk management plan that identifies actions on how to mitigate or manage the risks identified in the previous step. It should also include a timeline that shows how and when to carry out risk management actions.
- Risk resources involves a listing of objective references and information sources on the demand and supply market for that commodity. It should identify why each information source is valuable. Emphasis should be given to sources that are updated regularly.

Multiple supply sources can help mitigate and manage third-party supplier risks. Every additional supplier brings: (i) additional negotiating and contracting costs; (ii) material, informational and financial transaction costs; (iii) relationship management costs; (iv) measurement costs; (v) logistical costs; (vi) possibly higher prices as purchase volumes are divided among multiple suppliers; (vii) supply chain complexity costs; and (viii) costs resulting from increased supply chain variability. However, there is a benefit in diversifying port suppliers since they can help the port recover faster from disruption, or other risk events, due to additional sources of supply. This is a benefit that would outweigh the costs. For example, the supply of piloting services or relevant port equipment spare parts.

The disadvantages of single sourcing suppliers include the increased difficulty of moving to a new supplier, given prior performance issues or the rise of disruption, loss of competition, potential over-dependence of port on a particular supplier and vice versa, and general capacity issues.

When faced with supply chain risk or uncertainty, another approach consists of holding a **buffer or safety stock** at the port or at a convenient local storage facility. Safety stock, also called buffer stock, is the level of extra stock that is maintained to mitigate risk due to uncertainties or events affecting either the demand or supply side of port operations. Good reasons exist for considering the use of buffer, or safety stock, at a port; reasons include: (i) protecting against unforeseen variation in supply, perhaps due to supplier quality problems; (ii) compensating for forecast inaccuracies when demand exceeds supply; and (iii) preventing disruptions in port operations.

At the same time, deciding to increase buffer or safety stock has direct port operational and financial implications. On the financial side, safety stock results in greater inventory, which raises a port's current assets and has associated carrying costs (e.g. interest, obsolescence and warehouse space). On the operational side, a port that increases safety stock realizes all the supply chain-related costs related to planning, sourcing and holding a product. The only difference is that the inventory is held 'just in case' and, until used, creates only costs rather than revenue. An example where it might be appropriate for a port to carry buffer stock is to hold spares for key pieces of port equipment, e.g. cranes or other moving equipment.

Contracting is a powerful way for ports and relevant **third parties to address and manage risk in an explicit manner**. One way to ensure that contracts do not unintentionally create risk is by doing business with companies located in countries that have signed the United Nations Convention on the Internal Sale of Goods (CISG). The CISG is a multilateral treaty that establishes a uniform framework governing international commerce. Ratified by over 90 countries, the convention applies to a significant portion of world trade.

Parties to a contract can negotiate or agree to price but also some of the following items:

- Quality, delivery, and cycle time expectations;
- Technical support;
- Joint improvement activities and contracting management process;
- Extended warranties;
- Additional services provided by suppliers;
- Problem resolution mechanisms;
- Investment and resource commitments committed to by the parties;
- Volume commitments;
- Guarantees of supply over changing demand conditions;
- Non-performance penalties and continuous improvement incentives;
- Agreement on allowable costs;
- Risk and reward sharing, including business continuity;
- Agreement on exit clauses;
- Protection of intellectual property; and
- The management of currencies and insurance.

It is also important to have an appropriate contracting or supplier management process, particularly in respect of critical port suppliers/third parties. Contracting management practices a port may wish to consider include:

- **Involving the port's internal customers during contract development.** Most contracts aim to support the needs of internal participants. Involving them will ensure the quality management principle of understanding customers and their requirements.
- **Entering into agreements with world-class companies and individuals.** This recognizes the importance of supplier and customer selection as a core business process, with appropriate financial due diligence and referencing of third parties and key management team members.
- **Ensuring complete contracts to ensure that parties' obligations are well specified in the contract.** This reduces the risk of contract failure and the costs of monitoring the contract relationship.

- **Obtaining contract performance feedback from internal port customers.** They should be regularly surveyed about their satisfaction in areas directly related to a contract, including changes in respect of third parties that may indicate risk issues.
- **Assigning a relationship manager to major port contracts with performance accountability.** A highly used organizational design feature involves assigning specific individuals to manage supplier relationships, including their approach to risk management.
- **Measuring and reporting internal customer and site compliance to port-wide agreements.** An issue that can expose a port to risk is the failure to follow through on committed contractual items, particularly using a supplier that has not been approved through regular processes, or which could impact overall port purchase volumes.
- **Ensuring a system is in place to compares prices paid against contracted prices** to ensure compliance with negotiated prices and avoid creating financial risks.
- **Measuring real-time supply chain performance and service levels.** Real-time data supports the objective measurement and management of supply chain contracts. This is increasingly becoming available in ports in line with the digitization of supply chains.
- **Conducting periodic contract performance review meetings.** Regular contract review meetings should be the responsibility of relationship managers; these review meetings should include appropriate updates on risk management. The relationship manager should also conduct regular review sessions with internal customers to gain feedback on a contract and its performance.
- **Using contract management systems and systems technology.** Ports can use third-party contract management software (CMS) applications, where appropriate. A good practice is to have a contracts database to understand the current contractual commitments.
- **Benchmarking contract management practices against other ports or commercial organizations.** Ports should routinely benchmark their contract management practices against leading firms or industry contacts. Professional bodies, such as the Chartered Institute of Procurement and Supply, offer training and advice.

3.11 Risk transfer and insurance

To enhance its resilience, a **port can transfer certain risks to an insurance** company. It should be borne in mind however that many risks cannot be insured, there may be large deductibles and there can be delays before claims payments are made. Therefore, insurance needs to be seen in the context of a wider risk management plan.

Insurers assessing overall port risk look at several risk factors across areas including: (i) nautical services; (ii) natural hazards; (iii) property fire; (iv) management and leadership; (v) maintenance; (vi) management of contractors; (vii) environmental exposures and control; (viii) health and safety management; (ix) contract management; (x) security; (xi) ship-to-shore operations; (xii) road and rail infrastructures; (xiii) cargo handling; and (xiv) business interruption.[31]

Experience reported by some insurers indicates that out-of-service cranes, particularly those involved in the ship-to-shore movement are often the source of many port business disruptions and financial losses. In ports, collisions between cranes, other cargo handling equipment, or vessels are common occurrences. Larger cranes also face risks related to extreme wind events. Ensuring that cranes are regularly maintained can sometimes be a challenge, particularly as it can take between 12 to 18 months to replace a crane should one be damaged.

Insurers working on port issues, based on claims they have seen and the risk assessment work they have carried out, have a range of risks or potential risks as: (i) server rooms at or below water levels, therefore prone to flooding; (ii) infrastructure issues, such as port reliance on a single electrical substation; (iii) issues with the sole supplier of port piloting services; and (iv) a lack of appropriate weather forecasting capability to allow time to handle severe weather events.

[31] This example illustrates some of the considerations taken into account by Zurich insurance.

When considering the risk of collisions between vessels and cargo handling equipment, insurers take into consideration the following elements:

- Pre-arrival communications and exchange of information.
- Position of structures on quay and berthing angles.
- Use of tugs and pilots.
- Load and unloading planning, e.g. lighting, noise, traffic management, housekeeping, access/egress arrangements, suspended load controls, segregation of operational areas, supervision, etc.
- Non-planned/non-routine load-lifting, e.g. how are requests to lift additional equipment on/off the ship handled, planning processes for lifting mobile plant in/out of bulk cargo holds, etc.
- Limiting conditions for operation, e.g. weather, non-routine conditions, emergency response considerations, fatigue, shore crane interaction with ship cranes, incident reporting and recording.
- Minimum air-draught beneath ship loader in all tidal conditions.
- Precautions on ships and terminals during cargo handling.
- Ship-to-shore safety checklist and toolbox meetings.
- Manning and supervision.
- Safety features installed on quay cranes, such as boom anti-collision system and hoist snag load protection.
- Whether the ordered cranes have considered, in their specification, the likely future mix of vessels calling at the port.

B. CONCEPTS AND DEFINITIONS

Artificial intelligence (AI): Machines or devices that have software that learns from experience, adjusts to new inputs, and performs human-like tasks.

Benchmark test: Established criteria to determine whether a risk is significant to the organization.

Big data: A term that describes extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations.

Blockchain: A shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network.

Buffer stock: The level of extra stock that is maintained to mitigate risk due to uncertainties or events affecting either the demand or supply side of the supply chain; also called safety stock.

Business continuity plan (BCP): A plan to ensure continuity of business operations in the event of a serious incident that impacts the port.

Business impact analysis: Analysis to assess the potential damage, loss or disruption that would be caused by the failure of the port as a whole or part of it e.g. failure of critical business process or infrastructure.

Cloud-based supply chain risk assessment tool: A risk assessment tool that allows users to gain insight into an organization's risk exposures across an entire supply chain.

Cluster analysis: An analysis of the geographic concentration of entities within a supply chain including relating to a port facility to determine if any clusters present unusual risk.

Cognitive bias: A systematic pattern of deviation from the norm or rationality in judgment.

Cognitive computing: Technology platforms that, broadly speaking, are based on the scientific disciplines of artificial intelligence and signal processing.

Collaborative planning, forecasting, and replenishment (CPFR): A framework that aims to enhance supply chain integration through joint practices between organizations.

Commodity or category risk plans: Risk assessment plans developed by procurement to analyze the risks associated with sourcing a commodity (such as lithium) or categories of purchases (such as drayage services).

Compliance risk: Category of risk that is associated with the management of mandatory obligations.

Consequences: Effect on the strategic, tactical, operational and compliance core processes resulting from a risk materializing.

Contracting: the process of developing a contract, which is a legally enforceable agreement between two or more parties.

Control: Actions to reduce the likelihood and/or magnitude of a risk. Hazard controls can be preventive, corrective, directive, or detective.

Corporate Governance: Set of activities and policies that control the way in which an organization or port is directed, administered and/or controlled.

Corporate social responsibility: A self-regulating business model that helps a port be socially accountable to itself, its stakeholders, and the public.

Cost-to-serve: Involves the calculation of the profitability of a customer account, based on the actual business activities and overhead costs incurred to service that customer.

Current risk: Existing level of risk considering the controls in place, sometimes referred to as 'net risk' or 'managed risk', but most frequently as 'residual risk'.

Cyber insurance: Provides protection for cyber risk and cyber related events.

Cybersecurity: Refers to the body of technologies, processes, and practices designed to protect networks, devices, programmes, and data from attack, damage, or unauthorized access.

Data science: A multi-disciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from structured and unstructured data.

Detective control: Type of control designed to identify that a hazard risk has materialized, so that actions can be taken to avoid further or greater losses.

Directive control: Type of control based on giving directions to people to behave in a certain way and/or follow established procedures.

Digital twin: A digital replica of a living or non-living physical entity. It allows an organization such as a port to model its operations digitally and run several risk scenarios to look at the potential impact on port operations.

Digitization: The application of new technologies, including sensors, artificial intelligence, cloud computing, and predictive analytics allowing or assisting in the changing the way that ports operate.

Disaster recovery plan: Plan for use in the event of a serious loss, such as IT failure, fire, or earthquake to assist the recovery of the port or organization and support crisis management.

Enterprise risk management (ERM): Integrated and coordinated approach to all the risks faced by the port or relevant organization.

Extended value chain: Also called the extended enterprise; it not only includes the immediate value chain but also sub-tiers of suppliers and customers and other stakeholders.

Financial ratio analyses: The inputting of financial data into ratios to analyze various aspects of supplier and customer financial health and performance.

Governance, risk, and compliance (GRC): Integrated approach to risk management and risk assurance based on the three lines of defense.

Hazard Risk: Category of risk that is associated with the management of pure risks or perils – the effects of hazard risks need to be mitigated.

Hedging: Involves the simultaneous purchase and sale of contracts, often over a time frame that coincides with a purchase contract to protect against volatility; a common type of hedging is in respect of currency.

Impact: Effect on the finances, infrastructure, reputation, and marketplace when a risk materializes.

Inherent risk: Level of a risk before any control activities are applied, sometimes referred to as the 'gross level' or 'absolute level' of the risk.

Insurance: Risk response for risks outside risk appetite that the organization wishes to transfer or share with another party(s).

Leadership, involvement, learning, accountability, and communication: Set of attributes that should be present to achieve successful embedding of risk management in the port or organization.

Level of risk: Combination of the likelihood and impact of the risk, as established during the risk rating stage of risk assessment and can be determined at either gross (inherent) or net (residual) level.

Likelihood: Evaluation or judgement regarding the chances of a risk materializing, sometimes established as a 'probability' or 'frequency'.

Logistics management: The process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption.

Loss control: Range of activities to reduce the potential impact of hazard risks on the port or organization, including loss prevention, damage limitation and cost containment.

Maritime supply chain risk maturity model: A model that illustrates the maturity of maritime supply chain risk management through various stages such as visibility, predictability, resiliency, and sustainability.

Maximum Tolerable Periods of Disruption (MTPD): The most time that the organization or port can be without the service or facility.

Multiple source: The use of more than one supplier for an item or service

Network design: Includes the physical design and development of global supply chains. Design considerations include supplier locations, port and logistic routes, operations, distribution center location, distribution routes, customer service centers.

Operational risk: risk of loss or gain, resulting from inadequate or failed internal processes, people, and systems or from external events and capable of impacting the operations of the port or organization.

Operations management: The systematic design, direction, and control of processes that transform inputs into services and products for internal, as well as external, customers.

Predictive analytics: The branch of advanced analytics which uses data to make predictions about unknown future events.

Preventive control: Type of control that is designed to eliminate the possibility of an undesirable risk materializing.

Principles of risk management: Set of attributes defining the features of successful risk management, summarized as proportionate, aligned, comprehensive, embedded, and dynamic.

Probabilistic models: Models where uncertainty is explicitly considered in the analysis; also called stochastic models.

Process maps/value stream maps: Physical or graphical representations of organizational processes or the value streams that are designed to create customer value.

Qualitative risk indicators: Non-quantitative 'signals or indicators in the marketplace that suggest a deeper investigation of a supplier or customer is in order.

Recovery Point Objective (RPO): Defines the point to which information used by an activity must be restored to enable the activity to operate on resumption. In other words, what is the minimum level of information or data that you can have to operate a process.

Resilience: Ability to absorb and adapt in a changing environment (ISO 22300:2018)

Recovery Time Objective: Defines the period following disruption that the organization or port aims to recover or resume its activities, production, or service provision.

Risk: Effect of uncertainty on objectives. An effect is a deviation from the expected. It can be positive, negative or both, and can address, create, or result in opportunities and threats. Objectives can have different aspects and categories and can be applied at different levels.

Risk is usually expressed in terms of risk sources, potential events, their consequences, and their likelihood (ISO 31000: 2018.)

Risk analysis or assessment: Means by which significant risks are evaluated and prioritized by undertaking the three stages of risk recognition, risk rating, and risk ranking.

Risk appetite: Amount and type of risk that an organization or port is willing to pursue or retain; also referred to as risk tolerance or risk propensity.

Risk assurance: Means by which a port or organization receives reasonable assurance that the significant risks are being adequately controlled.

Risk capacity: Maximum level of risk to which the port or organization should be exposed, having regard to financial and other resources.

Risk categories: There are four categories of Risk: – compliance (or mandatory) risks; hazard (or pure) risks; control (or uncertainty) risks; opportunity (or speculative) risks.

Risk compliance: Includes the internal activities taken to meet required or mandated rules and regulations, whether they are governmental, industry-specific, or internally imposed.

Risk control room: A central command center where information is collected, categorized, analyzed, prominently displayed, and widely disseminated to the right people, at right place, at the right time.

Risk criteria: Basis for ranking or evaluation of the significance of a risk – will define the risk appetite of a port or organization.

Risk culture: The system of values and behaviors present in an organization or port that shapes risk decisions of management and employees.

Risk event: A risk event is a discrete, specific occurrence that negatively affects a decision, plan, firm, or port; a risk that has become a reality.

Risk exposure: Level of risk to which the organization is exposed, either regarding an individual risk or the cumulative exposure to the risks faced by the organization.

Risk governance: Includes the frameworks, tools, policies, procedures, controls, and decision-making hierarchy employed to manage a port or other organization from a risk management perspective.

Risk heat maps: A risk map that uses color coded display of risks, such as red, yellow, or green designation to identify risk probability and severity.

Risk management: Management activities to deliver the most favorable outcome and reduce the volatility or variability of that outcome.

Risk management framework: Set of activities that support the risk management process, referred to as the risk architecture; arrangements for designing, implementing, monitoring, reviewing and continually improving risk management.

Risk management information system (RMIS): Computer software system or part of the intranet of the port or organization that records and communicates risk information.

Risk management measures: measures or indicators whose primary focus is risk, including time-to-recovery (TtR) and value-at-risk (VaR).

Risk management policy: Statement of the overall intentions and direction of the port or organization related to risk management – usually a one-page document or poster.

Risk management process: Activities that deliver management and control of risks – can be defined as recognition, rating, ranking, responding, resourcing controls, reaction planning, reporting and review.

Risk maturity model: Structure for determining the level to which risk management is embedded within a port or organization, they should be looking to have a risk aware culture with a proactive risk approach where risk is considered at all stages.

Risk mitigation: Actions taken to reduce either the likelihood of a risk occurring or to minimize the extent of its impact after occurrence.

Risk priority numbering (RPN) indexes: Quantitative models that consider multiple factors to arrive at a single risk indicator score.

Risk ranking: Stage in the risk assessment process that analyses the likelihood and impact of a risk.

Risk rating: Stage in the risk assessment process that evaluates the risk with reference to the risk appetite or the established risk criteria, to help select the appropriate risk response.

Risk recognition: Early stage in the risk management process, which involves the identification of all the risks faced by the port or organization.

Risk register: Record of the significant risks faced by an organization, the controls currently in place, additional controls that are required and responsibility for control activities.

Risk resilience: The ability to 'bounce back' or adjust in respect of the occurrence of a risk event.

Risk response plan: A plan to implement actions to respond to risks, including decisions such as whether to tolerate, treat, transfer or terminate.

Risk severity and probability maps: A process by which organizations identify the types of risk they may be subject to, assess the relative impact of these risks, and determine the relative probability that these risks will occur, which are then mapped typically on a 2x2 grid. It is a similar approach to the use of heat maps.

Risk taxonomy: Practice of naming, and classifying and defining relationships between resources, risks, goals, and business processes in the port or organization. Without an organization wide taxonomy, every department and level would potentially speak a different risk language.

Risk tolerance: Deviation from the expected level of risk leading to implementation of risk escalation procedures – definitions of risk tolerance can vary considerably.

Risk vulnerability: Susceptible to harm; usually not as quantified as risk exposure-

Significant risk: Risk with the ability to impact above the established benchmark for that type of risk.

Strategic risk: Long-term or opportunity risk concerned with where the organization wants to go, how it plans to get there and how it can ensure survival.

Strategic supply management framework: a cross-functional, proactive process for obtaining-goods and services that features evaluating and selecting suppliers; managing suppliers; and developing and improving supplier capabilities.

Strategy portfolio matrix: A segmentation tool that helps supply chain managers develop an appropriate strategy or approach for sourcing goods and services.

Stress testing: A technique that tests a set of scenarios using 'what-if' and statistical analysis. The primary output is a prioritization of risk scenarios based on Value-at-Risk (VaR).

Supplier and customer bankruptcy indicators: Algorithmic formulas that use financial data to estimate a supplier or customer's bankruptcy potential.

Supplier audits: An objective examination and evaluation of a supplier's performance and practices to ensure they are in conformance with various requirements, laws, and standards e.g. Business continuity.

Supply chain: A set of three or more organizations linked directly by one or more of the upstream or downstream flows of products, services, finances, and information from a source to a customer.

Supply chain disruption: An unplanned breakdown or interruption to the production or distribution nodes that comprise a supply chain.

Supply chain management: Proactive management of the two-way flows of goods, services, information, and funds from raw material through to the end customer.

Supply chain mapping: The process of graphically representing the entities that comprise a supply chain, ideally beyond a firm's tier-one suppliers and customers.

Supply chain network: A network is an evolution of the basic graphically represented supply chain; compared with a supply chain, it is a more complex structure involving a higher level of interdependence and connectivity between more organizations into a network.

Supply chain (Third party) risk management (SCRM): The implementation of strategies to manage every day and exceptional risks along the supply chain through continuous risk assessment and management with the objective of reducing vulnerability and ensuring continuity.

Supply chain risk management roadmap: A cross-functional, proactive process for obtaining goods and services that features risk evaluating and selecting suppliers; managing suppliers; and developing and improving supplier capabilities.

Target risk: The ultimate level of risk that is desired by the port or organization when planned additional controls have been implemented.

Terminate: Risk response that is appropriate when the level of risk is not acceptable to the port or organization or outside risk appetite, also referred to as 'avoid' or 'eliminate'.

The Internet of Things (IoT): A sensor network of billions of smart devices that connect people, systems, and other applications to collect and share data.

Tolerate: Risk response that is appropriate when the level of risk is within risk appetite, also referred to as 'accept' or 'retain'.

Trade-offs: A compromise that involves giving up something in return for getting something else.

Transfer: Risk response for risks outside risk appetite that the organization wishes to transfer or share, by means of insurance or commercial contract.

Treat: Risk response for risks that can be (further) treated by introduction of cost-effective (corrective) controls, also referred to as 'control' or 'reduce'.

Value chain: The process or activities by which a company adds value to something, including production, logistics, marketing, and the provision of after-sales service.

VUCA – volatility, uncertainty, complexity, ambiguity: Elements related to operations including those in a port such as vessel activity that have the potential to create or contribute to risk (it is an acronym for volatility, uncertainty, complexity, ambiguity).

C. USEFUL RESOURCES

General

- Business Continuity Institute. Available at: https://www.thebci.org
- BCI Horizon Scan Annual Reports. Available at: https://www.bsigroup.com
- China Emergency Information Website. Available at: https://www.emerinfo.cn
- China Meteorological Administration China. Available at: http://www.cma.gov.cn/en2014/weather/Warning
- EU Emergency Response Coordination Centre (ERCC). Available at: https://erccportal.jrc.ec.europa.eu/Useful-links
- Global Disaster Alerting and Coordination System (GDACS): Provides alerts, analysis, and geospatial resources regarding natural hazards occurring around the world. Available at: https://www.gdacs.org
- NARDSI Emergency and Disaster Information Service: provides a live-updating map of various hazard types that may cause large-scale disruptions. Available at: https://rsoe-edis.org/eventMap
- National Risk Registers. Available at: https://www.gov.uk/government/publications/national-risk-register-2020 for the UK for example.
- Pacific Disaster Centre Map showing locations of disruptive incidents globally. Available at: https://disasteralert.pdc.org/disasteralert
- SLOCAT Partnership. Available at: https://slocat.net
- The Geography of Transport Systems. Available at: https://transportgeography.org
- UNCTAD Annual Review of Maritime Transport. Available at: https://unctad.org/topic/transport-and-trade-logistics/review-of-maritime-transport
- UNCTAD Port Management Programme, TRAINFORTRADE. Available at: https://tft.unctad.org/port-management
- World Economic Forum Global Risk Report. Available at: https://www.weforum.org/reports/global-risks-report-2022

Audit

- Chartered Institute of Internal Auditor. Available at: https://www.iia.org.uk/resources/risk-management/position-paper-risk-management-and-internal-audit

COVID-19

- 91-DIVOC. An interactive visualization of the exponential spread of COVID-19. Available at: http://91-divoc.com/pages/covid-visualization
- UNECE (2021), Handbook for national master plans for freight transport and logistics. Available at: https://unece.org/sites/default/files/2021-12/2017186_E_web%2BCorr.1.pdf
- UNCTAD, Port Management Programme, TRAINFORTRADE. Available at: https://tft.unctad.org/port-management/building-port-resilience

Crisis Response

- A useful source of crisis response information from the UK Government's Cabinet Office is available at: https://www.epcresilience.com/insight

Cyber Security

- British Ports Association (2020). Managing ports' cyber risks. Available at: https://www.britishports.org.uk/bpa-teams-up-with-astaara-to-highlight-growing-cyber-risk-management
- BIMCO. The Guidelines on Cyber Security Onboard Ships. Version 4. Available at: https://www.bimco.org/about-us-and-our-members/publications/the-guidelines-on-cyber-security-onboard-ships
- DCSA. Implementation Guide for Cyber Security on Vessels v1.0. 10 March. Available at: https://dcsa.org/wp-content/uploads/2020/03/DCSA-Implementation-Guideline-for-BIMCO-Compliant-Cyber-Security-on-Vessels-v1.0.pdf
- IACS. Recommendation on Cyber Resilience (No. 166). Available at: https://www.westpandi.com/publications/news/archive/cyber-resilience-iacs-recommendation-2020
- NIST (2018). Framework for Improving Critical Infrastructure Cybersecurity. Version 1.1. 16 April. Available at: https://www.nist.gov/cyberframework/framework

Earthquakes

- United States Geological Survey Latest Earthquakes. A sortable/filterable table of the latest earthquakes that have happened around the world. Available at: https://earthquake.usgs.gov/earthquakes/map/?extent=16.97274,-137.19727&extent=54.92714,-52.82227

Financial Evaluation Service Providers

- Creditsafe: https://www.creditsafe.com
- Corporate Finance Institute: https://corporatefinanceinstitute.com/resources/knowledge/credit/altmans-z-score-model
- Dun and Bradstreet: https://www.dnb.com
- Rapid Ratings and Bureau van Dijk: https://www.rapidratings.com

Fires

- Fire Information for Resource Management System (FIRMS). NASA satellite-detected "hot spots", indicating locations of potential fires globally. Available at: https://erds.ithacaweb.org/#home
- NFPA 307: Standards for the construction and fire protection of Marine Terminal, Piers and Wharves. Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=307
- NFPA 1405: Guide for land-based fire departments that respond to Marine Vessel Fires. Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1405

Flooding and Rainfall

- Extreme Rainfall Detection System (ERDS) ITHACA Extreme Rainfall Detection System (ithacaweb.org). Geospatial tool showing observed and forecasted locations of extreme rainfall globally. Available at: https://erds.ithacaweb.org/#home
- NASA Goddard's Hydrology Laboratory. Global Flood Mapping Satellite imagery indicating near real-time location of flooding events globally. Available at: https://firms.modaps.eosdis.nasa.gov/map/#d:today;@0.0,0.0,3z

Geopolitical

- BlackRock Geopolitical Risk Dashboard. Available at: https://www.blackrock.com/corporate/insights/blackrock-investment-institute/interactive-charts/geopolitical-risk-dashboard#risk-indicator

Horizon Scanning

- Institute of Risk Management (IRM). Available at: https://www.theirm.org/news/horizon-scanning-a-practitioners-guide-revealed-at-irm-leaders

Port Equipment

- See for example, guidance by Port Equipment Manufacturers Association (PEMA) available at: https://www.pema.org

Risk Culture, Appetite and Tolerance

Institute of Risk Management (IRM):

- Appendix A of the Institute of Operational Risks Risk Culture Guidance
- https://www.theirm.org/what-we-say/thought-leadership/risk-appetite-and-tolerance

Risk Management Training

Institute of Resources Management (IRM):

- https://www.theirm.org/qualifications/international-certificate-in-enterprise-risk-management.
- https://www.theirm.org/news/new-supply-chain-risk-management-certificate-launched-by-the-institute-of-risk-management-irm

Standards

International Organization for Standardization (ISO):

- https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100426.pdf
- https://www.iso.org/standard/75106.html
- https://www.iso.org/publication/PUB100442.html
- https://www.iso.org/standard/68508.html

Third-Party Alert Services

- Interos: https://www.interos.ai
- Everstream Analytics: https://www.everstream.ai
- Exiger: https://www.exiger.com
- Resilinc: https://www.resilinc.com
- Risk Analytics and Collaborative Methods: https://www.rms.com

Weather Storms and Cyclones

- Windy: Wind map and weather forecast. Animated map of current and forecasted wind speeds, rainfall, and many other weather hazards. Available at: https://www.windy.com/?49.083,-8.981,3

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