Impact of Digitalization in Driving Decarbonization in the Shipping Industry

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Executive summary

The transportation sector plays a significant role in global greenhouse gas emissions ("GHG emissions"). 80% of international trade relies on maritime shipping, accounting for nearly 3% of total worldwide GHG emissions. Today, the shipping industry is still facing significant decarbonization challenges, one of which is its continued reliance on paper documents. Paper documents are needed as legal and regulatory frameworks usually require physical signatures and original documents for authenticity. This continued dependency on paper documents contributes to a higher carbon footprint. Furthermore, the absence of a universally adopted digital platform poses interoperability challenges as the disparate digital systems can be as numerous as the stakeholders of the shipping process themselves, which also complicates the decarbonization effort.

As the maritime sector faces increasingly stringent environmental regulations and intensifies its focus on monitoring carbon reduction initiatives, organizations such as the Global Shipping Business Network (GSBN) are becoming pivotal players by providing a comprehensive data infrastructure and network, and facilitating a robust, standardized data repository. Given GSBN's position in the sector, this White Paper (hereafter "the Paper") aims to examine the environmental impact of traditional paper-based shipping document transactions, compared to the environmental benefits that digitalization offers to industry participants. The Paper proposes a methodology to measure the GHG emissions of shipping documents and the potential positive impact of digitalization, given that currently there are only conceptual guidelines. It aims to highlight the environmental consequences of using paper-based documents and provide solutions and recommendations to encourage key stakeholders to adopt more sustainable practices.

The research in the Paper draws from a comprehensive life cycle assessment comparing the environmental impact from creating and transferring traditional paper-based documents, with the impact when using digital exchanges. The study's analysis relies on three methods: a literature review of public and private studies, a dedicated process and environmental study conducted by industry experts, and interviews with key players in the shipping industry.

The Paper begins by examining digitalization trends and their benefits in the maritime sector, particularly related to the sector's decarbonization objectives. It then investigates the metrics and compliance standards that govern GHG emission calculations for shipping document exchanges. The Paper delineates and quantifies the GHG emitters across pre-defined scenarios, and calculates emissions derived from two specific case studies: one for the bill of lading ("B/L") process and another for the cargo release (with the delivery order document referred to as "D/O") process. The B/L and D/O processes involve physical handovers of the printed documents after their issuances and between the numerous stakeholders in the logistics chain. Examples of stakeholders who exchange these documents include carriers, freight forwarders, shippers, consignees, banks, ship and cargo agents,

and terminals. These exchanges of shipping documents are typically facilitated by road couriers and airmail, which are significant GHG emitters. For the digitalized processes, power consumption from hardware and data transfers are the primary drivers for GHG emissions, which are significantly less emissive than the traditional paper processes.

The Paper concludes that GSBN's solutions referenced in the case studies, their blockchain-enabled electronic bill of lading ("eB/L") and Cargo Release ("eD/O") solutions, can reduce the CO2 equivalent ("CO2e") by approximately 27.9 kg, and 16.9 kg, per document respectively. These potential reductions are based on specific scenarios developed in the case studies and can vary according to different situations when using the framework the Paper proposes. For example, potential reduction may vary based on variables like the distance between stakeholders. In 2023, over 120,000 eB/Ls were issued on GSBN's platform and over 1 million shipments were released with GSBN's Cargo Release ("CR") solution. Based on these data and the GHG emissions comparison calculated in the case studies, these two solutions may have saved up to 20,248 metric tons of CO2e.

Up to **3,348**

metric tons of CO_2e savings

with eB/L in 2023

Up to **16,900**

metric tons of CO_2e savings

with CR in 2023

Today, digital adoption of B/Ls worldwide remains low at just about 1.2%[1] . By scaling the results of the specific case studies under the chosen scenarios, with approximately 15.8 million B/Ls issued annually[2], GSBN's eB/L solution has the potential to reduce about 440,820 metric tons of CO2e. As illustrated in Figure 1 below, scaled transitions could yield sizable abatement impacts even at individual company levels based on their market share.

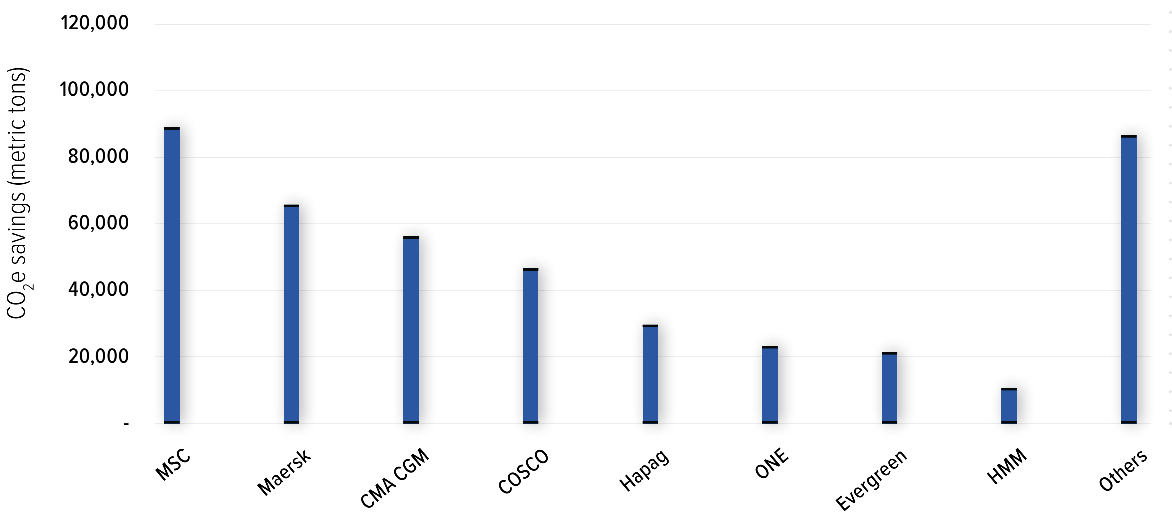


Figure 1: Estimated CO2e savings per carrier per year worldwide based on the case study results[3]

[1] DCSA. (2022). Streamlining international trade by digitalising end-to-end documentation
[2] Ibid.
[3] Source: Sia Partners estimations are based on the framework developed in the Paper and the scenarios from case studies, then applied with carriers' market shares.

As the shipping industry accelerates efforts to decarbonize amid increasingly stringent environmental regulations, the Paper also analyses the methodology adopted by the industry for GHG emissions quantification and explores the transformative potential of digitalization. As such, beyond environmental considerations, digital transformation provides several other benefits from different perspectives including cost, efficiency, security, etc., outlined further in the Table 1 below:

	Paper	Digital	Digital with blockchain
Carbon footprint	**High carbon footprint** from paper usage and handover by courier	Estimation of **over 99% CO2e reduction** compared to paper documents	
Speed / Efficiency	**Weeks** to transfer	**Seconds** to transfer **for eB/L and Minutes** to transfer **for Cargo Release** (efficiency gains from streamlined processes)	
Security	**High risks** of fraud or loss	**Reduced risks** of fraud or loss	**Tamper-proof** and no risks of loss with blockchain technology
Ease of use	**Complexity** of paper processing and management	**Easy access and usage** on a digital platform	
Costs	**High costs** from paper consumption, courier charges damages or delay	**Lower overall costs**	

Table 1: Summary of the benefits from switching from paper to digital documents

Interviews conducted with key industry stakeholders during the study have identified challenges that impede broader adoption, along with recommendations to overcome them, as summarized in Table 2 below. Coordinated solutions are necessary to expedite meaningful progress in decarbonization and reach their full digital potential. Digital solutions offer a promising avenue for stakeholders to streamline processes, enhance data integrity, and foster collaboration across the value chain. By adopting digital solutions, the maritime sector can achieve more secure and efficient operations, and when also leveraging blockchain, ensuring a higher level of data integrity, transparency, and trust among all stakeholders. This approach both assures document authenticity for stakeholders along the value chain, and propels the industry's digitalization agenda forward.

Encourage and accelerate adoption by all stakeholders across the shipping value chain by promoting the benefits and collaborating.

Improve interoperability among different platforms to support the transition to a digital ecosystem, including alignment on data standards.

Continue the efforts to **digitalize the remaining paper documents,** as stakeholders will be less inclined to use one digital document if there are several paper documents left in the end-to-end process.

Push for the **recognition and acceptance of digital shipping documents** among different legal authorities globally.

Table 2: Summary of the recommendations to promote the adoption of digital shipping documents

Chapter I - Introduction

Background and context

The maritime shipping industry contributes about one billion tons of CO2 equivalent, or 3% of total GHG emissions. Accounting for 80% of world trade[4] , maritime shipping is a central player in the transition to a carbon-neutral world. Given shipping's pivotal role in global trade, accelerating emissions reduction is urgently needed in the world's transition pathway.

The International Maritime Organization (IMO) has been pressed by the G7 members to advance their 2050 target, previously to decrease emissions by 50%, to now decrease by 100% and reach net zero. This target runs counter to global trade growth, with shipping volumes forecasted to double by 2050. This rapid increase in volume has the potential to inflate the shipping industry's share of GHG emissions from 3% to 17%[5]. It is clear that the industry needs to rethink practices across the entire value chain, to meet the new target in time. A proactive mindset will allow stakeholders to adapt and make necessary adjustments with enough time to ensure a smooth transition in challenging circumstances.

To date, efforts have focused on fuels as they are the primary GHG emitters in maritime transportation. However, fossil fuel combustion through maritime transportation is not the only source of GHG emissions in the shipping industry. GHG emissions are also emitted along the end-to-end value chain, including, but not limited to, cargo handling in ports, packaging processes, and physical handovers of shipping documents. In fact, the shipping industry remains highly manual. One critical example is document exchange such as the bill of lading (hereinafter referred to as B/L), which has struggled to digitalize and continues to rely on carbon intensive transactions through various stakeholders and transportation means.

While maritime sector has relied heavily on paper documents historically, digitalization is now becoming an imperative to tackle emission challenges. Industry stakeholders hoped that the coronavirus pandemic would have spurred increased digitalization, however the anticipated transformation has not yet fully materialized, and paper-based transactions remain ubiquitous in the industry. Shifting to digital solutions would enable key industry stakeholders to both enhance their operational efficiency and mitigate GHG emissions. The Global Shipping Business Network (GSBN), an independent, non-profit shipping industry consortium, has been at the forefront of this transformation, by providing a blockchain-based infrastructure and platform, enabling access and exchange of eDocuments.

[4] UNCTAD. (2023). Review of Maritime Transport.
[5] Le Monde. (2022). COP27: Maritime transport is a polluting sector that's slow to change course.

Purpose and objectives

The maritime industry faces increasingly stringent regulations from oversight bodies seeking to decarbonize, specifically to achieve net zero by 2050. Since 2018, the International Maritime Organization (IMO) requires ships to improve their energy efficiency in the near term and reduce their GHG emissions through amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL). While the maritime sector strengthens environmental measures with increased carbon reduction targets, it is critical to provide a monitoring infrastructure to ensure the implemented measures are respected, measurable, and effective. This involves setting up a reliable infrastructure to monitor carbon reduction efforts and synthesized reference calculation methodologies, which is quite challenging especially for shipping documents. Various industry players, such as GSBN, can provide the network, data platform and knowledge to key players in the maritime industry enabling them to meet these needs. By offering a secure data repository and platform, GSBN can support participants in verifying and disclosing their decarbonization data.

The need for a robust underlying data infrastructure is imperative in the face of an increasingly demanding regulatory environment, and as digitalization emerges as a key driver to achieve decarbonization targets. The Paper, recognizing the urgency of these needs, aims to develop methodologies to quantify and communicate the opportunities that digitalized shipping documents represent for the shipping industry's decarbonization efforts. It also seeks to provide a structured framework to evaluate the impact of shifting from traditional, manual processes to advanced, secured digital operations. The methodologies developed in the Paper will suggest an approach to calculate and report GHG emissions of the shipping documents across industry players.

Scope and limitations

A comprehensive study was carried out to break down the various stages involved in shipping documentation exchanges. The processes were carefully identified and validated through interviews with industry experts. The two case studies outlined in the Paper cover the B/L and cargo release (with the delivery order document referred to as D/O) end-to-end processes. Of these, seven scenarios were mapped, including four B/L scenarios and three D/O scenarios. The paper-based scenarios are compared to their digital equivalents using solutions provided by GSBN.

In compliance with international guidelines, such as Greenhouse Gas Protocol and ISO, a Life Cycle Analysis (LCA) of shipping documents will be conducted. This analysis covered material acquisition, production, distribution, storage, use, and end-of-life stages. Each source of GHG emissions was connected to specific parameters such as emission factors, document weight and volume, and the distance between interaction points. This approach sheds light on the environmental impact of these processes in the shipping industry.

The Paper made assumptions on various process steps to provide an overview of GHG emissions associated with shipping documentation processes. It suggests the LCA scope after the materiality assessment and its limitations related to potential data challenges.

Chapter II - Digitalization in the maritime industry: trends and environmental benefits

Overview of digitalization trends in the maritime sector

Some recent events, such as the pandemic, the Suez Canal obstruction and the Red Sea attacks have underscored the importance of information sharing, collaboration, and enhanced visibility in fostering resilience against potential disruptions. Digitalization plays a pivotal role in building resilience against potential communication and information flow risks. However, shipping documentation procedures remain largely manual, B/L, for instance, still relies heavily on multiple stakeholders printing, stamping, and signing various paper copies before physically handing over from origin to destination via express courier and airmail. These offline and manual procedures are costly, time-consuming, and susceptible to damage, loss and even fraud. Additionally, essential trade documents such as letters of credit and customs declarations depend on the paper-based B/L as a precondition for their creation and issuance. In this context, the establishment of the Digital Container Shipping Association (DCSA) in 2019 reflects the industry's commitment to digital integration and the recognition of the sector's collective drive towards digital standards.

Numerous digital technologies have been developed, each making a crucial contribution to the advancement and redefinition of operational processes in the industry. Open-source digital standards are being developed to facilitate seamless data sharing and interoperable digital solutions across various stakeholders. Intelligent digital supply chain platforms have emerged, facilitating data sharing, and allowing for real-time control over business operations such as orders, bookings, and document management from anywhere. Carriers are also prioritizing digital interfaces with strategic efforts focused on streamlining port processes and harmonizing declarative procedures. The proliferation of digital applications, including cargo information apps and quotation platforms, is providing stakeholders with critical information, enabling better visibility, and facilitating transactions. By leveraging these digital tools, stakeholders can make more informed decisions, optimize their operations, and enhance collaboration across the value chain.

While digitization has transformed many operations, trade documentation remains a relatively untapped opportunity. Despite nine major carriers endorsing the digital standards established for the eB/L, adoption remains low across the value chain, with only around 1.2% of B/Ls being digitized to date. Urgent and widespread uptake is needed industry-wide, including setting ambitious targets for digitalizing shipping documents, providing education and training for different stakeholders both internally and externally to enable the workforce to adapt to new digital procedures.

Benefits of digitalization of shipping documents

The advantages of shipping document digitalization extend beyond merely reducing GHG emissions. Taking eB/Ls and eD/Os as examples, additional benefits may include:

- **Speed/ Efficiency:** Paper-based B/Ls rely on several physical handovers with couriers, which can take several weeks. In contrast, eB/Ls are transferred electronically, which is done in a matter of seconds. And similar for Cargo Release (eD/O), only take minutes to transfer This saves time and enables efficiency gains due to streamlined processes.
- **Security:** With paper-based B/Ls, there is a high risk of fraud or loss. Blockchain-based eB/Ls are securely housed in digital repositories, limiting accessibility to only relevant and authorised stakeholders, and enabling the transmission of sensitive information through secure channels. Such aspects of the eB/L prevent this official document from being tampered or forged. Finally, eB/Ls can be tracked seamlessly throughout their entire course, with blockchain solutions also ensuring permanent logs for all actions related to documents.
- **Ease of use:** While paper-based B/Ls need to be physically processed and managed by one stakeholder at a time, eB/Ls can be easily accessed and used on a digital platform with decentralized storage, making it retrievable by authorized parties at multiple locations and at the same time.
- **Cost:** The adoption of eB/Ls can lead to significantly lower overall costs, as they are not subject to high costs from paper consumption, courier fees or storage like paper-based B/Ls are. Furthermore, additional costs due to e.g. delay or damage in the provision of shipping documents are avoided.

Fully capitalizing on already existing and emerging technologies is key to unlock full potential of digital solutions. Additionally, blockchain can serve as a complementary layer to address trust and security concerns in data exchange between parties.

Chapter III - Metrics for measuring GHG reduction impacts related to digitalization in the maritime sector

This chapter explores the use of digital alternatives for paper-based shipping documents and their potential to reduce GHG emissions in the shipping industry. It specifically focuses on two critical processes: 1) B/L issuance, endorsement, handover and surrender, and 2) D/O transactions. The chapter also presents the developed frameworks and models for calculating GHG emissions and comparing the potential emission reductions achieved through the adoption of digital solutions. This comparison was developed by identifying and defining key stakeholders and their associated emissions.

Terms and definitions

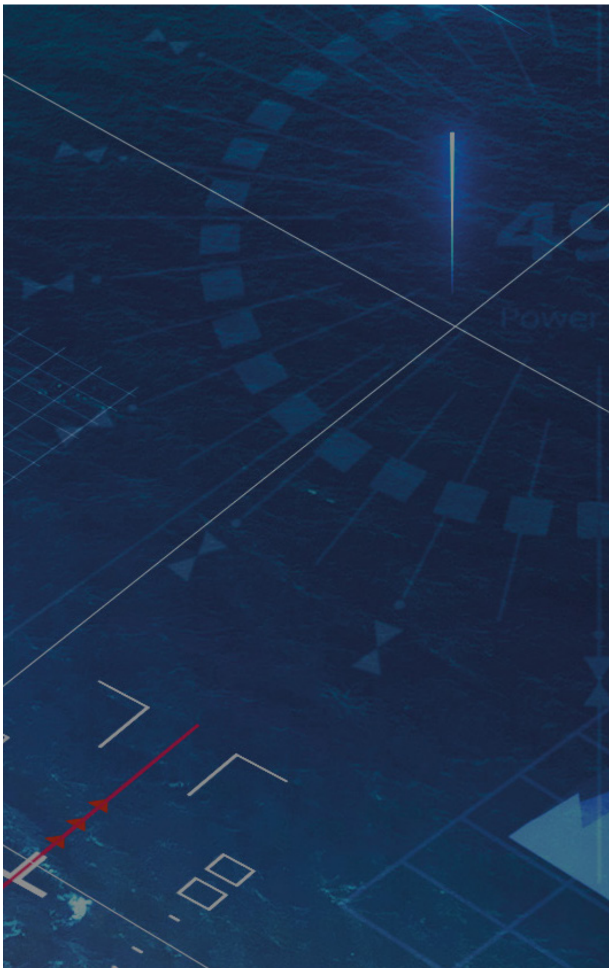
A list of the key definitions:

- **Shipper:** in the context of shipping documents, refers to the owner of the goods who provides the B/L information and entrusts the carrier with the cargo transportation.
- **Carrier:** the entity responsible for the actual transportation of the goods and the issuance of the B/L and the D/O.
- **Freight Forwarder:** the intermediary who arranges the shipping services and facilitates the exchange of documents on behalf of the shipper or the consignee.
- **Bank:** the financial institution that may be involved in the transaction, for example when the shipper requires a letter of credit. This document, issued by the bank, acts as a financial assurance that the consignee will pay after the goods have been shipped.
- **Bill of Lading (B/L):** a legal document issued by a carrier to a shipper that contains information about the type, quantity, and destination of the good being transported. It serves as a receipt, title of goods, and defines the contract of carriage.
- **Deliver Order (D/O):** a document issued by the carrier, in exchange for an original B/L, a telex release, or a Sea Waybill (hereinafter referred to as SWB), to release the cargo to the designated party.

Additionally, as the Paper involves contrasting paper-based formats with their digital counterparts, it is important to specify the scope of what is categorized as “digital”and “electronic”. In this context, “digital” encompasses structured data exchange, that can be with or without blockchain technology. “Electronic” refers to the exchange of electronic documents, such as PDFs. While the terms eB/L and eD/O can apply to both solutions, the subsequent chapter on case studies will specifically compare the GHG emissions of paper-based formats with digital formats using blockchain technology, based on the framework outlined in this chapter.

Mapping emissions sources in the paper-based processes

The Paper aims to determine where primary emissions occur in B/L, D/O, eB/L and eD/O transactions by first mapping the various processes of these shipping documents, from shipper to consignee. This clarifies the possible interaction points under seven different scenarios (four for B/L, three for D/O and their digital equivalents) based on interviews conducted with industry experts such as carriers, freight forwarders, standardization institutions, and BCOs. This step serves to identify the main sources of the GHG emissions. Some sources, such as emissions associated with distributing copies of documents to other various stakeholders like insurers and custom brokers, have been omitted for simplification. Furthermore, transactions related to other documents such as a letter of credit, which may be delivered under the B/L processes, have also been excluded when identifying emission sources.



Overview of the practical use of a paper-based B/L

To accurately identify the reductions in emissions achieved by switching to eB/Ls, it is essential to first establish a clear understanding of the traditional paper-based B/L processes. B/L processes can vary due to the diversity of usage and stakeholders involved in the chain. The Paper has brought forward the below four scenarios for the paper-based B/L process based on interviews conducted with industry experts such as freight forwarders, carriers, standardization institution and BCOs. These four scenarios are described hereafter (the order is based on the number of Master Bill of Lading handovers from less to more):

1. **Paper-based B/L scenario #1: carrier with freight forwarder**
2. **Paper-based B/L scenario #2: carrier with freight forwarder and banks**
3. **Paper-based B/L scenario #3: carrier without intermediaries**
4. **Paper-based B/L scenario #4: carrier with banks**

The following chapter of case studies will focus only on the calculation of the GHG emissions for Master Bill of Lading (hereinafter referred to as MB/L), which is issued by the carrier. Emissions related to other types of B/L, such as the House Bill of Lading, will not be included.

Paper-based B/L scenario #1: carrier with freight forwarder

The first scenario, in the below Figure 2, illustrates the process flow involving the shipper, consignee, carrier, and freight forwarder. If only the MB/L is taken into consideration, the process involves the issuance and exchange of three original copies of the MB/L, each following a different path:

- One original copy of the MB/L stays with the carrier and follows the cargo from the POL to the POD.
- One original copy of the MB/L is collected by the freight forwarder from the carrier's office and is kept at the freight forwarder's office at the POL.
- One original copy of the MB/L is collected by the freight forwarder from the carrier's office at the POL and is handed over by airmail to the freight forwarder's office at the POD. It is then surrendered to the carrier at the POD.

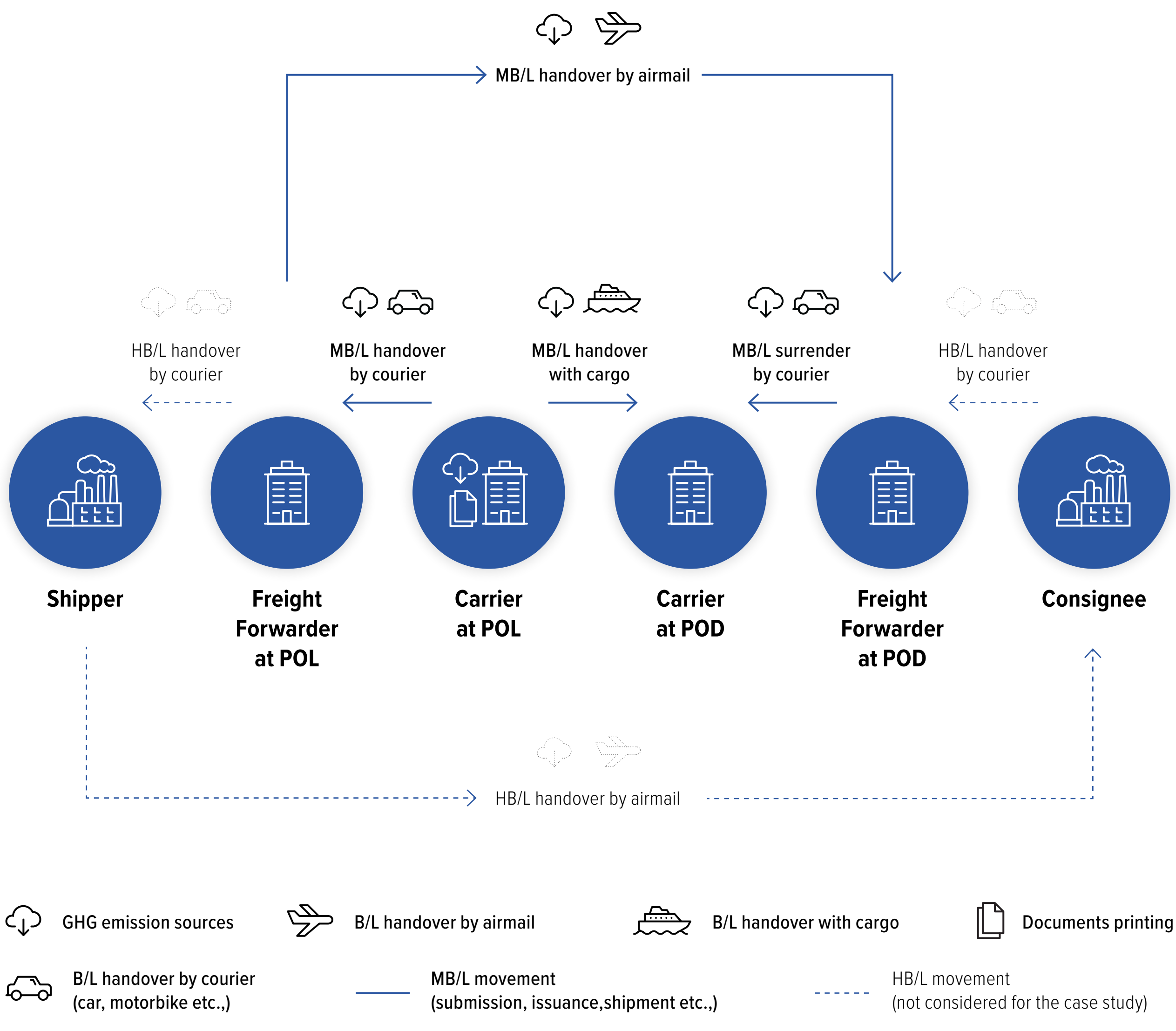


Figure 2: Map of paper-based B/L scenario #1: carrier with freight forwarder

Paper-based B/L scenario #2: carrier with freight forwarder and banks

Secondly, Figure 3 below illustrates the B/L process scenario involving stakeholders like shipper, consignee, carrier, freight forwarder, and banks. However, it is important to note that this scenario, even with the involvement of banks, is nearly identical to the previous scenario, as only the MB/L is taken into consideration here:

- One original copy stays with the carrier and follows the cargo from the POL to the POD.
- One original copy is collected by the freight forwarder at the carrier's office and is kept at the freight forwarder's office at the POL.
- One original copy is collected by the freight forwarder from the carrier's office at the POL and is sent over to the freight forwarder's office at the POD. It is then surrendered to the carrier at the POD.

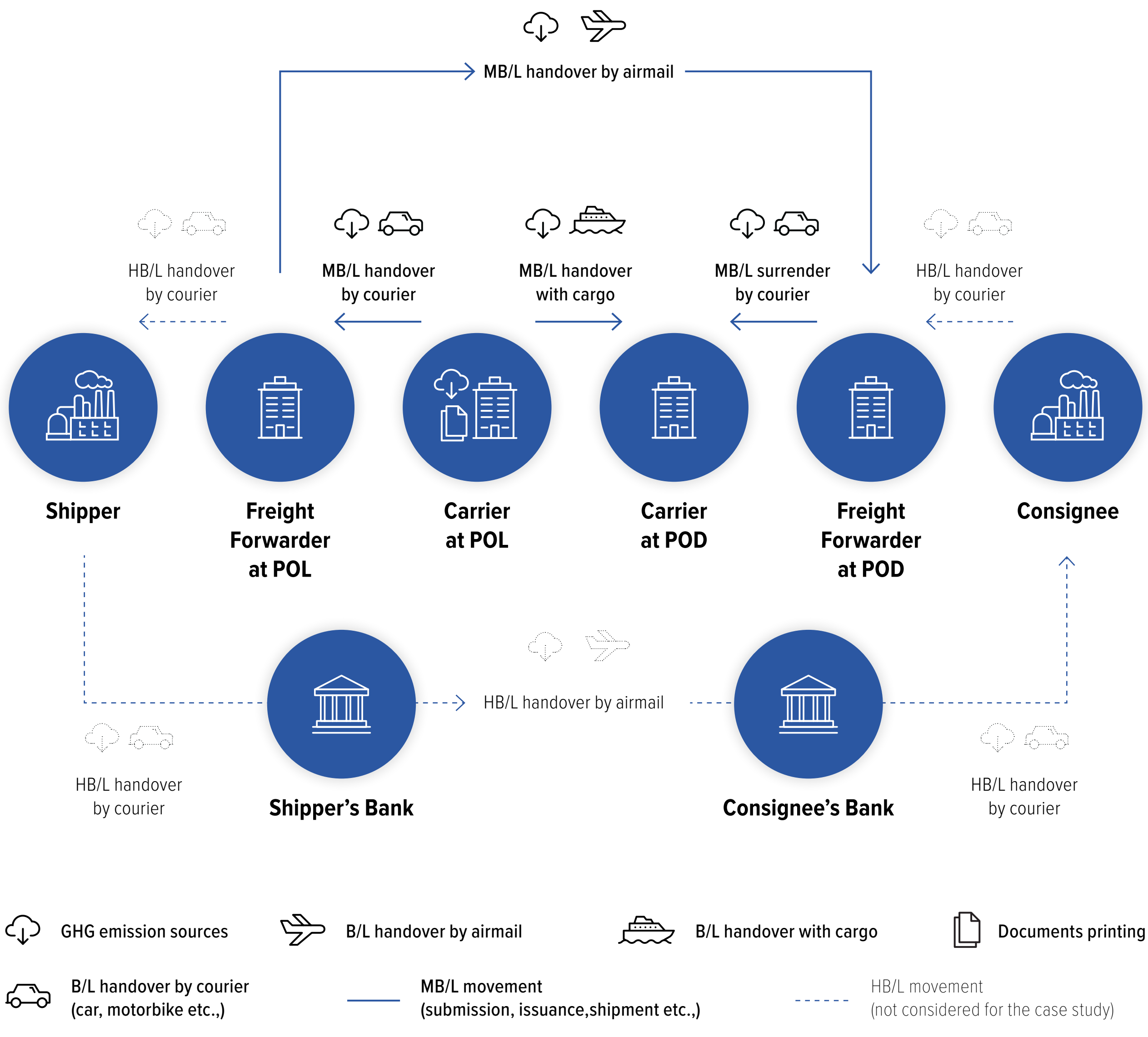
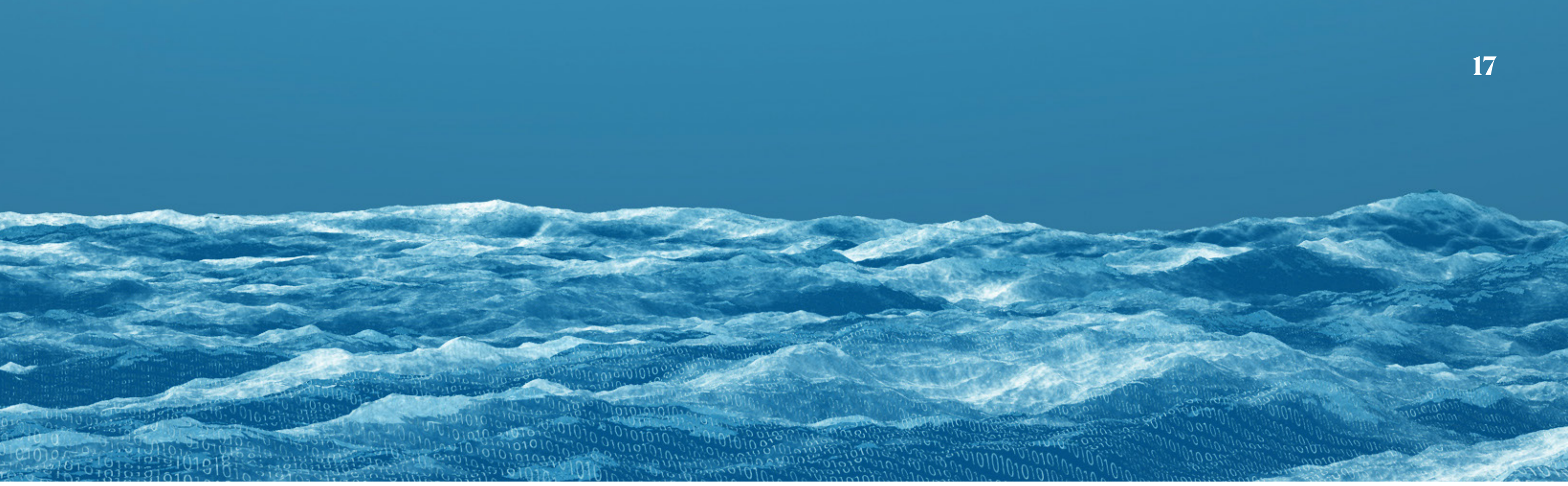


Figure 3: Map of paper-based B/L scenario #2: carrier with freight forwarder and banks



Paper-based B/L scenario #3: carrier without intermediaries

The scenario in Figure 4 below primarily consists of direct B/L transactions between the shipper, carrier, and consignee. The process involves the issuance and exchange of three original copies of the MB/L, each following a different path:

- One original copy stays with the carrier and follows the cargo from the POL to the carrier at the POD.
- One original copy is collected by the shipper from the carrier's office and is kept at the shipper's office at the POL.
- One original copy is collected by the shipper from the carrier's office at the POL and is handed over to the consignee's office at the POD by airmail. It is then surrendered to the carrier at the POD.

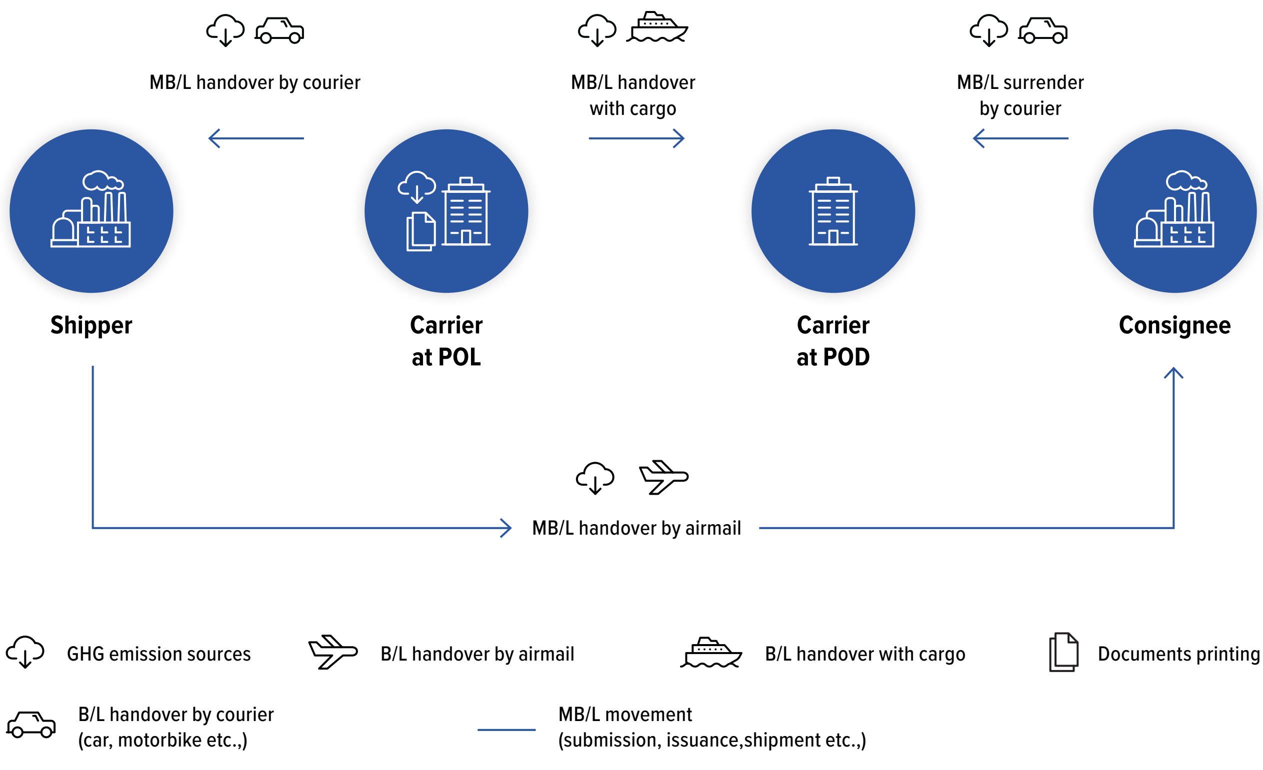


Figure 4: Map of paper-based B/L scenario #3: carrier without intermediaries

Paper-based B/L scenario #4: carrier with banks

The transactions illustrated in the below Figure 5 is the final type of scenario here, which includes the direct transactions of a MB/L between the shipper, the carrier, and the consignee, along with the involvement of the shipper and consignee's banks as additional elements. These inclusions introduce new exchanges and therefore additional sources of potential emissions. Different paths including:

- One original copy stays with the carrier and follows the cargo from the POL to the carrier at the POD.
- One original copy is collected by the shipper from the carrier's office and is kept at the shipper's office at the POL.
- One original copy is collected by the shipper from the carrier's office at the POL and is handed over to the shipper's bank, and then to the consignee's bank at POD by airmail. The consignee's bank then hands it over to the consignee's office at the POD. It is then surrendered to the carrier at the POD.

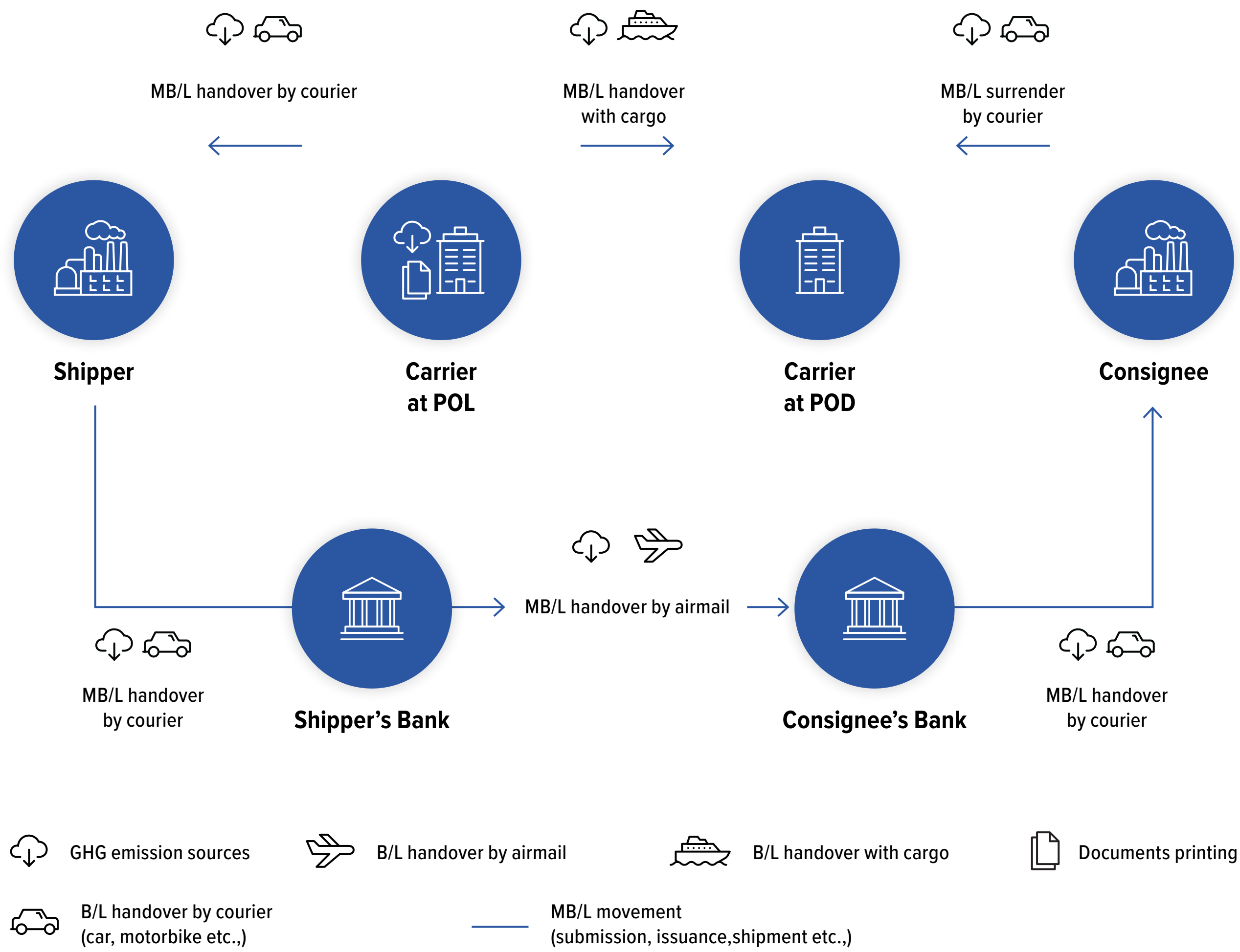


Figure 5: Map of paper-based B/L scenario #4: carrier with banks

Overview of the practical use of a paperbased D/O

In a similar way to the mapping done for the traditional paper-based B/L scenarios, the following three main scenarios of the paper-based D/O process have been identified during the study. These three scenarios are described hereafter (in no particular order as the number of D/O handovers is the same):

1. **Paper-based D/O**
   scenario #5: carrier with freight forwarder

2. **Paper-based D/O**
   scenario #6: carrier with agents (ship & cargo)

3. **Paper-based D/O**
   scenario #7: carrier without intermediaries

Paper-based D/O scenario #5: carrier with freight forwarder

Figure 6 illustrates the first scenario of the D/O process, which involves the participation of a freight forwarder. The carrier first issues an Arrival Notice and hands it over to the freight forwarder via road courier, signaling the arrival of the cargo. The freight forwarder then prepares to physically surrender the B/L to the carrier to verify shipment details. Upon successful verification, the carrier issues and hands over the D/O to the freight forwarder, by road courier. Then freight forwarder hands over the document to the trucker, who is responsible for collecting the shipment. The final step of the D/O process concludes at the POD, where the trucker presents the D/O to secure the release and collection of the cargo for its final delivery. In this scenario, because the freight forwarder is involved, the consignee will not be part of the D/O transactions.

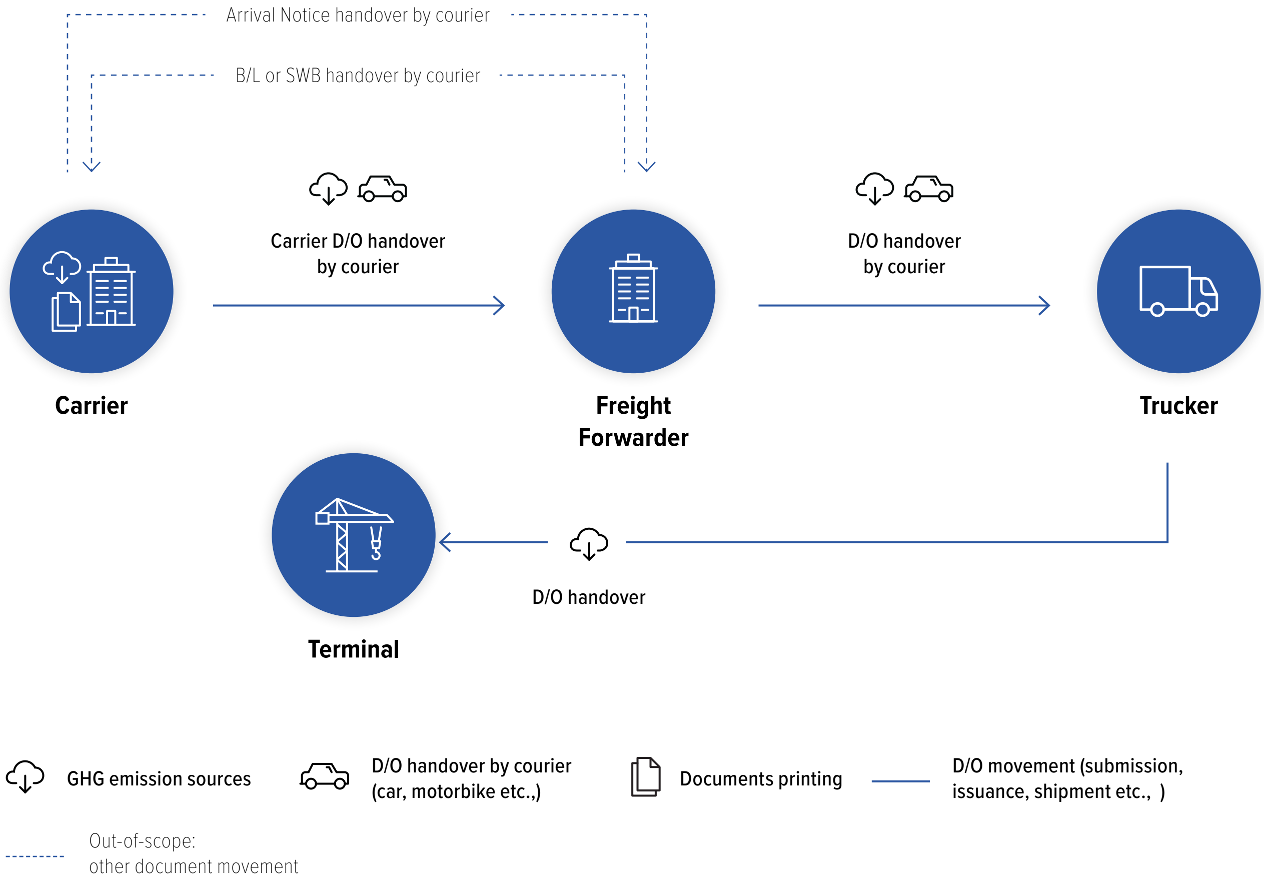


Figure 6: Map of paper-based D/O scenario #5: carrier with freight forwarder

Paper-based D/O scenario #6: carrier with agents (ship & cargo)

This scenario shown in Figure 7 begins when the carrier or ship agent first issues an Arrival Notice and hands it over to the cargo agent via road transport, signaling the arrival of the cargo. The cargo agent then prepares to physically surrender the B/L to the ship agent to verify shipment details. After receiving the necessary information from the carrier and upon successful verification, the ship agent issues and hands over the D/O to the cargo agent, by road courier. The cargo agent then transfers the document to the trucker, who is responsible for collecting the shipment. The final step of the D/O process concludes at the POD, where the trucker presents the DO to secure the release and collection of the cargo for its final delivery. In this scenario, because the cargo agent is involved, the consignee will not be part of the D/O transactions. As the ship agent is acting on behalf of several carriers and is aggregating a great number of documents, GHG emissions related to documents handover between the agent and carriers here are considered negligible and hence has been set as out of scope for the study.

Figure 7: Map of paper-based D/O scenario #6: carrier with agents

Paper-based D/O scenario #7: carrier without intermediaries

The last D/O scenario shown in Figure 8, depicts the scenario with the fewest stakeholders. In this scenario, the carrier first issues an Arrival Notice and hands it over to the consignee via road courier, signaling the arrival of the cargo. The consignee then prepares to physically surrender the B/L to the carrier to verify shipment details. Upon successful verification, the carrier issues and hands over the D/O to the consignee, by road courier. The consignee then transfers the document to the trucker, who is responsible for collecting the shipment. The final step of the D/O process concludes at the POD, where the trucker presents the D/O to secure the release and collection of the cargo for its final delivery.

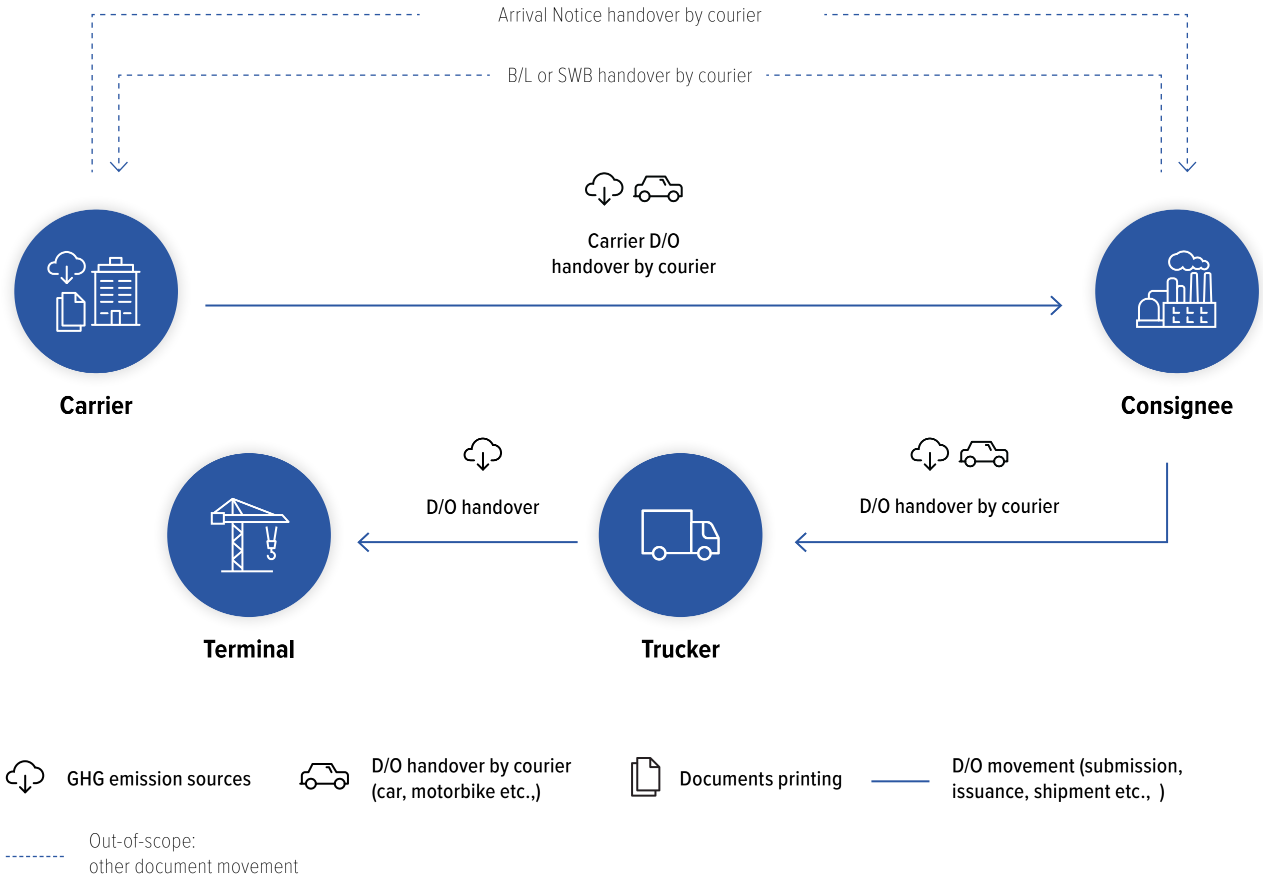


Figure 8: Map of paper-based D/O scenario #7: carrier without intermediaries

Mapping emissions sources in the digital processes

After outlining generic transfer processes for paper-based shipping documents (specifically B/L and D/O) from shipper to consignee and identifying potential sources of GHG emissions in these traditional processes, the focus shifts to exploring digital documentation scenarios. Specifically:

1. Digital B/L scenario using GSBN's enabled eB/L product.

2. Digital D/O scenario using GSBN's Cargo Release product.

Overview of the practical use of a digital B/L

Figure 9 below, depicts GSBN enabled solution, and the approach to digitalizing the traditional paper-based B/L. This solution harnesses blockchain technology to maintain the integrity and security of digital records.

In this scenario, the digital process starts with the carrier issuing the eB/L data, which includes the same information as a paper B/L and the clear delineation of each authorized party's role, to an eB/L App operating on GSBN's platform. This eB/L App subscribes and receives this data and establishes the foundation for all transactions. Initially, as specified by the carrier, the shipper holds both the title ownership and the eB/L. After endorsing the eB/L, the shipper escrows the document to its bank and transfers the title ownership to the consignee. Upon acquiring the status of eB/L Holder, the shipper's bank transfers this status to the consignee's bank. The bank, in turn, passes the status to the consignee, who then surrenders the eB/L to the carrier, allowing the carrier to proceed with the final delivery. Each transaction is done and logged on GSBN's blockchain, capturing a real-time reflection of the eB/L status. Every change in ownership and holder status is permanently recorded on the blockchain, offering crucial traceability for each stakeholder involved.

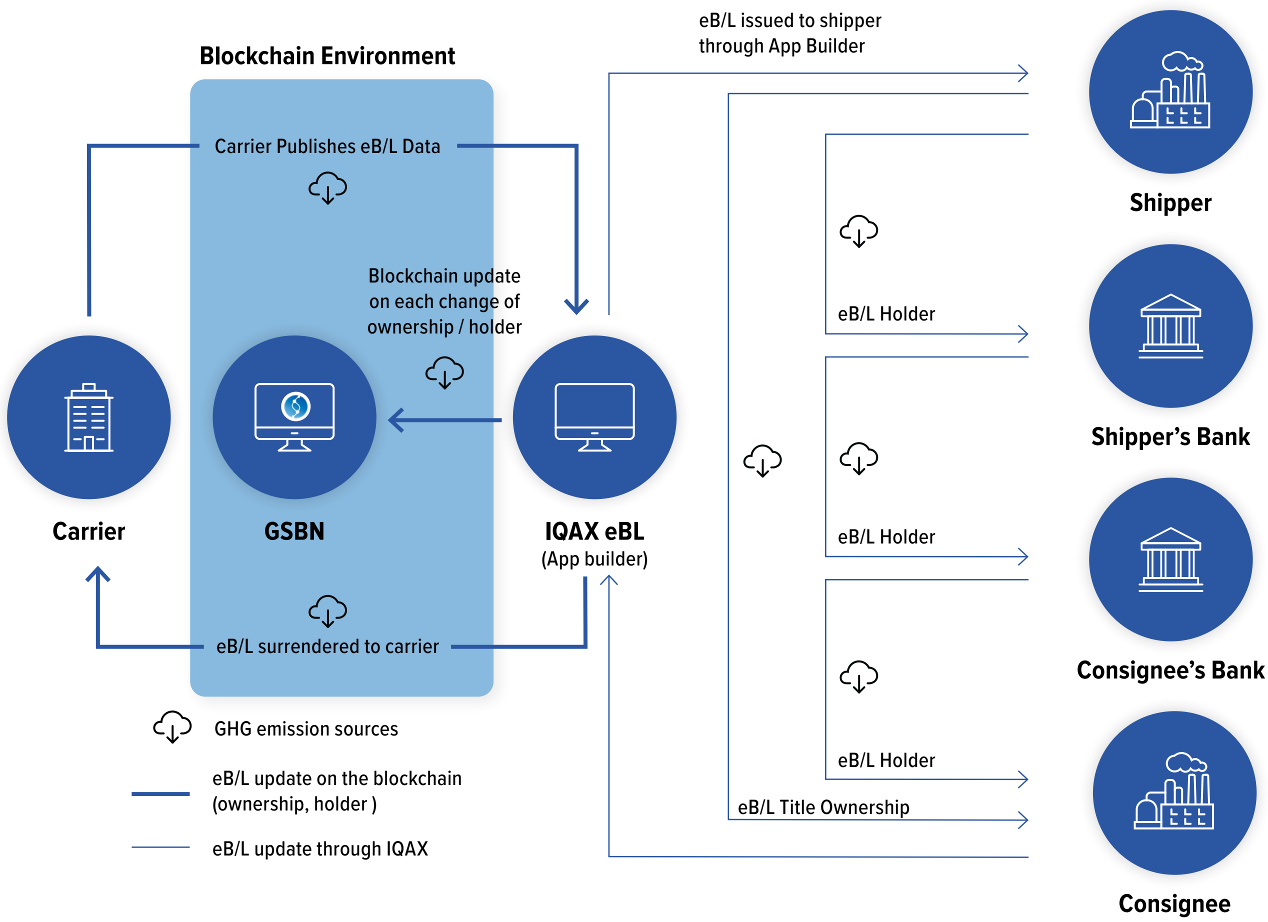


Figure 9: Map of Digital Bill of Lading Process

Overview of the practical use of a digital D/O

Figure 10 illustrates the eD/O scenario using GSBN's Cargo Release product, which aims to digitalize the document transfer and management during the delivery order process. In this scenario, the process begins with the carrier or ship agent issuing an eD/O to the consignee after the successful payment and verification of documents. The eD/O is then published to the terminal by the carrier through the GSBN's platform.

Once the eD/O becomes available on the GSBN's platform, the consignee or cargo agent is able to share it directly with the trucker, enabling a secure transfer. The carrier or terminal can further facilitate this transaction by sharing the eD/O to the consignee or cargo agent via their digital channels (e.g., email or portal platforms), ensuring all parties have access to the necessary documentation. The trucker, in possession of the e/DO, presents the digital document at the terminal to authorize the release of the cargo.

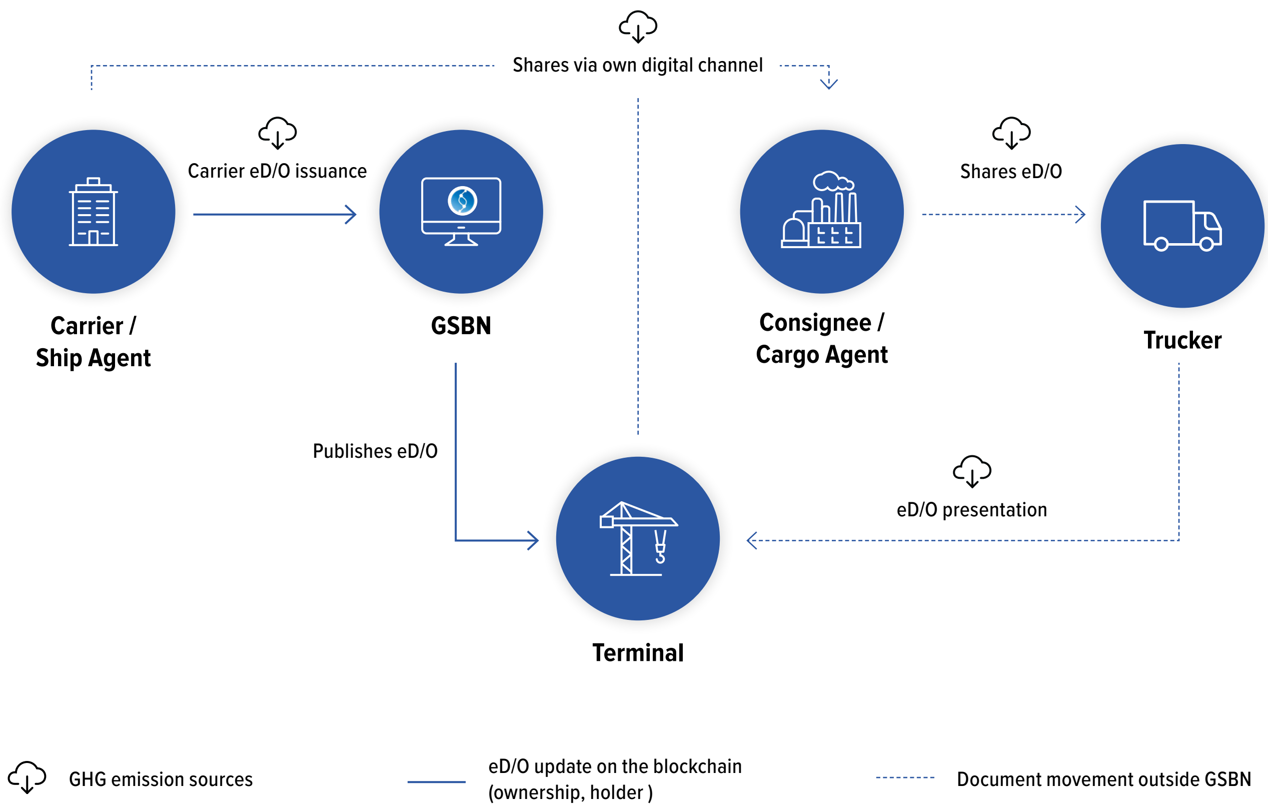


Figure 10: Map of Digital Delivery Order Process

Setting GHG measurement frameworks,calculation models, and methodologies

Parameters selection based on ISO and GHG protocol

Due to the absence of a defined framework for quantifying GHG emissions linked to shipping documents, the Paper aims to shape the initial stages of a framework and possible selection of parameters for B/Ls and D/Os particularly, taking guidance from the methodologies of prominent standard-setting entities from both the International Organization for Standardization (ISO), and the Greenhouse Gas Protocol (GHG Protocol). The reason to take reference from ISO and GHG Protocol is their worldwide recognition and the authoritative nature of their environmental standards. This ensures that the defined framework is reliable, can be applicable for different companies worldwide and help identifying the opportunities of digitalization associated with the shipping documents.

The framework developed in the Paper, takes root in the Life Cycle Assessment (hereinafter referred to as LCA) principles outlined by ISO 14040:2006 (Environmental management, Life cycle assessment, Principles and framework) and 14044:2006 (Environmental management, Life cycle assessment, Requirements and guidelines), as well as the Product Standard[6] of the GHG Protocol. This approach enables the consideration of both digital and traditional versions of B/Ls and D/Os as products with quantifiable environmental footprints. It involves conducting a comprehensive analysis that encompasses the entire lifecycle of these documents, including but not limited to the procurement of paper, their disposal or recycling at the end-of-life, and the energy consumption associated with digital document management. This ensures that the framework can effectively guide the measurement of the transition from paper-based to digital-based processes.

It is important to highlight that the environmental impact of each stage will be evaluated by utilizing various emission factors sourced from ADEME's Base Empreinte®. This database, provided by the French Environment and Energy Management Agency, is an officially recognized public resource containing emission factors and inventory datasets essential for conducting carbon accounting.

For a comprehensive approach, in line with the GHG Protocol's Product Standard, the framework encompasses the evaluation of product life cycle emissions across five distinct stages:

1. **Material acquisition and pre-processing**
2. **Production**
3. **Distribution and Storage**
4. **Use**
5. **End-of-life**

This categorization of GHG emission calculation parameters ensures a holistic assessment, capturing the environmental impact at each critical phase of a shipping document's life cycle.

[6] GHG Protocol. (Sep 2011). Product Life Cycle Accounting and Reporting Standard.

Parameters to consider for paper-based documents

The parameters for estimating the GHG emissions associated with paper-based shipping documents are systematically organized across the various stages of the shipping documents' lifecycle. Table 3 shows the detailed breakdown of the emission parameters for each stage. The Paper follows the GHG Protocol for the lifecycle assessment but simplifies some parameters. For example, the "Material Acquisition & Production" stages are combined because the available data may not distinguish them clearly.

The first stage, "Material Acquisition & Production", covers the emissions from both the creation of the documents using computers and their subsequent printing. One of the main GHG emitters in the paper-based document scenario is the "Distribution" stage, where printed documents are handed over to different stakeholders. This stage involves three key factors that affect the environmental impact: 1) the airmail from the origin to the destination airport, 2) the mode of road transport used, and 3) the distances between different parties involved. For instance, using a car, a truck, or a bicycle to deliver documents will have different emission outcomes. The number of documents transported for each road trip can also influence the emission outcomes. In the "Use" stage, the paper documents do not have much active "use" in theory, but the emissions from scanning and digital sharing of the paper documents within a single company are included. These emissions account for the internal sharing that may occur at each stakeholder involved in the document transactions (i.e., freight forwarder, carriers, banks etc.,).

For the "Storage" stage, both physical and cloud storage are evaluated based on information collected from expert interviews. Physical storage emissions are derived from the energy consumption in warehouses or office spaces, while cloud storage emissions are related to the digital archiving of previously scanned documents. Insights from industry experts suggest a common storage duration of approximately seven years for paper documents. The last stage of the lifecycle is the "End-of-life" stage, where the environmental impacts of recycling and incinerating paper documents, and deleting cloud data, are considered.

Product life cycle steps	Emission parameters accounted for
Material Acquisition & Production	**Creation** and **printing** of paper document · Emissions from the computer usage to create the documents · Emissions from paper printing (incl. paper, ink & printer emissions)
Distribution	Document **handovers** (with cargo, by air etc.,) · Emissions from transporting the printed documents to their point of use (with cargo by sea, by air and, by road)
Use	**Scanning** and **sharing** of received paper document · Emissions from scanning the printed document · Emissions from sharing by email the scanned document as an attachment
Storage	**Physical** and **Cloud** document **storage** · Emissions from the energy used to store the documents in a warehouse or in an office space (incl. lightning, heating, cooling...) · Emissions from storing scanned versions of the documents in the cloud
End-of-life	Document **recycling, incineration** and **EOL of hardware** · Emissions from recycling the paper documents · Emission from incineration (fully destroying) the paper documents · Emissions from deleting data stored in the cloud

Table 3: Selected parameters to be accounted for in calculating GHG emissions related to paper-based shipping documents

Parameters to consider for digital documents (with blockchain)

Digital documents also follow the five stages lifecycle; The first stage, “Material Acquisition & Production”, accounts for emissions from blockchain servers as well as the standard computing and platform server resources needed for document creation and access. In the “Distribution” stage, the document distribution happens on the blockchain platform, so the energy consumption and emissions of the blockchain platform and its protocol, along with the network usage needed for the system’s operation, are considered as key factors. The “Use” stage measures the emissions from energy consumed by devices when accessing or retrieving the documents. The “Storage” stage captures emissions related to the digital documents being archived and stored on the platform servers. Finally, the assumption made for the “End-of-life” phase is informed by the operational practices of GSBN, which indicate that data on their blockchain is not deleted. This practice eliminates the emissions associated with data deletion.

Product life cycle steps	Emission parameters accounted for
Material Acquisition & Production	**Hardware** (incl. PC, platform server) supply · Emissions from the computer usage to create and visualize the documents
Distribution	**Blockchain** · Emissions from platform & blockchain protocol power consumption · Emissions from network usage
Use	**Retrieval** of e-document · Emissions from the energy used by devices to access the documents
Storage	Structured data **storage** · Emissions from storing data on the blockchain & platform servers
End-of-life	Data **removal** · Emissions from deleting data from blockchain & platform servers · EOL of hardware

Table 4: Selected parameters to be accounted for in calculating GHG emissions related to digital shipping document

Challenges and considerations in measuring GHG reductions linked to digitalization of shipping documents

Estimating the potential GHG savings driven by the digitalization of shipping documents and their usage poses a significant challenge, primarily due to the time factor involved. The transition to digitalization is not an instantaneous switch, but rather a progressive process that requires a gradual shift from paper-based systems to digital ones over a specific period.

Besides the primary challenge of transition pace, an additional challenge is the absence of a standardized framework for measuring GHG emissions related to digitalized shipping documents. The lack of a clear and consistent baseline makes it challenging to accurately calculate the carbon footprint associated with digital documents and assess the potential reduction achieved by transitioning from paper-based systems. Another obstacle is data availability and quality. To accurately quantify the emissions of digital documents, reliable and complete data is needed from various sources, including device manufacturers, platform providers, network operators, and end users. However, data collection, sharing, and verification is often insufficient, posing a significant challenge for the analysis.

The Paper aims to establish a reference baseline for comparing two distinct scenarios: one that relies solely on paper-based shipping documents (specifically B/Ls and D/Os), and another that is fully digitized. This comparative analysis will serve as the basis for measuring and deriving the potential reductions in GHG emissions that could be achieved by switching to digital solutions. The following case studies will apply the methodologies to project and extrapolate these calculations, thus enabling informed observations on the possible progress and areas of opportunities.

Chapter IV - Case studies: GHG calculation model application

Turning to the practical implementation of the developed methodology, two case studies are examined: one focusing on the B/L and another on the D/O. Both cases aim to offer quantitative evidence that evaluates the benefits associated with transitioning from paper-based to digital documents.

This section presents the numerical application calculation of the methodology developed in the Paper for the two selected case studies. The more detailed calculation formulas, and the emission factors can be found in Appendix 1 and Appendix 2. Additionally, each of the distances between stakeholders used in the calculation formulas has been chosen by identifying stakeholder addresses in close proximity to relevant ports, to mirror, as much as possible, a real-life setting.

Case study #1: paper-based B/L vs digital B/L

The first case study applies the developed framework to compare the traditional paper-based B/L with its digital counterpart, in this case, GSBN's enabled eB/L product. There are a lot of variations based on the given parameters and calculation formulas. For this case study, the selected assumption involves transactions of only the MB/L among different stakeholders using the scenario #3 ("carrier without intermediaries") process from the previous chapter, and focusing on a cargo shipment from Shanghai, China to Rotterdam, The Netherlands as illustrated in the below Figure 11.

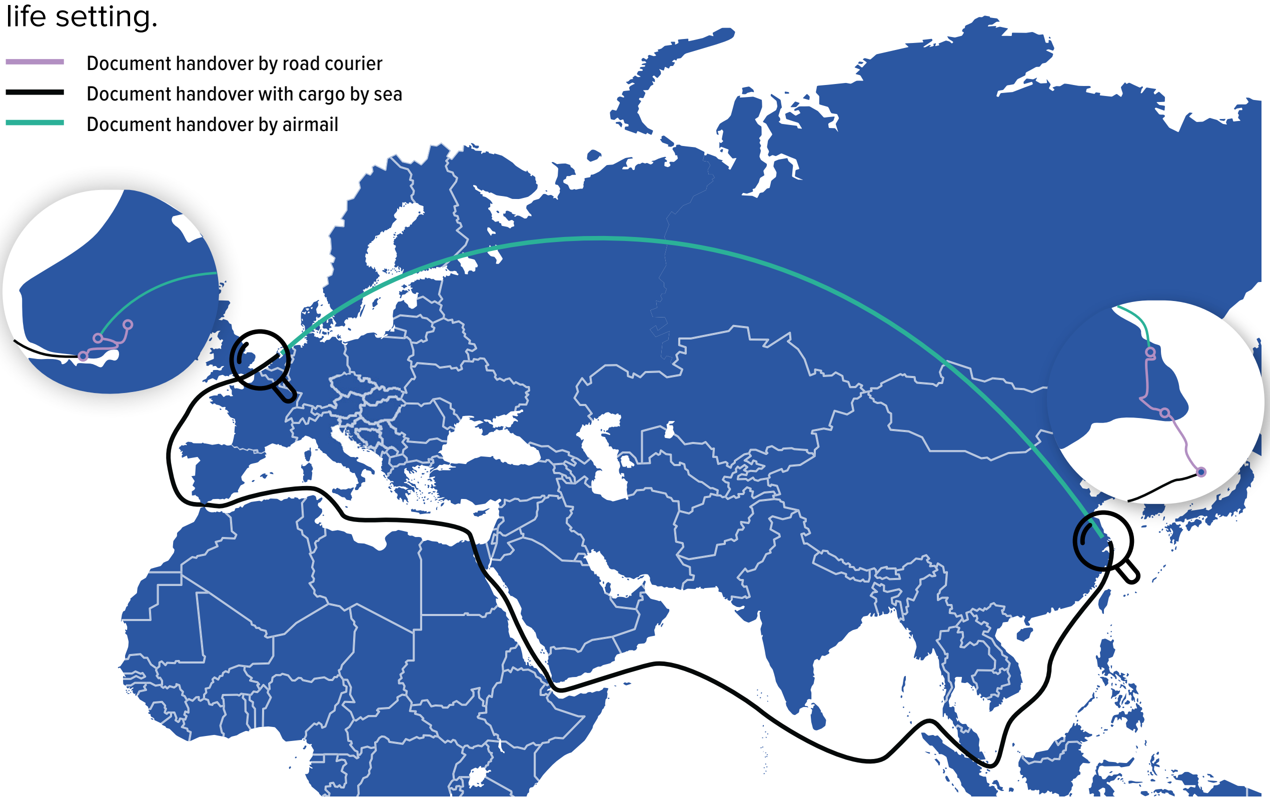


Figure 11: Document Handover Overview for the case study of the Bill of Lading

Case study #1: paper-based B/L (scenario #3 – carrier without intermediaries)

Further assumptions in this case study for a paper-based B/L are as follows:

- Carrier issues three original copies of MB/L, each comprising two pages.
- The mode of transportation, especially the type of vehicle used for courier handovers, may vary by country: scooters are often preferred in China, whereas passenger cars are more commonly used in European countries like The Netherlands.
- For the road courier transits, it is assumed that only one MB/L is transported per trip (it can be two of the original copies simultaneously).
- The total weight of one original copy of the MB/L, including the packaging, is around 25g (with the packaging alone accounting for 15g) and 25g is the number used for calculation.

The figure below shows the quantitative application of data following the LCA steps previously outlined for the paper-based B/L for scenario #3. The results of this case study calculation show GHG emissions of 27,911 gCO2e/BL.

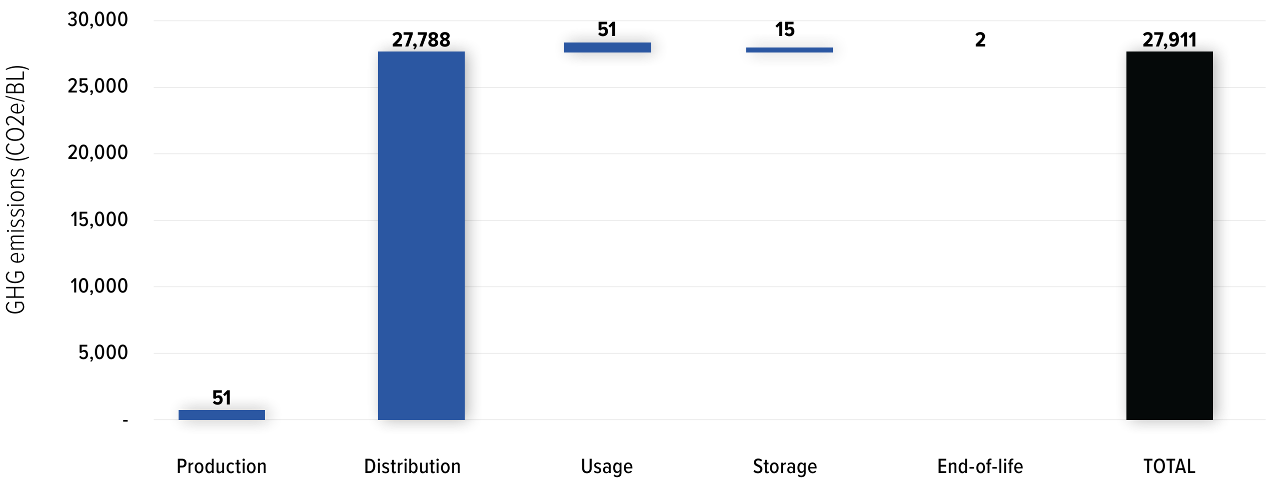


Figure 12: Quantitative Application for Scenario #3 of a Paper-Based B/L Transaction

Case study #1: blockchain-based eB/L

Continuing in the same line as the paper-based analysis, calculations on using blockchain based eB/Ls have been adapted. It encompasses the production of the original eB/L by the carrier, followed by an initial transaction that transfers title ownership and possession to the shipper. After endorsing it, another blockchain transaction assigns the title ownership and holding to the consignee entity. The process is finalized when the consignee validates the eB/L. The process used here does not involve banks unlike the scenario outlined in the previous chapter for GSBN enabled solution, as the scenario #3 was chosen for paper-based B/L GHG calculations, which doesn't include banks, this allows for a fair comparison.

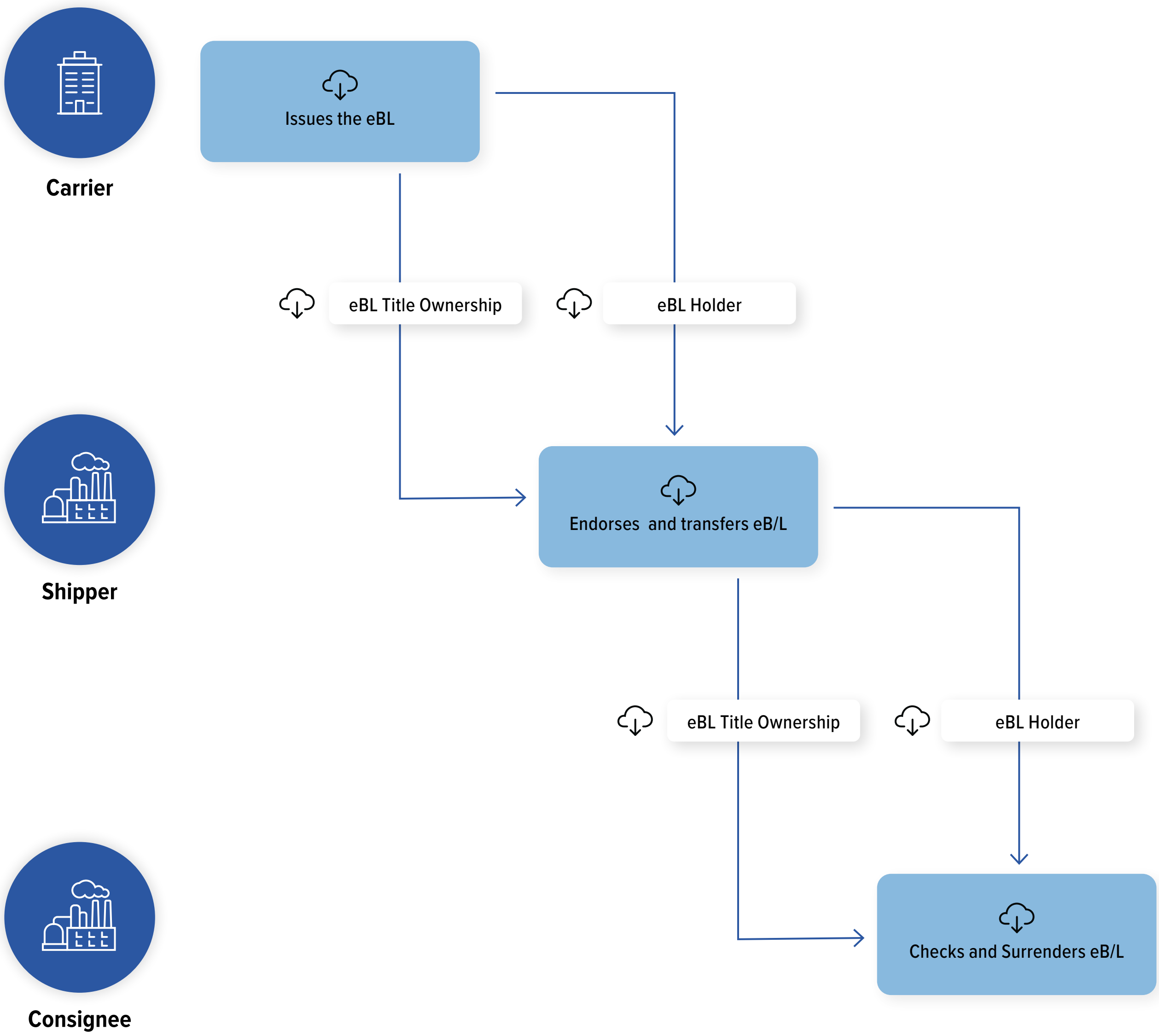


Figure 13: Document transfer and endorsement overview for the case study of the eB/L

The eCONBiL project, led by Bremerhaven University of Applied Sciences[7] , provides the basis for assumptions for Hyper Ledger Fabric blockchain performance, focusing on a use case that considers three transactions per B/L (as in the current case study). The below figure shows the quantitative application of data for the blockchain based eB/L.

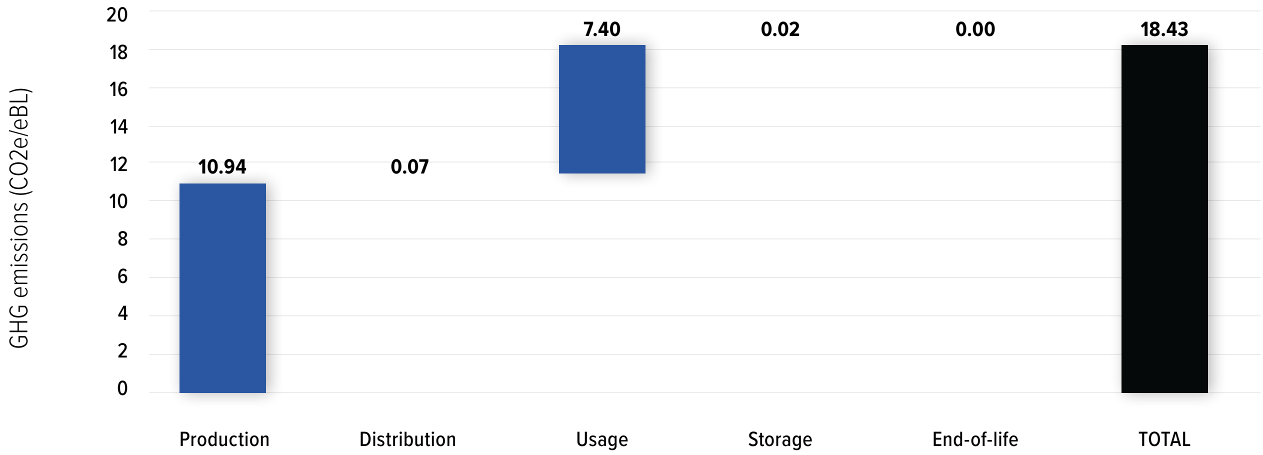


Figure 14: Quantitative Application for eBL Transaction

The calculation results show GHG emissions of 18.43 gCO2e per eB/L, in comparison to 27,911 gCO2e per B/L concluded from the paper-based B/L earlier, the difference is 27,892.57 gCO2e.

[7] Bremerhaven University of Applied Sciences. (2021). eCONBiL project

Summary of case study #1

After evaluating both paper-based (scenario #3) and digital versions of the B/L, the reduction of emissions that the digital transition could realize has been determined.

	Paper-based	Digital-based (with blockchain)
Master Bill of Lading		
Case study #1 carrier without intermediaries	27,911 gCO2e/BL	18.4 gCO2e/BL
Difference with the paper-based solution		- 99.9%

Table 5: Comparative Emissions for Master Bill of Lading Transactions

The analysis reveals that transitioning the B/L process to a digital format reduces emission levels by 99.9%. The bulk of emissions in the traditional paper-based process, accounting for 99.6% of the emissions, comes from the physical handovers necessitated by road, air, or sea. The shift to a digital format eliminates the need for these physical document exchanges, drastically reducing the environmental footprint of document handling within the shipping industry.

Case study #2: paper-based D/O vs digital D/O

The second case study focuses on the application of quantitative data to compare the paper-based D/O with its digital counterpart, in this case, GSBN's Cargo Release product. The selected assumption involves transactions of the D/O document between carrier, trucker, and terminal, for the release of a cargo shipment in Rotterdam, The Netherlands, to provide quantitative insights.

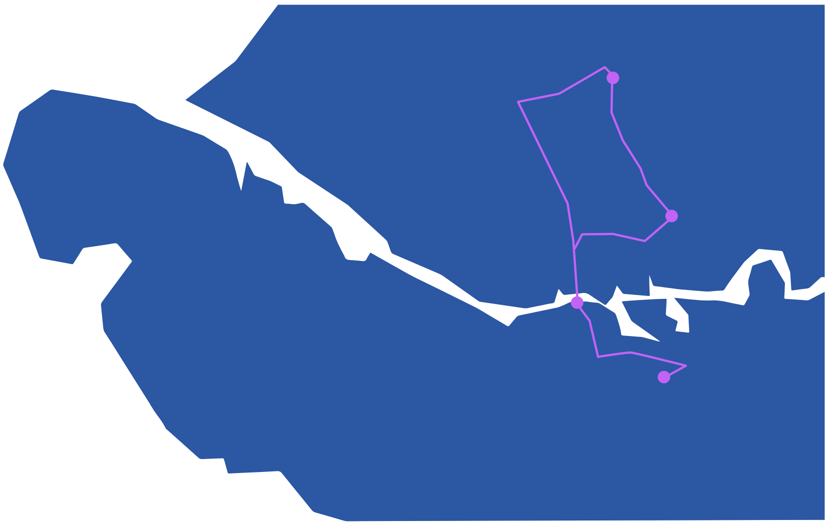


Figure 15: Document Handover Overview for the case study of the Delivery Order

Case study #2: paper-based D/O (scenario #7 – carrier without intermediaries)

Similar to the case for the B/L, further assumptions have been incorporated into the quantitative analysis for the D/O case study. These assumptions are as follows:

- Carrier issues one D/O, comprising two pages.
- For the mode of transportation, passenger cars are more commonly used in European countries like The Netherlands.
- Independent of the transportation mode, only one document is assumed to be transported at a time.

The below figure shows the quantitative application of data following the LCA steps previously outlined for the paper-based D/O scenario #7. The results of this case study calculation show GHG emissions of 16,985 gCO2e per D/O.

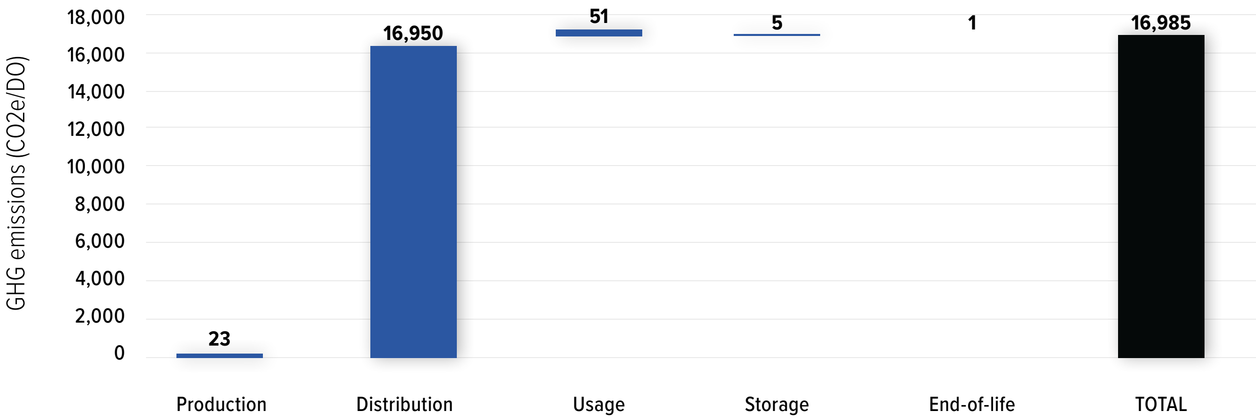


Figure 16: Quantitative Application for Scenario #7 of a Paper-Based D/O Transaction

Case study #2: blockchain-based eD/O

This case study is based on the GSBN's solution for the D/O process, Cargo Release. In this solution, GSBN's blockchain platform is used by the carrier to publish the eD/O to the terminal. Outside the GSBN scope, the carrier also sends the eD/O to the consignee by their own digital channel (such as a web portal), who then forwards it to the selected trucker. The structured data of an eD/O hosted on a blockchain is assumed to be the same size as the eB/L as information is fairly similar. By applying the framework, 66.0 gCO2e per eD/O has been calculated as a result, which is shown in the figure below.

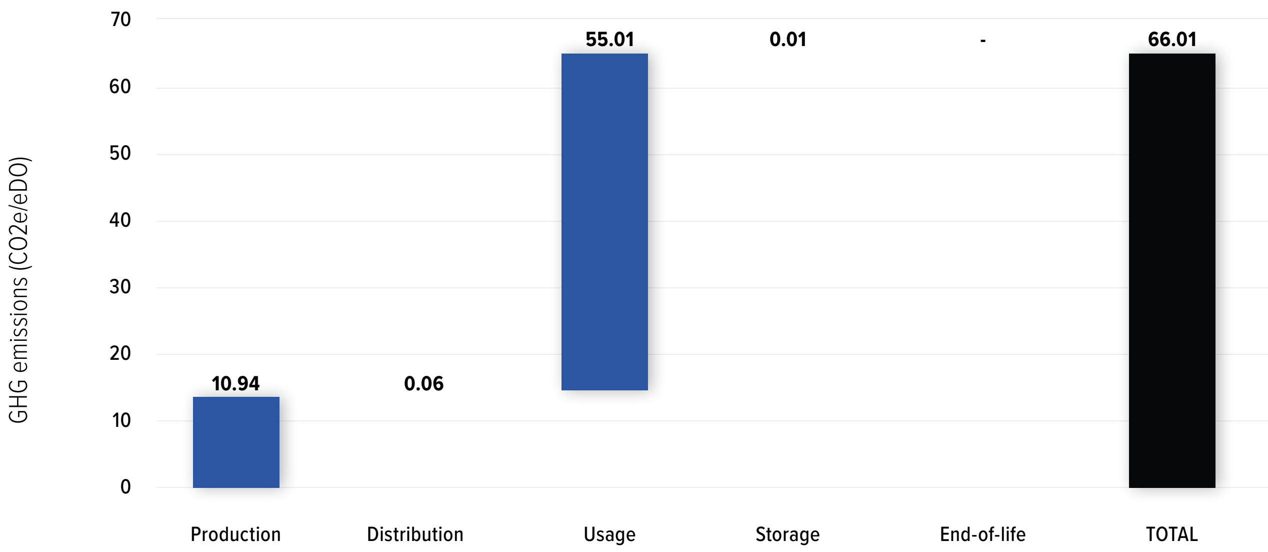


Figure 17: Quantitative Application for eD/O Transaction

Summary of case study #2

After evaluating both the paper-based and digital versions of the D/O, the emissions savings that the digital transition could realize have been determined.

	Paper-based	Digital-based (with blockchain)
Delivery Order		
Case study #2 carrier without intermediaries	16,985 gCO2e/DO	66.0 gCO2e/DO
Difference with the paper-based solution		- 99.6%

Table 6: Comparative Emissions for Delivery Order Transactions

The transition to a digital format for the D/O process is estimated to reduce emissions by 99.6%. In the traditional paper-based process, the major source of emissions comes from the physical handovers by road transport, coupled with the limitation in the number of documents transported per vehicle, affecting the efficiency of emission distribution.

Overview of results: emissions impact of transitioning to digital documentation processes

This chapter has shown using real-life case studies, how the use of digital solutions for shipping documents transactions can significantly reduce the GHG emissions compared to the traditional paper-based processes. The table below summarizes the results for all the seven scenarios mapped out in Chapter III:

	Paper-based	Digital-based (with blockchain)	Relative difference
Master Bill of Lading			
B/L scenario #1: carrier with freight forwarder	13,123 gCO_2e/BL	18.4 gCO_2e/BL	- 99.9%
B/L scenario #2: carrier with freight forwarder and banks	13,123 gCO_2e/BL	18.4 gCO_2e/BL	- 99.9%
B/L scenario #3: carrier without intermediaries	27,911 gCO_2e/BL	18.4 gCO_2e/BL	- 99.9%
B/L scenario #4: carrier with banks	36,295 gCO_2e/BL	25.9 gCO_2e/BL	- 99.9%
Delivery Order			
D/O scenario #5: carrier with freight forwarder	8,900 gCO_2e/DO	66.0 gCO_2e/DO	- 99.3%
D/O scenario #6: carrier with agents (ship & cargo)	9,929 gCO_2e/DO	66.0 gCO_2e/DO	- 99.3%
D/O scenario #7: carrier without intermediaries	16,985gCO_2e/DO	66.0 gCO_2e/DO	- 99.6%

Table 7: Comparative emissions for all scenarios of Master Bill of Lading and Delivery Order Transactions

The digital solution reduces GHG emissions by over 99% in every scenario by using the assumptions chosen in the case studies. This is primarily driven by the digital solution eliminating the need for the physical handover of paper documents, which is the main source of emissions in the paper-based process. These emissions are variable, depending on the type of vehicle used (car, scooter, e-bike, plane, etc.), the distance between the stakeholders, and the number of shipping documents carried per road courier trip. In B/L scenario #1 and #2, although more stakeholders are involved, the emissions calculated are lower than in B/L scenario #3, this is due to the proximity in terms of distance from the freight forwarder to the port. The same reason applies to D/O scenario #5 and #6 when freight forwarder or agents are involved. So both D/O scenario #5 and #6 have lower emissions than scenario #7.

Different digital scenarios can yield similar emissions numbers as they involve an equal number of participants. The eD/O scenarios, for instance, involve four stakeholders. The carrier and the consignee may have their respective agents, such as a ship agent or a freight forwarder/cargo agent, but the number of necessary document exchanges remains the same. In this process, the assumption is that stakeholders send emails to each other to transfer the document when operating outside GSBN Cargo Release scope. These emails are directly related to the D/O process, but some agents may want to keep their clients notified (even if they are not directly handling cargo) and this is not considered in the scope of this analysis.

Chapter V - Potential emissions savings derived from case studies

Potential emissions savings with eB/L

The global figure for B/Ls issued annually can fluctuate materially based on economic conditions, trade agreements, and other factors influencing international trade. However, in 2021, DCSA estimated that 16 million original B/Ls were issued by ocean carriers[8], with only about 1.2% digitalized. The previously established hypotheses assuming three original copies of B/L and two pages per copy, indicates that just under 100 million sheets of paper are required annually.

East Asia - Europe route savings

One example of this framework's application is the East Asia – Europe route, which includes the Shanghai – Rotterdam line as a case study. According to the data, eastbound and westbound containerized trade between East Asia and Northern Europe – Mediterranean region accounted for 24.2 million TEU in 2020, or about 15.6% of the global containerized trade[9]. Assuming this market share, out of the 15.8 million B/Ls, the estimated number of B/Ls for this route is around 2.46 million.

Carrier	Market share[10]	Estimated number of B/Ls per year	Estimated number of B/Ls per year for Asia-Europe route
MSC	20%	3.2 million	490,000
Maersk	15%	2.4 million	370,000
CMA CGM	13%	2 million[11]	320,000
COSCO	11%	1.7 million	270,000
Hapag	7%	1.1 million	172,000
ONE	6%	0.95 million	148,000
Evergreen	5.5%	0.87 million	135,000
HMM	3%	0.47 million	74,000
Others	19.5%	3.1 million	481,000
Total	**100%**	**15.8 million**	**2.46 million**

Table 8: Estimated number of B/L per year on the Asia-Europe route

[8] DCSA. (2022). Streamlining international trade by digitalising end-to-end documentation.
[9] UNCTAS secretariat. (2023). International Maritime Trade, based on MDS Transmodal (MDST), World Cargo Database.
[10] Based on 2024 Alphaliner data, Top 100 carriers
[11] This estimation calculated got confirmed during interviews

As a reminder, based on the scenario of the calculated case study, using a blockchain-based eB/L rather than a paper-based B/L can save 27.9 kgCO2e per B/L. With this estimated number of B/Ls from the above table, the emissions that can be saved with a switch to eB/Ls on the East Asia – Europe route can be calculated. The total CO2e emissions reduction, based on this extrapolation, is estimated at 68,634 metric tons per year.

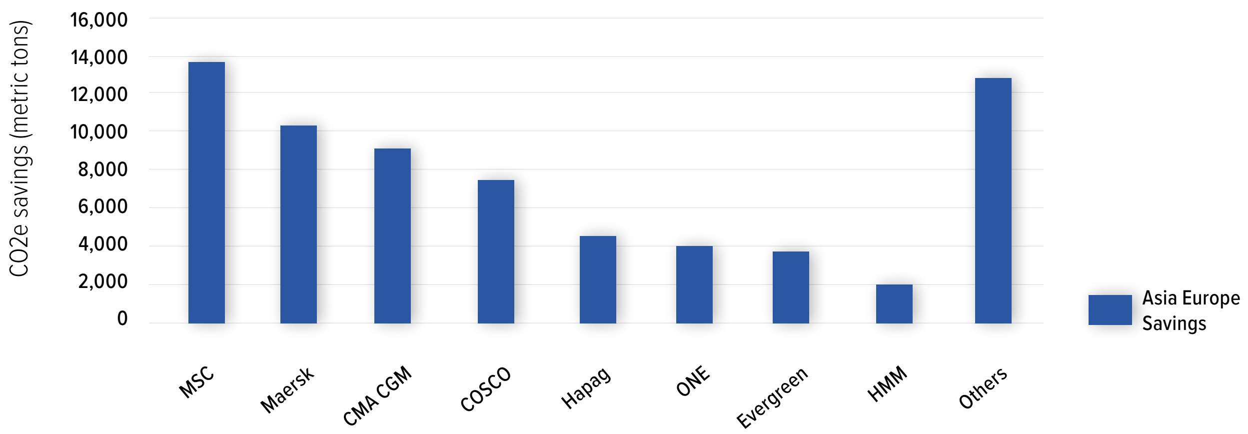


Figure 18: Estimated CO2e savings per carrier per year on East Asia – Europe route based on the case study results

Total savings

As demonstrated through the case study calculations, the emissions per B/L vary immaterially with the distances between POL, POD, and airports. Indeed, the primary emitter is linked to the distances traveled by road courier, depending on the stakeholders' locations. As these variables cannot be adjusted case by case for the Paper, the hypotheses related to the road courier distances remain the same for all the shipping routes (Transatlantic, Intraregional, South-South, North-South, and non-main East West) and enable an estimation of the potential emissions reduction linked to the digitalization of the worldwide, which is 15.8 million B/Ls. Multiplying CO2e emissions savings per B/L calculated in the case studies by the 15.8 million B/Ls, the total estimated CO2e emissions savings are 440,820 metric tons per year.

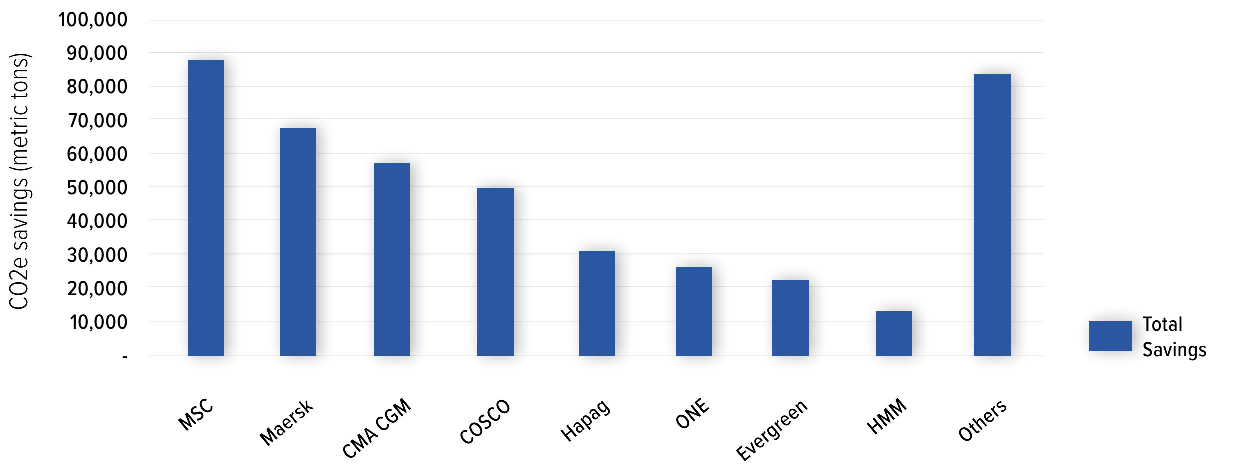


Figure 19: Estimated CO2e savings per carrier per year worldwide based on the case study results

Estimated 2023 savings with GSBN's solutions

In 2023, over 120,000 eB/Ls were issued on GSBN's platform and over one million shipments were released with GSBN's Cargo Release solution[12]. Therefore, based on the calculations from the case studies, GSBN's solutions contributed to estimated savings of 3,348 metric tons CO2e with eB/L, and 16,900 metric tons CO2e with Cargo Release.

Solution	CO2e savings in 2023 (metric tons)
eB/L	3,348
Cargo Release	16,900

Table 9: Estimated CO2e savings from GSBN's solutions based on the case study results

For the B/L and eB/L comparison, only MB/Ls have been taken into the consideration for the case studies, if paper-based HB/Ls also were replaced by GSBN's solution, the impact would be even bigger.

[12] GSBN. (2023). 2023 in numbers: Paving the way for the future

Chapter VI - How can GHG metrics be leveraged for transparency and reporting

GHG emissions reporting

Quantifying GHG emissions through a rigorous assessment is essential to develop effective climate strategies. It enables organizations to understand their environmental impact, identify emission sources, set reduction targets, and pave the way for sustainable decision-making. Having established the frameworks to quantify GHG reductions driven by the transition to digital documents along with the related case studies, the next step is disclosure and reporting.

There are five principles for reporting GHG emissions according to GHG Protocol: relevance, completeness, consistency, transparency, and accuracy. The transparency principle emphasizes the importance of openly disclosing the methods, data sources, and calculation procedures used in measuring GHG emissions. It is important to provide references to the methodologies and data sources when talking about transparency, which is also one of the Paper's targets. By leveraging the metrics and parameters provided in the Paper, companies can meet the transparency principle when reporting the GHG emissions before and after the digital implementation.

Another controversial point that can be addressed is whether the difference in GHG emissions following the implementation of digital solutions constitutes "avoided" or "reduced" emissions. Avoided emissions are defined by some international standards such as GHG Protocol, ADEME or ISO as: when a product is used as a substitute for other goods or services, fulfilling the same functions but with a lower carbon intensity. For example, an organization like GSBN, which does not initially provide the traditional paper service, offers a new blockchain based solution that replaces paper shipping documents with fully digital documents, thereby avoiding the emissions associated with printing or physical handovers using couriers and airmails. However, it has not yet been incorporated into any regulatory obligations, and there are no clear international standards on the subject. Therefore, it suggests that both terms can be used during reporting when using GSBN's solution.

The importance of independent verification: ensuring accuracy and credibility of GHG reduction claims

ESG or sustainability related information intended for investors and stakeholders requires a high level of confidence given its inherent importance. To ensure confidence in the disclosed information, it is imperative that sustainability reports should be verified by an independent third party.

In the context of the EU Corporate Sustainability Reporting Directive (CSRD), it's compulsory for sustainability reports to be verified by an independent assurance service provider. This obligatory third-party verification enhances the trustworthiness of the information reported. Sustainability information is at first subject to limited assurance, transitioning to reasonable assurance (a stronger and more demanding level including examination of a company's sustainability records and the verification of the accuracy of GHG data, etc.) from 2028. The Global Reporting Initiative (GRI) Standards also suggest obtaining external assurance. If a company does opt for assurance, the GRI Standards offer guidance on how to disclose it.

The International Federation of Accountants (IFAC) released a survey in 2023: The State of Play: Sustainability Disclosure & Assurance. As of 2021, 95% of surveyed companies reported some ESG information. Of these companies, 64% obtained some level of assurance on their report, a significant jump from 51% in 2019[13]. This rising trend reflects international reporting standards that increasingly make external assurance on ESG reporting mandatory.

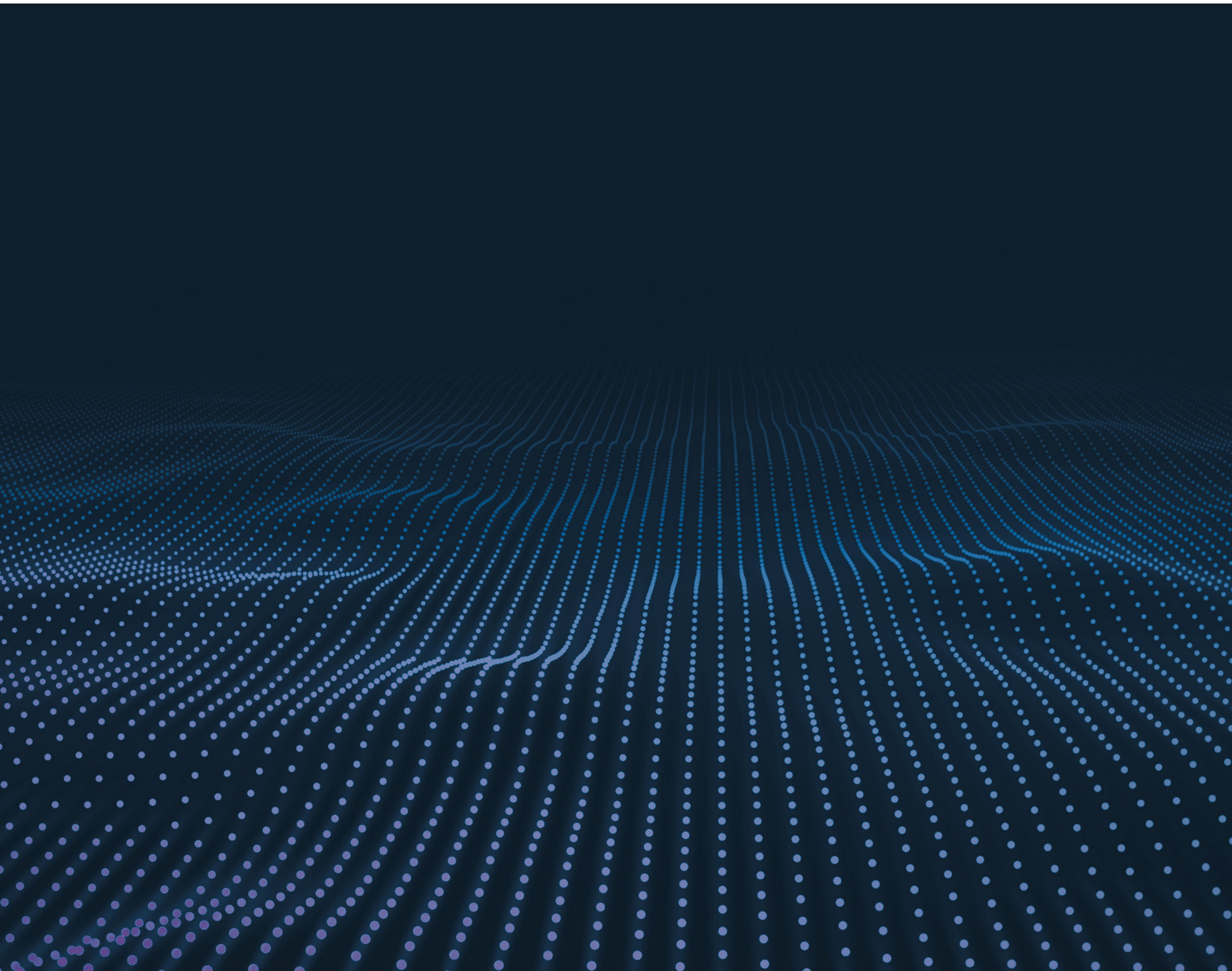
Although it is still lacking mandatory requirements on third-party assurance for sustainability reporting, a sustainability report verified by an independent recognized third party may be a requirement of potential investors or other stakeholders in the supply chain. Given that reporting effectiveness is dependent on its relevance and reliability, it is critical that the current level of reporting quality needs to be improved. Companies should monitor and communicate their sustainability performance with the same care and data quality as their financial performance. External assurance can play an essential role in building confidence for sustainability reporting, especially if it includes verification of sustainability data and conformance with the certain standards. The Paper wishes to provide a standardization framework for calculating GHG emissions associated with shipping documents, which external assurance service providers can eventually take reference from as well.

[13] PwC. (2023). Sustainability Counts II

Chapter VII - Conclusion and next steps

Overall, digital shipping documents represent a significant advancement in the shipping industry, promising a lower carbon footprint, enhancements in efficiency, security when involving blockchain, and lower costs. Switching from paper to digital shipping documents, such as eB/Ls and eD/Os, can drive more than 99% reductions per document in GHG emissions throughout the value chain.

In the near future, carriers are anticipating a significant transition from traditional paper-based shipping documents to digital solutions and are actively encouraging the growth of digital documents through partnerships with dozens of solution providers. However, there are still barriers to overcome to achieve global acceptance. Shippers, consignees, and banks often present challenges to adopting eB/Ls, each with specific requirements and concerns. Suggestions on how to overcome these challenges to reach a globally adopted solution are provided in the following section.



Remaining challenges to overcome for a global adoption

Although digital solutions, like eB/Ls, allow stakeholders to carry out their transactions more securely and efficiently, the current adoption rate among industry players is strikingly low due to persistent barriers. The following recommendations aim to overcome the remaining barriers holding back the adoption of digital documents.

- **Encourage and accelerate adoption by all stakeholders** across the shipping value chain by promoting the benefits and facilitating collaboration. The B/L process as an example involves numerous stakeholders (e.g., carriers, freight forwarders, shippers, consignees, banks), each of them must accept the eB/L to ensure that the solution is valid throughout the whole value chain. Promoting the benefits of digital documents, on environmental and organizational aspects, to the various stakeholders is expected to help accelerate adoption.
- **Improve interoperability among different platforms** to support the transition to a digital ecosystem. Collaboration among digital solution providers needs to be improved. It is also important to reach common frameworks and data standards for breaking down data silos, as well as making improvements on data quality and data governance.
- **Continue the efforts to digitalize the remaining paper documents,** as stakeholders will be less inclined to use one digital document if there are several paper documents remaining in the end-to-end process. Just as there are numerous stakeholders involved in the shipping value chain, several documents, other than B/Ls or D/Os, can still be paper based, such as certificates of origin, import licenses, customs declarations, or letters of credit. Digitalization efforts should not focus on just one document type, but on all of those required throughout the shipping process.
- **Push for the recognition and acceptance of digital shipping documents** among different legal authorities globally. Some stakeholders, such as banks, may have compliance constraints, particularly from a security and legal point of view, making it difficult to adopt digital documents. These constraints often vary from one regional legal framework to another, further slowing worldwide acceptance. For example, a bank may recognize an eB/L in Germany, yet, for regulatory reasons, a bank could reject it in Bangladesh.

Recommendations on data collection for implementing carbon accounting of the shipping documents

Effective GHG emissions measurement and analysis relies on the adoption of robust and precise data gathering methodologies. As shown in the previous calculations, most of the GHG emissions linked to paper-based B/L and D/O are emitted during the physical handovers of the documents from road couriers between the stakeholders. Therefore, to further adapt this model, it is essential to gather accurate data and information such as:

- The different distances between stakeholders along the end-to-end processes,
- The means of transportation for these documents,
- The number of documents carried per trip,
- Total number of documents issued/retrieved per shipping line per year.

Data collection will rely on individual departments within each company, emphasizing the need for effective coordination among all parties to ensure that the necessary information is compiled. In the context of this research, and based on the parameters selected in line with the GHG Protocol's Product Standard, three key departments are specifically identified as central to this significant data collection:

- The Sustainability (ESG) / CSR department is anticipated to lead in gathering the necessary data to evaluate and measure the company's impact.
- The IT / Data department is expected to handle the acquisition of more technical and advanced data, including emissions stemming from the power consumption of platforms and blockchain protocols, network usage, and the energy used for data storage on the blockchain and platform servers.
- The Operations department: is expected to possess an overview of the transportation used during the transactions of these shipping documents the other companies they interact with, and how digital documentation is, or has already been integrated. This should allow such departments to gain deeper insights into the annual volume of processed shipping documents, their routes, and their transportation modes, to facilitate a more precise data collection process.

The synergy across internal departments plays a pivotal role in measuring GHG emissions. To ensure data consistency and accessibility across the company and concerned stakeholders, and to maintain a cohesive GHG data management strategy, data collected by each department needs to be centralized in a unified data repository, with cross-functional teams overseeing all of the data collection and integration process.

Future opportunities

The Paper aims to provide a basis for quantifying the environmental impacts for shipping documents and helping companies understand the possibilities of calculating GHG emissions of the shipping documents and reporting avoided emissions once digital solutions are adopted. Digitalization of documents is not limited to B/Ls and D/Os, which have been discussed in the Paper, there are different documents that could be involved in the shipping process. Documentation for a single shipment can require up to 50 sheets of paper that are exchanged with up to 30 different stakeholders. If all the documents are digitalized, the GHG emissions savings will be much more significant than the ones calculated in the Paper for both industry and individual company levels. As discussed throughout the Paper, the involvement of different stakeholders in the value chain adds complexity, offering room for further improvement on the framework and methodology proposed in the Paper, along with all the practical cases and improvements of data availability.

Beyond environmental impacts, digital transformation provides several other benefits from different perspectives including speed, efficiency and security as concluded in the Chapter II. As the underlying technology continues to progress in the shipping industry, it is expected that digital document adoption will accelerate in the coming years, and the maturity of all the standards associated with documents will also improve.

Appendices

Appendix 1: Calculation theories

Theory #1: Paper-based B/L

The foundation for the calculation formulas is based on Table 3 (chapter III), which lists the selected parameters that are necessary for the calculation of GHG emissions associated with the handover of paper-based documents. For each pre-selected B/L scenario, multiple formulas from the table are combined and incorporated into a comprehensive calculation.

Product life cycle steps	Calculation Formula
Material Acquisition & Production	• [(laptop emission factor ÷ # of working hours per year) × time to create a B/L] • [(paper emission factor + printing emission factor) × # of pages per B/L × # of B/L]
Distribution	• [distance between stakeholders × road vehicle emission factor × weight of transported B/L] * • [distance between airports × cargo plane emission factor × weight of transported B/L] • [distance between ports × sea freight emission factor × weight of transported B/L] *• The counted distance will be for stakeholders from a same country (e.g., distance from shipper to shipper's bank)* *• Road vehicles used may differ depending on the distance or country, and may range from passenger car, bike to scooter*
Use	• [(scan emission factor × carbon intensity of electricity generation in issuing country × # of pages per B/L) × # of stakeholders] • [(emission factor of writing, sending and reading 1 email with 1 attachment) × # of stakeholders]
Storage	• [(1GB data storage emission factor × data size of scanned image × # of pages per B/L)] • [Total emissions for a given storage room × # of B/L stored in that room]
End-of-life	• Emissions from recycling the paper documents included in paper factor emission • [inceneration emission factor × # of B/L × # of pages per B/L × weight of transported B/L] • No direct emissions from deleting data stored in the cloud

Table 10: Calculation formula to measure GHG emissions related to paper-based B/L

These above-mentioned formulas will be used for the practical application of the B/L scenarios presented in the chapter: “Metrics for GHG reduction impacts related to digitalization in the maritime sector”. Scenarios presented in Chapter III were also calculated based on these formulas.

Theory #2: Blockchain-based B/L

For the blockchain based B/L, Table 4 (in Chapter III) is referred to, which lists the chosen parameters essential for calculating the GHG emissions tied to digital documentation usage. It is noteworthy to mention that contrary to the paper-based solution, the only determining factors between the scenarios for this blockchain based process are the number of participants and the resulting number of document exchanges.

Product life cycle steps	Calculation Formula
Material Acquisition & Production	• [(laptop emission factor ÷ # of working hours per year) × time to create a B/L] • [(server emission factor ÷ # of hours per year) × time to create a B/L]
Distribution	• [(blockchain server power usage ÷ # of B/L generated) × energy mix emission factor] • [network usage per B/L × # of nodes in the blockchain × emission factor of network usage] *• Distances between participants are not considered*
Use	• [(laptop emission factor ÷ # of working hours per year) × time to endorse a B/L × # of endorsement] • [(emission factor of writing, sending and reading 1 email with 1 attachment) × # of stakeholders]
Storage	• [(data storage emission factor per GB × data size of eB/L) × # of transactions]
End-of-life	• Emissions from deleting data stored in the cloud

Table 11: Calculation formula to measure GHG emissions related to blockchain-based eB/L

The GSBN solution is based on the Hyperledger Fabric blockchain. Hyperledger Fabric is an open-source modular blockchain framework project from the Linux Foundation. It is the standard for developing enterprise-grade applications and industry solutions. Participants operate a permissioned blockchain amongst a set of known, identified, participants operating under a governance model that yields a certain degree of trust in the main validator: GSBN. The blockchain provides a way to secure the interactions between the entities involved in the exchange of maritime documents by keeping a trace of every transaction. In such permissioned context, the consensus algorithm to validate transactions does not require heavy computing power and can be run on a standard server. This means that an additional server to host and operate the blockchain may not be necessary depending on the number of B/Ls processed.

Companies often choose to use a cloud service provider to host their server and computing power for the necessary hardware is shared among the provider's clients. As such, the GHG emissions of cloud server hardware should be split between the clients. Solution providers, like Microsoft Azure or AWS, often allow their clients to monitor the carbon impact of their cloud usage for a very precise estimation. However, for transparency purposes, and to estimate the order of magnitude of the server impact on the total GHG emissions, one additional server to host the solution should be considered. As long as the server is not underused, the related carbon impact is therefore an overestimation.

Appendix 2: Emission factors

Emission Factor	Units	Source	Details
Paper	0.919 kgCO2e/kg	ADEME	Paper/Medium/Out-of-use and end-of-life ➔ Considering 1 sheet = 5g CO2 equivalent per kg × weight of one sheet in kg
Laptop	45.3 kgCO2e/year	ADEME	Average impact of a laptop, in-cluding manufacture, transport, and end-of-life for professional use, based on one year's use. Laptop; use mix, professional use; average configuration: 15.4 inch-es screen, 1 CPU, 15 GB RAM, 660 GB SSD, 4 years lifespan; RAS
Print	0.003 kgCO2e/year	Assumption	based on 1500W BP-50C26 printer assumptions: 15 seconds to print 1 sheet, Carbon intensity of electricity generation in China: 531.15 gCO2/kWh
Road - Scooter	0.0736 kgCO2/ passenger.km	ADEME	Motorcycle =< 250cm3. Urban use for passenger transport. Assumed to be similar for transporting paper documents.
Road - Passenger Car	0.0736 kgCO2/ passenger.km	ADEME	Passenger car/Core range - Com-pact vehicle/Hybrid, full, Prius
Air - Cargo Plane	1.2 kgCO2e/t*km	ADEME	Medium-haul air transport (includ-ing fleet, utilization and infrastruc-ture) [tkm], GLO
Sea - Cargo	0.00875 kgCO2e/t*km	ADEME	Bulk shipping 100-200,000 t (in-cluding fleet, utilization and infra-structure) [tkm], GLO
Scan	0.000066 kgCO2e/BL	Assumption	based on 45W EPSON GT-S85 scanner assumption: 5 seconds per scan (1 page), Carbon intensity of electricity generation in China: 531.15 gCO2/kWh

Emission Factor	Units	Source	Details
Email with attachment	0.0171 kgCO2e/mail	ADEME	Write, send and read 1 e-mail of 1MB (attachment) to 5 recipients via a fixed connection, storage for 10 years and 3 redundancies for sender and recipient Configuration : Write, send and read an email; 1MB size, to five recipient, with a fixed-line connec-tion, 50% desktop computer, 50% laptop computer, 10-year storage with 3 redundancies on the send-er and receiver sides; FR Impacts take into account end-user devices, networks and data centers. They are an average configuration. Usage profile in active mode: desktop 3.45 hours/day, laptop 3.45 hours/day. Power in active mode: desktop 79.41 W, laptop 23.11 W, monitor 55.59 W Data center block + transmitter storage: server power per user 0.22 W/user, PUE = 1.16 Service life: fixed computer 6 years, laptop 5 years, Firewall 5 years, Switch 5 years, Router 5 years, Server 5 years, Storage 5 years, Support equipment and architecture 25 years Number of e-mails sent and re-ceived per day: 117.7 e-mails Time to receive and read: 0.1667 min Datacenter based on market av-erage Number of users per server: 1668 users considering 367W per serv-er Average storage fill rate: 50%. Network impact: see NegaByte data
Cloud Storage	0.0253 kgCO2e/GB	ADEME	Store 1GB of data in the cloud via a fixed connection for 10 years Storage in the cloud; 1GB of da-ta, for 10 years, via a fixed con-nection, end-user equipment not included; EN Impacts take into account end-user networks and data centers. They are an average configura-tion. Block data center + transmitter storage: Netflix technical perfor-mance; PUE = 1.3 Lifespan: Firewall 5 years, Switch 5 years, Router 5 years, Server 5 years, Storage 5 years, Support equipment and architecture 25 years Network impact: see NegaByte data
Physical Storage	2700 kgCO2e/year	Assumption	For a 60sqm storage room Assumptions: based on French DPE - D class building with emissions of 45 kgCO2e/sqm/year 70% of the room can be used (= 42sqm), 1 sheet of paper is 0.063 sqm (hence 667 sheets or 333 B/L)
Incineration	0.0528 kgCO2e/kg	ADEME	Waste incineration - Paper waste, RER

Emission Factor	Units	Source	Details
Network	0.00443 kgCO2/GB/year	ADEME	Impact transferring 1GoB of data with a Fixed-line network. Data come from the installation of hardware and the energy con-sumption in a 2020 ADEME study.
Server	732 kgCO2/year	ADEME	Configuration: Server; use mix; mix of rack and blade, 1U, average configuration: 2,5 CPU, 36 cores, 22,5 RAM 43,3 GB each, 7,2 HDD 6,7 TB each, 11,8 SSD 0,71 TB each, 5 years lifespan; cradle to tomb. The configuration is based on an average of more than 40 server configurations (industry sources). Average weight: 24.1 kg

Table 12: Emission Factors List

Appendix 3: Glossary of terms, abbreviations, and acronyms

B/L	Bill of Lading
HB/L	House Bill of Lading
MB/L	Master Bill of Lading
D/O	Delivery Order
POD	Port of Discharge
POL	Port of Loading
eB/L	Electronic Bill of Lading
eD/O	Electronic Delivery Order
LCA	Life Cycle Assessment
EOL	End-of-life

Appendix 4: Table of figures

Appendix 5: Table of tables

Appendix 6: Table of references

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About GSBN

The Global Shipping Business Network (GSBN) is a neutral, not-for-profit consortium whose mission is to enable paperless, accessible and sustainable growth in global trade with its data infrastructure and ecosystem of partners. GSBN facilitates trusted collaboration between participants across the shipping industry to enable greater efficiencies, and paperless trade as well as supporting the shipping industry's decarbonisation transition.

GSBN's ecosystem includes shipping lines, terminals, banks, application developers and other consortia. The entire network accounts for more than half of the containers handled in the world.

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