Blockchain for real.

Maritime Blockchain Labs

Findings & Conclusions

April 2020

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Labs

Contents

Foreword by Lloyd's Register Foundation

How can we make the world a safer place? What are the biggest safety challenges? These questions drive the purpose of the Lloyd's Register Foundation, which is to secure high standards of design, manufacture, construction, maintenance, operation and performance, enhancing the safety of life and property at sea, on land and in the air. We also advance public education and skills for engineering.

We are a growing global charity with a strategy that focuses on the goals of making the sea safer, making food safer and improving society's understanding of risk. But global challenges require global solutions. They cannot be tackled by working alone. We will be at the forefront of building new coalitions, tirelessly promoting these issues and seeking out willing collaborators who share our deepest values and strong social purpose.

Having jointly published a report with the Alan Turing Institute in 2017 that explored distributed ledger technologies and their role in supporting the safety of engineered systems, we sought partners to help us accelerate application of the earlier research. In 2018, we partnered with Bloc to set up Maritime Blockchain Labs whose role was to explore the application of blockchain technology in maritime risk and safety through building collaborative networks and undertaking demonstrator projects.

Foreword by Bloc

Through our partnership with and funding from Lloyd's Register Foundation, we were able to bring stakeholders from all over the shipping sector to come together under Maritime Blockchain Labs. Using three demonstrator labs, we set out on a mission to explore the use of blockchain for the assurance and safety of critical infrastructure and drive new business models for the global maritime industry. These labs have shown us that the time is ripe for the maritime industry to collaborate and collectively address the challenges it faces.

Lessons learned from our collaborations show that there is a willingness to take part in this collective effort, to share experiences and ideas, to co-create innovative solutions and that there are still many challenges to overcome. Scaling ideas and innovations stemming from the labs proved how such collaborations can result in successful ventures, while others showed additional barriers that need to be addressed and learned from. Ultimately, the labs have provided a means for global cooperation to tackle cross-industry problems, and further efforts should be promoted and supported to continue the development of impact-driven solutions.

Our objectives were twofold: to get real-world applications on the ground as soon as possible, and to share knowledge and methodologies among users. To that end, we are pleased to deliver this report and to share our findings with the industry.

Background

With the ongoing expansion of world trade, shipping faces the need to continually transform in order to maintain its competitiveness. With a backdrop of growing regulatory and societal pressures, the industry is constantly searching for cost-effective technology and business solutions to ensure that their fleet and assets remain future-proof.

The speed of technological change is accelerating, and with appropriate leadership the shipping industry should be well positioned to take advantage of this whilst improving safety and addressing the key issues of the United Nations Sustainable Development Goals. As a UN body, the International Maritime Organization (IMO) is actively working towards the 2030 Agenda for Sustainable Development[1] through, for example, the adoption of its 2018 Greenhouse Gas Strategy[2] and efforts towards the reduction of harmful emissions both to the air and the sea.

As the maritime industry moves forward and responds to these challenges, it is critical to explore opportunities for new approaches to innovation and take a leading role in building sustainable solutions that manage risk, improve efficiency and safety, address environmental concerns, and deliver customer value across the global supply chain. Fostering the development of these solutions for transformational change and impact requires cross-industry collaboration and cooperation. At present, these types of industry initiatives are few and far between, and where they do exist, they are often impeded by competitive and traditional mindsets towards data sharing.

1 UN (2015), Transforming our World: The 2030 Agenda for Sustainable Development. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

2 IMO (2018), Initial IMO Strategy on Reduction of GHG Emissions from Ships. http://www.imo.org/en/OurWork/Documents/Resolution%20MEPC.304%2872%29%20on%20Initial%20IMO%20Strategy%20on%20reduction%20of%20GHG%20emissions%20from%20ships.pdf

Recently in the maritime industry, there has been an increase in interest in digital technology solutions that are often seen as a panacea to overcoming industry challenges such as operational efficiency. However, in order to deliver the step changes that the maritime industry needs, greater focus should be placed on solutions that more effectively connect digital aspects to physical practices. The few applications of these digital solutions are often particular to certain companies or stakeholder groups. Furthermore, the degree to which community or network advantages are leveraged to solve such collective challenges facing the industry is limited. This often leads to development of technological solutions that fail to address cross-industry problems and end-user needs in the real world.

In 2017, we witnessed an explosion of development in cryptocurrencies and their underlying technology known as "blockchain". Blockchain is unique in that it combines different technologies to create a decentralised database that is designed, in theory, to be sovereign, incorruptible and globally accessible. Its application fosters transparency, verifiable information and traceability, positioning blockchain as a key component within the next generation of digital solutions. This technology represents an extraordinary opportunity to help deliver collaborative solutions to some of the grand challenges of the global maritime industry; making shipping sustainable and safer and enabling new business models to enhance efficiency and competitiveness. However, while blockchain is likely the most hyped emerging technology on the market, there are few real world applications and we lack an open forum and network for discussing best practices, application, knowledge sharing and thought leadership within blockchain and maritime.

Blockchain Basics

Blockchain, often referred to as Distributed Ledger Technology (DLT), is used as an umbrella term for IT systems that combine elements of (i) a replicated and shared distributed ledger, (ii) cryptographically secure transactions, and (iii) consensus algorithms for validation of these transactions. Transaction data can be stored on these distributed ledgers and are bundled in blocks that are validated at specific time intervals and chained to previous blocks through a string of cryptographic hashes.

Though the original implementation of Blockchain is focused on financial transactions, blockchain technology can in principle have many other uses, in the sense that virtually any form of relevant transaction data can be recorded in a shared ledger (e.g. chain of custody records, identity documents, digital certificates, etc.). This feature is what makes blockchain interesting for use within the maritime industry.

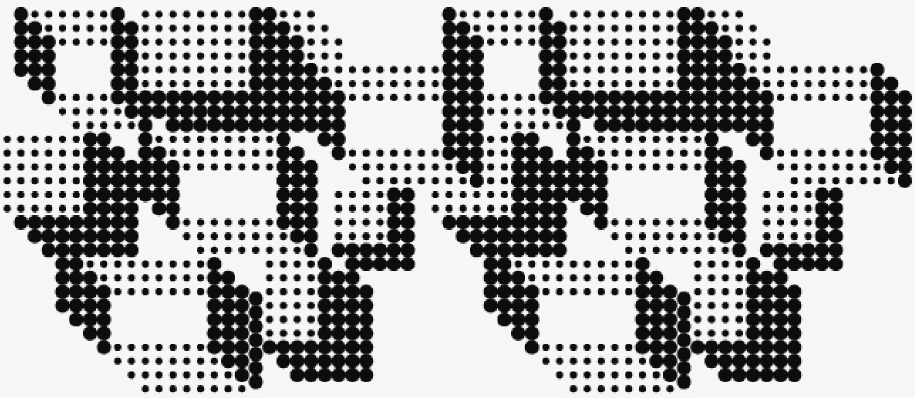
Within this context, we believe that an open innovation network for blockchain in the maritime sector is needed to allow the shipping industry to collectively identify how the technology can deliver value through reimaging business models and processes and to bridge any gaps in commercialising its use. This is important in order to create, promote and implement blockchain solutions that will modernise and digitise processes on a global scale, and increase the safety of engineered systems and life at sea. Consequently, Bloc, with the support of Lloyd's Register Foundation, launched its Maritime Blockchain Labs (MBL). This initiative aimed to investigate and assess the applicability of blockchain technology for three business challenges in the maritime sector relating to risk and safety.

Maritime Blockchain Labs

MBL brought together consortiums to define, test, and validate blockchain prototypes for future applications and assess the new business models created. Through active collaboration, we sought to promote thought leadership, capacity building, rapid prototyping, and real world application development. Its mission was to bridge the physical/digital and industry/technical divides to create impactful and scalable technology for the global maritime sector. We demonstrated this by designing, developing and deploying technical solutions in close partnership with the maritime industry. The objective of MBL was to de-risk early stage technology development and ensure companies build relevant solutions to address their collective challenges.

Between April 2018 and December 2019, MBL took the lead on collaboratively creating solutions and sharing them with the maritime community. This was done through building and demonstrating the technology in an industry setting, and facilitating and participating in events to openly share insights, business models and lessons learned. These events were also used to source industry insights, participation, engagement and global talent pools. Robust yet agile governance was in place to ensure checks and balances, democratic steering and decision making, and industry buy-in.

This report presents the results and findings from MBL. The following sections detail (1) the approach and methods applied for industry open collaboration and co-creation of technological solutions, (2) overview and key insights from each of the demonstrator labs, (3) scaling challenges and successes of validated solutions stemming from each of the labs, and (4) conclusion and way forward.



Collective Approach to Problem Identification

The maritime industry is heterogenous in many respects; stakeholders include those such as systems and equipment providers, ship yards, shipping companies, governments and classification societies. Activities span shipping and transport, banking and insurance, oil and gas production, seafarer and crew management, cruise shipping and tourism, among a plethora of others. As a consequence, it stands to reason that this industry is fragmented and often fails to engage in effective, collective challenge identification and problem solving. There is therefore a need to support the maritime industry in undertaking such collaborative governance[3], wherein multi-stakeholder consortiums come together to find a common approach to widespread issues too complex to be addressed effectively without collaboration.

Yet bringing these diverse sets of stakeholders and industry representatives together is a challenging task that requires thorough preparation and planning. We had to ask ourselves critical questions: What do you want these labs to accomplish? What approach and methods can be applied for each lab? How should we decide on a topic or issue? Who can be involved in these labs? How do you find stakeholders to participate? How often should we meet? What are we asking them to do? What are the legal concerns for industry collaboration? Answering these questions helped to ensure that we instituted appropriate checks and balances and facilitated democratic steering and decision making for our lab settings.

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3 Ansell, C. and Gash, A. (2008), Collaborative Governance in Theory and Practice. Journal of Public Administration Research and Theory, 18(4): 543-571. https://sites.duke.edu/niou/files/2011/05/Ansell-and-Gash-Collaborative-Governance-in-Theory-and-Practice.pdf

Structure and Governance

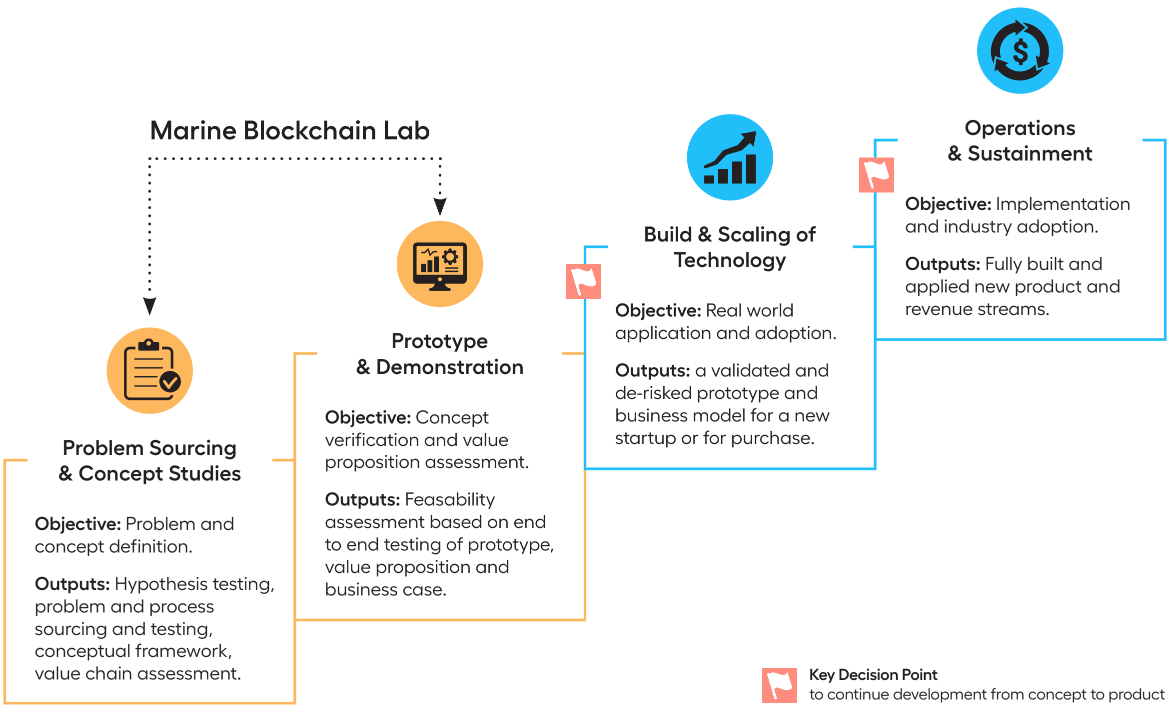
Taking a step back, our goal with MBL is to foster open innovation, collaboration and co-creation. To realise this, we needed to carefully deliberate on our structure and planned governance. Central to this is the role that Bloc played, wherein we acted as a neutral party tasked with coordinating and facilitating each of the labs. This neutrality enabled the creation of a safe space for collaboration and knowledge sharing, which helped to build a level of trust for industry experts to come together and share their experiences without fear of market competition or anti-trust accusations. Hence, Bloc provided dedicated resources and personnel to mediate between the divergent industry actors and to ensure appropriate work flows and communication channels. The structure we employed for MBL can be broken down into three hierarchical parts: the Steering Committee, the Programme Director and the labs (see figure 1 below and Annex 1 for more detail on roles and responsibilities).

Figure 1: Governance Structure of Maritime Blockchain Labs

Creating and Managing Labs

Our approach to managing the labs was inspired by a systems engineering methodology, wherein we broke down the product development pathway into four phases from ideation to market launch and operation (see figure 2). For our labs, we aimed to de-risk early stage innovation by facilitating problem definition with the problem holders themselves and co-creation of solutions together with the industry. This situated the labs squarely within the first two phases, focusing on problem conceptualisation and solution prototype validation.

Figure 2: Technology Development Framework



The process underpinning each lab can be broken down into seven distinct steps spanning the two phases above from problem sourcing & concept studies to prototype & demonstration (see Annex 2 for more detail):

1. **Open problem sourcing**
2. **Value chain and process tracing**
3. **Stakeholder assessment and consortium formation**
4. **Collective problem definition and concept development**
5. **Proof-of-concept development**
6. **Prototype testing and feedback**
7. **Value proposition testing, business model definition, and concept validation**

The first few steps are the most important as they provide a filter to narrow down on a pragmatic scope of the topic given time and capacity constraints. Core to the objective of MBL, Bloc engaged with the maritime industry for open problem sourcing as the first step towards ensuring that efforts are focused on addressing real-world challenges facing the maritime industry. Omitting this step for sourcing a problem topic would not only go against the spirit of collaborative governance, but risks efforts being misdirected to addressing a less pressing self-identified industry problem. After completion of the open problem sourcing step, a refined list of potential lab topics as presented to the MBL Steering Committee for deliberation, final selection and approval of a topic. Once a topic was chosen, consortiums were created of actors across the industry that represent the supply chain of the selected topic.

Investing the time and resources to undertake these initial steps are critical for laying the foundation of lab scope and feasibility. Taking the time to complete these steps creates a streamlining of problem topics and a gauge of their impacts across industry stakeholders; removes topics with too few or too many affected parties; assesses market engagement and potential interest for collaboration; identifies first movers or entrenched players; as well as determines if a problem topic has already been covered through previous collaboration efforts and initiatives. Without this process, there would be a risk of complications due to a lack of problem definition and structure.

The whole 7-step process follows an iterative design approach, a cyclic process of prototyping, testing, analysing, and refining upon the learnings from each step. To challenge the feasibility of the solution, the last step is dedicated to value proposition testing, business model definition, and concept validation. The main question asked in this stage is: is this a feasible commercial solution that addresses the identified challenge? The output of this step is a critical evaluation of what was developed, assessing its strengths and weaknesses as well as confirming with industry representatives their willingness to adopt and use such a solution. This step is extremely important in determining if the solution is viable for commercial development. If the produced solution fails to provide value to each consortium member, or there are practical limitations to its adoption, these are signs that the proof of concept was not validated and either no further development is necessary or a reiteration of the process starting at the concept development step is in order.

The Approach in Practice

The MBL process provides a roadmap towards building a practical technological solution to address real world industry challenges. However, it is also important to consider the tools that aid in this collective problem solving approach. One valuable tool critical for the participation of consortium members was a Memorandum of Understanding (MOU). This document set the expectations and confidentiality considerations for all participants. Without it, parties may have been unwilling to share information and experiences and their organisational practices, let alone data and insights. Being sensitive to the legal ramifications and aversion of antitrust allegations, the MOU issued by Bloc ensured proper antitrust and competition law measures were in place to enable the creation of a neutral setting for collaboration to take place. It also set the terms for Intellectual Property (IP), wherein all background IP (i.e. all existing IP) remain as property of their original owners, and foreground IP (i.e. any new IP developed during the lab process) would be owned by Bloc.

Other tools utilised during the collaboration process aimed to facilitate communication and knowledge sharing. In-person and online meetings were used to encourage discussions, share experiences and information for collective problem definition, provide updates and demonstrate the prototype. Interviews also helped to draw out inputs and feedback from less outspoken members, as well as confirm or delve deeper into specific topics or comments mentioned. The main communication channels employed included emails, phone calls, and online video meetings, supplemented by briefings to document discussions and key takeaways. For the sharing of documents such as presentations, reports, and examples of documentation or work samples, we utilised a combination of tools including shared folders and documents, as well as emails with web links and attachments in different formats.

While the methods of collaboration and communication were adjusted and fine-tuned over time, some cross-cutting lessons remained true for each of the labs. This served to highlight the in-practice advantages and disadvantages of our approach.

Advantages of the Approach

Each of the labs generated a positive response to the sourcing and selection of problem topics. The open problem sourcing stage provided the maritime industry an outlet to triage complicated and pressing problems they faced and wished to address. Though it is recognised that the robustness of this approach was limited due to outreach and time constraints, it was still regarded as highly beneficial and welcomed by industry consortium members. Indeed, MBL provided a mechanism for the creation of a forum where industry representatives could come together to find a common approach to addressing a wide-spread, complex issue. The design and development of a technological solution was not only an objective but also a means to showcase to the maritime industry how and why collaborative governance is needed and can be accomplished.

Another key advantage of this approach is the educational value of our process. Though technical and procedural knowledge of participants varied between participants, MBL facilitated the cross sharing of knowledge for wider awareness and uptake. In particular, participants expressed an eagerness to better understand blockchain, how it can be applied to their problem area and the insights from the varying perspectives of their fellow consortium members. Likewise, Bloc gained insights from the industry expertise that the participants hold. Having an overview of the whole process and identifying various pain points[4] helped to better contextualise the problem for many individuals.

Challenges of the Approach

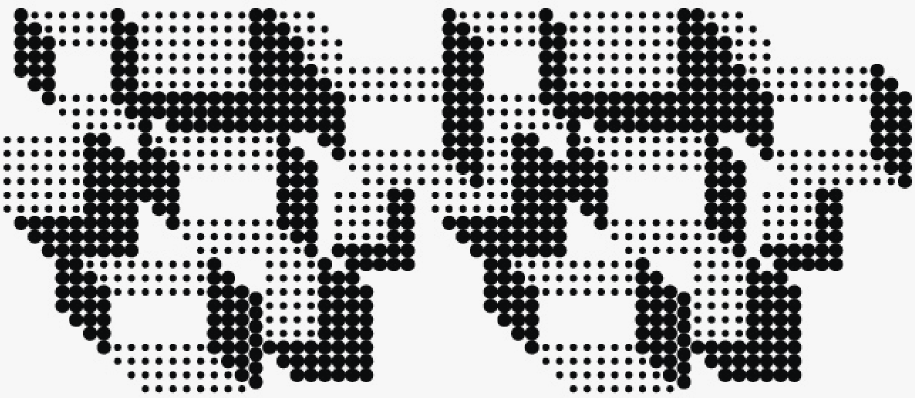
Each of the labs experienced some of the usual challenges with group collaboration. For example, some consortium members were quite forthright and open in sharing their experiences and knowledge while others were less-so, but perhaps more open to sharing in private. As such, the collaborative approach and developed technological solution can only be as good as the degree to which participants and experts are willing to engage and to the effectiveness of the facilitator in accommodating the members. If one consortium member is more responsive and communicative, then the information gathered and utilised throughout the process potentially becomes tailored or biased toward that party. Flexibility and agility in the process and handling participants is therefore important. Acknowledging this, tailoring the communications to suit individual member's requirements and reminding consortium members of the benefit of sharing their knowledge and experiences was an important role of the project coordinator.

Finding members for the consortium was occasionally challenging, and we did not always manage to source stakeholders representing all of the roles in the supply chain being addressed. Though it is possible to conduct a lab without full representation by all actors, and achieve valuable results and insights from the collaboration process, lesser representation does to some extent adversely impact the robustness and validity of the developed solution.

Furthermore, it is important to consider not only the role of an organisation within the process, but also the role of an individual within an organisation.

4 A pain point is a specific problem that prospective customers of businesses are experiencing, in other words, pain points can be seen as problems.

These persons and their ability or capacity to internally communicate with others in their organisation, thereby drawing in additional inputs or specific topical knowledge, sometimes became a challenge or barrier to proceeding with the lab steps. This was particularly the case for process tracing, problem definition, and technological concept development.



Maritime Blockchain Labs

This section aims to provide a brief overview of the three labs and their key lessons learned. For each lab, we describe the problem topic and its relevance to the maritime industry, the design and development of the proposed blockchain-based solution, as well as the general outcome of the lab and insights from applying the collective problem-solving approach described above. Further information and details for each of the labs can be found in separate topic briefs.

MBL 1: Marine Fuel Assurance

Background

The first of the labs focused on maritime fuel and issues regarding its quality assurance in the bunkering supply chain. Focusing on quality was important for multiple reasons, foremost of which was its relevance to the risk associated with the regulation, blending and contamination of bunker fuel. Reliability as well as operational and environmental performance of vessels and their equipment are dependent upon careful control of the specifications for type and quality of fuel being used. Improper fuel blending can lead to fuel contamination or incompatibility of the blended fuels which can subsequently lead to engine failures and loss of propulsion, placing the safety of the ship and its crew at risk. In turn, this can also affect the safe navigation of other ships sailing close by, resulting in events such as grounding or collision with potential loss of life and severe damage to the environment. Indeed, such events were seen during the 2018 crude oil contamination crisis, which saw millions of barrels of tainted crude oil flood the market[5].

With the IMO announcement of the effective implementation date of its marine fuel sulphur cap, which came into effect in January 2020[6], fuel quality issues became more problematic. Under this new regulation, ships are required to

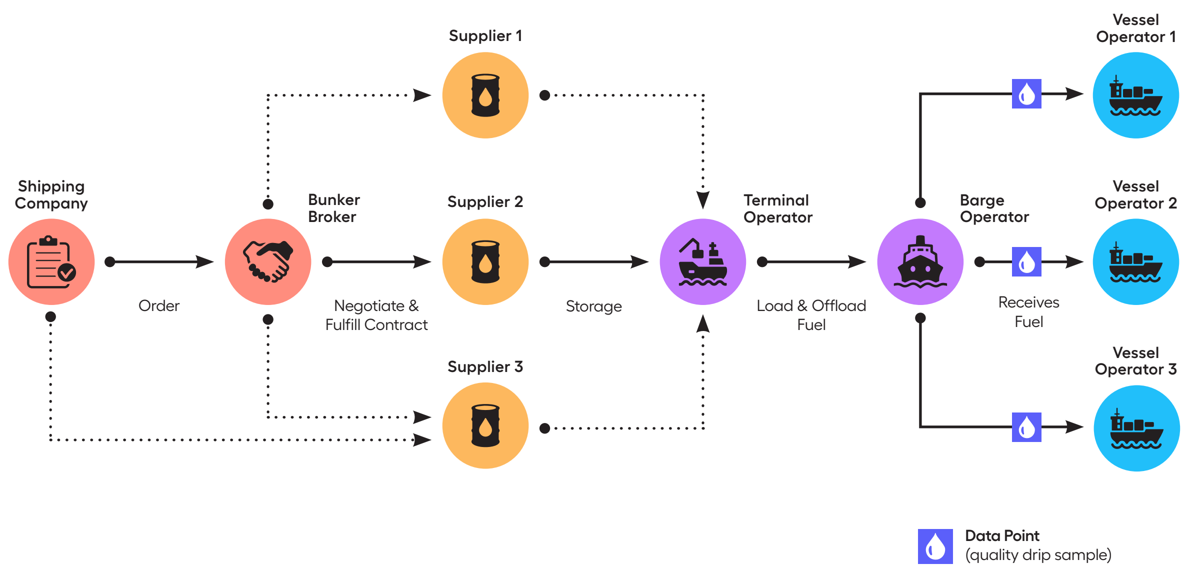
5 Atlantic Council (2018), Contaminated fuel is poisoning global shipping. https://www.atlanticcouncil.org/blogs/energysource/contaminated-fuel-is-poisoning-global-shipping/

6 IMO (2016), IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/MEPC-70-2020sulphur.aspx

use marine fuels with a sulphur content of no more than 0.5% against the previous global limit of 3.5% in an effort to reduce emissions from the shipping sector. At the time, however, there was not a large supply of high quality low sulphur fuels and the mixing and blending of fuels to meet sulphur limits can cause further contamination and quality issues. Though regulations and standards exist regarding fuel quality and associated components such as sulphur content, the often paper-based processes of bunkering make enforcement difficult and quality cannot be assured as fuel passes through the bunkering supply chain, especially when blended with other fuels.

A key finding in the value chain tracing exercise was that the bunkering supply chain is dominated by manual and paper-based processes. This makes the availability of data on fuel transfers and blending procedures difficult to obtain and susceptible to manipulation. Data on fuel quality comes from drip sampling during the bunker delivery, but even these samples cannot be trusted as they may have been intentionally exchanged with a different fuel supply for the falsification of records and not representative of the actual fuel. Fuel tests are of significant importance as ships could refuse to accept off-specification fuel and subsequently need to “debunker” or offload it.

Figure 3: Process Tracing for Marine Fuel Assurance



Solution

The scope for this lab was to create a clear and immutable chain of custody of the bunkering supply chain. The implications of a chain of custody is to enhance visibility into the supply chain and provide a decision support system for quality assurance.

The consortium members included representatives from the following organisations: Lloyds' Register Fuel Oil Bunker Analysis and Advisory Service (FOBAS), the International Bunker Industry Association (IBIA), BIMCO, GoodFuels, Precious Shipping and Heidmar Inc.

What are timestamps and hashes?

Timestamps are records of the time and date of a transaction. Timestamping is a technique used to prove the existence of certain digital data prior to a specific point in time. The advent of cryptocurrencies and blockchain enables some level of secure timestamp accuracy in a decentralised and tamper-proof manner[7].

Hashing is the function of mapping data to tables of data. The values are used to index a fixed-size table called a hash table[8]. Digital data can thus be hashed and the hash can be incorporated into a transaction stored in the blockchain, which serves as evidence of the time at which that data existed[9].

Understanding the challenges described above, the lab working group focused on a solution for providing vessel owners assurance before purchasing fuel for their ship. The use of blockchain was investigated with the value proposition that it would underpin the immutable chain of custody by storing

7 Kolydas, T. (2019), Timestamping Metadata Using Blockchain: A Practical Approach. In: Garoufallou E., Fallucchi F., William De Luca E. (eds) Metadata and Semantic Research. MTSR 2019. Communications in Computer and Information Science, vol 1057. Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-030-36599-8_42

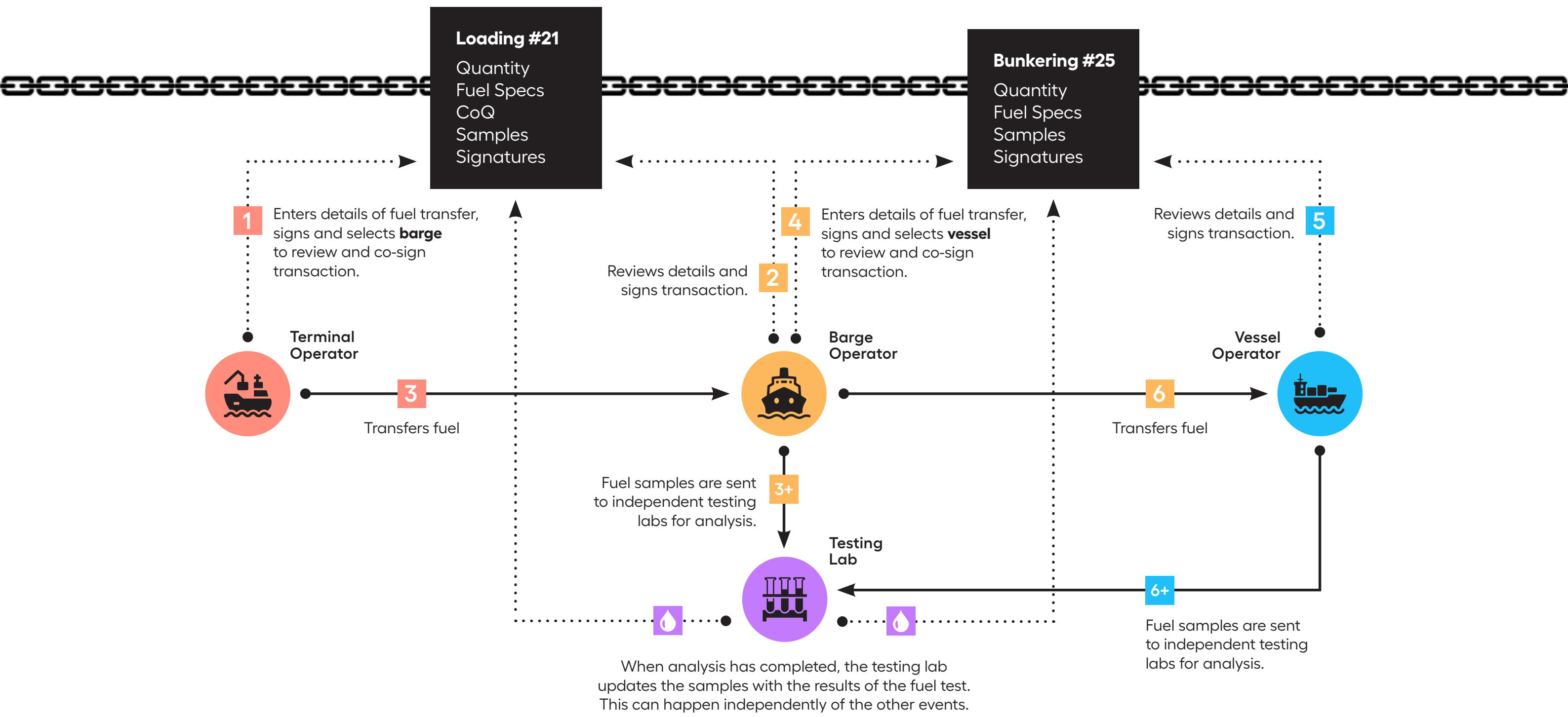
8 BlockGeeks (n.d.), What is Hashing? [Step-by-Step Guide-Under Hood Of Blockchain]. https://blockgeeks.com/guides/what-is-hashing/

9 Gipp, B., Meuschke, N. and Gernandt, A. (2015), Decentralized Trusted Timestamping using the Crypto Currency Bitcoin. In Proceedings of the iConference 2015. March 2015, Newport Beach, California. https://arxiv.org/abs/1502.04015#

timestamped hashed records of the information collected through a digital bunker delivery note and linked to a specific bunkering transaction. The data points to be collected through the digital bunker delivery note included the quality analysis documentation in the form of test results of fuel, the signing off of fuel transactions, the documentation of the fuel specification from a supplier and additionally the test results from independent testing labs.

A digital bunker delivery note application would be needed for the users to enter in and review details of fuel transactions and to capture the transfers between terminals, bunker barges, and receiving vessels. A hashed record of fuel transactions would be stored in a blockchain to serve as an immutable attestation to the information. These inputs across the supply chain would comprise the data required for an end-to-end digital chain of custody and possibly even an immutable reputation system to deter illicit activity.

Figure 4: Prototype Solution for Marine Fuel Assurance



For the purpose of demonstrating this end solution through a prototype, we limited the prototype to be a simple digital bunker delivery note form accessible by consortium members. On the backend of this form was a direct push of the information to a private instance of the hyperledger blockchain. The prototype had five primary features: (1) user roles for a supplier, a bunker barge, a testing lab and a vessel owner, (2) a simple bunker delivery note to input the bunker specification information, (3) a push notification for the lab role to append test results, (4) the BIMCO bunkering terms and conditions to agree to and (5) a digital signing feature before passing the delivery note to the next user. We demonstrated the prototype with consortium members each playing a role and carrying out a simulated bunkering operation from end-to-end.

Key Findings

Overall, the process to collaborate on a blockchain-based solution to address marine fuel quality faced a few challenges and achieved some successes.

Challenges:

- **Digital traceability** represented a step in the right direction; however, there was still no link from the physical fuel to the digital system to identify if the fuel was adulterated or mixed on its journey or where this may have happened if it did.
- **The 'garbage in / garbage out' problem** of information was a concern as without a way to verify information in the physical world, the information in the system is only as good as the information put into it. Incorrect or poor-quality input from users would produce faulty output that would not be able to be amended due to the immutable nature of blockchain technology.
- **Fuel test results and the chain of custody** would have to be verifiable to hold up in a court of law or in an insurance claim in order to avoid liability and would require further work to get there.

Successes:

- **The collaboration seen and enacted between industry consortium members** throughout the lab duration showcased their ability and willingness to jointly tackle this cross-industry challenge.
- **Agreement on key fuel quality issues and pain points**, as well as the identification of needed documentation for digital recording of fuel transactions.
- **The co-creation and testing of a prototype solution** to demonstrate the industry's feasibility to interact and share their needs in a clear way, with further recommendations for prototype improvement based on real-world parameters.
- **The validation of a digital chain of custody** for the bunkering supply chain through the demonstration of an end-to-end bunker fuel delivery with digital traceability.

More information regarding the next steps of this lab and efforts for further development are described in the scaling section of this report.

MBL 2:
Crew Certificates

Background

The second lab focused on improvements to the management, verification and validation of seafaring crew certificates. Verifying crew information and certificate authenticity and validity is essential to the safe and efficient operation of a seafaring vessel. Under the IMO Convention on Safety of Life at Sea (SOLAS)[10] and Convention on Standards of Training Certification and Watchkeeping (STCW)[11], each crew member is required to prove their competency for specific areas of work and responsibilities onboard.

Improper seafarer training could lead to increased risks for the safety of the crew, the ship and the marine environment. However, the management of seafarer identification, certification, and documentation is a highly cumbersome process, because no two seafarers are alike and several vendors supply the various training requirements. Crew members aboard seafaring vessels consist of a diverse group of individuals spanning multiple nationalities, languages and cultures. Seasonally or over time, crew members will move between different ships and companies, reinitiating verification processes and incurring unnecessary costs.

Adding to this complexity is the fact that many records are paper-based, requiring crew members to maintain such files to prove their skills and experience, potentially risking these files to getting damaged or lost over time. However, with

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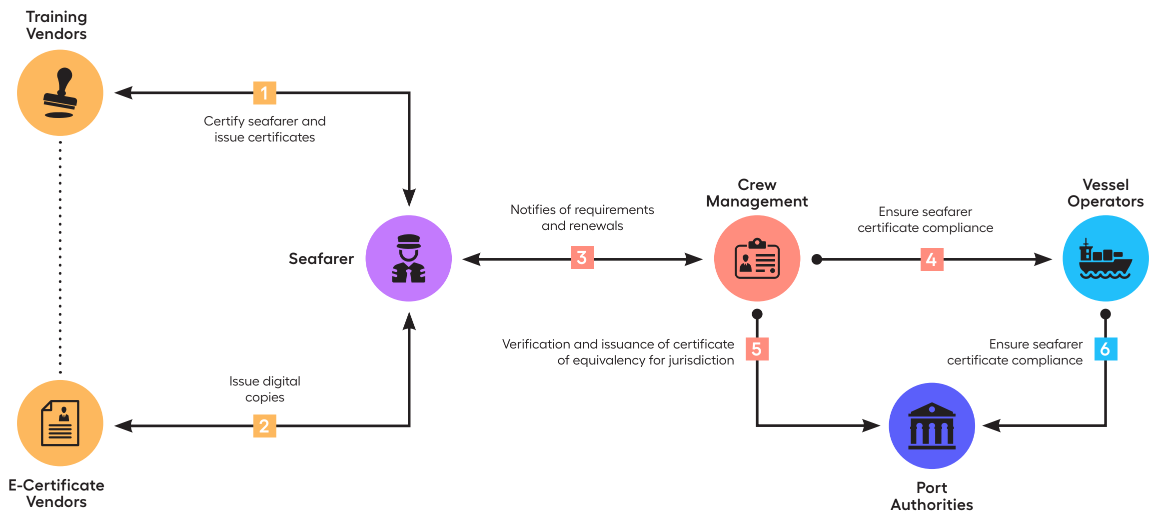
10 IMO (2020), International Convention for the Safety of Life at Sea (SOLAS), 1974. http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx

11 IMO (2020), International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx l

new technology, digital certificates or e-certificates, are a promising innovation for seafarers and authorities alike. Yet, complications arise when considering the emergence of these e-certificates alongside the traditional Port State Control processes and the current analog and paper-based information flows of documentation. Furthermore, with many e-certificate providers, seafarers and authorities must balance the use of several platforms, providers, vendors, and websites in order to retain the data trail for all relevant certificates. Often in the case of both paper-based and electronic processes, the company employing the seafarer has little to no oversight of all of the disparate documentation stored across multiple vendors, jurisdictions and data silos.

Figure 5: Process Tracing for Crew Certificate Management



Solution

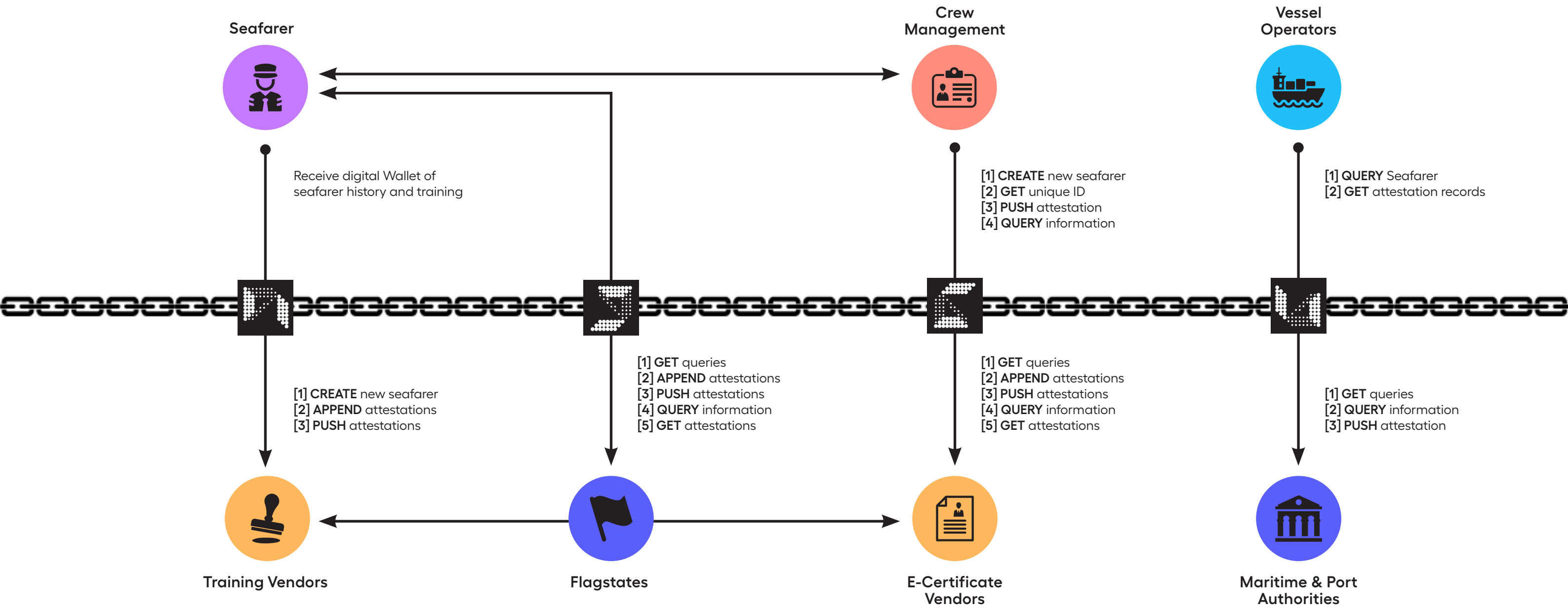
The scope for this lab was to design a minimum viable prototype by (1) focusing on one type of seafarer (engineering officers) and one type of certificate (the STCW Initial Issuance); (2) securely sourcing and transferring digital copies of the required certificates and documentary evidence to complete a simulated, electronic STCW Endorsement of Recognition approval process; and (3) using the same certificates and documentary evidence compiled to complete a simulated, electronic STCW Clearance of Embarkment approval process onboard a vessel.

The purpose of this scope was to validate the value proposition of multiple parties bringing together and interacting with the same information and attesting to it across jurisdictions without having to access multiple platforms and sources.

The consortium members included representatives from the following organisations: Philippine Transmarine Carriers (PTC), The Mission To Seafarers, Heidmar Inc., A.P. Møller - Mærsk, Hanseaticsoft, Liberian Registry, Shell, C-LOG, Navozyme and myCert.

The resulting vision for the solution sought to lay the foundation for a non-jurisdictional, digital platform that serves the seafarers, crewing agencies, vessel managers and maritime administrations. This platform would mainly serve to support the issuance, management and clearance processes for crew certifications, as well as log and record necessary training hours. The proposed prototype consisted of a blockchain-based certificate notarisation and exchange platform that served as a database for crew certifications, and also facilitated the safe sharing of seafarer information with industry stakeholders involved with the origination, authentication, transfer, or otherwise active management of crew certificates.

Figure 6: Prototype Solution for Crew Certificate Management



The platform would serve as an exchange platform, enabling training organisations, manning departments, vessel operators, software providers, government agencies and other relevant vendors and stakeholders to share their attestation of various documents, ID's, and training certificates. Signatures would be collected on accreditations as per IMO, individual flag state and company requirements.

For the purpose of demonstrating this end solution, the prototype had of six primary features: (1) user roles for each organisation involved in the value chain; (2) permissions, rights and actions associated to each user role; (3) digital token generation for verified user credentials and e-certificates; (4) a query function and ledger explorer to view seafarer certificates; (5) a function for e-certificates electronic endorsements for Port State Authorities; and (6) an API integration point for organisations to connect to the platform. We then demonstrated the prototype with consortium members to simulate an end-to-end process in line with our scope, meaning an electronic e-certificate endorsement and an electronic vessel embarkment approval for a seafarer based upon an e-certificate.

The end goal of the solution would need to ensure that each seafarer and their individual accreditations will be verified/endorsed by the stakeholders interacting with the system, which in the end will create a full profile of accreditations for the seafarers skills, complete with a log of all the organisations that have signed off on the seafarers accreditations.

Key Findings

Overall, the process to collaborate on a blockchain-based solution to address crew certificate management faced a few challenges and achieved some successes.

Challenges:

- Participation of multiple, similar technology providers within the working group made it sometimes difficult for open collaboration due to competition concerns.

- Subjective review processes and multiple interpretations for certificates at both flag state and company levels made it hard to make a one-size-fits-all solution. Harmonisation of standards and review procedures in collaboration with the IMO is needed to ensure recognition of e-certificates and attestations across geographies.

Successes:

- The developed prototype integrated into multiple, separate e-certificate sources. Though well liked, consortium members suggested it could move towards a single source that combines all certifications into one area for ease of use and sharing.

- Demonstration of a technical solution with a focus on a bottom-up, collaborative and industry-driven approach that addresses sustainable seafarer management and creates trust.

- Testing of the prototype solution provided a means for the industry to further identify needs and action areas relating to seafarer certificate management.

- This lab also fostered the grounds for consortium members to initiate subsequent breakout projects and collaborations stemming from their work.

- More information regarding the next steps of this lab and efforts for further development are described in the section on scaling below.

MBL 3: Misdeclaration of Dangerous Goods

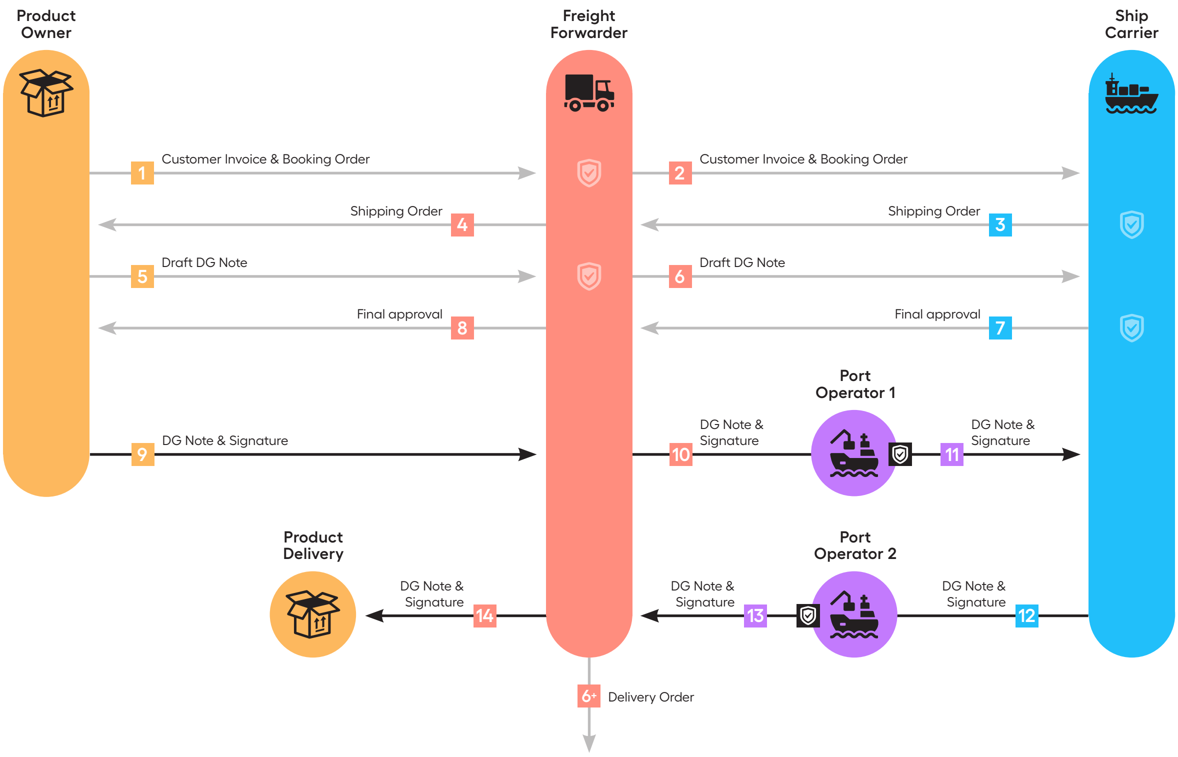
Background

The third and last of the labs focused on the issue of misdeclaration of dangerous goods. Dangerous goods and hazardous substances are items that pose risks to crew health and safety, to ship property or pollution of the marine environment. Some common substances that fall under this classification include fireworks, propane, gasoline, lighters, bleach, paint, aerosols, rat poison, and lithium batteries. Recognising this risk, the IMO's Convention of the Safety of Life at Sea (SOLAS) and the Convention for the Prevention of Pollution from Ships (MARPOL 73/78) mandate the International Maritime Dangerous Goods (IMDG) Code when transporting dangerous goods by vessel. The code regulates the safe shipment of dangerous goods and hazardous materials by sea, defining aspects such as terminology, packaging, labelling, placarding, markings, stowage, segregation, handling, and emergency response.

Misdeclaration (i.e. wrongly classified, labelled, packed or inaccurately identified dangerous cargoes) can lead to risks such as fire with consequences such as loss of life, millions of dollars of cost in ship damage and asset availability, and delays in cargo supply chains. Widely referred to as the 'iceberg' risk in the maritime industry, the misdeclaration of dangerous goods is a large and growing concern for all industry stakeholders. In response to these growing concerns, multiple shipping lines have declared their intent to impose fines for shippers and the strengthening of inspection procedures.

Dangerous goods misdeclaration is a complex problem, involving multiple actors across jurisdictions. Efforts to further define the problem area highlighted how the current process for declaring and transporting dangerous goods is largely paper and email-based, requiring different actors to manually extract and input data into their separate systems, resulting in the risk of human errors from copying and pasting. In some cases, additional information is required from the shipper or freight forwarder, which can cause delays and an unnecessary amount of interaction between supply chain stakeholders. In addition, there is often a lack of oversight between what is declared on paper versus what is actually packed in the container to be shipped.

Figure 7: Process Tracing for Misdeclaration of Dangerous Goods



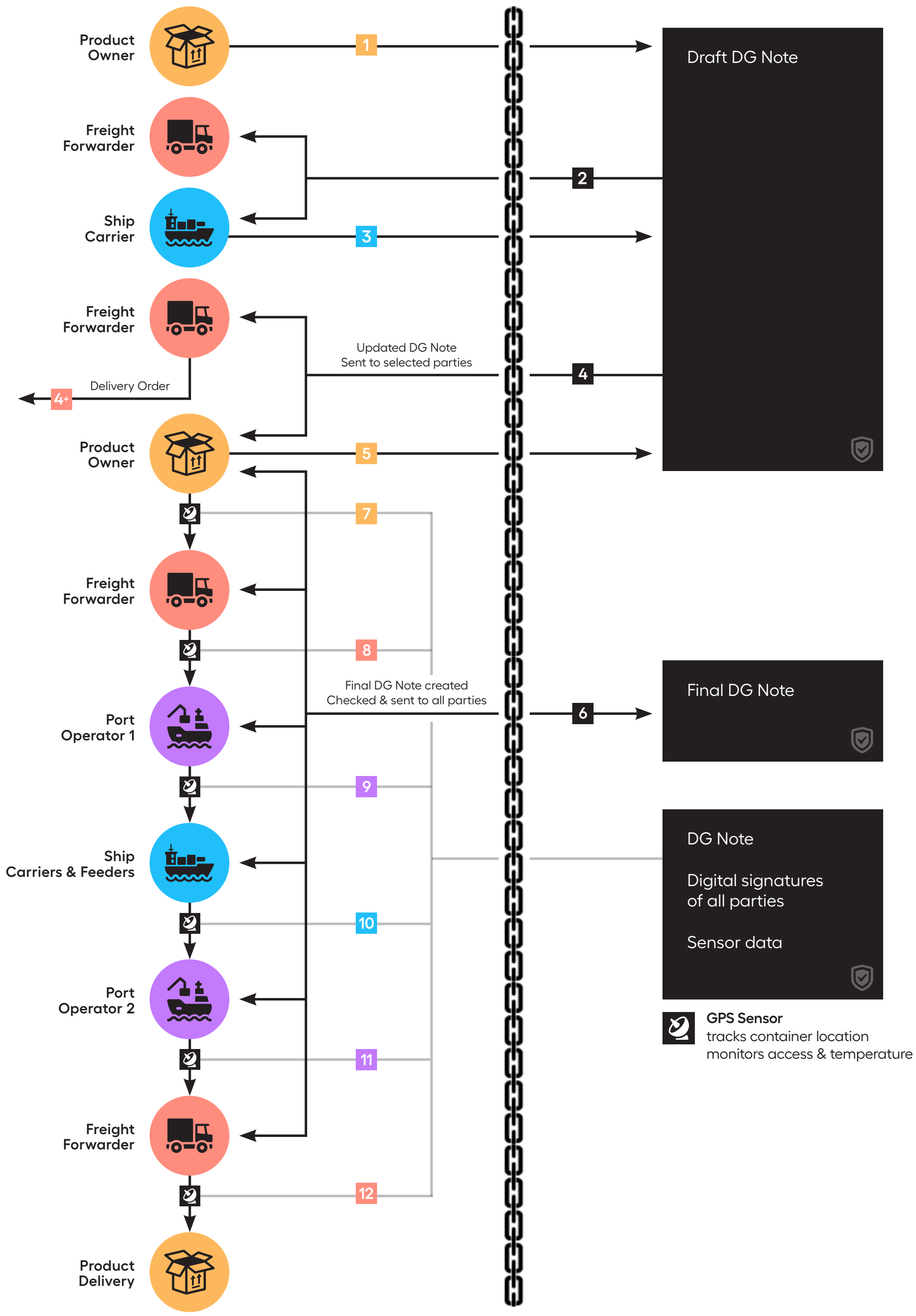
Solution

The scope for this lab was to trace an end-to-end delivery of a dangerous good and record all declarations, approvals and receivals along the way which form the basis of the chain of custody for insurance and trust.

The consortium members included representatives from the following organisations: Exis Technologies, Agility, Port+, Flexport, Marine Transport International (MTI), SecureSystem, Copenhagen-Malmö Port (CMP), DSV, X-Press Feeders and Lloyd's Register Group (LRG).

The aim of this lab was to discourage misdeclaration and support proper documentation and declaration of dangerous goods. To address the challenge of input from multiple data sources as well as sending the data to various applications, a blockchain-based data adapter was proposed. The data adapter is an integration tool that connects various applications together, manages data flows to create data standardisation and connects to distributed ledgers (or blockchains). This adapter was used to (1) facilitate the generation of a regulatory compliant and electronic Dangerous Goods Note at point of origin to reduce human errors relating to documentation; (2) connect to systems that would verify the dangerous goods documentation and eradicate the need for multiple checks and data extraction throughout the supply chain; and (3) automate transactions between different parties.

Figure 8: Prototype Solution for Misdeclaration of Dangerous Goods



For the purpose of demonstrating this end solution, the prototype had of four primary features: (1) user roles for a dangerous goods supplier, a freight forwarder, a port operator, shipping container line, and technology providers; (2) permissions, rights and actions associated to each user in the shipment process; (3) a digital signing feature before passing the dangerous goods to the next user (handoff); and (4) a timestamped record of user actions. We then demonstrated the prototype with consortium members to simulate an end-to-end documentation and shipment of a dangerous good, recording relevant document details, receivals and handoff digital signatures.

Key Findings

The challenges and successes that evolved out of this process to collaborate on a blockchain-based solution for addressing the misdeclaration of dangerous goods included:

Challenges:

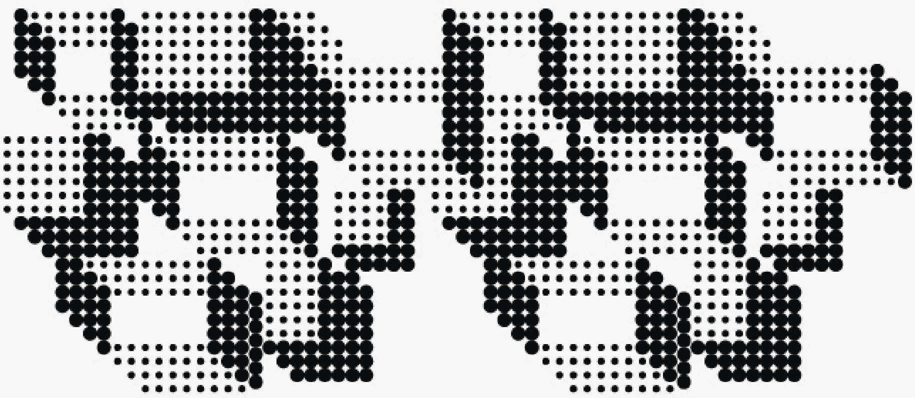
- The 'incomplete' coverage of the supply chain, whereby there was no major carrier or shipping line represented, impacted the overall problem context and definition, solution validation, and business model scoping. Lack of input from this role limited the holistic perspective needed to address this complex problem.
- Not being able to perform the technical integration of systems and test real time data sharing due to time and capacity restraints.
- Lack of a means to securely and concretely verify on behalf of a shipper or product owner the contents and packing of a dangerous good within a container.

Successes:

- Collaboration between industry members resulted in a re-imagining of what the dangerous goods declaration process could look like, and agreement on needed digitalisation of such transactions.

- The combination of technology providers and their respective components created a prototype solution that increased transparency and smoothed the communication of important dangerous goods information between previously separated parties.

- Demonstration of a proof of concept of an end product that traced a dangerous good from end-to-end, and provided increased transparency and efficiency gains to stakeholders throughout the supply chain.



Scaling of Solutions

MBL was designed to focus on the first phases of product development, namely, problem sourcing & concept studies and prototype & demonstration. Each of the labs developed, tested and validated a proof of concept for a prototype solution to address three maritime issues. These concept validations showed that the maritime industry would be willing to consider the adoption and use of these solutions given positive business model conditions (i.e. price, money or time saved, data security, etc). The last phase of product development, build & scale technology, was outside of our scope of MBL, so the question that each consortium raised at the end of each lab was: what comes next?

To propose next steps, Bloc synthesised the findings and feedback from the working groups for each of the labs and developed a tailored proposal to continue efforts towards further developing the solution. As mentioned above, the reflections for each lab highlighted areas for improvement and modification, in line with an iterative design approach. The proposals for all of the labs sought to continue this collaborative approach by inviting consortium members to participate and invest in the subsequent phase of development. The proposals for each were the following:

Marine Fuel Assurance

The scaling proposal for the marine fuel assurance lab set out a plan to conduct a commercial pilot to test the applicability of the blockchain solution for fuel tracing over a 6-8 month period. Interested partners were requested to provide financial support to undertake this next step. Minimum partners identified for the pilot included 3 fuel suppliers, 3 shipping owners/operators, a fuel testing body, an academic partner, and additional technology providers. Bloc offered to provide system design, project management, technical management process, assessment and evaluation.

Crew Certificates

The crew certificates lab proposal focused on the need for policy lobbying and standardisation relating to (1) industry harmonisation in the interpretation of IMO qualification standards for seafarers as well as (2) the recognition of e-certificates by flag states, Port State Control Officers and other authorities. A cooperative ownership structure was offered, in which larger partners would share in the cost of future development, while SMEs and NGOs were asked to provide in-kind contributions of personnel time. Minimum partners identified for the short-term scaling phase of 5 months included 1 flag state, 1 crew management organisation, 2 seafarer employers, 2 maritime authorities, 1 NGO and additional technology providers. Bloc offered to provide project management, stakeholder coordination, research and analysis, and support on technology development.

Misdeclaration of Dangerous Goods

The lab for misdeclaration of dangerous goods had a scaling proposal of a plan for the technical build and programming of the prototype solution, including integrations with interested partners along the supply chain. A cooperative ownership structure was offered, in which larger partners were requested to provide financial support, while SMEs and NGOs were asked to provide in-kind contributions of personnel time. Minimum partners identified for the scaling phase included 1 container shipping line, 2 port authorities, 2 freight forwarders and additional technology providers. Bloc offered to provide project management, stakeholder coordination, design of governance and permission structures, and support on technology development.

Results and Key Takeaways

Grant Funded De-Risking

Bloc received grant funding with the purpose of de-risking the innovation process, focusing on industry wide problems as defined by the problem holders themselves and validating solution concepts with the industry before building technology. We sought to do that through collaboration with a representative group of companies that could lend expertise and guide us in this process with their experience and knowledge. This proved to be a great success; the willingness of the maritime industry to collaborate to solve challenges was high and the participation of our stakeholders was valuable.

Consortiums for Concept Validation, Not for Scaling

Once concepts were validated, however, we tested and ultimately learned that industry consortiums are not necessarily the ideal model for building and scaling these solutions in their next stage of development. Our key findings suggest this is due to two reasons. First, once the concepts are developed and validated, if the technical development and scaling of the solution is a straightforward process, then it can be undertaken by one entity and does not require the input of multiple companies at this stage. Second, while it would be an innovative model in any sector, shared industry ownership is not yet a viable model for technology development in the maritime sector.

An alternative approach based upon these findings could be in the form of a separate initiative, led by for example Bloc, to develop the IP and solution as a traditional IT product. From there, collaboration processes and consortium members could be relied upon for pilots partners and first mover adopters, but not for sharing in the development itself. This is not only a theoretical takeaway, this was the model used for the development and scaling of what is now known as BunkerTrace, the spin out product from the Marine

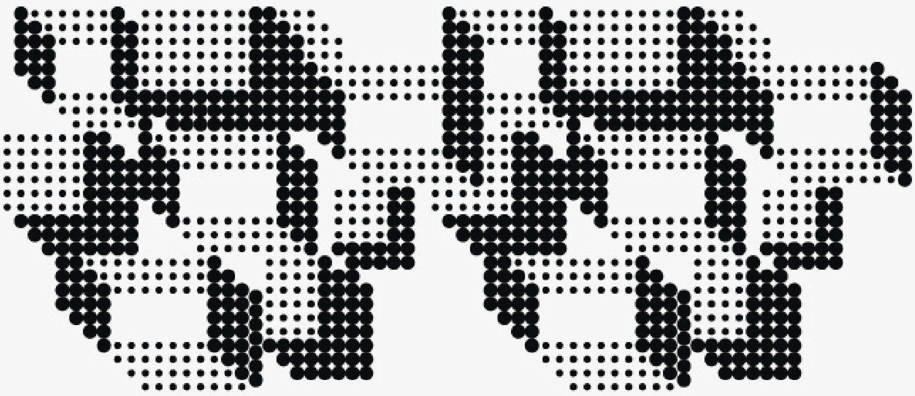
Fuels Assurance lab (see case study below). To summarise, the approach identified for scaling is to (1) utilise grant or applied research funding to de-risk upstream development, pilot testing and validation of a solution with industry stakeholders; (2) after validation, utilise capital investment for product development (venture capital; company funds); and (3) bring it to market with an already existing client base and industry awareness and support.

Value Must Outweigh Cost of Change

The labs also indicated that to have a successful prototype and potentially scalable solution, it must present value to all stakeholders across the supply chain. Targeting pain points for each segment of the supply chain can be difficult, but is essential to ensure viability for the prototype in later stages of development. Interviews with lab participants emphasised that if the solution presents too significant a change, adds complexity to existing processes, or fails to adequately address the pain point of one stakeholder along the supply chain, then there is the chance that the solution will fail to incite the necessary momentum for industry uptake or address the larger problem facing the industry.

Traceability and Accountability are the Blockchain Value Propositions

Lastly, the use of blockchain as a system element arguably provided some value within each of the prototype solutions. Though Bloc often takes a critical perspective to the use and application of blockchain technology, we realised that the maritime industry is actively seeking solutions to improve traceability and accountability as a means to address widespread and complex issues. The use of blockchain for these purposes can provide an advantage in the inherent generation of an immutable chain of custody, with potential applications for insurance, carbon emissions accounting, and sustainable supply chain management. As blockchain is still a relatively new innovation with few real-world applications in the maritime field, the scaling of these solutions requires digital competence from certain actors that may not be prepared to fully understand or adopt such technology. As seen in the labs, much of the existing processes within the maritime industry are analogue and paper- or email-based. Consequently, the value propositions for the prototype solutions inherently entail efficiency gains due to the digitalisation of these processes, but also present challenges should an organisation not be prepared to take on this change.



Case Study: The Evolution of BunkerTrace

The conclusion of the first lab on marine fuel assurance saw the development of a prototype based on digital tracing for marine bunkering fuels for quality assurance. When faced with the option to further develop the prototype together, industry members declined to support the endeavour financially but offered other assistance in the form of knowledge sharing, introducing network contacts and positive communication. From the input of our consortium, Bloc also recognised that without connecting the digital to the physical to follow the fuel, a digital only application would be of limited use to the industry.

Given its innovative potential and after a successful pilot demonstration, Bloc was a finalist at the 2018 Lloyd's List Global Awards under the category of "The China Merchants Port Holdings Innovation Award". Bloc met Forecast Technology at the awards and both recognised the potential of combining Bloc's digital solution and Forecast Technology's patented DNA tracer. The joint solution would combine synthetic DNA tracers with blockchain technology to bridge the physical and digital and create a chain of custody following the fuel and its components throughout the bunkering supply chain.

In 2019, the two created a UK based joint venture called BunkerTrace and brought their teams together to co-develop and market the product. Another successful pilot and further product development helped pave the way to the attainment of BunkerTrace's first commercial contract in 2020. BunkerTrace has already been recognised as an upcoming and industry-changing innovation, attested by winning the Lloyd's List Europe Award for Excellence in Supply Chain Management in 2019.

Despite the challenges initially faced with overcoming the barrier of financing of the Building & Scaling phase, BunkerTrace is a positive example of how industry collaboration on concept development and later piloting the solution can provide the groundwork and validation to co-create impactful solutions.

Conclusion

The global and transactional nature of the shipping industry is often seen as a challenge that has led to fragmented IT systems, under-regulated markets and lack of interoperability between systems, processes and actors. However, rather than viewing the maritime industry as inordinately complex, slow to move and outdated, the global nature of this supply chain leads to many opportunities for collective goals and ambitions.

Rather than competing for the margins, companies in this space stand to gain from collaboratively solving the collective problems they share. The nature of the maritime industry represents an opportunity to rethink value in relation to the role of assets, the types of competitors and the borders of industries, or in other words, a shift towards ecosystem-driven value creation. The innovation process that underpins value creation will be largely driven by collective problem solving, new forms of governance and collaborative technologies. One such collaborative technology is blockchain. Based upon open source protocols, blockchain is positioned to drive opportunity from an ecosystem approach as well as create the basis for standardisation between the communications protocols used by the industry, thus removing the friction between jurisdictions and legacy systems.

This opportunity, however, can be tempered by the very nature of the maritime industry itself. Recent years have seen a rapid growth in the development of blockchain initiatives within the maritime field, examples of which include the Global Shipping Business Network (GSBN), TradeLens, Maqta Gateway, Samsung SDS, among others . Indeed, during the time the labs have been running, a wide range of proofs of concept have been developed in the maritime space, some of which have been developed and released to the market. As the number of these innovations mature and grow, so too does the inconsistency between technical standards and protocols. Even the blockchain technologies themselves differ, ranging between Ethereum, HyperLedger, R3 Corda and others. This raises concerns regarding different blockchain solutions' interoperability and governance , with some arguing for a neutral regulatory authority to step in and fill this regulatory gap . Others point out the risk of governments over regulating disruptive technologies like blockchain, which can dissuade many companies from investing and exploring its use and application, hindering potential valuable development and deployment opportunities .

Such points that raise concerns regarding the practical application and use of this technology serve to highlight the maturing shift in discourse and thinking from the original hype surrounding blockchain. Across the three labs that have been run within MBL, we have demonstrated that these technologies could play a fundamental role in addressing safety, risk and environmental challenges. Used as a tool to support effective, global, collaborative solutions, they enable the delivery of individual user and commercial value through the provision of neutrally governed software-underpinned systems.

MBL and its lessons can be used as guidelines for the maritime industry and other sectors in the context of collaboration and in relation to the development of technological solutions to address industry challenges:

- Collaborative forums offer a means for sectoral cooperation to tackle widespread industry challenges and test solutions.
- Open innovation and knowledge sharing is essential to create a setting for collaborative governance.
- Facilitation by a neutral party and structured approach to IP management and confidentiality addresses concerns regarding antitrust and collusion.
- Creating validated prototypes alone is insufficient, failed attempts to scale proved how such industry collaborations are not suitable for all stages of product development.
- Additional support is needed to reduce obstacles to innovation financing and break down institutional barriers towards shared ownership models.
- The opportunities to continue addressing complex industry challenges through collaboration is endless with implications beyond the maritime field.

- Further efforts should target the continued development of collaboration-based impact-driven solutions, especially those that mitigate or reduce risks and improve safety.

As the economic slowdown of the shipping industry is met with the growth of the digital economy and e-commerce, the physical processes that drive the logistics industry are being met with new ways of handling data. The opportunities and new business models derived from data management systems are there for the taking. If the maritime industry itself is to capitalise on this opportunity rather than being replaced by outside incumbents that do, open collaboration initiatives with representatives across the maritime supply chain need to be fostered and encouraged. Such collaborations can generate new ideas and potential solutions that harness digitalisation trends. This will require not just the process of digitisation but the careful creation and development of global digital infrastructure for the shipping industry. The key drivers of growth will be digitally enabled companies with innovative commercial practices, as well as the bridging between the digital and the physical without the need for intermediaries. If proven and scaled, the role of blockchain as a backbone to the next generation of federated and accessible digital infrastructure is one of the highest value driving opportunities that this technology is poised to provide to the shipping industry.

Annex 1: MBL Governance

The **steering committee** was responsible for the high level oversight, steering and governance of the MBL and helped set direction for future priorities and actions. In addition, the committee advised on, approved, and reviewed each of the MBL labs and their topics. This independent committee was composed of representatives from five organisations: Bloc Labs, Lloyd's Register Foundation, Rainmaking Transport, BLUE Communications, and Niels Bjørne Consulting. Total steering committee members were limited to a maximum of five and had to be unanimously approved by previously onboarded members. In this way, the MBL labs were governed in an agile fashion and supported by an industry consortium.

The role of the **programme director**, filled by Deanna MacDonald from Bloc, mainly acted to help establish lab working groups, identify potential lab topics, scope upstream problem sourcing and steer the lab projects to completion. Furthermore, this role encompassed proper reporting and communication of MBL lab activities to the steering committee, ensuring high-level objectives were met and consistency across labs. Additional responsibilities for this role included the reduction of risk within each lab as well as a mediator for dispute resolution. This entailed that the programme director was the first person to be notified if there were any delays within each of the labs, or if there were problems between members of the labs.

Lastly, each MBL lab consisted of a **project coordinator** and a **lab working group**. The project coordinator, also a role fulfilled by Bloc, saw the day-to-day facilitation and management of the lab working group and its constituent members. This included documentation of interviews and process tracing with consortium members; coordination of technology advice, input and development; and synthesising shared knowledge and experiences. In addition, the Project Coordinator acted as an intermediary between the upper governance levels of the programme director and the steering committee, reporting and flagging activities within each of the labs that required additional review or input.

Lab working groups were established for each lab and their respective topics. These groups included the **consortium members**, represented by relevant industry experts due to their knowledge or influence concerning the problem or challenge addressed, technologists as domain experts, and NGOs as social experts. In addition to the main consortium members, each lab working group consisted of a tailored **advisory board** consisting of external consultants and topical experts. Furthermore, **technology experts** were also brought in to provide insights into capabilities, limitations and costs relating to technological solutions and applications. All three sub-groups were tasked with the contribution of insights, expertise and knowledge, in-kind resources to define the existing processes and technologies, and validating new business models.

Annex 2:
MBL Implementation Steps

1. **Open problem sourcing** consisted of an open industry call for problems and challenges. Multiple sourcing options were pursued in this step, including but not limited to submissions made via the Bloc website page and email correspondence, conference or session topics, industry news media and communication channels, as well as personal contacts and discussions made via networking events. The problem selection process reviewed the number of times a topic was submitted or mentioned and a shortlist was created for further review and final approval of a topic by the steering committee.

2. **Value chain and process tracing** consisted of desk-based research and analysis to provide a high-level overview of the problem context value chain. This step aimed to identify the main activities associated with the selected problem topic, identify the dynamic and structure of companies responsible for each activity, and analyse the geographic scope and governance of the problem area. Conducting this step provides an overarching breakdown of the problem stakeholders and therefore the minimum viable consortium members for the MBL lab, as well as their geographic relevance and role within the problem context.

3. **Stakeholder assessment and consortium formation** based on the value chain analysis conducted in the previous step, this step utilises the areas identified within the process tracing to map the actors needed for lab collaboration. Activities consisted of reaching out to several stakeholder groups and other companies, including competitors and suppliers, and asking them their willingness to be involved within a MBL lab consortium and to identify links to other potentially relevant stakeholders and actors. The goal was to include a member for each area identified through the process mapping.

4 **Collective problem definition and concept development** consisted of reaching out to consortium members and asking them to elaborate in more detail on what they consider the problem to be, how it affects their business or day-to-day functions, what are the root causes of the problem, as well as provide input on problem boundaries and scope. This step ensures that the selected problem is viewed from multiple perspectives and pain points across the process flow or value chain are identified. In addition, this step draws forth desired aspects or functions of a potential solution from the various consortium members.

5 **Proof-of-concept development** consisted of the consortium members and the project coordinator, with support from the advisory board and technology experts, researching and assessing potential means to address the problem and associated pain points through various technology options. Though each lab specifically looked into the viability for the application of blockchain technology, this aspect can be broadened to consider other digitalisation and technological innovations. A conceptual framework outlining technology options and suggesting a possible solution or combination thereof was then created and shared with consortium members for review and feedback.

6 **Prototype testing and feedback** consisted of taking the reviewed and updated conceptual framework developed in the previous step and initiating the technical build for the proposed solution prototype. The actual technical build and its development for each of the labs differed depending on the proposed solution and its subsequent parts. Where appropriate, Bloc would draw upon expertise from the technology experts and/or bring on additional support to oversee the programming development and any necessary integrations. The prototype would then be tested end-to-end with consortium members in a simulated scenario wherein each member played a role.

7 **Value proposition testing, business model definition, and concept validation** consisted of gathering individual feedback from each consortium member regarding their views towards the prototype, potential gaps or pitfalls, what values such a solution would provide to their respective business and its operations, as well as information on whether this solution would have a business case. Taken together, these aspects provide an indication of whether the proposed solution and its concept are validated by industry actors.

Annex 3: Industry Consortium

The process tracing exercise for bunkering helped to identify the type of stakeholders that should be included in the consortium. After reaching out and garnering interest in MBL, a consortium was brought together to (1) bring industry expertise and process knowledge; (2) design an initial prototype to demonstrate proof of compliance with requirements (technical, operational, human) in a simulated setting; and (3) provide feedback while assessing the value propositions to their operations.

Representatives from the following organisations took part in the MBL lab:

MÆRSK

A.P. Møller - Mærsk is the world's largest container shipping company, with a fleet of over 700 vessels. Mærsk provided insights into the process of hiring and managing crew onboard, the current systems for managing crew and the pain points in that process, as well as tested the proposed solutions.

Agility

Agility Global Integrated Logistics offers ocean, air and road freight, warehousing and distribution, and integrated supply chain services in more than 100 countries. Agility represented the perspectives and insights of transporters of dangerous goods, and helped to assess potential impacts on operations and ability to ship dangerous goods.

BIMCO is the world's largest international shipping association, with around 2,000 members in more than 120 countries. BIMCO participated as an advising partner on contractual aspects of bunkering, leveraging the industry association for sourcing of knowledge, funds and dissemination of best practices.

C-LOG is a start-up focusing on enabling dynamic, transparent and secure data collaboration among stakeholders in the maritime industry. C-LOG provided knowledge on the front-end certification management process, securing authenticity of crew certificates.

Copenhagen-Malmö Port (CMP) is a full service port, and offers transport and logistics services as one of the largest port and terminal operators in the European Nordic region. CMP provided insights into how ports manage and monitor shipments of dangerous goods.

DSV is a global supplier of transport and logistics services and provides and manages supply chain solutions. DSV provided insight into the process of shipping and documenting dangerous goods, and helped to assess potential impacts on operations and ability to ship dangerous goods.

Exis Technologies is the leading supplier of compliance systems for the management of dangerous goods in sea transport. Exis Technologies and their solution HazCheck provided knowledge and input on the declaration of dangerous goods and required documentation verification processes.

Flexport is a digital freight forwarding and customs brokerage company. Flexport provided insight into the process of shipping and documenting dangerous goods, and helped to assess potential impacts on operations and ability to ship dangerous goods.

GoodFuels is a one-stop shop for industry customers integrating the entire supply chain for sustainable biofuel. GoodFuels is a supplier of marine bio fuels and participated as a fuel supplier.

Hanseaticsoft's system offers a single, cloud-based source of centralised information for all employees, crews at sea and external partners, that drastically reduces data exchange efforts. Hanseaticsoft provided technical feedback and shared insights on integration options to their online crew management tool.

Heidmar Inc. is one of the world's leading commercial tanker operators with a fleet of approximately 80 ships. Heidmar provided early insights and discussions, including knowledge into the process of hiring and managing crew onboard and test proposed solutions.

Lloyd's Register Group (LRG) is a marine classification society and provides independent assurance, consulting, and advisory services. LRG participated as an advisor and advocacy partner. **Lloyds' Register Fuel Oil Bunker Analysis and Advisory Service** team is Lloyd's Register's fuel testing services. LR FOBAS shared knowledge and information about the fuel supply and quality testing process, as well as provided bunker quality test data for the building and piloting phase. LR FOBAS provided an environment for piloting and input to dispute resolution.

Marine Transport International (MTI) specialises in moving cargo around the world, bringing technology and logistics together. Their Adapter solution is an open modular integration tool that allows teams to create, connect and manage distributed ledgers, enterprise DLT networks, smart contracts, data mapping and data flows. MTI provided technical expertise and knowledge relating to the transport of dangerous goods.

myCert is a digital platform that acts as a veritable digital ecosystem for all maritime certificates, connecting the issuers, holders and verifiers. mycert provided insights on integration options and further scaling of the solution.

Navozyme is a start-up focusing on digitally secured maritime certificates. Navozyme provided insights and contributed to the consortium's discussions on the conceptual framework of the proposed solution.

Philippine Transmarine Carriers (PTC) is a large crew and ship management company based in Manila deploying thousands of Filipino global maritime professionals annually. PTC provided input on the management of crew certification and training, market insights and seafarers' perspectives, identity management and hiring, as well as insights into current systems and R&D.

Port+ is a business partner for companies serving ships and terminals in the port communities of Belgium and Zeeland. Port+ provided early insights, including knowledge into the process of declaring dangerous goods to Port Authorities.

Precious Shipping is a pure dry cargo shipowner operating in the Handysize, Supramax and Ultramax sectors of the tramp freight market where ships do not have a fixed schedule or published ports of call. Precious Shipping participated as a buyer and off-taker of marine fuel oils.

SecureSystem and their sensor technology delivers an IoT-enabled supply chain intelligence solution for the security and integrity of shipments. SecureSystem provided technical expertise and support relating to active monitoring of dangerous goods container shipments.

Shell Shipping & Maritime provides commercial, ship management and technology services, along with assurance advice. With an interest in around 2,000 vessels, including managing one of the world's largest fleets of LNG carriers, Shell plays a vital role in the safe and secure delivery of energy around the world. Shell provided knowledge about seafarers, crew and ship management, as well as insights and learnings from the broader offshore industry.

The Liberian Registry is the world's second largest Flag State with over 4,500 vessels representing over 12% of the world's ocean-going fleet. The Liberian Registry aims to combine the highest standards of safety for vessels and crews with the highest levels of responsive and innovative service to owners. Liberian Registry provided insights into certificate issuance and endorsements.

The International Bunker Industry Association (IBIA) is the voice of the global bunker industry and represents all stakeholders across the industry value chain. IBIA participated as an advisor and advocacy partner.

The Mission to Seafarers is a charity serving merchant crews to help and support the 1.5 million people with welfare and emergency support services. The Mission to Seafarers represented the global seafarers sharing perspectives and insights from their members, including how we could add value to the individual seafarers.

X-Press Feeders is the largest independent common carrier in the world, providing transportation services to container operators. X-Press Feeders provided knowledge and information relating to the shipment of dangerous goods between shipping liners.

Date
December 2020

Authors
Katrina Abhold and Deanna MacDonald (Bloc)
and Gary Pogson (Lloyd's Register Foundation)

Bloc and Lloyd's Register Foundation (2020).
"Findings & Conclusions"
Maritime Blockchain Labs Topic Brief under grant no. XXXXX

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