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Matchmaking the Emerging Demand and Supply Need in the Maritime Supply Chain Domain: A System Design Framework

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Abstract: The maritime supply chain is a colossal ecosystem and the interface of the intercontinental trade market. Within this ecosystem, freight transportation is considered a fundamental component of all supply chain systems. As a matter of its demanding multimodal and intermodal character, freight transportation is a highly competitive market where actors involved, demand reliable and high-quality services at competitive prices. However, even though its systems keep evolving, being spurred by developments at multiple levels, the maritime actors' fundamental operational processes keep an unprecedented low pace of evolution and transformation, and the maritime supply chain market is considered to be as hyper-fragmented as ever. This paper investigates how the effective, efficient, and sustainable matching of the demand and supply needs of the actors involved in the maritime supply chain domain can be strategically achieved and supported through specialised information systems. The paper, also presents a holistic framework for designing these systems. The analysis was based on the outcomes received from a number of interviews conducted with strategically positioned experts, pointing out their emerging needs and the challenges they face. The outcomes showed that digital transformation is still in its infancy but that the embracement of a decision-matchmaking system could be a real game changer.

Keywords: matchmaking system; transportation needs; maritime ecosystem; supply chain; framework; sustainability; architecture of integrated information systems; event-driven process chain diagrams

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1. Introduction

Since the 1950s, the world's international trade has increased continuously while supply chains have evolved massively. Within this expansion, maritime transportation keeps a dominant role by handling almost 80% of the volume and 70% of the value of international trade [1]. As a consequence, freight shipments have been increasingly expanded throughout the years, and the majority of the cargo volumes carried by specialised bulk fleets have been gradually undermined by the growing competition of global container operators. This new era of commencing containerisation provoked unbalance in the maritime transportation ecosystem as it caused the reconsideration of its independent position as a node in a global network, which allowed the interconnection between the foreland with the hinterland [2].

Within the repositioned maritime transportation ecosystem, freight transportation, which can be described as the 'physical process of transporting commodities and merchandise goods and cargo' [3], enabled the movement of goods between many distant locations. Freight transportation is considered a fundamental component of all supply chain and logistics systems [4]. The mobility of freight is vital to every national economy's resilience and corresponding economic development due to its intensive use of infrastructures [5]. The imperative importance of freight transportation for the European economy, as well, is mirrored in one of the goals of the European Union (EU), which is to create a sustainable, greener, and efficient transportation network by 2050 with the Trans-European Transport (TEN-T) Network policy, which attempts to integrate all transportation modes [6]. As a matter of its demanding multimodal and intermodal character, freight transportation is a highly competitive market where customers require and demand reliable and high-quality (both in terms of cost and time) services at competitive and low prices. Nowadays, freight transportation systems keep evolving at an unprecedented pace, being spurred by developments at multiple levels, such as the accelerating digitalisation of economies, the undeniable growing environmental awareness, and notable technological advances and developments [7].

Ocean transportation, alternatively named maritime transportation or waterborne transportation, is an integral part of the supply chain for most industries and the backbone of global freight distribution due to its nature to combine the capacity and ability to carry freight over long distances and at low costs. According to Rodrigue and Browne [8], maritime transport nowadays keeps its dominant role in international trade, as around 80% of the majority of goods are transported by ships [9]. However, the challenges it faces are only getting greater. The increasingly challenging economic environment which leads to imbalances between demand and supply (Figure 1), as well as that of traffic flows, at origins/destinations (backhaul traffic challenges), the volatile freight rates, [10] and the rapidly changing (mainly environmental) regulatory framework, which tries to speed up the decarbonisation of the sector [11,12] in order to meet the sustainability requirements, are only some of the emerging challenges that the maritime sector is continuously asked to respond to and find solutions to overcome.

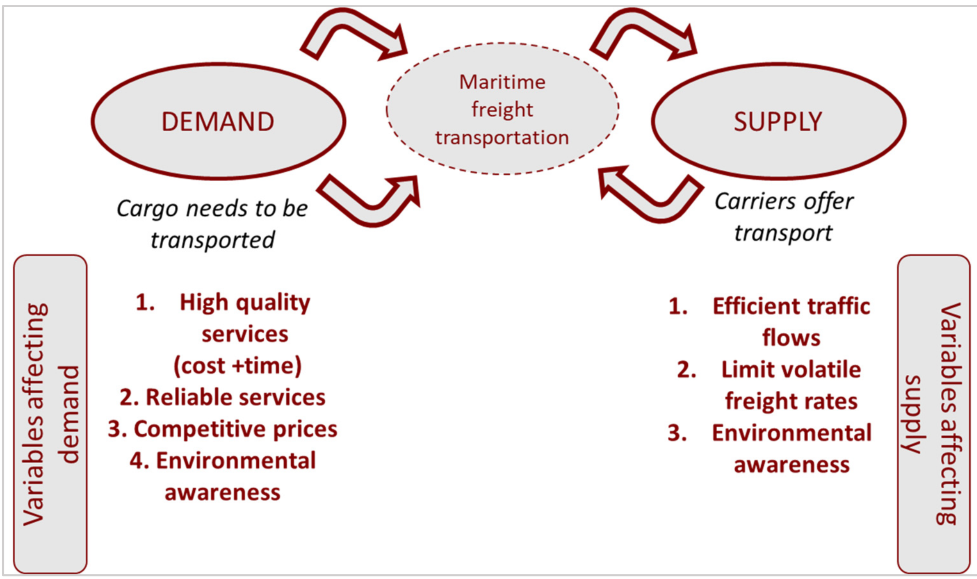


Figure 1. Relationship between demand and supply.

At the same time, the maritime industry is a constantly evolving business sector which continuously tries to maintain its competitiveness by embracing innovation, which is widely recognised as a determinant of success. Disruptive technologies and systems have been recently receiving a lot of attention, in part, due to their strong potential to revolutionise the landscape of the maritime industry and make it more efficient, collaborative, green, and sustainable. Sustainability, decarbonisation, and energy efficiency are among the top priorities of the maritime sector throughout its entire supply chain [13]. Digitalisation is a key factor and acts as a driver to decarbonisation, as it is the proven enabler of new concepts of transparency and collaboration and, at the same time, of the provision of complete and integrated data for better decision-making [14].

Towards the same direction, the maritime supply chain ecosystem involves various parties, who, indubitably, need to sustain their position in the maritime market and remain competitive. Lun et al. [15] mentioned that demand for commodities in a given location is the driving force and triggers the supply for shipping services and freight transport. It is, therefore, evident that the movement of cargo freight by sea transportation comes as a consequence of trade between one party (the consignor) that is selling commodities to another party (i.e., the consignee), who is the person or company to whom the commodities are shipped. Thus, they need to frequently examine the market situations of supply and demand mechanisms, as the maritime sector is considered very volatile with a lot of fluctuated aspects, including containerisation, trade volumes, fleet capacity, freight rates, etc. (Figure 2) [9,16,17]. By also taking into account the sensitive and fluctuating nature of the shipping industry, it makes imperative the need for all parties involved to be concerned and actively, rather than promptly, reacting to market situations constantly and continuously. It seems that timely decision-making is becoming a pivotal moment in the shipping industry.

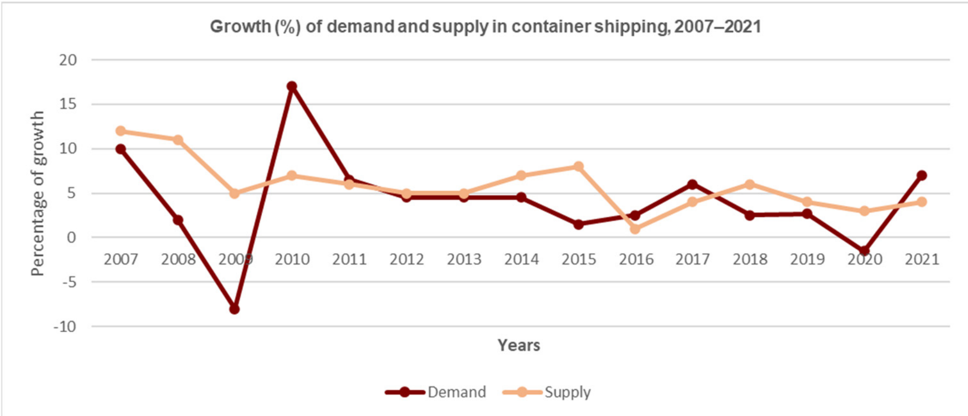


Figure 2. Growth (%) of demand and supply in container shipping, 2007–2021 [17].

Effective decision-making, which refers to timely informed decision-making and effectiveness, was first introduced back in the 1960s by the concept of "information systems". However, at the beginning of the 21st century, due to the need to collect large amounts of information, Enterprise Resource Planning (ERP) Systems were made available, providing a complete view of real-time business data [18]. Within the shipping industry, where a huge pool of information has to be managed effectively and efficiently to sustain its competitiveness, proactive communication between the key actors is more than important for reducing the hassle, as well as the risks, associated with their business operations and development. Therefore, the use of technologically advanced information systems is more than imperative. In addition, as underlined by Russo et al. [19], it is often characterised as more time-consuming to solve administrative and financial issues than to execute the physical movement of goods. Considering, also, that key actors continue to operate and collaborate via the use of obsolete means of communication (e.g., fax machines), the situation is becoming even more challenging due to the significant waste of time and financial resources, as well as of the cascading effects that are created between demand and supply. As mentioned by Trelleborg [20], in contrast to other transport industries, the maritime industry lags behind concerning the use of information and communications technology, with only a few players within the maritime domain currently leveraging big data. The same vision is also shared by Zeng et al. [21], who underlined that even though information systems have substantially supported the smooth running of maritime supply chain operations, their level of acceptance within the maritime sector remains variable and fragmented. This reluctance can be justified by a number of identified barriers to successful digital transformation [22], such as the existence of heterogeneous and independent information systems and a lack of standards and cooperation among stakeholders, etc. However, as stated by Russo et al. [19], emerging information communication technology can efficiently ease the horizontal interactions between the different actors involved and enable a more advanced level of communication between them.

Considering all of the above and based on recent attempts that reveal a penetration of digitalisation into the maritime sector [22,23], this paper aims to investigate how the effective, efficient, and sustainable matching of the demand and supply needs of the actors in the maritime domain can be strategically achieved and supported through specialised information systems. The paper also presents a holistic framework for designing such a system.

2. Materials and Methods

System design processes, in general, are considered highly iterative and demanding processes, which should result in a validated set of requirements and a validated design solution that satisfies a set of stakeholders' needs [24]. In the literature review, there are a few different types of system development methodologies, which give particular emphasis on how stakeholders are involved in the system or are catered for [25], which typically consists of four steps: developing stakeholder expectations, technical requirements, logical decompositions, and design solutions [24]. However, these methodologies find it difficult to set requirements representatively into context for both the stakeholders and systems engineers/developers and do not consider the user sufficiently in the design process.

The following approach within this paper for a matchmaking system design framework is based on a personas-oriented method. The persona method is a part of the user-centric design (UCD) method, which is a recognised and established method (e.g., ISO13407: human-centred design processes for interactive systems) for system planning towards giving an emphasis on the involved users' needs. Persona-centric service design methodologies denote all actors involved in a service system as personas and demonstrate their interactions toward fulfilling their needs [26].

The initial step in this process was the identification of the key actor categories (shippers, freight forwarders, carriers) as well as the challenges they face through the literature review in order to understand their needs derived from the interview process. The next step in our design process was the identification of the required scenarios. The addition and embracement of this step, as part of our system design approach, was based on the fact that scenarios help both stakeholders and system designers to understand how a process moves from point to point without misunderstanding and/or losing critical aspects of the system. According to Rosson et al. [27], scenarios are high-level informal narratives describing the actors' interactions with the matchmaking system so as to achieve their goals. A scenario is a story about how a system may be used to improve existing processes. A scenario is also more comprehensible by people since it is described in the form of a coherent narrative story, and consequently, it is easier to follow. According to McKay [28], 'A scenario describes a specific target user trying to achieve a specific goal or perform a specific task in a specific context'. Scenarios may include references to more than one actor. Scenarios are considered appropriate whenever there is an intention to describe a system's interaction from the user's perspective.

The upcoming step toward the direction of the system design modelling process was the elicitation of the key functionalities/requirements and their prioritising. The requirements elicitation process is related to the search for information concerning the functions that a system should perform and for the constraints beneath which the system should operate [29]. According to Holbrook [30], requirements analysis is described as the process of identifying user needs and of determining how a system can be designed. This paper capitalised on the scenario-based requirements elicitation method (SBRE) [30], which facilitates both the development of a high-level design and, at the same time, a realistic set of requirements. Last but not least, the concept of functionalities' prioritisation emerged with the increased demand and need for complex information systems by stakeholders [31]. According to Bukhsh et al. [32], requirements prioritisation is a decision-making process where information system engineers try to elicit the actors' demands with the view of defining an implementation order of the requirements. The prioritisation technique that has been followed within this paper is MoSCoW analysis [33]. MoSCoW was initiated and developed with the aim of reaching a common understanding among the actors of a system on the importance they place on each requirement. Each of the four prioritisation categories (Must have, Should have, Could have, and Won't have) constitute the term MoSCoW, while the interstitial Os have been inserted to make the word pronounceable.

The final step in the system design framework process was the modelling process via the employment of event-driven process chain diagrams (EPC). Event-driven process chains (EPCs) diagrams are used to describe the operational sequence of business processes and workflows. The purpose of documenting the processes in EPC is to systematically describe how the system should support the matchmaking process. At the same time, EPC diagrams represent a formal and comprehensible way to communicate the systems requirements drawn up by the analysts to the system developers. EPC diagrams are a diagrammatic language within the control view of the ARIS framework. The ARIS (architecture for integrated information systems) is a concept that can be described as a framework for the development and the optimisation of integrated information systems as well as for the description of their implementation [34]. According to Scheer [35], the event-driven process is a set of related tasks or activities performed to produce a product or service. The event-driven process consists of events triggering activities. The event-driven process describes which activities are performed during a process, who participates in the process execution (persons, groups of persons), what data are used as the input and output, which IT systems are involved, and which events take place during the execution process.

Figure 3 below presents graphically the approach to the design process followed in this study.

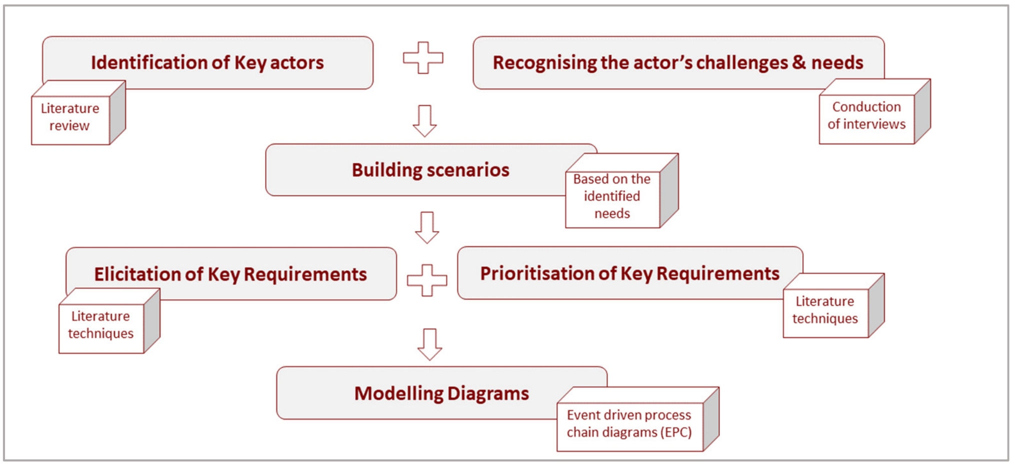


Figure 3. The approach to design process.

3. The System Design Framework

3.1. Actors within the Maritime Freight Transportation Process

From the supply chain management ecosystem to the maritime transportation ecosystem and shipping, transactions involve multiple actors in multiple fields (Figure 4) [36]. For example, in the regulatory field, there are the national and European regulatory bodies, the flag and coastal states, etc.; in the legal field, there are the layers, the maritime courts, etc.; in the financial field, there are the banks, the stocks, the shipbuilders, etc.; in the technical field, there are the ship repairers, the ship scrapers, the insurers, etc.; in the operational field, there are the bunkers, the port staff, and the cargo handling staff, etc.; and, finally, in the commercial field, there are the shippers, the carriers, the freight forwarders, the brokers, the agents, the charterers, etc. [36].

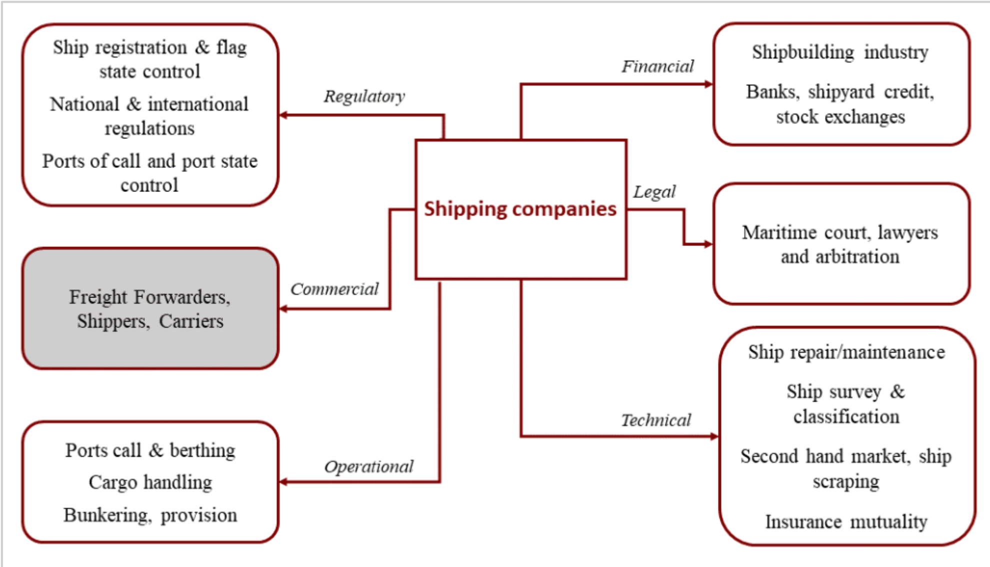


Figure 4. Maritime industry players in different fields.

Such actors involved have, as an ultimate aim, strategic collaboration and cooperation, which, in turn, emerges as the need for a highly competitive environment with the view to increase their scope. More specifically, within the movement of cargo by sea, which is a fundamental part of efficient logistics, we can distinguish three main key actors. These actors are the exporter (also referred to as the consignor or shipper), who sends the commodity to another party, the importer (also referred to as the consignee or as the receiver), who is the party that receives the commodity and the carrier and is the party who delivers the commodity [37] (Figure 5).

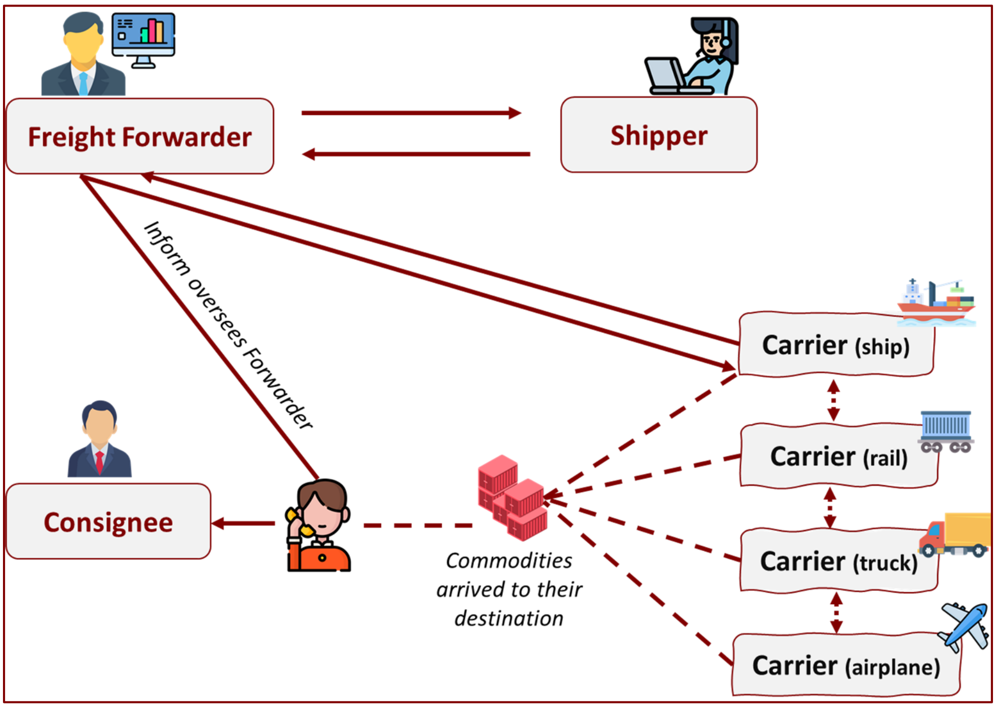


Figure 5. Actors involved in the maritime supply chain.

In more detail, a consignor (the shipper) is the actor that ships the commodity. It is a person or company who is usually the supplier or owner of the commodities shipped; it may be a factory or a distribution centre, or anyone really, that has signed a contract to ship goods. The ownership of the goods remains with the consignor until the consignee pays off for them. The consignee is the recipient of the commodity that is being shipped and, therefore, is the customer or client. They could be an individual or a company, or even an agent or a bank nominated by the buyer. A carrier is a person or company responsible for the transportation of the commodity until it reaches its destination and is responsible for any possible loss of the goods during its transportation. Carriers can make use of a variety of shipping modes, including ships, airplanes, trucks, and railroads, and they often capitalise on using multiple modes for a single shipment.

At this point, it is worth mentioning that among the aforementioned key actors, a substantial part is also undertaken by freight forwarders. A freight forwarder, otherwise called a forwarder or forwarding agent, is a person or company that is responsible for coordinating and shipping commodities for individuals or companies to get goods from the manufacturer or producer to a customer, market, or final distribution point. Freight forwarders usually get in contract with a carrier or multiple carriers via air, marine, rail, or highway to guarantee the shipment of goods between different countries. A freight forwarder does not actually move the goods but acts as an expert (or intermediate) in the logistics network.

In addition to the shipper, the freight forwarder, and the carrier, sometimes, though rarely, a third party may be involved in the commodities' shipment and logistics operations. This party is called the "third-party logistics provider (3PL)". The difference between a freight forwarder and a 3PL is that a third-party logistics provider typically offers many more services (such as order management, fulfilment, shipping, warehousing, packing, delivery, shipping, and other related functions) than a freight forwarder (including freight forwarding). The 3PL does not own the products that are being shipped but act as an intermediary. As a matter of fact, the shipments that are destined for a third-party logistics (3PL) company cannot list the 3PL as the consignee, as the consignee is the owner of the commodity who has actually paid the corresponding cost for it [38]. Last but not least, 3PL, as well as 4PL, and 5PL, are rarely involved in the cargo shipping process.

Transportation in the maritime chain is a really complex process and varies between different modes of shipping (e.g., liner shipping, bulk shipping, etc.). However, following an extremely simplified description, maritime freight transportation can basically be divided into three main parts: a sea voyage and two land-based transportation. The commencement of transportation begins at the production site, the factory, or the distribution centre, where the commodities or goods are usually stored before being moved and shipped to their destination. From the storage location, they are transported to the port, usually by a truck or a train (if the location permits). At the port area, they are usually stored in the container yard before being loaded onto the ship and transported by the carrier (via sea, air, road, or rail) to their final destination [39].

The freight transportation process starts with the consignor/shipper (the cargo holder), who usually hires a freight forwarder in order to arrange, on his behalf, the transportation of the freight. According to Schramm [40], the reason that the shipper employs the freight forwarder to deal with the cargo/freight transportation process is based on the fact that the rise in costs is more than that compensated by the value of the forwarder's service in reducing transaction costs. As a matter of fact, the forwarder is competitive as long as his charging fee is lower than the consignors' cost of arranging the transportation himself.

The freight forwarder, who communicates with the shipper via phone, fax, or email, acts as a representative of the shipper, and he undertakes, via a forwarding contract, the responsibility of transporting the goods. According to Stopford [39], sometimes, the freight forwarder only acts as a "contracting carrier", who procures the actual transportation to one or several "performing carriers". Consequently, the forwarder using a wide network of carriers, arranges, via phone, fax, or email, the carriage of goods by land, sea, or air within a certain country or across borders, both effectively and efficiently (timely and monetarily), and their transportation from the production site, factory or distribution centre to the nearest port container yard and finally to their destination [37] (Figure 6).

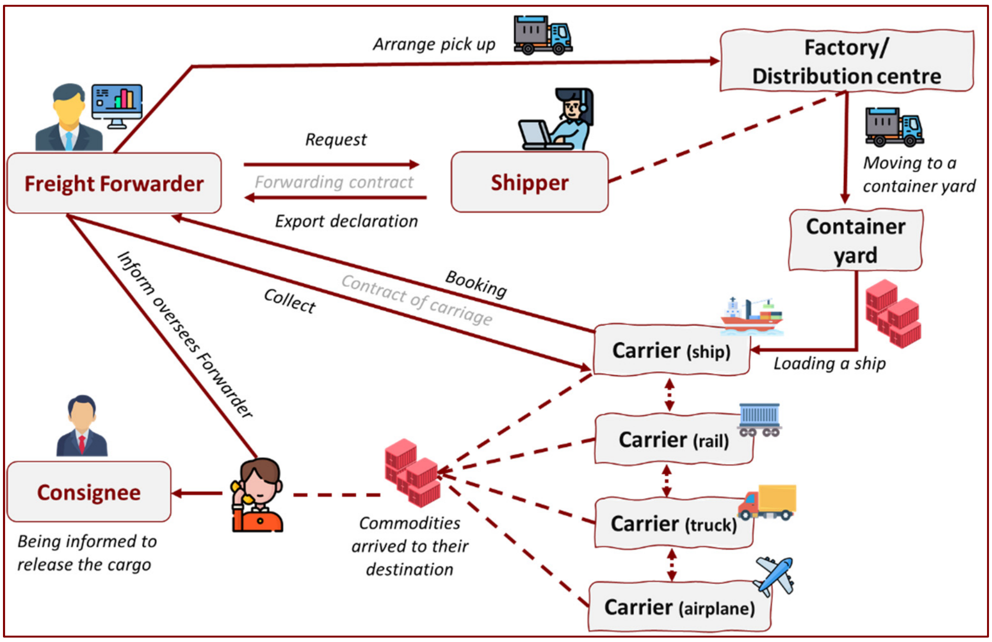


Figure 6. Description of freight transportation process.

Acting as an intermediate, the freight forwarder must provide the shipper with—but not limited to—the quickest and cheapest way of transportation (they have extensive knowledge of knowing and negotiating the freight rates), ways to solve any potential packing problems that may arise for the freight and/or cargo transportation, a way to deal with the customs clearance, trade regulations, and other required extensive documentation, insurance coverage and dealings with insurance claims for the transportation of commodities, advise on warehousing and distribution—if needed—and supervision both effectively and efficiently (both timely and monetarily) of the storage and movement of goods [41]. As a matter of fact, freight forwarders have become, in the process, supply chain, warehousing, packaging, and documentation experts, without requiring assets in terms of ships, trucks, trains, or planes. As such, the freight forwarder is positioned strategically within the wider transportation market, and it can be said that he serves as a manual platform between the shippers and carriers towards optimising time and costs and representing reliability [42].

3.2. Research Interviews

Within the current study, a qualitative research methodology based on semi-structured interviews was followed. The semi-structured interviews followed a conversational mode enhanced with instantaneously generated questions during the interview. Interviews were used, as the intention was to emphasise getting as much information on the processes, roles, responsibilities, and interactions as possible. Interviews also served the purpose of stimulating discussions with the relevant stakeholders and eliciting thorough feedback on a variety of points of interest.

In total, 15 interviews were conducted with representatives from all the key actor fields of operation. More specifically, the following categories of experts have been interviewed: 4 freight forwarders, 4 shippers, 2 consignees, and 5 carriers. The aim was to collect information about their roles, their responsibilities, their interactions with the rest of the key actors in the maritime shipping supply chain, and their current needs, as well as make suggestions and recommendations on how to enhance their collaboration with the rest of the key actors. The interview questions covered 3 main pillars: the current practices, the daily challenges, and potential planning/facilitating tools. The aim was to identify the actors' role within the maritime supply chain, to collect detailed information about the current process, to recognise the peculiarities in the interactions among the involved actors, to be familiarised with the data transmitted, to be informed about the communication channels that are currently in use, and to point out the associated risks. At the same time, the interview participants were asked to provide their viewpoints and feedback about any systems they were using and if and how an improvement of the process was needed or required for their businesses.

3.3. Emerging Needs

Although maritime transportation is expanding rapidly due to the current digital transformation of the systems, the maritime actors' fundamental operational processes have kept an unprecedented low pace of evolution and transformation since the 1980s. Part of the freight forwarding industry continues (even nowadays) to cooperate with the rest of the key maritime supply chain actors using analogue rather than obsolete means, namely, physical paper, fax machines, telephones, and in-person presence [43]. Robinson [44] mentioned that, even in 2020, these disjointed communications had become the norm in freight management for finalising a shipment from dock to dock. However, this status quo is no longer efficient and sustainable for the freight forwarder, as the waste of time and financial resources in the manual processes is significant. According to Yaron [43], freight forwarding still suffers from analogue processes and missing transparency, and it is subject to disruption by digital technologies. On top of that, not only freight forwarders but also shippers and carriers face rapidly eroding margins, in every and each process of the transportation of freight, due to unnecessary inefficiencies.

On the other side of the fetch, the number of freight and/or cargo transportation companies (including carries and freight forwarders) have embraced digitalisation in their activities and have leveraged technology trends, such as SaaS, real-time monitoring, blockchain, AI, etc. (e.g., Cluster Community System [45], CargoStream [46], Mix-Move-Match [47], AEOLIX [48], TradeLens platform [49], Naviporta [50], eCustoms [51], and ENTRANCE EU Matchmaking Platform [52]). As a matter of fact, and in order to keep up with an effective and efficient horizontal collaboration, they have modernised their information systems and come up with products, such as the matchmaking systems, by aiming to fill the gap between supply and demand and optimise the shipping process via maritime supply chain actors who are in contact and automate some of the communication procedures. However, even though the aforementioned systems pave the way for an interconnected maritime supply chain world, they have addressed the needs of only a part of the actors in the maritime supply chain, such as shippers, LSPs, etc. Their services need to address more actors in the maritime supply chain; instead, they do not cover the whole spectrum of the needs as they focus on solving particular problems (e.g., documentation services, data sharing without optimisation, etc.).

As an effect of the above, freight transport systems are trying to cope with an ever-growing demand and increasingly stringent requirements. According to Tavasszy and Reis [7], the pressures for performance improvement in the supply chain, in terms of costs, speed, reliability, and safety, are still increasing. Lun et al. [15] highlighted that when demand for shipping capacity is uncertain and a significant lead time may exist for additional capacity, shipping firms must proceed with care but also make rapid considerations about their capacity decisions. In recent years, technology has provided the real-time monitoring of flow, processes, and resources and also transparency across multiple points (e.g., blockchain). What the industry needs to do, is leverage digital capabilities and embrace the collaborative perspective. According to Deloitte [42], matchmaking platforms/systems have to enable direct interaction between two or more sides.

On top of that, there is still high demand, for integrated services, following the increasing trend in intermodal freight transportation [42]. Arjen and Berg [53] defined intermodal transport as a combined transport by two or more modes. In a globalising marketplace with dwindling transport costs, shippers increasingly expect the freight forwarders and their carriers and logistics service providers to supply more rapid and reliable delivery services so as to minimise the costs associated with distance (which has negative elasticity) warehousing, inventory holding, and other aspects of production and distribution [15].

Carriers must also supply the right containers at the right time and in the right place to shippers. At the same time, they need to ensure that empty containers are available for the use of shippers, as otherwise, they need to cope with the associated costs (equipment cost, storage cost, movement cost, and administrative cost) [15]. Following a common consensus from the interviews conducted, it was admitted that a system providing a dynamic update of transport statuses based on near-real-time data could be a real game changer for the efficiency of freight transportation and the sustainability of the maritime supply chain domain. At the same time, the automation of such processes would definitely lead to the daily operations' improvement as well as to increased productivity and operation sustainability.

In the highly competitive maritime transportation and distribution service industry, it is imperative that demand and supply needs be accommodated rapidly in order for commodities to be moved with efficiency and at lower costs. Consignees are demanding improved services that only technology and information systems can provide. To meet the aforementioned needs and challenges, the key maritime supply chain actors require a decision-matchmaking system that can provide information for the freight and cargo transportation and delivery, with information including—but not limited to—the available transport modes, the best (in terms of time and cost) schedule and routing for the freight, re-planning and re-routing options, tracking technology, and cargo consolidation.

The decision-matchmaking system must have a set of matchmaking system features, such as:

- Authentication/authorisation processes,
- The availability of actor profiles (including certification requirements, e.g., freight forwarders must meet ISO 9000 quality certification standards),
- The insertion of cargo details and transport characteristics,
- Features of the schedule,
- Capacity and cost details,
- The availability of transport options ranking,
- Price requests/quotations,
- Messaging capabilities,
- Order confirmation and capacity updates,
- Order editing and route recalculations,
- The provision of alternative transport modes and associated costs,
- The display of route characteristics (timing, stops, costs, etc.),
- Instant communication channels between shippers,
- Carriers and freight forwarders,
- The collection of datasets in a specific and unified format,
- The reporting of order details and automated invoicing.

In parallel, it must include the reporting of transport services, including several attributes, such as the associated environmental footprint, the number of transhipments, and the estimated time of arrival (EtA) and departure (EtD). The ability of a system to provide a feature for the estimation of GHG emissions could actively motivate the user to proceed with a more environmentally friendly transport mode selection when, especially, there are cases with similar delivery times and costs. Furthermore, the ranking of carriers based on their provided services through a transparent rating scheme could optimise the quality of the provided services and reward the most efficient and reliable providers. Such actions could be a stepping stone towards the reduction in the associated environmental footprint and towards meeting climate neutrality targets imposed by the European regulation.

3.4. Identification of System's Scenarios

According to Rosson et al. [27], scenarios are high-level informal narratives describing the actors' interactions with the matchmaking system so as to achieve their goals. A scenario is a story about how a system may be used to improve existing processes. A scenario is also more comprehensible by people since it is described in the form of a coherent narrative story, and consequently, it is easier to follow. Scenarios may include references to more than one actor. Scenarios aim to help designers understand what motivates actors/users when they interact with a system—a useful consideration for ideation and usability testing [54]. Table 1 below presents the identified scenarios as part of the current study.

Table 1. System Scenarios.

Scenario 1: Account/profile creation process	The user needs to enter into the system. The system requires the acquisition of the user's credentials. The user's credentials are generated from a profile/account creation process by requesting a number of obligatory parameters, such as name, surname, email, user name, and password. When finalising the signing up and before using the system, the user is asked to set his/her profile and provide the corresponding mandatory details (the category he/she belongs to, the name of the company, location, contact email, certification ((if it is a freight forwarder)), and a short description of activities).
Scenario 2: New order initiation	The user (in this case, a shipper or a freight forwarder) enters into the systems, using his/her credentials, and starts a new order. The system opens the order unified interface and asks the user to insert input parameters regarding his/her cargo (type, volume, weight) and the details of the required transportation (origin, destination, departure/arrival). The system then provides the available transportation options and requests the user to select the preferred criteria (cost, total duration, emissions). The system analyses and presents the routes that fulfil the requested order's input parameters and sorts them in order of preference based on the defined selection criteria. Each route includes information regarding the mode of transport (or possible combination), the total cost, the total duration, and the total emissions. The system asks the user to assess the available routes and their characteristics and select the preferred one. The system confirms the order and exports a report with the selected route, along with its characteristics. The user receives the payment invoice and then proceeds to the payment in order to confirm the order. The system transfers the user to a secure environment, where he/she executes the payment. Then, the user receives proof of payment, and the transportation request is sent to the selected carrier.
Scenario 3: Rating of provided service	When the order reaches its destination, the system notifies the user, and a rating process is available so as to give his/her feedback on the selected carrier(s), based on the service provided.
Scenario 4: Edit order	The user enters into the system by using his/her credentials. The user (in this case, a shipper or a freight forwarder) requests to edit an existing order. The system asks the user to edit the required parameters regarding his/her cargo (type, volume, weight) and the details of the required transportation (origin, destination, date, etc.). The system analyses and presents the routes that fulfil the requested order input parameters and sorts them in order of preference based on the defined selection criteria. Each route includes information regarding the mode of transport (or possible combination), the total cost, the total duration, and the total emissions. The system asks the user to assess the available routes and their characteristics and select the preferred one. The system confirms the order and exports a report with the selected route, along with its characteristics. The user then proceeds to pay (if required) in order to confirm the order. The system transfers the user to a secure environment, where he/she executes the payment. If the payment balance is positive, the user is asked to pay it, while if the balance is negative, the credited amount is stored in the payment system to be redeemed on the next order. Then, the user receives proof of payment, and the updated transportation request is sent to the selected carrier.

Table 1. *Cont.*

Scenario 5: Carrier availability insertion	The user enters into the system by using his/her credentials. The user (in this case, a carrier) requests to add a new transportation option. The system opens the transportation option unified interface and requests the user to insert the input parameters regarding the new transportation option (means, route ((origin-destination)), duration, time schedule, capacity, cost, emissions, etc.). The system creates the new route and makes it available.
Scenario 6: Order assignment	The user (in this case, a carrier) enters into the system using his/her credentials. The user receives a notification about the receipt of a new order request based on one of the available transportation options. The system requests the user to accept the assignment. Once the assignment is accepted, the system asks the carrier to update the transportation status, so the order can be easily tracked by all involved actors (the shipper or freight forwarder and carrier(s)) and provides him with an assignment confirmation report.
Scenario 7: Messaging functionality	The system is initiated, and the user logs in to the system using his/her credentials. The user selects the messaging functionality and types the name of the user he/she would like to contact in order to react to the aspects that are not covered by the standardised elements of the systems (e.g., price negotiation, customs arrangements, cargo insurance, etc.) and communicates the message. The system provides a notification to the communicating parties when a new message is available.
Scenario 8: Occurrence of an unexpected event	The carrier is informed about an unexpected event during the cargo transportation (severe weather) that causes its immobility. The user initiates the system and logs in using his/her credentials. An instant updated notification is sent to the shipper or the freight forwarder.

3.5. Elicitation and Prioritasion of Requirements

The requirements elicitation process followed the scenario-based requirements elicitation method (SBRE), where a decomposition of the scenarios to requirements was made by taking into consideration that the derived requirements can be considered complete, consistent, and verifiable [30].

The prioritisation technique followed within this study was MoSCoW analysis. MoSCoW was initiated and developed with the aim to reach a common understanding, among the actors of a system, on the importance they placed on each requirement. Each of the four prioritisation categories (Must have, Should have, Could have, and Won't have) constitute the term MoSCoW, while the interstitial Os have been inserted to make the word pronounceable.

More specifically, the categories of the MoSCoW technique [33] are as follows:

- *Must have:* Requirements labelled as MUST are considered high-priority items or key features. If even one MUST requirement is not included, the system development should be considered a failure.
- *Should have:* SHOULD requirements can add value to the system and make it more appealing and successful, and they are also considered important and of a high value to the user. However, the system can be launched without them.
- *Could have:* requirements described as COULD are desirable but not necessary and could improve the user experience or user satisfaction These will typically be included if time and resources permit.
- *Won't have:* requirements labelled as Won't have, have been described by the system actors as the least critical.

Applying the SBRE and deconstructing the scenarios mentioned in Table 1 above and Table 2 below presents a list of the system's key functionalities/requirements, as well as the association to the scenario each one of them is derived from and the MoSCoW prioritisation outcome per functionality.

Table 2. System's key requirements.

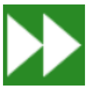
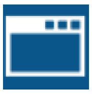
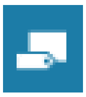
ID	Key Functionalities (KF)/ Requirements	Related Scenario (SC) Reference	MoSCoW Prioritisation
KF1	Authentication/Authorisation	SC1	MUST
KF2	Actor profiles (with dedicated interfaces for the insertion and updating of profile details, incl. certification requirements)	SC1	SHOULD
KF3	Insertion of cargo details and transport characteristics (e.g., cargo type, volume, weight, destination, departure/arrival dates, etc.)	SC2, SC4, SC5	MUST
KF4	Schedule, capacity and cost details	SC2, SC4, SC5	MUST
KF5	Available transport options	SC2, SC4	MUST
KF6	Price request/quotation	SC2, SC4	SHOULD
KF7	Messaging capabilities	SC2, SC4, SC7	MUST
KF8	Order confirmation and capacity update	SC2, SC4, SC5	MUST
KF9	Order editing and route recalculation	SC4	MUST
KF10	Provision of alternative transport modes and associated costs	SC4	SHOULD
KF11	Display of route characteristics (timing, stops, costs, etc.)	SC6	MUST
KF12	Reporting of transport services, including emission savings	SC2, SC4, SC5	SHOULD
KF13	Reporting of order details	SC2, SC4, SC6	SHOULD
KF14	Template for unified data format	SC2, SC3, SC4, SC5	SHOULD
KF15	Automated communication	SC2, SC4, SC6, SC7	COULD
KF16	Direct access to information related to transport means and details—less manual communication	SC2, SC4, SC5	MUST
KF17	Dynamic update of transport details	SC5	SHOULD
KF18	Near real-time information for unexpected events	SC8	SHOULD
KF19	Feedback about transport status	SC3, SC6, SC8	COULD
KF20	Transparency in available transport services	SC5, SC6	MUST
KF21	Publication of all available service providers	SC5	SHOULD
KF22	Provision of multimodal options	SC2, SC4, SC5	SHOULD
KF23	Access to all transport routes and rates	SC2, SC4, SC5	SHOULD
KF24	Combination of orders—empty container management	SC5	SHOULD
KF25	Classification rating scheme for carriers	SC3	COULD
KF26	GHG emissions estimation	SC2, SC4	COULD
KF27	Automated invoicing	SC2, SC4	SHOULD

3.6. Modelling Diagrams

Eight identified scenarios were modelled via employing event-driven process chain diagrams (EPC) and by ensuring that the associated-to each scenario) requirements were satisfied. Event-driven process chains (EPCs) diagrams are used to describe the operational sequence of business processes and workflows. They are a diagrammatic language within the control view of the ARIS framework [34,35].

The EPCs make use of a sequence of core elements, such as the events and the functions, as well as the rules and the operators, to facilitate the transformation of a number of parameters to desired logical outputs. According to Panayiotou et al. [55], '*these elements allow the functions' procedural sequence modelling, within individual processes. As a matter of fact, the actions are illustrated by indicating the successive function with arrows delivering messages regarding the occurrence of an event to the next function, and thus activating it. Before the next function the messages are placed in the queue for processing. Messages can contain additional attributes transmitting special processing information to the next function*'. The logical relationships (connectors) between the objects in the diagram are used to split and join the control flow. Split connectors have one incoming and several outgoing connections, while it goes vice versa for the join connectors [34,35]. Connectors are represented using the OR, AND, and XOR symbols of the ARIS methodology. The following Table 3 presents the elements used in the matchmaking system design modelling process under this study.

Table 3. EPC modelling elements.

EPC Element	Key Functionalities (KF)/ Requirements
	An *event* describes a state that controls or influences the progression of the process. They trigger functions and are the results of functions.
	A *function* is a task or activity performed to deliver process outputs and support business objectives.
	The *system* is a software system that is used to support the execution of a function.
	The *internal person* illustrates the specific person who is performing an activity.
	A *document* carrier stores knowledge/data.
	An *entity type* is a group of related real or abstract objects that play a specific role in the function of a system or part of it.
	*OR* considers at least one path
	*AND* considers all paths
	*XOR* (exclusive or) considers exactly one path.

The EPC modelling process is also governed by a set of rules, which must be followed in the modelling activity. These rules are highlighted below:

- An EPC diagram starts and ends with at least one event.
- The alternation of events and functions can only be interrupted by the use of logical connectors.
- Events and functions have only one input and one output.
- The creation of different paths (branches) and their reunification into one process is performed only by the use of logical connectors.
- Many events, combined with each other, can trigger a function only with the use of a logical connector.
- Logical connectors have either one input and many outputs or many inputs and one output.
- The logical connectors determine the permissible path of the process after a decision.
- The decision-making functions are always followed by a logical connector.
- Reconnecting a process that has followed different paths is conducted by using the same logical connector as the one responsible for its initial separation.
- Decisions are made only by functions.
- The use of logical connectors OR and XOR after an event is prohibited.
- The events after a logical connector shows the possible results of a decision.
- Any number of distinct branches is allowed in the branches.

The eight developed modelling diagrams that accompanied each of the identified scenarios (see Section 3.4) are presented in Figures A1–A8 as part of Appendix A. Indicatively, as part of this section, the modelling diagram of the account/profile creation process (Figure A6) is depicted below:

4. Discussion

In today's era, where a sustainable and efficient maritime transportation network is required, maritime transportation is expanding rapidly, and the economic vitality of freight mobility is incontestable, the digital transformation of systems will become an imperative need. The maritime sector needs to embrace digitalisation and integrate comprehensive innovative solutions towards capitating on intermodal transportation. In addition, within the broader maritime transportation network, the involved actors face rapidly eroding margins in every and each process of the transportation of freight due to unnecessary inefficiencies. The competitive character of freight transportation fosters the emerging demand for effective, efficient, and high-quality services at competitively low prices and minimised timeframes.

The digital era has made customer expectations more demanding and the cooperation environment more competitive between not only the freight forwarders and carriers but also between the freight forwarders and shippers. As a consequence, digitalisation and digital transformation [56] have become the most intriguing and challenging aspects and the only way forward for all key actors to keep up with the continuously growing challenges that a digital market pose.

The development of the previously modelled matchmaking system showcased in Section 3.6 can, therefore, undoubtedly provide enhanced productivity, efficiency, as well as sustainability, and transparency for all involved processes. It can also provide a competitive advantage by effectively and efficiently connecting all the involved actors in the maritime supply chain and beyond [57].

However, it is also worth mentioning that the potentially high costs of development and maintenance, as well as compatibility issues and process interoperability problems, could be considered impediments to the system adoption of the maritime industry. On top of that, the overall management and coordination of such a system may be considered another crucial point of discussion between the involved actors, who may be spurred by their reluctance towards its abandonment.

By taking into consideration the previously mentioned user acceptance risks and as far as the recommendations for further research are concerned, future studies should aim to replicate this research study in a wider range of stakeholders by taking into consideration the needs of the actors that belong to the wider maritime supply chain environment. In addition, future research could fruitfully explore the enhancement of the already defined matchmaking system components by embracing innovative concepts, such as the physical internet, and capitalise on emerging technologies, such as blockchain (e.g., for ensuring immutable and tamperproof transactions, etc.) and 5G for their convergence, in order to facilitate the execution of more complex and specialised business scenarios. In addition, market penetration studies should also be conducted by taking into consideration all associated costs, and analyses on the formulation of the cooperation and management framework should be realised as well. Last but not least, the emergence of novel technologies can be coupled with the assessment of the applicability of the new and innovative business model, harnessing the benefits of short supply chains (e.g., short sea shipping).

5. Conclusions

This paper studied how the effective and efficient matching of the demand and supply needs of the key actors in the maritime domain can be strategically achieved and supported through a system-designed framework, capitalising on the use of specialised information systems. The paper identified the key actors involved in the movement of freight by sea while at the same time demonstrating their needs and revealing the challenges they face. Eight scenarios were built, an elicitation process, as well as a prioritisation of the key requirement based on the identified challenges, and, finally, matchmaking system modelling diagrams were developed.

The research process followed within this study attempts to offer an appropriate solution to the collaboration problem that the maritime freight transportation sector faces and to bridge this real-life existing gap by providing an automated collaborative solution. It is the first holistic attempt towards enhancing horizontal collaboration between the involved stakeholders by automating some processes within their collaboration. The study does not cover the whole spectrum of the collaboration flows between the involved actors, but it provides a first design framework for covering their key and crucial needs. Further efforts need to be applied both in the direction of upscaling the study to a wider range of actors and in the direction of embracing state-of-the-art technological solutions by analysing more complex collaborative scenarios.

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Appendix A

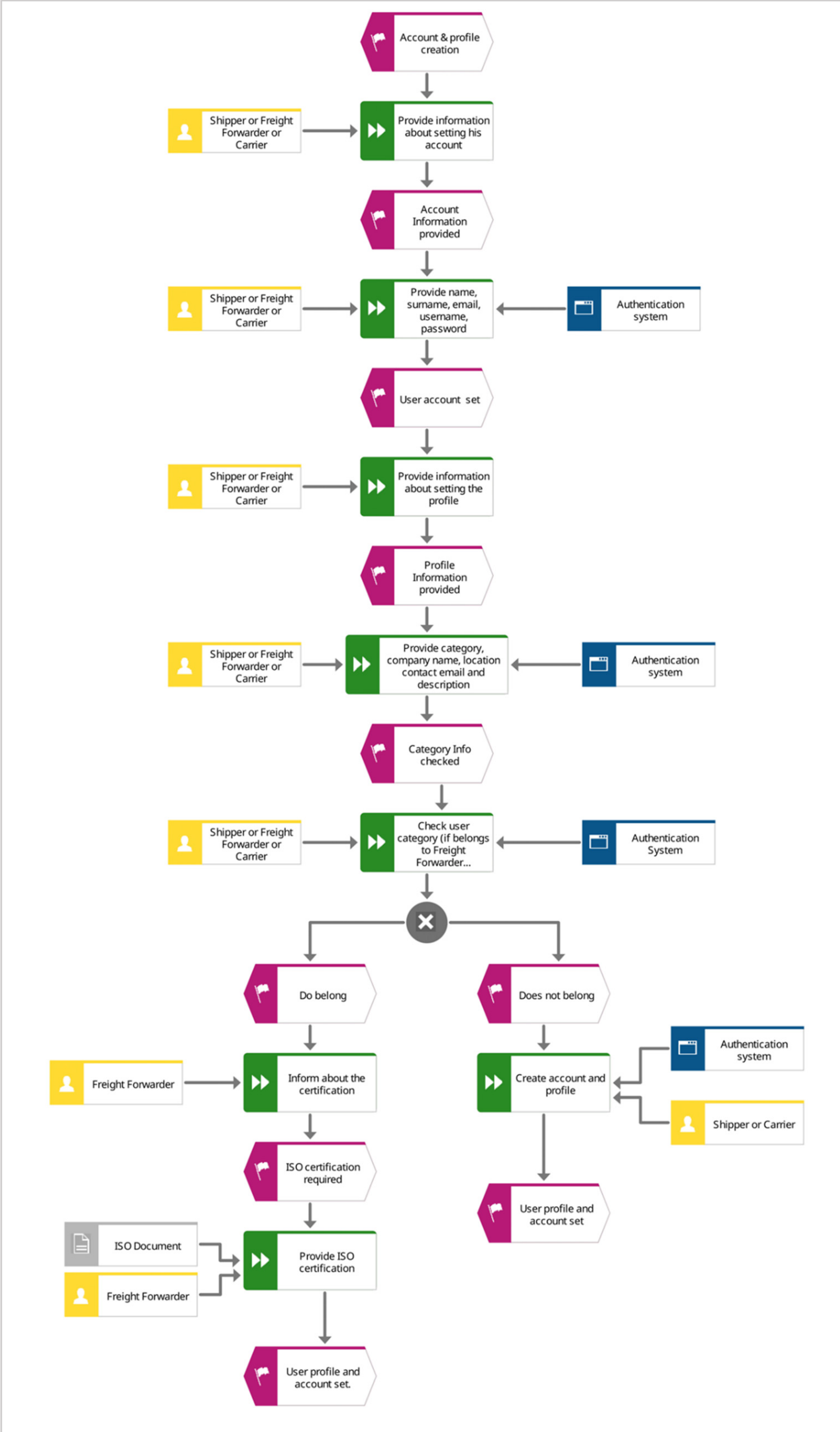

Figure A1. Modelling diagram of the account/profile creation process.

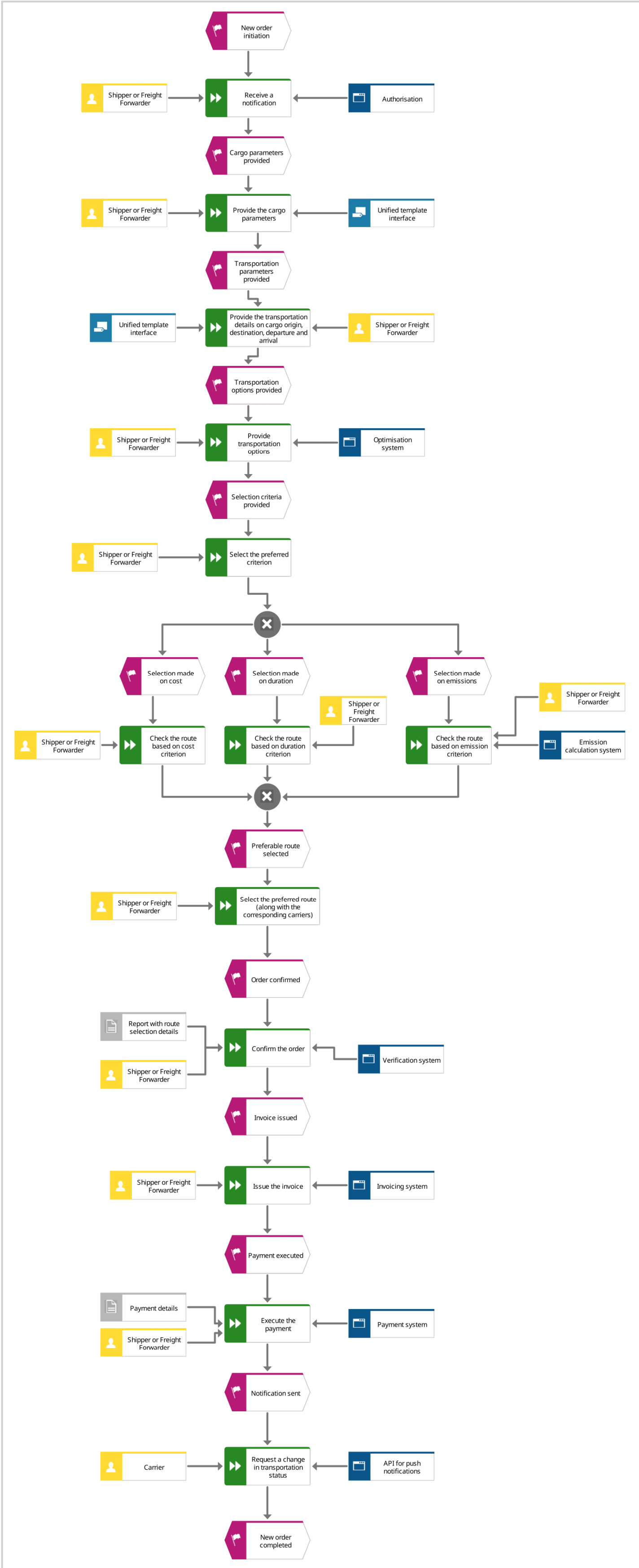

Figure A2. Modelling diagram of new order initiation.

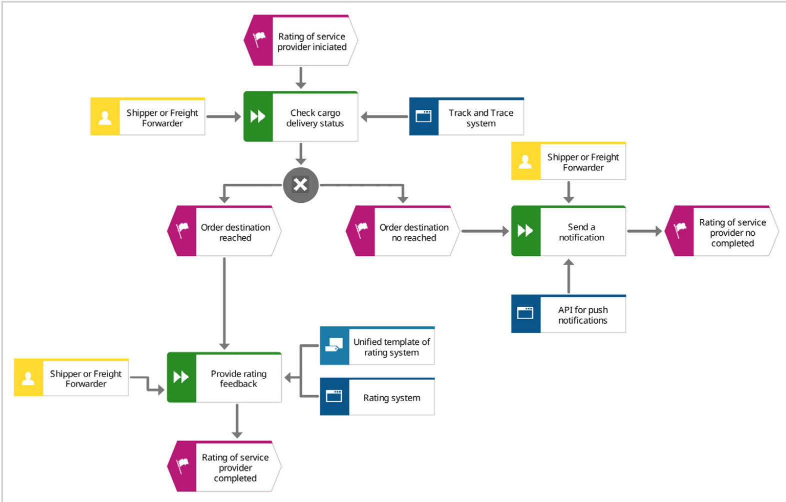

Figure A3. Modelling diagram of rating of provided service.

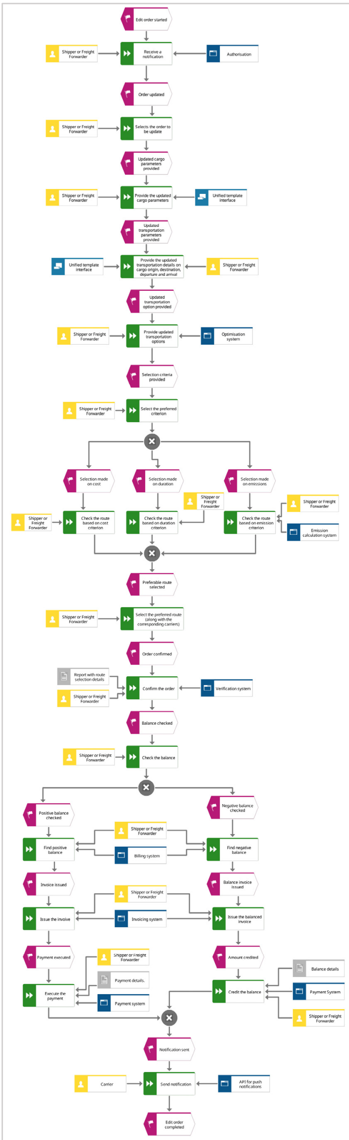

Figure A4. Modelling diagram of editing an order.

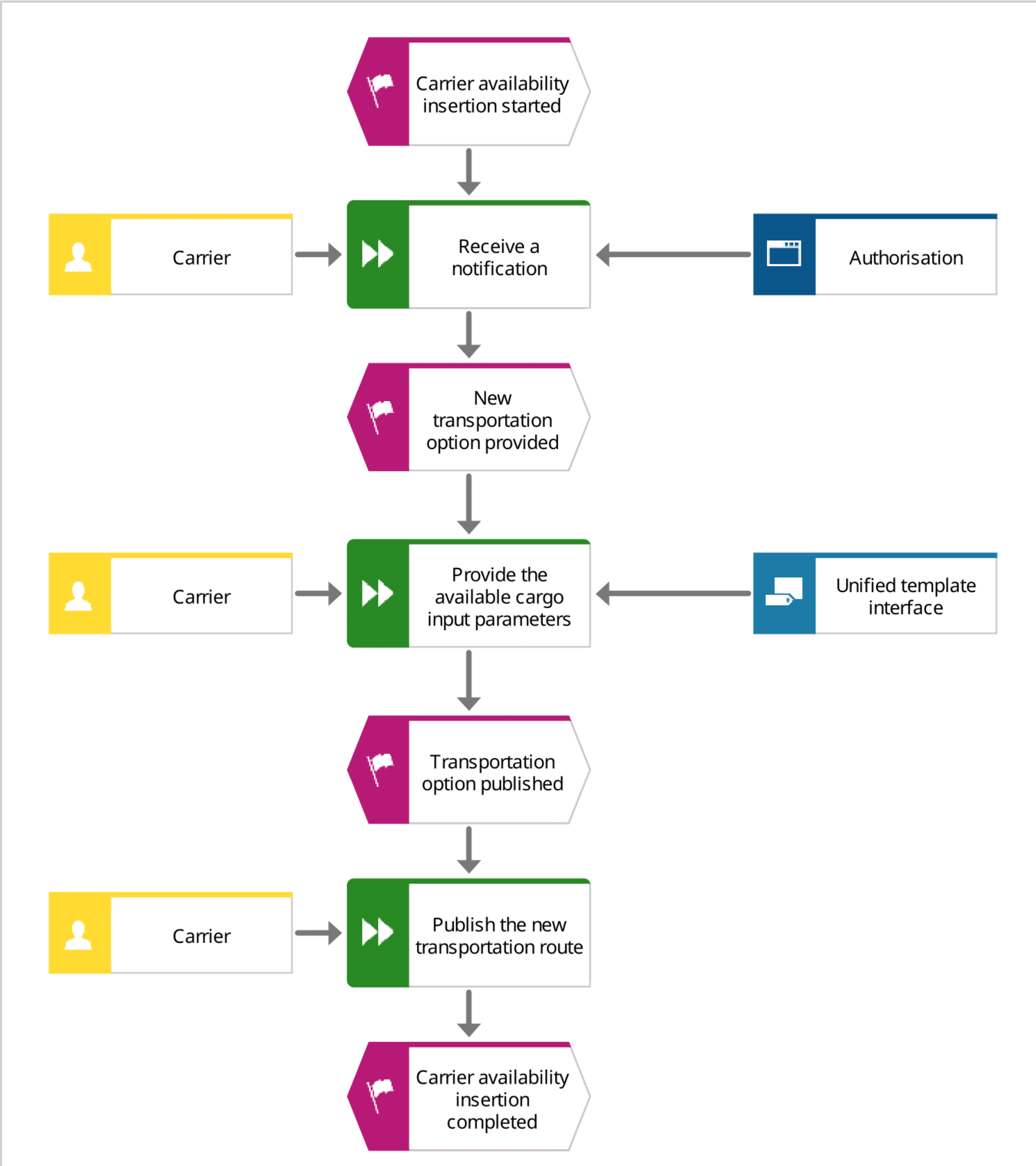

Figure A5. Modelling diagram of carrier availability insertion.

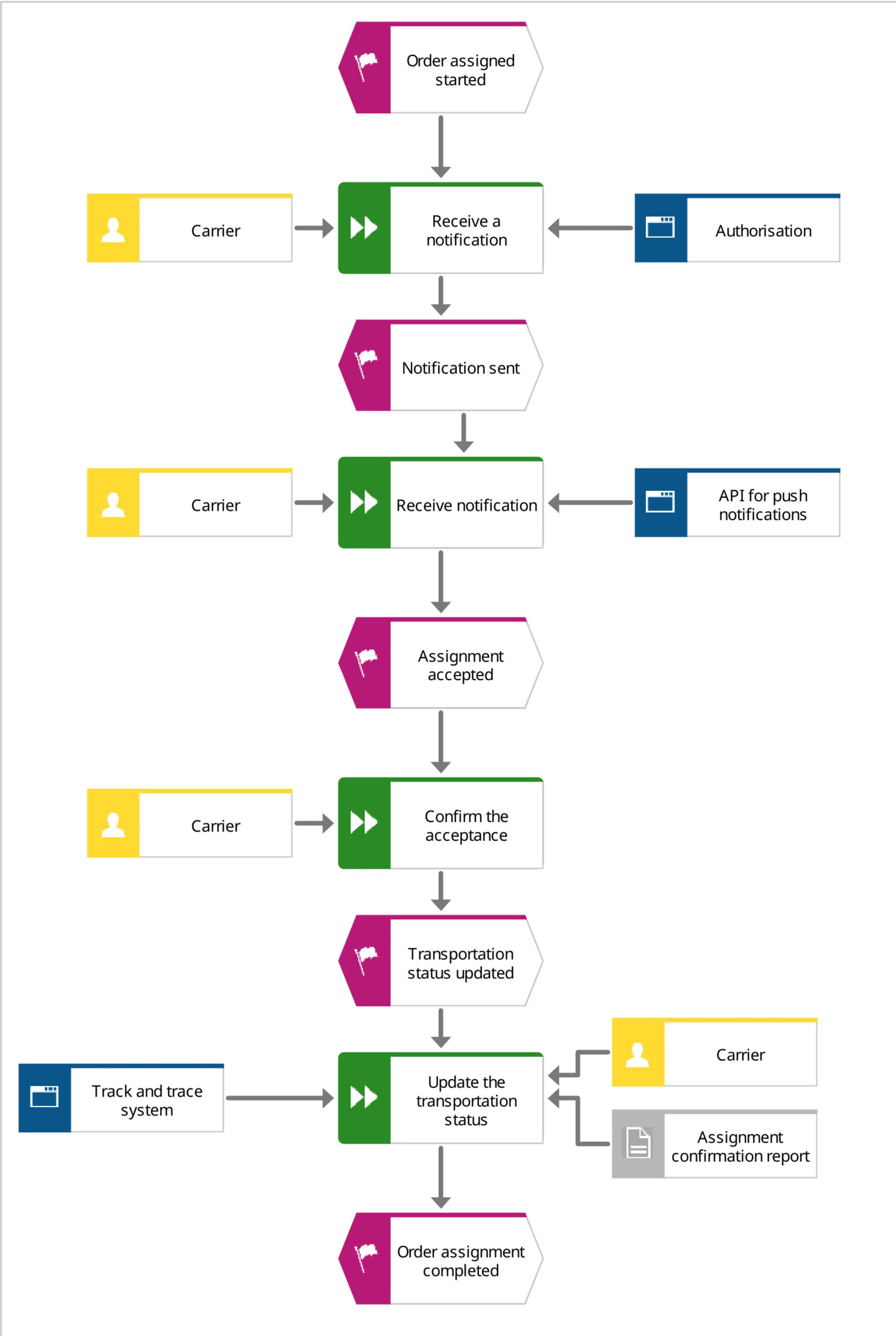

Figure A6. Modelling diagram of order assignment.

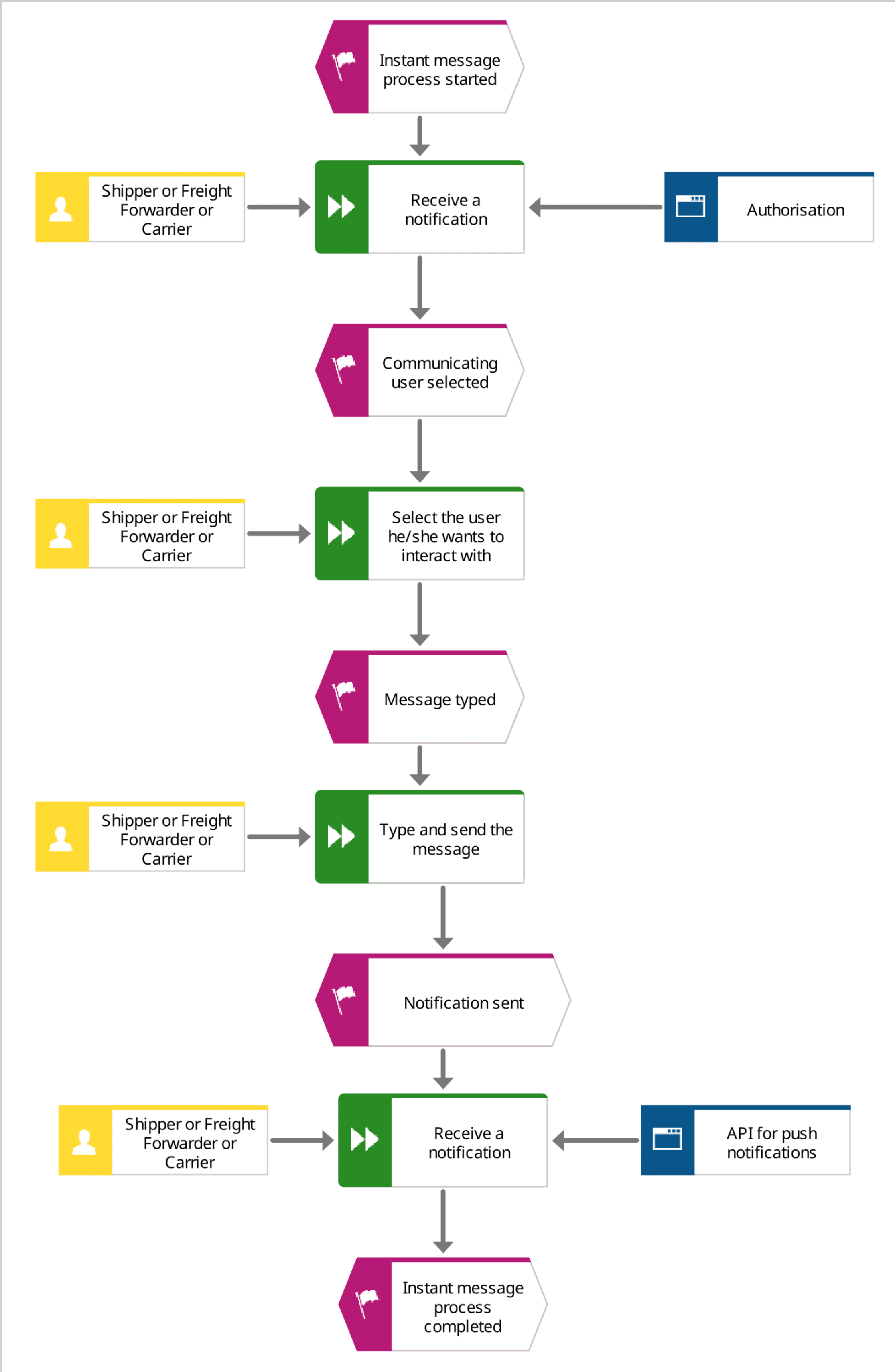

Figure A7. Modelling diagram of messaging functionality.

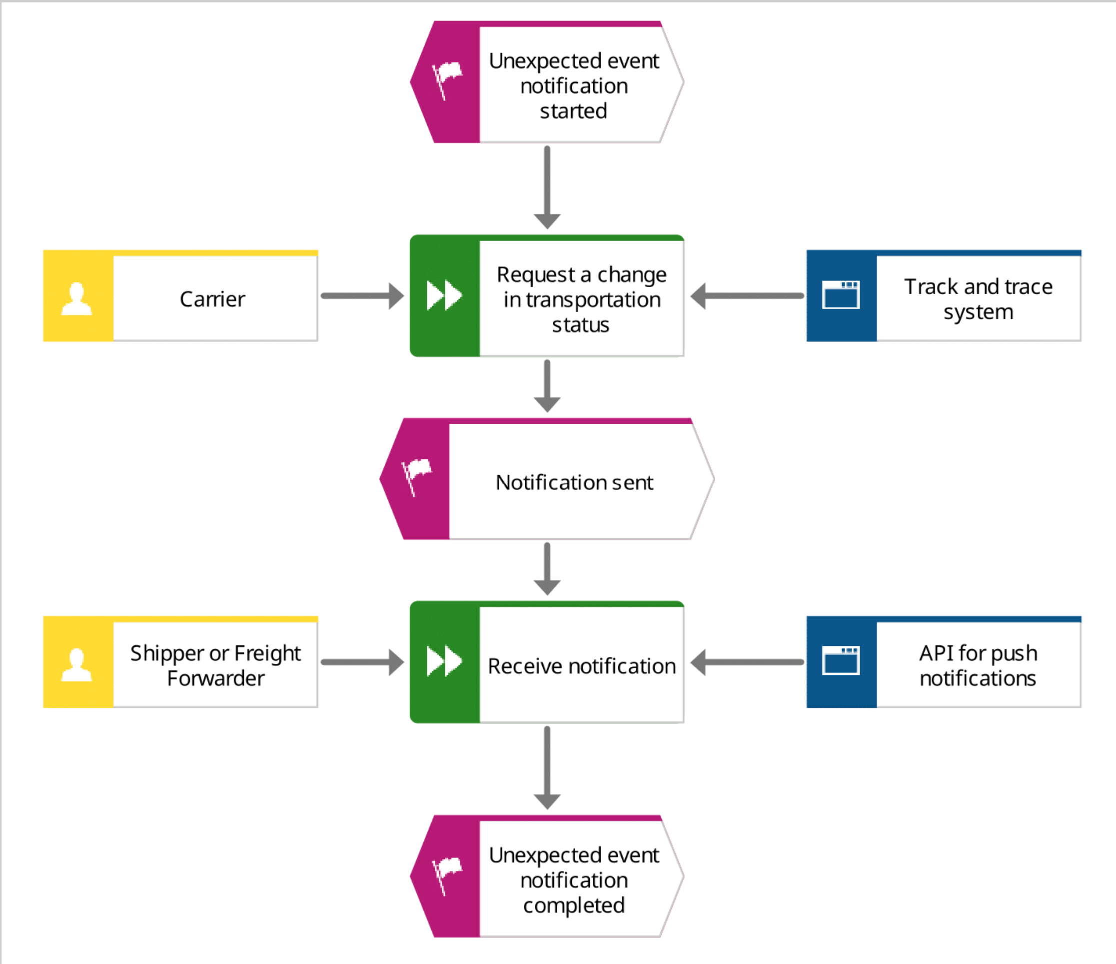

Figure A8. Modelling diagram of the occurrence of an unexpected event.

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