Solving the Global Supply Chain Crisis with Data Sharing

Improving operational efficiencies and reducing emissions across the freight system

COALITION FOR
Reimagined Mobility
Transportation Policy that Puts People First

International Transport Forum

JUNE 2022

Solving the Global Supply Chain Crisis with Data Sharing

Improving operational efficiencies and reducing emissions across the freight system

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June 2022

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About ReMo

The Coalition for Reimagined Mobility (ReMo) is a global effort to shape more equitable and sustainable transport policy to improve the movement of people and goods. ReMo conducts research-informed advocacy campaigns to advance mobility policies and platforms that leverage technology and prioritize people, while ensuring the wellbeing and security of the planet.

The Coalition is proudly guided by individuals on its Commission, who bring diverse expertise and a shared passion for our mission across the transportation, energy, environmental, and technology sectors, along with public sector leaders, spanning three continents.

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• For more information, please visit **reimaginedmobility.org**.

Acknowledgments

The Coalition for Reimagined Mobility would like to thank the following individuals for contributing their expertise, constructive feedback, and support as members of the working group convened for this research initiative:

Daniel Murray, American Transportation Research Institute

Thad Bedard, APL Logistics Ltd

David Glauber, APL Logistics Ltd

Virgil Welch, Caliber Strategies

Jared Cohon, Carnegie Mellon University

Danielle Tap, DCSA

Paul Warburton, Envorso

Mary Nichols, Former Chair, California Air Resources Board

Andreas Nettstraeter, Fraunhofer IML and Open Logistics Foundation

Carl Pope, Inside Straight Strategies

Guineng Chen, International Transport Forum

Luis Martinez, International Transport Forum

J. Rod Franklin, Kuehne Logistics University

Monique Rodriguez, Qualcomm Technologies, Inc.

Ann McGrane, Stantec, Inc.

Rik Arends, Stichting Smart Freight Centre

Asma Ouchan, Stichting Smart Freight Centre

Ruth Banomyong, Thammasat Business School

Erin Spring, The Goodyear Tire & Rubber Company

Henk Van Tuyl, The Goodyear Tire & Rubber Company

Zach Thomas, The Northwest Seaport Alliance

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Foreword

Global supply chains are the backbone of our daily lives. These systems deliver critically needed goods and products to billions of people across the planet every single day. The supply chain crisis that we have all experienced over the past few years, however, has been a stark warning that the current system is not working.

The inability for people to get the products they need when they need them has created hardships for families around the world. Manual systems, outdated technology, and siloed methods of communicating are still common when transporting goods—often creating delays that not only cost time, but also come at the cost of our planet. These tools no longer keep up in a world that now relies on instantaneous connectivity enabled by the internet, particularly as the freight system continues to grow.

Working with the Coalition for Reimagined Mobility (ReMo) over the past year, we have begun to fully understand how supply chain inefficiencies and lack of system resilience are dramatically exacerbating global carbon emissions. The freight sector is on course to become the highest carbon emitting sector in the world by 2050.

Business as usual is not an option. In addition to continuing the push to increasingly cleaner, low and zero carbon fuels, vehicles and vessels, businesses and governments must come together to act now to implement solutions that can be deployed quickly to enhance systemwide resilience and deliver critically needed climate benefits.

Standardized data exchange across supply chains and in the broader freight system gives the industry a huge opportunity to streamline information sharing, communication, and collaboration. A transition to standardized data exchange will drive the industry towards a more resilient future with dramatically reduced freight sector emissions.

We are eager to take the recommendations included in this report to work with policymakers and businesses across the world to change the way that we all do business in the freight sector. The time for action is now—because all of us and our planet depend on it.

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Executive Summary

Our livelihoods and the global economy depend on functioning and resilient global supply chains. In the face of geopolitical turmoil, natural disasters, and disease, we have seen how unforeseen disruptions and lagging modernization comes at a cost to people everywhere.

Starting in 2020, the COVID-19 pandemic created significant challenges and impacts for unprepared operators of the global freight sector. Antiquated, impractical, and siloed processes highlighted the breakdown of reliable access to goods for people, businesses, and governments worldwide.

Then in 2022 Russia invaded Ukraine, compounding the pressure on the entire freight system, while exacerbating a global oil crisis that further underscored the need to reduce our dependence on fossil fuels.

As we look to the future, the global freight sector can forge a new path to reinvention, resilience, and sustainability by embracing digitalization: adopting standardized digital tools capable of transforming freight data sharing to improve system-wide operational efficiencies and reduce emissions.

This report reveals how critical stakeholders, policymakers and advocates can leverage digitalization today to deliver a clean, more efficient, and resilient global freight system and supply chains for all by standardizing the exchange of freight data.

As we look to the future, the global freight sector can forge a new path to reinvention, resilience, and sustainability by embracing digitalization.

Freight data exchange standards can increase system resilience and sustainability while reducing oil dependence

Global freight system and supply chain stakeholders could have mitigated the challenges posed by the COVID-19 pandemic and Russian invasion of Ukraine with better stakeholder communication and coordination. These crises did not create the sector's current state of instability; rather, they exacerbated its already fragile state. For decades, as supply chains grew in complexity due to globalization and other forces, communications tools failed to evolve. Now, by standardizing the exchange of freight data, the freight system and supply chains can develop the resilience and operational efficiencies needed to reduce oil dependence and better manage disruption.

Freight data standards that are freely available through open technical specifications define how to share critical information. Standardizing this exchange of freight data will support a transition from siloed to widespread software-enabled communication, forming the backbone of better stakeholder coordination.

The Coalition for Reimagined Mobility (ReMo) found that standardized freight data exchange can deliver operational efficiencies that reduce the need for oil while reducing emissions by 22 percent by 2050. Digitalization and increased access to freight data also has the potential to lead to an over six percent decrease in freight costs per kilometer, a substantial cost saver for an industry operating on thin profit margins. In the process, Figures 1 and 2, focusing on the journey of a chair and the power of digitalization, illustrate how improved freight data exchange could reduce delivery times in this one example by nearly 13 days.

Digital modernization has lagged while market and regulatory failures have created barriers to change

Over the last half century, technology, deregulation, and trade agreements transitioned supply chains from local production and manufacturing to specialized, globally distributed production of individual components. This transition resulted in a multitude of stakeholders facilitating new trips and creating longer and more complex global supply chains. A stakeholder's manufacturing and distribution processes are now dependent on potentially hundreds of other stakeholders across the world.

The shipment of goods across today's supply chains requires a high degree of coordination. Yet, instead of transitioning fully to the digital age, supply chain stakeholders continue to rely on manual and inefficient communication tools and processes. Communications breakdowns are a common occurrence as stakeholders search an array of websites with information that may be out of date or inaccurate. Rather than relying on software platforms capable of automating processes based on near real-time data flows, stakeholders manually validate information while coordinating by email, phone, and even fax.

Communications challenges are also being perpetuated by market and regulatory failures. Private sector freight stakeholders are hesitant to share operational data due to the perceived risks of giving away a competitive advantage. International regulatory bodies, such as the International Maritime Organization (IMO), lack both enforceable regulatory instruments and governance authority to drive meaningful change.

In the absence of strong leadership from policymakers, freight stakeholders continue to operate in data silos, thus failing to reap the benefits of an efficient, coordinated global freight system. Where deployed, standardized digitalization is fostering resilience as goods move significantly faster, more cost-efficiently, and more sustainably. But a patchwork of digital software systems is not enough to spark global reinvention. Furthermore, when it comes to digitalization, many stakeholders, particularly smaller and medium-size enterprises with limited capital budgets, are unsure how to prioritize investments. With a globally adopted standard for freight data exchange, the freight sector will have the digital architecture needed to make digitalization accessible for all system operators. Freight data exchange will accelerate transformation at the speed and scale needed to improve overall performance, avoid irreversible damage to the planet, and create resiliency to navigate future disruptions.

> The urgency of reducing global freight sector emissions calls for a comprehensive approach that also provides fast, near-term benefits.

Freight data exchange standards reduce emissions by 22 percent

The current approach to decarbonizing the freight sector primarily relies on transitioning to electric and low emission vehicles and ships, which is a necessary but insufficient intervention to meet global climate goals. To reduce global emissions in accordance with the Paris Climate Agreement, additional steps are needed.

ReMo explored how standardized freight data exchange can improve efficiencies that reduce the need for oil and increase freight sector sustainability, and defined additional, critical steps for policymakers seeking to decarbonize the economy. ReMo partnered with the International Transport Forum (ITF) to use its globally renowned freight emissions model to quantify emissions reductions that could be generated by data exchange and found that data-driven operational efficiencies can conservatively reduce emissions by 22 percent by 2050. The urgency of reducing global freight sector emissions calls for a comprehensive approach that also provides fast, near-term benefits, and freight data exchange standards promise to deliver on both counts.

Lessons from Port Community Systems

To understand the role of freight data exchange standards to improve how stakeholders currently communicate, ReMo studied three port community systems (PCS), or software systems used to exchange information at ports, distributed across the world. PCS are digital freight tools that streamline communication within the port system. ReMo studied the PCS of the ports of Hamburg, Germany; Los Angeles and Long Beach, California; and the national pan-Indian PCS. Each PCS varied as far as being either publicly or privately led, publicly or privately operated, and under short- or long-term contract. They also span different geographic regions and regulatory environments. These case studies were then used to identify best practices and lessons learned to apply to whole-scale freight digitalization and data exchange standards.

Policy Recommendations

Action is needed now by policymakers around the world to establish freight data exchange standards that are freely available to enable scalable sector efficiencies. This report calls for both public and private sector participation in the development and upholding of freight data exchange standards to drive long-term global supply chain resilience.

As a result, ReMo's report recommends that policymakers take the following actions:

- **Require** the use of freight data exchange standards as a condition for accessing ports.
- **Deploy** freight data exchange standards that communicate near real-time operational data.
- **Allocate** authority to national governments and ports to require the use of freight data exchange standards.
- **Allocate** seed funding to ports and industry stakeholders to deploy data exchange standard pilots and projects.
- **Initiate** and fund targeted intermodal exchange and smart steaming programs to realize near-term emissions reduction benefits.

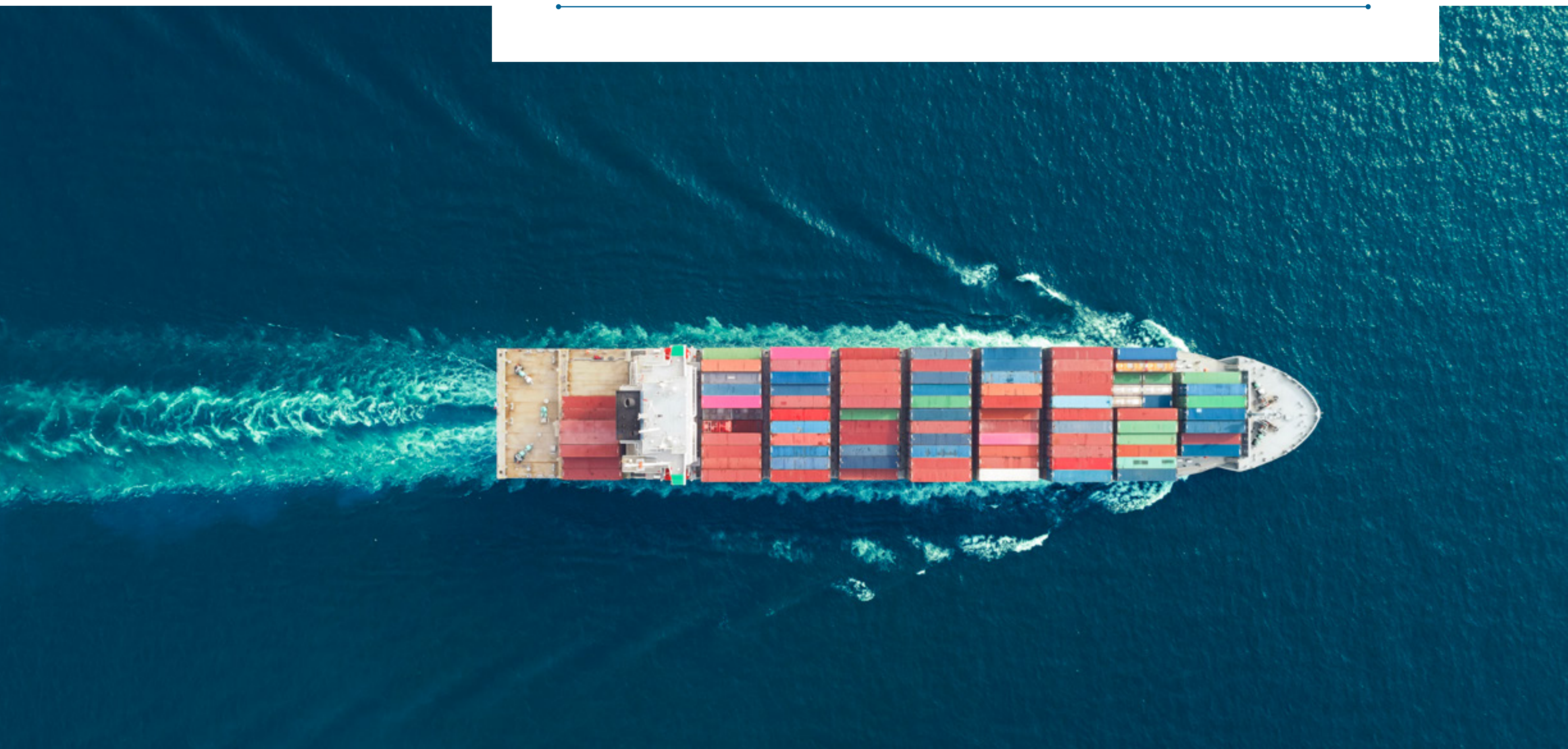


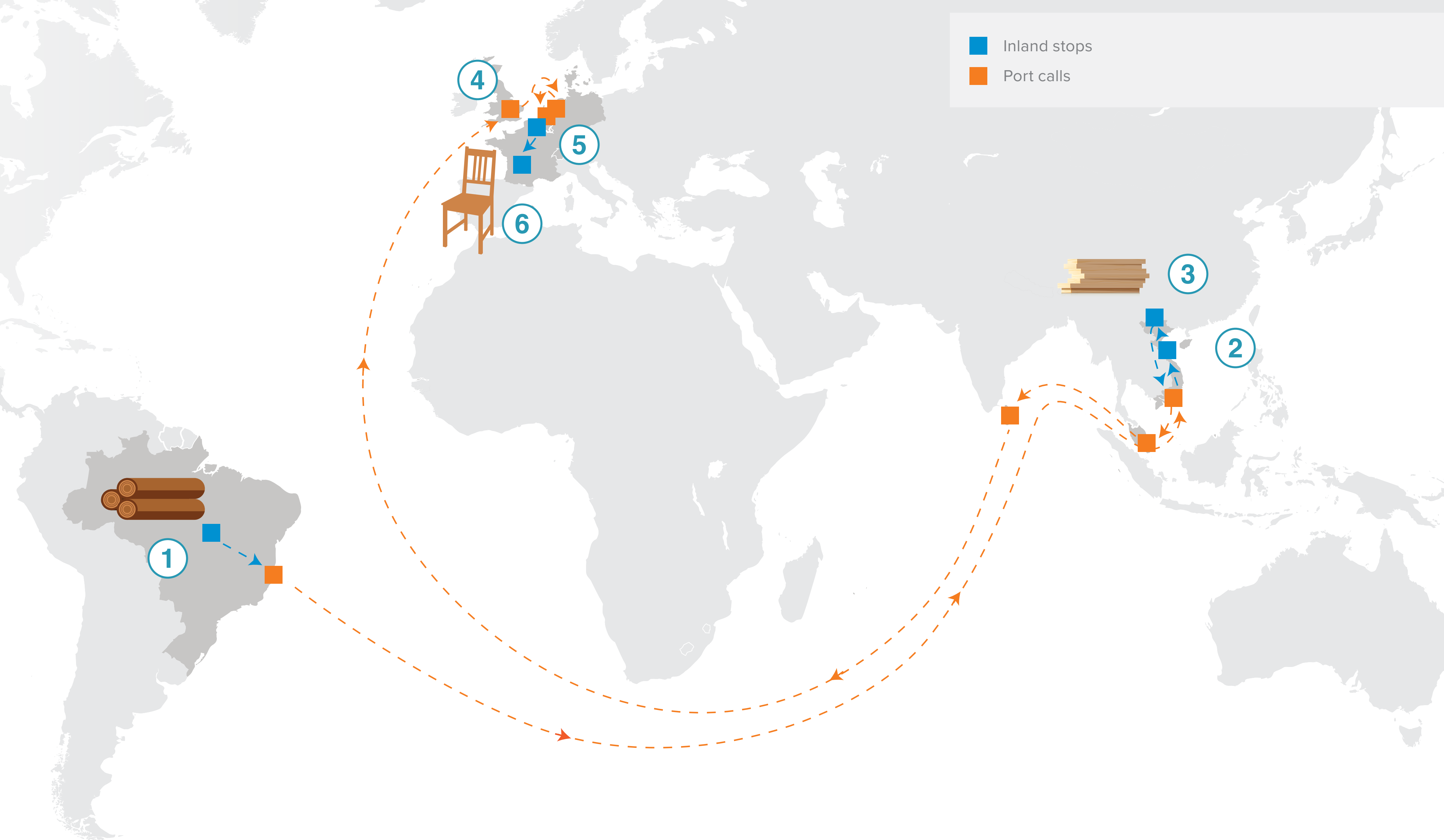
FIGURE 1

How Goods Move

We all rely on the supply chain to receive goods, but its day-to-day operations are highly complex and opaque.

Journeys can involve dozens of supply chain actors and require copious manual documentation to comply with laws and carrier policies. Demand is often unpredictable, resources are scarce, and data vacuums prevent proactive planning and decision making.

• To shed light on this complexity, **let's look at a typical journey of a chair, from forest to factory to the kitchen table.**



FOREST TO FACTORY

1. Wood for the chair is sourced in the forests of central Brazil. It's trucked to port and then heads to Vietnam on a dry bulk vessel.

2. From the port in Vietnam, the raw wood is brought by truck to an inland processing plant.

3. The processed wood is taken by rail to the supplier to the factory that makes the chairs.

FACTORY TO WHOLESALER

4. The container ship from Vietnam arrives at the port in Germany after calling in Indonesia, Sri Lanka, the UK, and the Netherlands. A truck brings the container to a warehouse in central Germany and unloads the chairs.

WHOLESALER TO STORE

5. A few chairs are bought by a retailer in Belgium and brought there by truck.

STORE TO HOME

6. A consumer in France purchases the chair online via the Belgian retailer's website. It is delivered by truck.

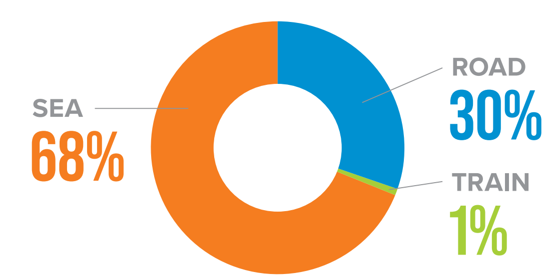
TRIP AT A GLANCE

TOTAL DISTANCE

47,430 KM

(greater than the circumference of Earth)

TRIP EMISSIONS BY MODE



DISTANCE BY MODE

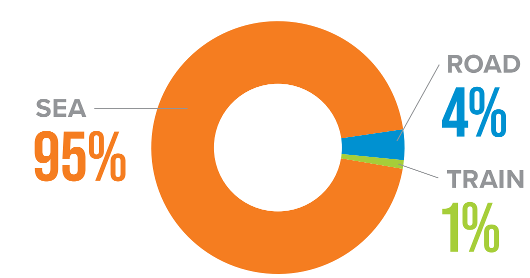


FIGURE 2

The Power of Digitalization

Zooming in on the second leg of the journey—from the factory to the wholesaler—shows the complexity and inefficiencies of the supply chain's physical operational processes and equipment, regulatory processes, and communication streams.

Included here are some common challenges that lead to unnecessary delays, longer transit times, and, as a result, increased emissions.

• **With data sharing and digitalization,** many of these challenges can be ameliorated and even avoided.

Time Saved by Digitalization

13 DAYS, 16 HOURS

26% of Trip

Trip Time: From Factory to Port

CURRENT PRACTICE: 19 HOURS

Antiquated communications: Shipment details are communicated by fax machine. With no standardized port codes and incorrect information, the driver goes to the wrong port, miles away.

Hours of traffic: Once at the correct port, the driver has to wait for hours due to traffic at the truck gate.

DIGITALIZED SOLUTIONS: 6 HOURS

Improved communications: The trucker can access all accurate information—including the port identification—via a mobile application.

Smart scheduling and technology: Using real-time traffic and port congestion data, the truck schedules its optimal departure time to minimize idling along the route. Smart gates at the port reduce entry delays.

19 Hours

6 Hours

Wait Time: Leaving Port

CURRENT PRACTICE: 7 DAYS

Inefficient scheduling: After customs, the offloaded shipping container sits in the yard for up to a week while waiting to be loaded onto a ship.

DIGITALIZED SOLUTIONS: 6 HOURS

Smart scheduling: With more precise scheduling and visibility of equipment, the container is offloaded from the truck directly onto the ship.

7 Days

6 Hours

Trip Time: At Sea

CURRENT PRACTICE: 42 DAYS

Inefficient scheduling: At sea, the container ship calls at multiple ports. Due to port congestion, it is delayed by four days.

DIGITALIZED SOLUTIONS: 38 DAYS

Smart scheduling: The container ship exchanges estimated and requested arrival times from each port, securing berth availability prior to arrival, reducing delay.

42 Days

38 Days

Wait Time: At Destination Port

CURRENT PRACTICE: 2 DAYS, 18 HOURS

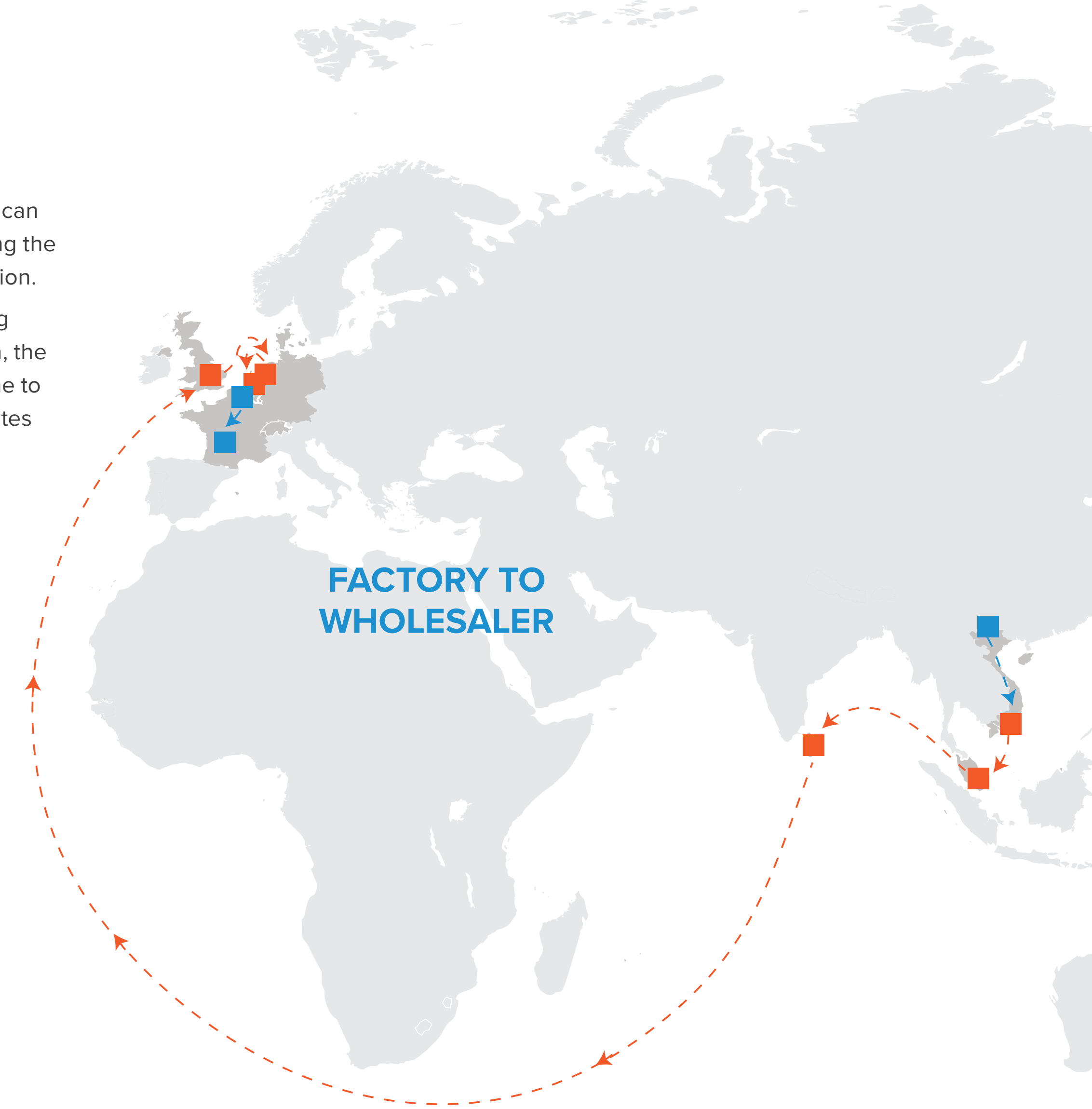
Equipment delays: A truck driver arrives to pick up the shipment, but no chassis is available to carry the container. The driver has to wait 10 hours for a chassis to return to the port before heading to the warehouse.

DIGITALIZED SOLUTIONS: 9 HOURS

Improved equipment visibility: With accessible information about the shipment and equipment availability, the chassis is reserved and available on arrival and the truck can pick up the shipment and proceed to the wholesaler warehouse.

2 Days, 18 Hours

9 Hours



- Inland stops
- Port calls
- Current practice
- With digitalization

Introduction

The COVID-19 pandemic and Russian invasion of Ukraine have spotlighted weaknesses in the global supply chain and the harmful effects of a freight system that is inefficient and dependent on oil.

This report demonstrates how stakeholders, policymakers, and advocates can forge a path to global supply chain and freight sector resilience and decarbonization through digitalization supported by freight data exchange standards, which are freely available or open technical specifications that define how to share critical information among stakeholders to facilitate freight logistics.

The Coalition for Reimagined Mobility (ReMo) found that standardized freight-data exchange can deliver operational efficiencies that reduce the need for oil while reducing emissions by 22 percent by 2050. Digitalization, or the transition from manual processes to software driven processes, and improved access to operational data has the potential to lead to an over six percent decrease in freight costs per kilometer, a substantial cost saver for an industry operating on thin profit margins. Figures 1 and 2, focusing on the journey of a chair and power of digitalization, illustrate how improved freight data exchange could reduce delivery times in this example by nearly 13 days.

This report outlines a proposal to increase supply chain resiliency, enhance global security, and reduce freight sector emissions through data exchange enabled by open freight data standards. It identifies policy recommendations to leverage technology and near real-time data exchange to improve communication and optimize freight networks, while protecting sensitive information.

- Stakeholders, policymakers, and advocates can forge a path to global supply chain and freight sector resilience and decarbonization through digitalization.

A threat to the security of nations

Oil use and emissions within the freight sector are projected to increase as demand volume is expected to grow 2.6-fold by 2050.[1] The freight system's reliance on oil makes nations vulnerable to hostile actors such as Russia that can manipulate oil supply, threatening the security of democracies and exacerbating climate change. Furthermore, the freight sector's lack of resiliency in managing disruptions enables geopolitical events to further impact the price of oil.

Aggravating climate change

The freight system also remains out of step with other sectors of the economy now on a path to decarbonization. Scientists at the Intergovernmental Panel on Climate

Change (IPCC),[a] a United Nations agency, have issued decisive research indicating that emissions must peak by 2025 and reduce to net zero by 2050 to meet global climate goals.[2] Yet, while nations have made commitments to reduce land-based freight emissions, the International Maritime Organization (IMO), the United Nations agency responsible for regulating shipping, has yet to set a date for net-zero emissions.

The global freight sector is now investing in a transition to clean fuel vehicles, but the timeline for transition far exceeds the timelines as defined by the Paris Climate Agreement,[b] the international treaty on climate change. To achieve global carbon emissions reductions within the defined timeline, the regulatory approach for the freight sector will need to be more ambitious and go beyond relying on the transition to clean fuels.

Numerous stakeholders make communication challenging

Over the last half century, technology, deregulation, and trade agreements transitioned supply chains from local production and manufacturing to specialized, globally distributed production of individual components. The development of standardized containers, the ability to transport goods on larger vessels, and advancements in fuel economy are just a few of the technological advancements that have all contributed to reducing the cost of freight transportation allowing for this globalization.

This transition resulted in a multitude of stakeholders facilitating new trips and creating longer and more complex global supply chains. A stakeholder's manufacturing and distribution processes are now dependent on potentially hundreds of other stakeholders across the world.

Lack of system resilience

Global supply chains are built on a brittle foundation. Instead of transitioning fully to the digital age, supply chain stakeholders continue to rely on manual or inefficient communication tools and processes. Communications breakdowns are a common occurrence as stakeholders search an array of websites with potentially inaccurate or outdated information. Rather than relying on software platforms capable of automating processes based on near real-time data flows, stakeholders manually validate information while coordinating by email, phone, and even fax.

Siloed technological advancement

Nearly 20 times every second, someone swipes on an app or clicks on a website, setting the largest global online marketplace in motion.[2] As the package arrives overnight, the buyer might be led to believe that the platform they used, or the digitally enabled journey they followed, represents the freight system writ large. Yet parcel

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[a] IPPC is an intergovernmental body of the United Nations responsible for advancing knowledge on climate change.

[b] The Paris Agreement is a legally binding treaty on climate change adopted by 196 parties at the COP 21 conference in Paris in 2015 whose goal is to limit global warming to well below 2 degrees, preferably to 1.5 degrees Celsius. To limit warming to 1.5 degrees Celsius, the International Panel on Climate Change (IPPC) estimates that emissions must reach net zero by 2050, and have peaked by 2025.

• Private sector stakeholders do not have naturally aligned incentives to transition to freight data exchange standards without government intervention.

delivery services provided by the likes of Amazon, FedEX, UPS or DHL, among others, make up only 0.2 percent of all ton-kilometers travelled. Most of the global freight system operates without interconnected software services that support parcel delivery. Parcel delivery systems operate within easier-to-coordinate closed loop systems that are managed by individual players or a small group of stakeholders.

Outside parcel delivery, the consequence of siloed development is that the benefits of digitalization fail to extend beyond the operations of the firms embracing them, or to benefit deliveries as cargo moves from one carrier's hand into the next.

Carriers, ports, and individual firms have adopted in-house digital tools to optimize operations within individual verticals. Carriers, for instance, have adopted cutting-edge global positioning system (GPS) technology and weather forecasting tools that have made huge strides in more accurately predicting journey times. Yet, the benefits of these tools have been similarly limited to individual modes or companies.

Standardized data exchange will illuminate industry advancements in digitalization to support information transfer among other carriers, ports, and individual firms.

Port Community Systems

An example of siloed advancements are port community systems (PCS). These digital freight tools are a best-in-class solution used in the port environment as a centralized source of data to streamline communication within a port system. While they were introduced in the early 1980s, adoption remains low and limited to major ports,[c] in part due to cost and implementation challenges. These challenges are largely a function of PCS having been typically built using proprietary integrations rather than open standards.

Stakeholders typically share data through bespoke integrations or manual processes, both of which can be costly. This also means that data typically only flows in one direction: from the stakeholders to the ports. The proprietary nature of the software also makes PCS hard to replace and results in ports being beholden to their original software vendor.

Why the problem exists

The use of standardized freight data exchange will advance a more resilient, sustainable future and prove to be beneficial for the operations and profits of shippers and their customers. This raises the question: What is slowing down progress on deploying what would seem to be in everyone's best interest?

Private sector stakeholders do not have naturally aligned incentives to transition to freight data exchange standards without government intervention. Meanwhile, regulatory actions have been limited and ineffective. There are two key reasons why ineffective communication across supply chains and the freight sector persists.

1. Market failure

While there are many stakeholders facilitating freight movements, supply chains are largely operated by the private sector, suggesting that business incentives could resolve communication challenges. Yet, the communication challenges that have cascading effects are not those within an individual business or small group of businesses.

[c] For more information, refer to the Open Data Institute: https://theodi.org/topic/open-standards-and-open-apis/

Instead, communication failures typically occur when many stakeholders must connect with many other stakeholders to facilitate the coordination of a supply chain. The large number of stakeholders means that an individual business cannot resolve communication issues of their own will and investment. There must instead be a centralized approach to standardizing communications across stakeholders.

Further, businesses typically do not share any operational data externally because there is a perception that those data could give away a competitive advantage. A private sector player is therefore not well positioned to be the first mover due to the risk that their industry partners may still choose not to share data without a requirement from government.

Additionally, developing and managing data standards is a capital-intensive endeavor requiring broad consensus and technical development, which are often not financially feasible for private sector stakeholders. This is in part due to the cyclical nature of global shipping: Freight actors can be hard hit by lows and need to act opportunistically during peaks. The volatility of the freight sector can make it challenging for freight actors to invest in long-term solutions and systems.

2. Regulatory failure

International regulatory bodies lack both enforceable regulatory instruments and governance authority to drive meaningful change. In the absence of strong leadership, freight stakeholders are not empowered to participate in data exchange.

This demonstrates the need for public sector intervention and regulatory nudges to increase participation. International organizations (IOs) such as the IMO or the International Chamber of Commerce (ICC) are theoretically best positioned to develop and enforce global regulations for the freight sector because supply chains and freight movements are inherently global. However, IOs have generally demonstrated an inability to drive meaningful change in emissions reductions across the sector.

The IMO, for example, has not yet set a date for achieving net zero emissions within the shipping sector. IOs also typically use policy instruments that encourage specific behavior, rather than binding policy measures that have enforcement mechanisms. Even when binding policy instruments are agreed upon, they rarely include enforcement mechanisms. In most cases, implementation is the responsibility of members and may require changes in legislation at the national level.[3] The combination of political will and governing authority at IOs demands for alternative governing bodies to set the tenor of conversation to shift towards open freight data exchange standards.

Existing open freight data standards

The low penetration of PCS is not simply a function of ports being slow to change, but also due to the cost of the available options. Markets built on open standards, however, are typically more competitive and can reduce the cost of software. This effect has been seen in the micromobility, public transit, and banking industries.[d] Open standards reduce cost barriers, allowing choice of software vendor and greater participation in digital tools and data exchange. Without the scalability that freight open standards provide, the freight system cannot meet its global emissions reductions targets either. More information on PCS, including an in-depth look at the benefits and limitations of these systems, can be found in Appendix 4.

> Transformation cannot occur until improved communication supported by digitalization occurs on a larger scale.

While there is the need to introduce new or updated open freight data exchange standards, a range of standards exist today. Early freight standardization efforts have sought to reduce regulatory barriers to international trade, usually by standardizing customs paperwork. These early customs standards remain the most widely adopted,[4] but they are not well suited to enabling improved operational efficiency. Over the last decade, groups have begun to standardize components of operational data exchange. Still, no clear, comprehensive standard for near real-time operational data has emerged. The most promising efforts have focused on containerized cargo, which only constitutes 13 percent of maritime trade. An annotated overview of existing freight data standards can be found in Appendix 3.

Making data exchange accessible for all stakeholders

Efforts to improve communication across the freight sector and supply chains through localized technological solutions, or even nascent data standards, are great initial steps. Yet, wholescale freight digitalization will not be possible without coordination and the use of data exchange standards by all stakeholders.

While individual companies can work to improve the efficiency of operations within their own managed systems, the network effects of cross-industry communication will only occur once stakeholders are able to communicate about and respond to disruption. In other words, transformation cannot occur until improved communication supported by digitalization occurs on a larger scale.

Freight data exchange standards will accelerate digitalization

Data exchange enables a transition to software-enabled communication, forming the backbone of better freight sector stakeholder communication and coordination. It also has the potential to support interoperability across global supply chains, without which multiple software programs cannot easily communicate with one another.

Open freight data exchange standards also reduce friction for a stakeholder selecting a software provider. The low cost of switching software vendors fosters a competitive marketplace, which both expands product options and reduces the cost of access. The combination of these benefits reduces barriers to entry for stakeholders across the board, thereby driving towards wholescale open freight data exchange standard adoption and associated benefits.

Digitalization will not scale without open freight data exchange standards, and open freight data exchange standards will not scale unless policymakers establish a regulatory framework. It is likely that stakeholders may need seed money for initial development. This would be a worthy public-sector investment, as data exchange will lead to advancements that reduce emissions and create operational efficiencies that lessen the need for oil.

Working collaboratively, policymakers, stakeholders and advocates have an opportunity not only to transform the global freight system and supply chains, but to help shape a more resilient, sustainable, secure future for all.

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[d] For more information, refer to the Open Data Institute: https://theodi.org/topic/open-standards-and-open-apis/

Improved communication would allow stakeholders to conduct analyses to have better predictions of goods' availability across ports, making it easier for trucking companies dealing with labor and equipment shortages to be responsive to real world conditions.

PART ONE

Open freight data exchange standards for a better future

With innumerable stakeholders interacting, freight sector resilience hinges on effective communication that supports global business continuity even during intense disruption.

Scaling freight data exchange will improve communication across the freight sector, building resilience across global supply chains, helping to ensure the security of nations, and reducing freight sector emissions.

Resiliency benefits

Resiliency gaps across the global freight system and supply chains are linked to frequent service disruptions, and the freight system's interconnected nature means that these disruptions are typically not isolated incidents. For example, in March 2021 a container ship blocked the Suez Canal in Egypt. As a key freight corridor, this blockage created a ripple effect across the entire freight system, resulting in goods on the other side of the world finding themselves in a standstill. Ultimately, economists and insurers calculated that the blockage reduced annual trade growth by 0.2 to 0.4 percentage points,[5] which negatively impacted businesses and consumers around the world.

Port congestion from COVID-19 disruptions caused U.S. retailers importing through Californian ports to incur US$321 million in added interest expense on inventory in 2021.[6] These costs are ultimately paid for by the end consumer, as demonstrated by pandemic-related increases in shipping prices directly contributing to a predicted 1.5 percentage point increase in global consumer prices in 2022.[7]

These disruptions could be better managed by a system leveraging open freight standards for data exchange to improve communication. Improved communication would allow stakeholders to conduct analyses to have better predictions of goods' availability across ports,[8] making it easier for trucking companies dealing with labor and equipment shortages to be responsive to real world conditions. Or, in the event of strategic geopolitical changes such as Russia's invasion of Ukraine, improved data quality would give decisionmakers greater visibility, allowing them to more nimbly respond to embargoes placed on Russian goods or those of any other country in the future. The ability to plan for and respond to long-term or ongoing disruptions can build a more responsive and resilient global freight system and is a core component of data exchange standards.

Economic resiliency, on the other hand, is the ability to avoid, withstand, or reduce the economic cost of shocks to the freight system, and can only be achieved through cross-sector communication. While individual companies can work to improve the efficiency of operations within their own managed systems, the network effects of cross-industry communication will only occur once stakeholders are able to communicate about and respond to a disruption.

The costs associated with freight system disruptions cannot be avoided through efficiencies achieved by just one business and can only be reduced and managed through cross-industry communication and freight data exchange standards. ReMo's research found an over six percent decrease in freight costs per kilometer with improved access to data. In an industry that operates on thin profit margins, this is a substantial cost saver. While a resilient freight system can help to better manage disruptions, it cannot prevent them. Unpredictable events such as extreme weather events, geopolitical instability and global health crises are likely to increase in frequency due to climate change and an increasingly constrained supply of natural resources. Nonetheless, investing in a resilient global freight system will help to ensure that the network can react quickly to disruption and avoid long-term impacts.

• The ability to plan for and respond to long-term or ongoing disruptions can build a more responsive and resilient global freight system.

Solutions for deploying freight data exchange

Efforts to improve communication across supply chains and the freight sector have been insufficient to date, but thoughtful regulation and policy solutions can overcome existing barriers.

To realize the benefits of open freight data exchange standards, they must first be developed. A container ship journey offers an example of both the critical types of data necessary and the potential for deploying data exchange. Data exchange could enable the container ship to share its location, the number of containers it is carrying, and the containers' destination with its destination port in near real-time. This data could help the destination port better plan for the ship's arrival and expedite processing of goods. Near real-time data is dynamic and periodically updated to represent changing conditions on the ground. With near real-time information about the location and status of shipments, as well as information about capacity or conditions on the ground, the transport of goods can be streamlined and better coordinated.

Supporting this regulatory framework, the development of open freight data exchange standards must use best practices for data protection and privacy. It is critical that standard development have an ethos of data minimization, which is the practice of limiting data that is exchanged or collected to what is directly relevant and necessary to accomplish a specific use-case. Standard development would thus be an iterative process, as standards would need to be developed with specific use-cases in mind. A full range of other security strategies will also be critical to protect both data that could become personal data and data that may be sensitive to a business.

> The development of open freight data exchange standards must use best practices for data protection and privacy.

The risks associated with an individual company sharing data are often perceived to outweigh the benefits. Yet, if all companies share the same data that risk is neutralized. A regulatory requirement and enforcement mechanism are necessary to ensure that all companies are sharing the same data and to drive adoption.

Ports are best positioned to cascade the benefits of freight data exchange and digitalization due to their ability to trigger a domino effect, enabling a chain reaction of other ports and stakeholders across the industry adopting or requiring data exchange. To drive adoption of open freight data exchange standards across the full freight sector, including (but not limited to) trucks, rail, and ships, a requirement must come from an entity that interacts with all modes and with a wide array of stakeholders across the industry. This approach will also mean that it is not necessary for all ports to implement these standards at once. In fact, having a few larger ports be the first movers will create less cost and friction for the ports that later adopt similar standards.

While current events may paint a harrowing future in terms of the resilience of supply chains, the security of nations, and climate change, scalable freight data exchange has the potential to overcome these issues within the freight sector. Through deploying open freight data exchange standards and enacting requirements for data exchange at major ports across the world, supply chain stakeholders will be better equipped to manage uncertainty and future disruptions.

PART TWO

Emissions benefits from freight data exchange standards adoption

- The widespread adoption of operational data exchange would reduce freight emissions by 22 percent by 2050 in comparison to the baseline scenario.

To better understand the benefits of freight data exchange standards, ReMo partnered with the International Transport Forum (ITF) to use its globally renowned freight emissions model to quantify emissions reductions that could be generated through a transition to standardized freight data exchange.

Informed by an extensive literature review (Appendix 2) and interviews with key industry thought leaders,[e] ReMo defined seven data-driven operational efficiencies (Figure 3) that could be enabled by freight data exchange standards. This analysis found that the widespread adoption of operational data exchange would reduce freight emissions by 22 percent by 2050 in comparison to the baseline scenario.

Model assumptions

This modeling effort compared a "digital freight scenario," which was a combination of the data-driven operational efficiencies, against a baseline scenario.

The baseline scenario, informed by 2019 data, assumed the following:

- Widespread transition to low-carbon road freight.
- New infrastructure construction and improvements to existing infrastructure.
- Increasing fuel efficiency improvements across all modes as derived from the International Energy Agency Mobility Model.
- Growth in trade, gross domestic product (GDP), and population.

[e] Stakeholder outreach included interviews with academics, international organizations, cargo owners, and multimodal freight industry representatives including ports, air cargo, trucking, rail, maritime carriers, third party logistics, freight technology firms, sensor companies, and national, state, and local government officials.

The digital freight scenario which incorporated the data-driven operation efficiencies assumed:

- Adjustments to the baseline model including fuel, time, and utilization efficiency gains tied to each of the seven data-driven operational efficiencies.
- Accelerated transition to digital tools in the freight sector using impacts measured in real-world examples.

Importantly, the model is constrained by data inputs from 2022 real-world examples and does not reflect potential advancements, such as computing speed, or widespread adoption of freight data exchange standards yet to be developed. For example, in the future, processing speeds and storage capabilities will likely improve. In addition, capabilities to easily derive insights from higher quality, standardized data from a wider variety of sources will likely expand. Therefore, this analysis should be considered conservative as it is derived from the real world using 2022 technology despite the speed in which we have seen advancements in computing power, big data, telecommunications, and artificial intelligence.

A detailed review of the modelled impacts associated with each operational efficiency, assumptions, and methodology is available in Appendix 2.

Key findings

ReMo's global analysis found that the widespread adoption of freight data exchange standards would reduce emissions by 22 percent by 2050 in comparison to the 2019 baseline scenario. Key findings include:

- Carbon emissions reduced by 22 percent
- Sea freight emissions reduced by 280 million tons of carbon per year
- Road freight emissions reduced by 360 million tons of carbon per year
- 2.5 billion fewer barrels of oil per year
- Costs per ton-kilometer reduced by 6 percent

This section provides additional detail on the benefits of each data-driven operational efficiency. Though each efficiency is described individually, successful digitalization of the freight sector requires all efficiencies to be pursued concurrently.

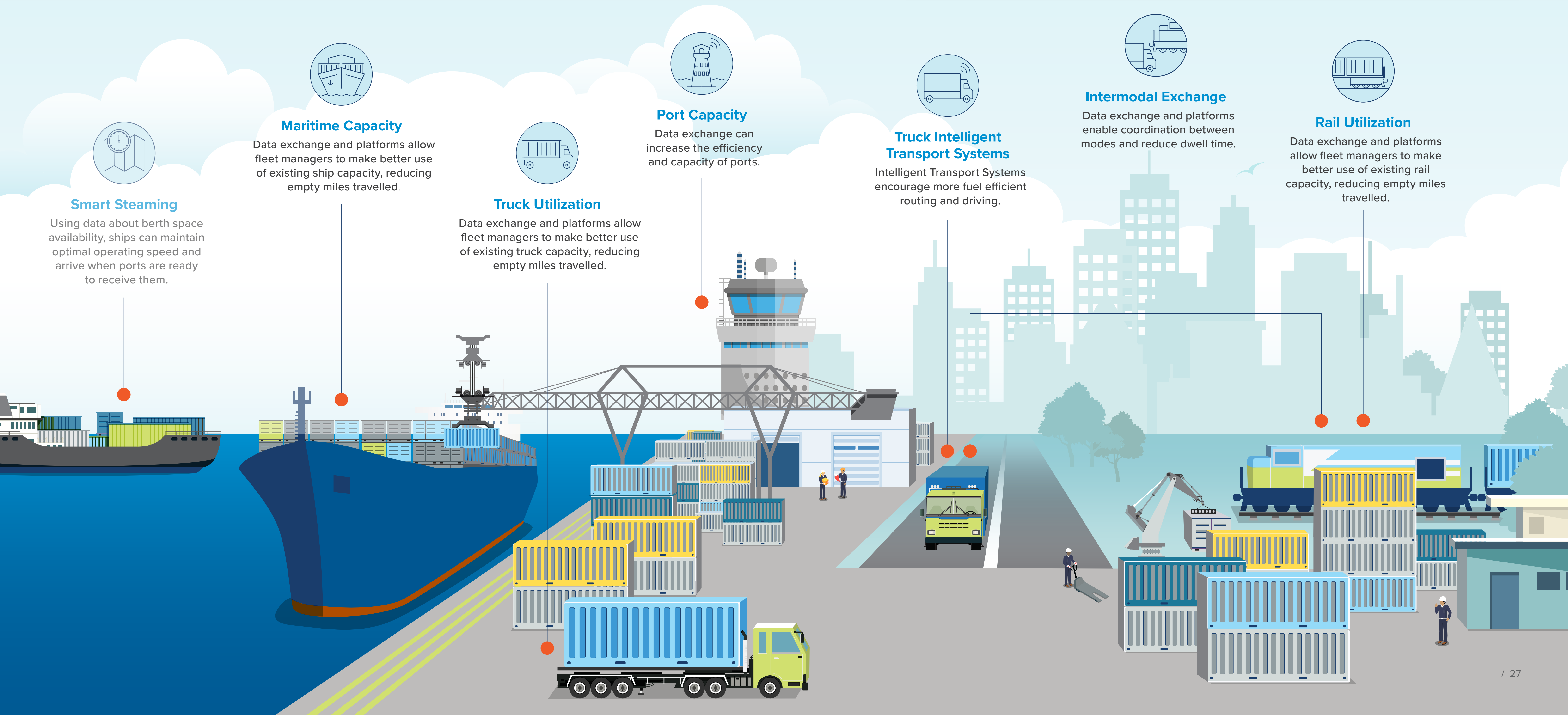
FIGURE 3

Data-Driven Operational Efficiencies

The widespread global adoption of a freight data-exchange standard can enable seven data-driven operational efficiencies across the supply chain.

By 2050, digitialization could result in the following improvements, as compared to the baseline scenario:

22%	280M	360M	6%
lower carbon emissions across the freight sector	**tons of carbon reduced sea freight emissions** per year	**tons of road freight carbon emissions reduced** per year	**lower costs per ton-kilometer** across the freight sector



	CHALLENGE	DIGITAL SOLUTION	RESULT
Smart Steaming	Upon arrival at a port, ships are typically served on a first-come-first-served basis, which often leads to "hurry up and wait" behavior: Ships may "hurry" to the next port, only to discover that a space to unload is not available. **This can result in waiting for many hours, days, or even weeks.**[9]	**Smart steaming, also known as dynamic arrival,** uses near real-time data to match the arrival of the ship with the availability of space at the port.[f] With smart steaming, the streamlined exchange of data between ports and maritime vessels allows a ship to maintain the optimal operating speed, thereby saving fuel, and arrive at a port when there is space to unload.	By 2050, smart steaming alone could decrease sea freight emissions by **390 million tons of carbon per year** compared to the baseline scenario.
Truck Utilization	Scheduling truck fleets is complex and small-to-medium-sized businesses often lack the resources to invest in transportation management software. In part due to the limited exchange of information across stakeholders, trucks often travel with sub-optimal or empty loads, leading to more miles traveled. To put that in context, **almost 50 percent of trucks travel empty on their return trip after making a delivery.**[10]	**Software programs** can help fleet managers streamline workload scheduling while ensuring fleet efficiency. Expanding the availability of near real-time data to support route planning and trip-matching[g] will result in more efficient use of existing vehicle capacity, reduced growth in the truck fleet size over time as truck space is more effectively used, and reduced empty miles traveled.	By 2050, truck utilization alone could decrease road emissions by **390 million tons of carbon per year** compared to the baseline scenario.
Maritime Capacity	The majority of freight by volume travels by sea, with dry and liquid bulk accounting for 72 percent of sea freight volume and container vessels accounting for an additional 13 percent of sea freight volume.[11] **Dry and liquid bulk ships frequently travel with an empty return trip.**[12] **Additionally, an estimated 33 percent of maritime freight containers are moved empty.**[13]	**Digital tools and platforms** can increase maritime load factors, reducing both empty miles and the number of trips required.	By 2050, maritime utilization alone could decrease sea freight emissions by **270 million tons of carbon per year** compared to the baseline scenario.
Rail Utilization	**While rail is a lower emitting mode, because of its fixed routes, it often loses market share to more flexible options such as trucks**. This loss of market share contributes to a significant increase in emissions, as a single freight train movement at a port can replace several hundred trucks.[14]	**Digital strategies** can build flexibility and capacity into the rail freight system through making better use of railroad cars or allowing trains to travel closer together by reducing the time delay required between each rail movement.	By 2050, rail utilization alone could decrease rail freight emissions by **19 million tons of carbon per year** compared to the baseline scenario.

[f] Contractual agreements may limit ships' ability to slow steam. Frequently dry and liquid bulk vessels carrying commodities are chartered through contracts with "due dispatch" clauses, which require them to travel with the utmost speed to reach the destination port. Commodities are priced on a spot market, which means that their value depends upon when they can be unloaded. Slow or smart steaming under these clauses is considered a breach of contract and necessitates specific language to meet this need.

[g] Trip matching is matching demand for trucking services to trucks available to carry the good.

	CHALLENGE	DIGITAL SOLUTION	RESULT
Truck Intelligent Transport Systems	**Road freight is carbon-intensive, and its impact is growing with exponential growth of global road freight miles traveled.**[15] Optimizing each road freight mile traveled is key to reducing emissions and oil use.	**Intelligent transportation systems (ITS)** are communication and information technologies that make transportation safer, more efficient, and more sustainable.[16] Their use can increase truck fuel efficiency through more efficient routing and encouraging fuel-efficient driving behavior. ITS also allow drivers to avoid congested areas, use major roads for longer distances, and avoid steep ramps and junctions.[17]	By 2050, road ITS alone could decrease **20 million tons of carbon per year** compared to the baseline scenario.
Intermodal Exchange	**Trucks and rail lines spend significant time idling at intermodal facilities due to a lack of accurate information on the timing of loading and unloading vehicles, increasing emissions and costs.** There is often significant built-in slack time due to unreliable arrival times, which make it challenging to schedule modal transfers.[h] Incorporating slack time into trip planning helps prevent carriers from missing intermodal connections. However, slack time increases total costs for both shippers and carriers and reduces the competitiveness of more energy efficient modes (rail, maritime, inland waterways).[18]	**Freight data exchange standards** can improve connections between modes and reduce transfer time. **The use of data-driven software** can make operations more efficient and reduce the transit time penalty associated with intermodal transport.[19] A consistent reduction in transfer times then reduces the slack time that intermodal stakeholders must build into their trip planning decisions, allowing for more modes with previously longer transfer times (rail, maritime, inland waterway) to be more competitive against higher emitting modes (truck, air).	By 2050, more efficient intermodal interchanges alone could decrease **125 million tons of carbon per year** compared to the baseline scenario.
Port Capacity	**Standards for freight data exchange can increase port throughput** by giving port users better insight into cargo available for pick up and enhancing users' ability to plan intermodal transfers. Increased port capacity, expressed in terms of containers or vessels per unit of time, can be achieved through streamlined documentation and processing procedures.	**Digital platforms, such as port community systems (PCS),** can improve throughput without capacity enhancements or additional yard equipment. While additional port capacity is projected to result in 30 million tons of additional carbon per year, investments in improved port capacity support the freight system, reducing the need for costly, lengthy, and high-emitting expansion projects by accommodating higher throughput in the existing system. This calculation does not include emissions that are avoided by reducing the need for expansion projects as a result of increasing the throughput of existing facilities.	By 2050, port capacity alone could increase freight emissions by **30 million tons of carbon per year** compared to the baseline scenario.

[h] The lack of reliable data means that fleet managers need to schedule vehicle movements with a high degree of uncertainty. This uncertainty is factored into fleet management as "slack time."

PART THREE

Port digitalization case studies

To understand how best to drive adoption of freight data exchange standards, ReMo developed case studies of three Port Community Systems (PCS) adopted by ports across the world to enable digital communication within the port ecosystem.

While the ports highlighted in these cases largely have not adopted open standards for freight data exchange, their experiences provide important lessons for the transition to using software to facilitate communication. They also demonstrate challenges that today's PCS experience due to data exchange protocols that are not built on standards.

Case study selection prioritized diversity in geography and governance models. In addition, case studies focused on ports with significant inland connections to highlight implications for intermodal transfers. Additional detail on case study selection and methodology can be found in Appendix 1.

The case studies included in this report are:

- The Port of Hamburg
- The Ports of Los Angeles and Long Beach
- Pan-Indian Ports

Port of Hamburg

The Port of Hamburg (PoH) in Germany sits on the Elbe River, approximately 100km upstream from the North Sea. It is the third busiest container port in Europe, the world's largest rail port,[20] and the leading employer and driver of economic development in the region.[21] In 2021, the PoH handled 8.7 million twenty-foot equivalent units (TEU)[22] of cargo capacity. The PoH is also a landlord port,[i] managed by the Hamburg Port Authority (HPA), a public institution established in 2005 and owned by the City of Hamburg.

FIGURE 4

Port of Hamburg

Early PCS adoption

In the early 1980s, PoH's private sector community found that regulatory paperwork to process cargo through the port was exceedingly burdensome, impeding the port's ability to remain competitive.[23] The PoH also faced geographic challenges requiring meticulous vessel schedule planning to align operations with tidal conditions, which offered limited ability to expand.

In response to these capacity constraints and paperwork burdens, a coalition of stakeholders collaborated on the development of an early PCS through DAKOSY, a company created specifically to develop the PCS. Implementing the cutting-edge technology of the day, DAKOSY developed a PCS that included individual modules for processing import, export, and customs documentation. To develop these modules DAKOSY defined an electronic data-interchange standard that prescribed how carriers should share data with port stakeholders. This required the standardization of the non-digital port procedures, ultimately turning 26 different forms into one paper format.[j]

Driving adoption through mandates

Uptake of the PCS and its platforms across port users was slow but steady. Despite its role as a so-called "neutral third-party" and investments to ensure system compatibility for users, many stakeholders had fears about sharing data that they perceived to be sensitive. These fears were largely a function of the potential for competing businesses to gain access to commercial information and are typical across most businesses. To overcome these fears, DAKOSY developed trusting relationships with carriers that were codified by contractual mechanisms.

To accelerate adoption of the PCS, participation in certain digital port management tools was eventually mandated by PoH, including the truck appointment system and a module for reporting dangerous goods. When the truck appointment system first

[i] Landlord ports are ports where the port authority owns the basic infrastructure and leases it out to operators.
[j] Port orders define port operating procedure for specific processes such as exports or imports.

launched in 1994, participation was voluntary. By 2017, participation became mandatory. This requirement proved to be relatively easy to enforce because trucks were unable to enter the port without a reserved slot.

Ultimately, the strategy of mandating the production of data as a condition to access the port proved effective. By the early 1990s, 200 companies were exchanging data with the PCS. By the early 2000s, participation scaled to more than 2,000 stakeholders. Today, all carriers who access the port interact with the PCS in some way. The success of PoH in using regulatory and conditional requirements to drive data sharing can be a useful model for ports across the world.

Tension between public sector and private sector stakeholders

While DAKOSY was driving value for the private sector stakeholders, the full benefit of insights from the data could not be shared with the Hamburg Port Authority (HPA) due to business contracts between DAKOSY and its stakeholders. In 2014, with the support of DAKOSY, SAP and T-Systems, HPA embarked on developing digital tools to better manage and gain insights into truck movements through data through a project called "Smart Port Logistics." However, the new tool was a poor market fit and in response, HPA received public scrutiny for the poor use of public funds.[24] In 2016, HPA discontinued its efforts, and is continuing to work with its stakeholders to develop appropriate approaches to information sharing.

Yet HPA has not lost hope on bridging the gap between the management of logistics and infrastructure through data exchange. In January 2022, a new initiative was funded that aims to enable better data sharing between DAKOSY and HPA. The project seeks to identify "essential" data for port operations. Approved data will then be bi-directionally exchanged between DAKOSY and HPA. The challenges that HPA and DAKOSY have had in developing an appropriate approach to sharing data-driven insights highlights the benefit of having both the public and private sector players at the table when developing a software solution and associated contracts.

Standards to drive system efficiency

With a PCS in place, PoH began working to scale the operation strategy of smart steaming using freight data exchange. In 2020, PoH launched two pilot projects to test transitioning from static to dynamic data exchange using open standards to enable smart steaming operations to reduce fuel consumption.[k] The open specifications enable bi-directional data exchange between ships and the port.

Lessons Learned

As an early mover in PCS development, PoH exemplifies how data exchange enables safer, streamlined communication between ship and shore. Open data exchange standards make it easier for the ship to comply with navigational—routing and timing—instructions because they are sent directly into the ship's navigation system. This allows the captain to acknowledge safe receipt of instructions and avoids the risk of non-compliance, which could cause severe congestion within the constrained harbor.

• Open data exchange standards make it easier for the ship to comply with navigational—routing and timing—instructions because they are sent directly into the ship's navigation system.

[k] One pilot in partnership with a software provider Wartsila used the Sea Traffic Management standards, whose development was funded by the European Union. In 2021, a separate project piloted the Digital Container Shipping Association's "Just-In-Time Port Call Programme" standards framework.

Previously, navigational instructions were shared via a static PDF passage plan to the vessel via intermediaries and did not enable the authorities to confirm that the ship had received the instructions and whether it would abide by them. These efforts demonstrate the safety and operational benefits of freight data exchange standards, and an interest in building on the cross-industry operational efficiencies that are feasible by leveraging them.

Key lessons include:

- **Private and public sectors should develop digital solutions together.** In the case of Hamburg, private sector stakeholders identified a problem and developed a solution. This process was effective in digitalizing information exchange at the port. Yet, because the port authority played a smaller role in this effort, they were unable to set the terms and conditions of access to data or insights. To ensure public and private sector alignment, it is likely more effective to have both sectors at the table during the development phase.
- **Mandates for data sharing are possible and can be an effective tool to drive compliance.** After many years of voluntary use, in 2017 the truck appointment system became mandatory. This requirement is easily enforceable because truckers need a reservation to access the terminal.
- **Early smart steaming pilots make the case for data exchange standards enabling operational efficiencies in other areas.** While still in their infancy, two projects piloting two different sets of open freight data exchange standards have begun to make the case for using open standards to enable, and scale, operational efficiencies in areas such as smart steaming. Both projects move from static to dynamic data exchange, making it easier for both ships and shore ports to coordinate movements within the harbor and further out at sea.

Ports of Los Angeles and Long Beach

The Port of Los Angeles (POLA) and the Port of Long Beach (POLB), together referred to as the San Pedro Bay Complex, make up the largest port complex by volume in the United States and handled a combined 20.1 million Twenty-Foot Equivalent Units (TEUs) of goods in 2021.[25,26] As trade has expanded between the United States and Asia, these two mega ports have become the key link to the rest of the United States, and are supported by an extensive rail network. The ports are in separate cities and are governed by separate Harbor Departments.[I] Both ports operate as landlord ports, which means that each city owns its respective port but leases port terminal operations to several hundred private sector leaseholders, overseeing a combined 14 container terminals.

Developing the Port Optimizer

In the mid-2010s, with the rise of increasingly large container ships, labor shortages, and limited ability to expand the port footprint, POLA began exploring ways to increase capacity. In response, POLA partnered with General Electric (GE) Transportation, now Wabtec Corporation, in 2016 to develop and pilot a software solution to manage and streamline port operations, called the Port Optimizer. The pilot was later expanded to include POLB.

Port Optimizer is a software solution that enables port users to view conditions at the port, such as updates of average waiting times for vessels or trucks or insights into planned shipments to the port over a three-week time horizon. Information provided by the Port Optimizer enables more streamlined operations and improved trip planning.

While both ports participated in the initial piloting phase, POLB did not continue its participation due to prior investments in an alternative system and the natural competition between the two ports. Before launching the Port Optimizer, the terminal operators at POLB invested in a separate system called eModal, which had a limited scope and was used by the terminal operators to schedule truck appointments and make fee payments. Additionally, while POLA and POLB share a complex, they ultimately must compete against one another, making it difficult to collaborate on shared solutions. Therefore, while Port Optimizer promised advanced visibility of shipments by drawing from more data sources and being accessible to a broader range of port stakeholders, POLB did not move forward with full-scale implementation.

FIGURE 5

Ports of Los Angeles and Long Beach

Building buy-in among stakeholders

For the Port Optimizer to drive value to POLA and offer the maximum benefit to users, stakeholders

[I] Harbor Departments are departments established within California city governments. Governed by a Board of Harbor Commissioners, the Harbor Department has the authority to oversee the management and control of navigable waters within city boundaries as well as all harbor and port facilities.

needed to share their operational data. To garner support for data sharing across stakeholders, the Los Angeles Harbor Department created the Ocean Common Carrier Incentive Program, which enabled ocean carriers to receive incentive payments at $10 per container for each container above a set minimum in return for transmitting specific data to the Port Optimizer. Additionally, the port made terminal operators eligible for financial incentives in return for meeting specific goals. For terminal operators to access these incentives, they must share data with Port Optimizer to verify eligibility.

Ultimately, buy-in for these incentive programs, which operated between 2018 and 2022, was lower than anticipated. In the case of the Ocean Common Carrier Incentive Program, the cost and time needed to comply with the data exchange requirements outweighed the benefits of distributed incentives. Furthermore, the minimum thresholds associated with the incentives were not feasible in part due to COVID-19-related instability. While the incentive programs themselves were not wholly successful, they did create an opportunity for increased communication among stakeholders regarding the needs for increased data sharing, which ultimately increased the level of data sharing to the port on a voluntary basis. This experience highlights both the challenge of developing an effective incentive program and suggests that there may be limitations to using incentive programs to change behavior.

While the incentive programs themselves were not wholly successful, they did create an opportunity for increased communication among stakeholders regarding the needs for increased data sharing, which ultimately increased the level of data sharing to the port on a voluntary basis.

The benefits of Port Optimizer

While driving buy-in of stakeholders to share data has been challenging, the Port Optimizer has helped POLA better manage capacity during a period of rapidly increasing demand. In 2021, POLA's container volumes grew by 13 percent, translating to 1.5 million additional containers. The ability to quickly locate containers using the Port Optimizer was critical to managing this growth and reducing backlogs that can occur when facilitating intermodal transfers. In the same year, when imported containers were sitting at POLA for extended periods, the Port Optimizer allowed the port to develop targeted solutions to reduce the length of stay by 75 percent. POLA's experience demonstrates that, even with adoption barriers, the Port Optimizer and its associated data requirements improved insights about port operations and managed disruptions.

Conflicting systems

As a proprietary solution that was developed in the absence of globally recognized data standards, Port Optimizer's purview does not extend to its direct neighbor. Because of POLB's reluctance to participate, the Port Optimizer only offers data visibility to approximately 70 percent of the San Pedro Bay Complex due to data gaps. Meanwhile, the POLB is in the process of creating a separate platform, the Supply Chain Information Highway, in collaboration with Amazon Web Services using a platform developed by UNCOMN.[27,28] In order to collaborate on a shared solution, both ports would need aligned incentives or supporting regulation. However, within the port complex, in addition to terminals competing for customers, such regulation or incentive structure does not yet exist. In the absence of open data exchange standards or upfront collaboration, it is unlikely that these two systems will be able to communicate without costly integrations and the system as a whole will suffer and be suboptimized. It is only with open freight data exchange standards that the sector will be able to solve these problems locally, nationally, and globally.

A hefty bill

The capital and ongoing expenses of the Port Optimizer introduced a new budget line item for POLA. Initial development costs for the Port Optimizer totaled approximately US$13 million, with an ongoing maintenance cost of approximately US$75,000 per month. Cumulatively, Port Optimizer cost POLA approximately US$20 million over a 6-year period, though POLA and Wabtec have a profit-sharing agreement for potential future revenues. With an annual operating budget of US$1.7 billion,[29] POLA was able to accommodate this expense.[m] However, capital investments of this size may be out of reach for ports with smaller operating budgets.

To date, funding for the system for both startup and ongoing maintenance costs has come directly from the port operating budget. However, an API (application programming interface) store where users can incorporate customized data feeds from the Port Optimizer into their own systems aims to become a future revenue stream for both Wabtec and POLA under their profit-sharing agreement by selling users customized data products to meet their specific needs.

Lessons Learned

POLA was able to see benefits from their investments shortly after development. Nonetheless, there have been several challenges to driving broadscale adoption of data sharing across stakeholders. Key lessons include:

- **Proprietary systems are limiting.** While the neighboring POLA and POLB piloted the Port Optimizer together, they ultimately did not collaborate on its full implementation. With two separate approaches it will be challenging and likely expensive to enable cross-system communication without upfront collaboration or freight data exchange standards. With standardized ways to communicate as part of an open platform, each port could continue to use their software system of choice while still getting the benefit of a full view of the operations.
- **Ports are incentivized to make a profit rather than to collaborate.** Like business owners, port managers focus on increasing their customer base and growing their revenue. Ports compete for customers and to increase market share and productivity. There are no built-in incentives for ports to collaborate on shared data solutions. This is demonstrated with the reluctance of the neighboring ports of POLA and POLB to develop a shared software system. However, ports are public entities and there is opportunity to overcome this reluctance to collaborate through public policy.
- **Purpose-built software can be expensive.** As Port Optimizer's first customer, POLA financed the development of the software, which proved to be costly. While POLA negotiated a profit-sharing agreement for future revenue generated from the intellectual property created, it is unclear if this will enable the port to recoup its investment. From the perspective of POLA, the expense of developing the Port Optimizer was outweighed by the benefits of the system. However, many ports do not have access to the capital to make a similar investment.
- **Incentives may be insufficient to drive meaningful change.** While Hamburg used requirements to drive data sharing, Los Angeles used incentives. Ultimately, the use of incentives was less successful than anticipated and the port is exploring new approaches to encourage increased data sharing.

[m] The annual operating budget of the Port of Los Angeles includes approximately $500,000 of annual operating revenue (2021) collected from fees for shipping services, rental fees, and other forms of service fees and concessions. Finance and Administration Bureau of Port of Los Angeles. (2021, December). *Annual Comprehensive Financial Report for the Fiscal Years ended June 30, 2021 and 2020.* Port of Los Angeles. https://kentico.portoflosangeles.org/getmedia/2ee547df-6743-4fe7-ba34-3726fd7bd655/Annual-Financial-Report-FY2020-21

Pan-Indian Ports

Governance at the ports of India is different than in Hamburg or Los Angeles. The twelve major ports of India are owned and managed by the Government of India as opposed to more local control in many other places. India's twelve major ports moved 56 percent of all maritime cargo traffic in the country in 2021.[30] The other 212 non-major ports across the country are owned and managed by state governments.[n] In 1966, the Federal Ministry of Ports, Shipping, and Waterways (MoPSW) created the Indian Port Association (IPA) to manage the development of the twelve major ports.

FIGURE 6

Ports of India

Solving a paperwork mess

In the mid-2000s, the MoPSW found that paperwork was making transactions cumbersome. This negatively impacted port operations and resulted in a loss of revenue. For cargo to leave an Indian port, it needed a range of up to 12 pre-arrival documents, 16 documents related to imports, and 13 documents related to exports, all obtained only within limited working hours of 10 am–5 pm.[31]

In response to this challenge, the MoPSW convened an inter-ministerial group to study best practices for streamlining paperwork. This effort identified port community systems as the leading solution. The IPA was tasked with overseeing the implementation of a pan-India PCS and allocated 16 crore INR (adjusted for today's rates, US$10.5 million)[o] towards the initial build.[32]

In 2006, CrimsonLogic India, a subsidiary of a Singapore-based software firm, won the 10-year tender to build and maintain the PCS.[p] They were asked to build a bespoke, centralized platform that would allow the exchange of electronic information between maritime stakeholders, including ports, shipping agents, customs, banks, and immigration. Work commenced in August 2006 and the first version was completed by December 2007.

Launch of PCS 1.0

India's initial PCS, referred to as PCS 1.0, was designed to facilitate paperless transactions by allowing electronic filing. Time-consuming and manual procedures, like booking cargo and getting clearances, could now be done online. Ports and operators

[n] Of the 212 ports, only 66 handle cargo. The rest are small scale jetties and captive facilities.

[o] 1 USD value in 2006 was 45.31 INR, 160000000INR/45.31=$3.5M in 2006

[p] CrimsonLogic developed the Portnet PCS for the Singapore Port.

were able to share data on arrival, departure, or delays of shipments, helping to improve efficiency at ports. The IPA estimated that PCS 1.0 reduced pre-arrival registrations and import-export documentation process times from two days to one to two hours and eliminated 23 person-to-person interfaces through its online submissions.

PCS 1.0 becomes outdated

Less than a decade after its launch in 2007, IPA found that PCS 1.0 was outdated. Yet, the contract had not anticipated technological advancements, which made it difficult to respond to stakeholder needs in an innovative way. The outdated software had a poor user experience and lacked interoperability with online processes that other government agencies were implementing.[33] For example, the Ministries of Commerce and Finance wanted near real-time integration between PCS 1.0 and e-portals of related government agencies, which the system could not support. Additionally, private sector operators and shippers were concerned about competitive business data not being adequately secured.

In 2018, the IPA introduced a tender to update the PCS 1.0 system's software technology and integration with other platforms. Portall Infosystems Pvt. Ltd, a unit of Indian logistics conglomerate JM Baxi Group, proposed a new PCS 1x system based on an internal PCS that they had implemented for their private port facilities across India. Portall won the tender to revise the system, scrapping the old PCS 1.0 and building PCS 1x in six months at a cost of INR 30-35 crore (approximately US$5.5 million).[q] The new cloud-based system launched in December 2018.[r]

PCS 1x is an API-based[s] system built on a "latch-on" model, which is a modular design that allows the different parts of the system to be independently created, replaced, or exchanged with other modules or systems. In comparison to PCS 1.0 with 2,500 registered users across 16 ports, the 1x version increased its adoption to 16,000 registered users across 27 ports.

The new software technology influenced this acceptance, but regulation also played a key role. A 2018 executive order by the MoPSW required all ports to adopt PCS 1x. The endorsement of PCS 1x by all the federally controlled major ports compelled others to follow suit or lose access to these port environments. Building on the executive order, the Indian Ports Bill in 2021 consolidates and amends laws relating to the management of major and non-major ports. The bill creates a legal framework for the Government of India to prescribe centralized systems like the PCS 1x to all ports, and to impose punitive measures if these are not followed.

Lessons Learned

The Pan-Indian Ports experience is a departure from the other cases because it benefitted from national level oversight, theoretically enabling greater reach and adoption of the PCS solution. Key lessons include:

- **It is valuable to prioritize the development of a contract that is adaptable to future needs and enables the ability to switch vendors.** In less than a decade after the initial investment in PCS 1.0, the Indian Port Association found that their solution was outdated. Rather than building on their existing product, IPA procured a wholly new solution at relatively high cost. As ports can generally anticipate that technology

[q] The winning bid included Portall Infosystems Pvt. Ltd and Inspirisys Solutions, (India) and dbh Logistics (Germany)

[r] PCS 1.0 was built on the Oracle Solaris Unix OS, migrating all its features to PCS 1x was estimated to cost more than scrapping and rebuilding from scratch

[s] Application Programming Interfaces (APIs) are software intermediaries that define the way in which two separate systems communicate or exchange data.

will advance and that their needs and use-cases will evolve over time, developing a contract that better contemplates that reality will likely reduce costs over the long-term.

- **Port environments with low digitalization levels can implement digital strategies providing big gains.** The IPA implemented a PCS solution in a low-tech environment where cumbersome paper-based, in-person processes were the only option for facilitating the movement of goods. Despite a previously low level of digitalization, the PCS solutions implemented by IPA led to substantial operational adoption gains in a relatively short period of time. While the cost of creating a similarly customized PCS may be a barrier to entry, the operational savings in Indian ports demonstrate that digital solutions can have large impacts on improving freight operations in regions with similarly low levels of digitalization that are still widely dependent on paper-based transactions.
- **Clear, enforceable regulations requiring data sharing as a condition to access ports can drive adoption.** PCS 1.0 did not have regulations mandating its adoption. In contrast, MoPSW issued an executive order in 2018 that authorized all ports to require adoption of PCS 1x from maritime stakeholders to access the port environment. A legal framework through the 2021 Indian Ports Bill goes a step further and proposes monetary fines for administrative lapses or non-compliance.[34] To drive adoption most effectively, national regulations that require the use of data-sharing systems to access a port environment may be required.

FIGURE 7

Port Inefficiency

Most ports do not exchange information to support the efficient movement of goods.

• This graphic illustrates how **freight data sharing can directly improve a port's operational processes to streamline and expedient goods movement.**

BY THE NUMBERS

A MEGA-CONTAINER SHIP HOLDS AS MANY AS

20,000

containers and takes **3 days** to unload.

A MAJOR PORT MOVES AS MANY AS

800,000

containers per month.

TODAY, WITHOUT DATA SHARING

• HURRY UP AND WAIT

The ship is contractually obligated to race to the port. But the company cannot claim a berth—or obtain any information about berth availability— until the ship arrives in the vicinity.

Result: Ship anchors outside of port and waits for several days until a spot is available.

• LACK OF PLANNING

A berth finally opens up for the ship. But the terminal does not have the proper staff on location because it didn't know when the ship would berth.

Result: Only one crane is staffed and functioning, adding unnecessary offloading time.

• THE SEARCH IS ON

Once the truck arrives, the container cannot easily be located.

Result: The container is finally found—buried five containers deep. This requires several cranes to move containers to access the correct one, while the truck driver waits.

• PAPER TRAIL

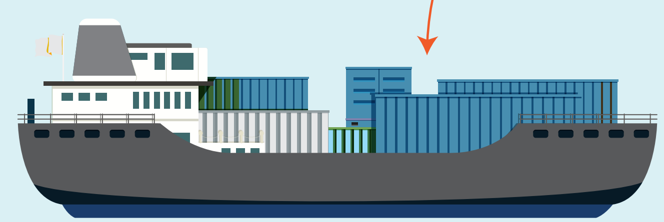
Once the truck is loaded and gets to customs, some of the paperwork for the container turns out to be missing.

Result: The driver needs to wait until the proper paperwork is faxed over to the customs office so the container can be released and the truck can finally leave port.

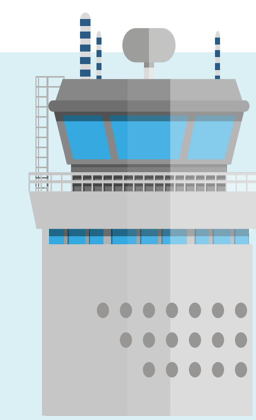
IN THE NEAR FUTURE, WITH DATA SHARING

• INFORMATION AT THE READY

Data about the location and speed of the ship, individual containers, and other shipments is easily accessed by all appropriate stakeholders. **This allows everyone to plan in advance for the most efficient movement of goods.**



The ship shares its time of departure with the port and is able to queue virtually. The ship receives a berthing window from the port and can reduce its speed to arrive on time. By sharing-up-to-date information about its arrival time, the terminal staff is ready to unload the ship as soon as it arrives.



The port and terminals within the port give and receive information from the ships, trucks, and railways accessing the port to ensure efficient operations.

The truck shares the number of the container it's arriving to pick up at the gate. By the time the truck reaches the yard, the container is ready to load.

The railway receives information from the port about when its shipments are ready for pick up. Similarly, the railway is able to share information with the port about its expected arrival times and which goods it is planning to load once it arrives.

PART FOUR

What policymakers and advocates can do

> While a budding coalition of stakeholders from across the world have begun to champion the benefits of freight data exchange standards on an open platform, additional leadership from policymakers is needed.

The ongoing COVID-19 pandemic, Russia's invasion of Ukraine, and a mounting global climate crisis are threatening people's ability to predictably access goods they need when they need them.

Freight data exchange enabled by open standards can improve systemwide communication and support a promise that we can build a more resilient global freight system that reduces oil dependency across supply chains, mitigating the harmful effects of climate change and enhancing the security of nations.

While a budding coalition of stakeholders from across the world have begun to champion the benefits of freight data exchange standards on an open platform, additional leadership from policymakers is needed. To build more resilient supply chains, accelerate decarbonization, and reduce dependence on oil from hostile governments, policymakers must marshal every tool in their toolkit to deploy freight data exchange standards broadly.

Key Takeaways

Freight data exchange standards enhance freight sector resilience and operational efficiencies while reducing dependence on oil.

Freight data exchange standards that are freely available on an open platform improve system resilience by enabling more effective communication across the industry's numerous stakeholders. Moreover, data exchange standards help to drive operational efficiencies that reduce oil dependence and reduce freight sector emissions by 22 percent, thereby bolstering the security of nations and reducing the freight sector's contribution to global climate change.

Communication is challenging within the freight system due to the number of stakeholders, leading to inefficient operations.

A product that arrives at a consumer's door has encountered dozens of stakeholders. A system with innumerable stakeholders is dependent on clear and effective communication. Today, the global freight sector relies on a patchwork of manual processes, such as phone calls, fax machines, and emails, in concert with piecemeal and proprietary digital tools. This approach hampers communication, undermines system resilience, and contributes to rising freight sector emissions through inefficiency and wasted fuel.

Port community systems (PCS) are an important technological step forward, but investing in systems that use freight data exchange standards on an open platform will drive broader scale adoption and lead to greater benefits.

The PCS highlighted in this report were developed to reduce communication challenges within the port environments. In general, these systems use proprietary integrations or manual processes to access data, which can be time consuming and expensive to the port and its stakeholders. The freight data exchange standards being piloted at the Port of Hamburg have the potential to reduce barriers to data sharing. Building the next generation of PCS using open standards will result in increased data exchange and broader adoption of digital tools across the world, leading to increased resilience, efficiencies and reduced emissions.

Policymakers and industry must partner to develop freight data exchange standards.

Comprehensive freight data exchange standards that enable sharing of near real-time operational data do not yet exist. Policymakers and the industry must partner to develop a complete set of data standards to support opportunities for data exchange.

Freight data exchange standards can enable interoperability and create a competitive market for software solutions.

The case of the San Pedro Bay Complex, where the Ports of Los Angeles and Long Beach do not use the same software solution, highlights the challenges associated with building systems that are not interoperable. The case of the Indian Ports Authority, on the other hand, highlights the potential high costs of transitioning to a new software vendor to enable the digital exchange of data that is not future-proof. Freight data exchange standards on an open platform can help to remediate both issues by allowing software products to easily integrate while reducing the costs of switching to a new vendor, thereby fostering a competitive market.

Smart steaming and optimized intermodal exchange can lead to near-term reduction in oil use.

Better coordination of vessel arrival and intermodal movement on its own will lead to meaningful reductions of oil use and reduced emissions. Investments in smart steaming and optimized intermodal exchange can occur on a short timeline, yield meaningful benefits, and be an important step to towards achieving net zero emissions by 2050.

Policy Recommendations

Policymakers across the world must take immediate action to deploy freight data exchange standards to build a more resilient global supply chain and reduce freight sector oil dependence. Informed by the research in this report, the Coalition for Reimagined Mobility (ReMo) developed global-level policy recommendations that are applicable to policymakers across the world.

The following policy recommendations will solve the friction and market failures that threaten the adoption of data exchange across the freight sector. The time to act is now. ReMo recommends that policymakers:

- **Require** the use of freight data exchange standards as a condition for accessing ports.
- **Deploy** freight data exchange standards that communicate near real-time operational data.
- **Allocate** authority to national governments and ports to require the use of freight data exchange standards.
- **Allocate** seed funding to ports and industry stakeholders to deploy data exchange standard pilots and projects.
- **Initiate and fund** targeted intermodal exchange and smart steaming programs to realize near-term freight sector emissions reduction benefits.

Require the use of freight data exchange standards as a condition for accessing ports.

Incentives are typically insufficient to drive adoption of data sharing due to perceived risk of sharing business data externally and the capital and maintenance costs of data sharing infrastructure. For example, the Port of Los Angeles used incentives to drive broader data sharing, which ultimately were ineffective. The Port of Hamburg and the Indian Port Authority, on the other hand, transitioned from a voluntary data-sharing system, which was moderately effective, to an enforced requirement, which drove broad-scale adoption. Requiring data sharing can also help to manage perceived business risks associated with data sharing because it is less likely that an individual business could use those data to gain a competitive advantage. Governments must require and enforce the use of data exchange to drive global adoption supported by the data protection to protect individual business and consumers.

To do this,

1. National level governments must adopt legislation and regulation to require the production and consumption of data in conformance with freight data exchange standards as a condition for accessing a port, and
2. Ports must implement and enforce these regulations.

Deploy freight data exchange standards that communicate near real-time operational data

Comprehensive freight data exchange standards available on an open platform that communicate near real-time operational data have yet to be developed. Freight data exchange standards will be most effectively developed through a partnership between the public and private sectors. The public sector must define use cases, data protection and privacy standards, and provide funding. The private sector must collaborate with the public sector to define the data and the approach for sharing data that considers the complexity of the various systems across global stakeholders. The development of freight data exchange standards will be an iterative process but must use the strengths of both the public and private sectors.

Policymakers must fund and support a neutral third-party group that will bring industry and public sector stakeholders together to develop freight data exchange standards that communicate near real-time operational data.

Empower national governments and ports to require the use of freight data exchange standards.

While private sector freight stakeholders have been effective in using data to improve operations within individual companies or across a small group of stakeholders, freight stakeholders have been less effective in improving communication across supply chains and the broader freight system. This is in part due to the perceived risks associated with data sharing in addition to the costs of deploying and maintaining data sharing infrastructure, which are typically better managed by the private sector.

Many national governments do not have the authority to require the use of freight data exchange standards at ports. While ports typically have some amount of flexibility to deploy and enforce requirements, many ports would benefit from the political cover that national level requirements provide. To effectively require the use of freight data exchange standards, national governments and ports must have appropriate oversight to deploy and enforce requirements.

- Policymakers must fund and support a neutral third-party group that will bring industry and public sector stakeholders together to develop freight data exchange standards that communicate near real-time operational data

Allocate seed funding to ports and industry stakeholders to deploy data exchange standard pilots and projects

The transition towards global adoption of freight data exchange standards will require significant capital investment. To accelerate this critical transition, governments must develop programs to allocate funding toward ports and industry stakeholders to deploy freight data exchange standard pilots and projects and catalyze the creation of software systems built using standards on an open platform.

Initiate and fund targeted intermodal exchange and smart steaming programs to realize near-term emissions reduction benefits

Targeting specific use cases in a port environment, such as smart steaming and optimized intermodal exchange, can allow for quick wins at ports. Namely, smart steaming and reduced idle time decrease fuel consumption and emissions—both carbon and particulates—which is beneficial to carriers, cargo owners and neighboring port communities, which are often low income and with poor air quality. These interventions are achievable in the short term and can kick-start the exchange of operational information at a port with an immediate payoff. These initiatives can quickly reduce vehicle loading delays, optimize port capacity, and maximize vehicle utilization for vessels and vehicles arriving and departing from the port.

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Appendices

The following hyperlinks link to Solving the Global Supply Chain Crisis with Data Sharing's four technical appendices, which are referenced throughout the body of the report.

Appendix 1	Hypothesis and Methodology
Appendix 2	Emissions Modeling
Appendix 3	Freight Data Standards
Appendix 4	Port Community System Case Studies

The Coalition for Reimagined Mobility would like to thank the International Transport Forum, CPCS, and GS1 for their contributions to these appendices.

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