Information Flows' Criticality Assessment on Intermodal Freight Transportation

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Abstract

Intermodality has been one of the most discussed concepts in recent years in the freight transportation sector. It is unanimous that the future of freight transportation includes this modality and its efficiency and necessity relies greatly on the integration level of the intermodal chain and in the cooperation between agents. Therefore, the sharing of communication and exchange of information are extremely important for the efficiency of freight transportation, especially on intermodal transport.

The aim of this research is to analyse the intermodal freight transport business, characterizing and evaluating information flows along an intermodal chain, and define moments and critical flows in the chain performance. Based on the literature and on observation and perception of different agents, models of information flows for different intermodal chains typologies will be described and their critical information flows evaluated. This study tries to cover the maximum chain possibilities, defining flows for generic chains based on *Woxenius*' typologies.

The proposed models were validated by interviewing some agents with different roles along the chain. And the conclusions were that information flows associated with incoming and outgoing freight processes on international terminals may be considered the most critical and that despite the many different agents, chain critical moments are still usually common.

Keywords:
Freight Transportation, Intermodality, Information flows.

1. INTRODUCTION

Intermodal freight transportation has been discussed worldwide in the past years as a key factor for economic, environmental and resources efficiency. Besides efforts to implement this type of transportation, there has been many barriers to its success. In fact, this modality relies too much on modes integration and agents' communication and cooperation, so it is difficult, even today, to ensure that all these requirements are fulfilled. (Reis, 2014)

To reverse this situation, information systems on freight transport have been widely applied in order to integrate the agents and make the intermodal business more transparent. (Giannopoulos, 2004)

Freight transportation business, especially intermodal chains, involves the production of many documents and information which have to be shared between the agents involved in the process, to guarantee a correct sequence of processes during a service. (Rodrigue et al., 2013) Thus, the intermodal transport business can be divided in two layers; the physical layer, associated with merchandise movement from origin to destination, and the administrative layer, which refers to the information that flows parallel to the processes. (Reis, 2014)

This flow chart is presented in Figure 1.

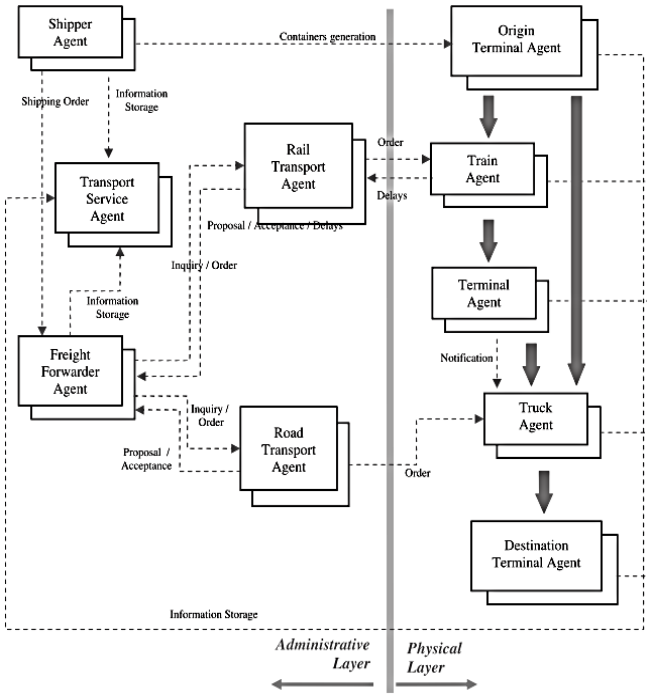

Figure 1 - Intermodal business agents and division in physical and administrative layers. Source: Reis, 2014

Based on the importance level of information flows along intermodal freight chains, the purpose of this study is to analyse information flows along the chains and assess the critical points found and compare them to the chains overall performance.

Literature on this subject is scarce and focuses essentially on specific cases or on some parts of a chain only. This study is not intended to be specific but rather more generic to include all chain phases, addressing the existing gap in the literature.

There are many definitions for intermodal freight transportation in the literature. The one adopted in the study indicates that intermodal transportation is the movement of cargo from origin to destination by several modes, in an integrated manner, where the cargo can be consolidated or unconsolidated and/or transfered to another transport unit.

2. METHODOLOGY

This section explains how this study was developed and the reasons for adopting the methodology.

The work was made in partnership with Maeil's company, an information systems engineering firm focused on the freight transportation sector. The initial study about information flows in intermodal freight transport was prepared not only based on literature but also with constant follow-ups from Maeil's services and some of its partners Ibero Linhas and SeaWorld, active players in transport chains.

This process helped to understand how the business operates, the information systems used, and the information flow procedures produced during a transportation chain in real world, and to compare it with the perception taken from the existing literature.

Afterwards models about intermodal freight chains were developed based on Woxenius' (2007) generic typologies, direct link, corridor, hub-and-spoke and connected hubs. Those models were designed to characterize the chains and all information flows necessary at any time, making it possible to identify critical point in the flows' criticality.

All data regarding the assessment and evaluation of the impact on the chain was provided by interviews with more agents and existing case studies in the literature. This was the chosen method since this is an unpredictable business, where companies perception is that any firm can make and solve the same question in a completely different way and it is difficult to standardize processes like modelling. So interviews were seen as the most truthful way to obtain the intended results.

The companies interviewed were the freight forwarders Ibero Linhas, SeaWorld, Transitex, Geocargo and Pentatrans, and the terminal operator Sotagus.

3. STATE OF THE ART

Rabah e Mahmassani (2002), Ketikidis et al., (2008), Rantala (2009), Pigni et al. (2010) and Qrunfleh e Tarafdar (2014) presented studies about the influence and impact of information and technology systems (ITS) on supply chains and logistics.

On freight transportation it is also common this type of analysis. Giannopoulos (2004) and Gattuso, and Savia (2014) have done research on the application of ITS in freight transport in general. Schilk and Seeman (2012), and Harris et al. (2015) made the evaluation study on multimodal transport; Caris et al. (2013) on intermodality, and Spikker (2014) on synchromodality. It is unanimous the importance of those systems for the effectivity and efficiency of the processes.

Besides all those studies and as mentioned above, literature is scarce on characterizing information flows and assessing the impact cause by the delay or lack of these flows.

So taking a closer look at the purpose of this research, the existing literature can be divided in three groups. The first group about customs processes, the second about architecture of information systems in freight intermodal transport and the last group about information sharing between agents in terminal areas.

3.1. Customs processes

Hellberg and Sannes (1991) wrote about the impact of an EDI system to communicate during the customs processes in Norway. And Volpe and Martincus et al. (2015) evaluated the consequences of delays and absences on customs processes during the exportation of merchandise in Uruguay.

Those papers describe the information flows behind merchandise legalization and emphasize the idea that some mistakes in these processes can actually stop the whole chain. Taking a closer look at both flows and at the geographic differences and contexts between these two studies, one can conclude that the flows needed during customs procedures are roughly similar from country to country, but the information needed may vary and it is crucial to have a previous knowledge of the necessary requirements of cargo for its legalization.

3.2. Architecture of Information systems

Macário and Reis (2008) proposed an information system for an intermodal service between Portugal and Spain while Bendriss et al. (2008) a model to design a track and trace system.

These papers cover an important part of the intermodal chain, the negotiation and adjudication of the service, and reveal that is possible to use a common platform for all communications.

Both studies agree that the service starts with the client and after the confirmation of the service with a freight forwarder, the client becomes an off-mode agent and just follows the chain at a distance. Bendriss et al. (2008) centered all the communication on the freight forwarder, defining this agent as the responsible player for making the link between all other agents along the chain.

3.3. Terminal Areas - Case Studies

The sharing of information between agents during the arrival and shipment of cargo in terminal areas was analyzed by Almotairi et al. (2011), Sebastian et al. (2011) and Elbert and Pontow (2013). These case studies discuss the change of the cargo from maritime mode to railway mode in a terminal area and the last two take Hamburg port as an example.

Almotairi et al. (2011) define the information flows needed from the moment the cargo is in a ship in transit to a Sweden port until its arrival at an hinterland terminal and analyse the integration level of the ITS used.

To characterize those flows, authors established as fundamental requirements the information regarding the physical location of the container, transmission trigger, activity, key data content, transmission media and agents involved in the transmission of information.

Sebastian et al. (2011) support the idea of anticipated information transmissions and define ideal timings for these transmissions, concluding that these could have an important impact on the chain efficiency in terminal areas.

Elbert and Pontow (2013) try to create an integrated system and make a standardization of the flows capable to make the chain more efficient and better for all agents. To that end, the study answers three important questions:

- On which junctures of the business processes of the considered agents is the information flow standardized and integrated?
- Why is the information flow standardized or integrated on those particular junctures and not on other junctures?
- Which junctures in the transport chain have potential to improve the efficiency of the existing infrastructure, already in use, through a standardized and integrated information flow?

Thus, from the literature it is possible to conclude that most cases focus on the arrival and departure process from a terminal area. One can also assume that loading/unloading processes, customs procedures and transfers between modes are considered critical points in an intermodal chain.

This chapter helped to understand that none of the studies shows a complete analysis of the whole chain; most of them refer only to specific situations.

4. INTERMODAL CHAINS MODELS AND INFORMATION FLOWS

This chapter presents the models and the characterization of the information flows.

Five models were designed, one for the negotiation and adjudication phase and four for each Woxenius' (2007) typology adopted for the transportation phase. The adopted typologies are represented in Figure 2.

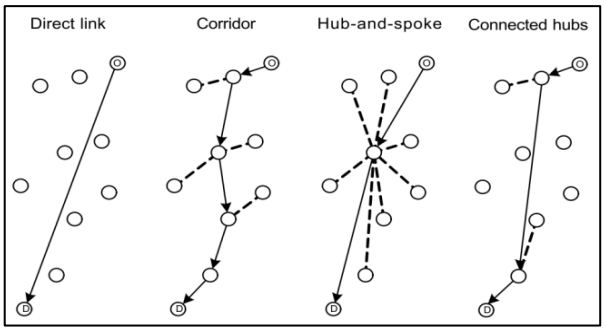

Figure 2 - Intermodal chains typologies. Source: Woxenius, 2007

All models were complemented with a table that describes all flows using the following fields:

- Container localization
- Transmission trigger
- Activity
- Keys data
- Transmission media
- Agents involved
- Ideal Timing
- Consequences of delays or mistakes
- Other observations

For each moment were also considered payments and responsibilities between agents, based on most frequently used incoterms for each case.

In the end, the flow was classified regarding its criticality as follows: irrelevant, minor, serious and critical.

Table 1 - Explanatory models key

Symbol	Associated Flow	Transmission media
	Cargo movement	Directly
	Informative messages	E-mail, phone or dedicated software
	Notifications and permissions	E-mail or dedicated software
	Documentation and/or payments	E-mail, dedicated software or directly

4.1. Negotiation and Adjudication phase

This phase, depicted in Figure 3, is initiated when the client orders the service, and comprises negotiation and adjudication processes and, finally, the preparation of the service, where is included the emission of all the documentation needed for the transportation.

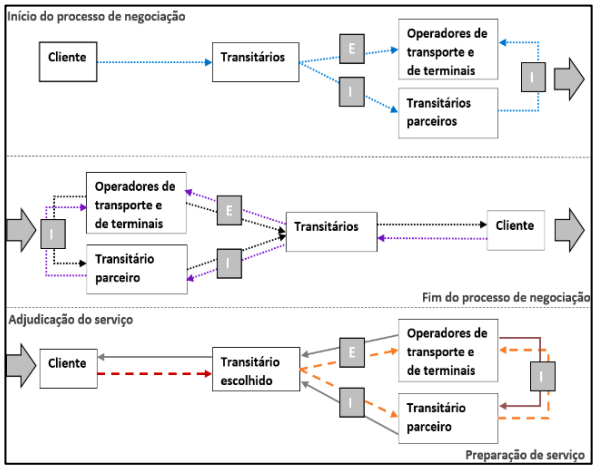

Figure 3 - Negotiation and Adjudication Phase Model

The most important information here is the origin and destination of the cargo, type of cargo, quantity and intended schedules.

This is the phase, where the difference between an import or export service is more pronounced.

The main difference is the dependence, or not, of other freight forwarders to prepare the service. But the same model applies to any typology.

4.2. Transportation Phase

The direct link typology only includes the transport between an origin terminal and a destination terminal. This makes the direct link the simpler typology, since it uses just one mode, with less agents involved and less information transmitted.

There are no significant differences between an import or export situation and only one freight forwarder is involved. This typology is consists of steps **1**, **3** and **4** of Figure 4.

The corridor typology is very similar to the last one, but has stops during the origin and the destination, completing the **4** steps in the Figure 4.

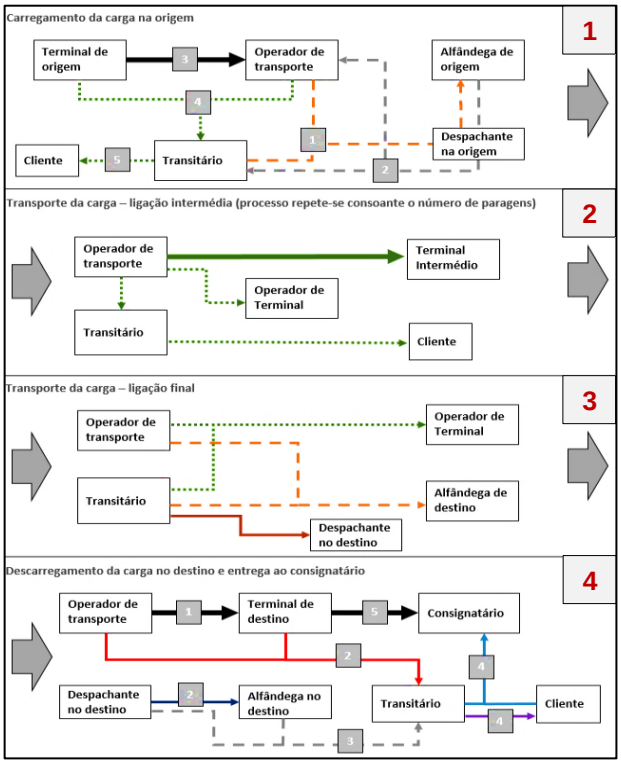

Figure 4 - Direct Link and Corridor Models

The number of information flows and agents involved increases according to the number of stops made, repeating step **2** in Figure 4.

Typically just requires one mode like direct link. However, due to the time lapse between nodes, coordination is needed to ensure the chain efficiency. When cargo is not unloaded and remains in the vehicle, it is not necessary to inform the customs.

The other two typologies typically include more than one mode. The models presented for these typologies are based on an import situation, because they cover more than one freight forwarder in both cases; one responsible for the whole service and a partner responsible for the transportation within the foreign country. It is therefore evident that these two typologies have more flows of information and are more complex. The big difference between a hub-and-spoke situation and a connected hubs situation is the last hinterland connection; last step in Figure 5.

That is only contemplated in the typology of connected hubs. So, hub-and-spoke is a door-to-port case and connected hubs a door-to-door case.

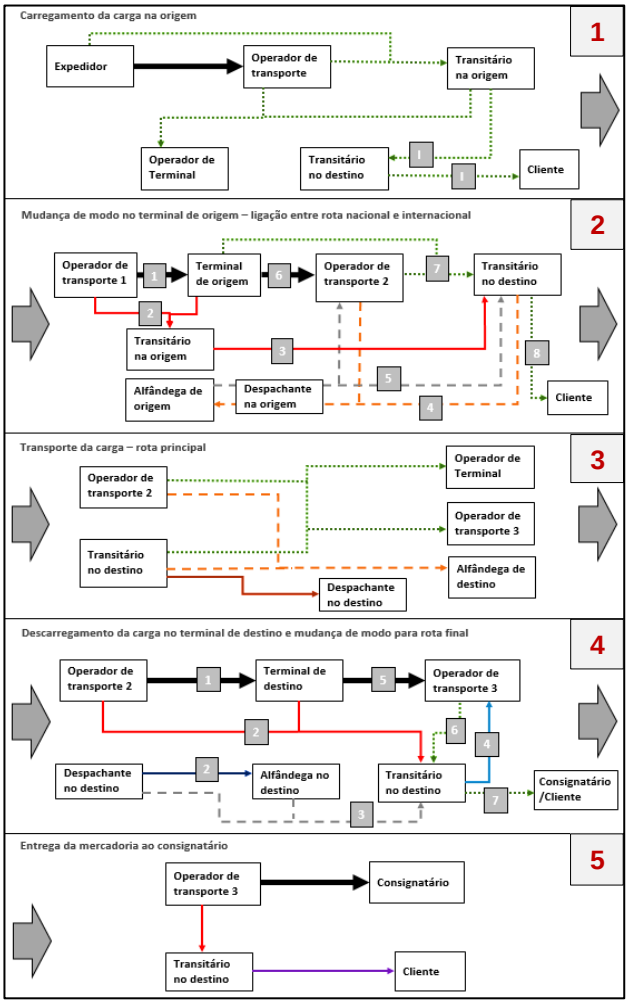

Figure 5 - Connected Hubs Model

While using more than one transportation mode, the transportation processes are similar, but require an extra effort to transmit the information and link the different modes. These typologies will, necessarily, involve more agents and more transfers and, in this regard, they are more prone to delays and errors.

Those configurations do not exhaust all possibilities since they can be combined to include more cases.

Thus, those models and flows can be used in situations that are not contemplated in this study.

5. Results Discussion and Validation

The final validation, which was performed based on interviews with chain' agents, confirmed the models and helped to classify the existing flows. As critical, if the errors and delays found were able to bring the whole chain to a halt, serious, if they include significant delays or more costs, Minor, for small delays, and irrelevant, if the chain is not affected and when the only issue is lack of information.

Table 2 characterises the flows in the connected hubs typology. This example was chosen because it is the one which shows more complexity.

The service preparation phase is fundamental to chain development and, in that regard, the associated flows should be classified as serious.

Critical flows are similar and all typologies showed the same number. These are key flows for any international intermodal chain and are related to customs processes and cargo legalization.

International routes flows reveal medium-high criticality compared to national routes. International routes flows show more complex phases with more serious consequences and any issue will affected more agents.

In terminal areas the cargo beyond be subject to customs procedures, and should any issue arise, it will cause delays in transportation routes and this will consequently increase costs and hamper terminal operations. So, one may conclude that this will also affect a larger number of agents too. These flows are therefore of great importance in the whole chain performance.

According to the literature, most case studies agree with the interviewed agents, and classify terminal areas and customs procedures as determinants of chain efficiency, emphasising that they should be considered highly critical.

Table 2 - Information Flows Characterization for Connected Hubs Typology

FASE	Observações	Localização do contentor	Estímulo para a transmissão da informação	Actividade	Dados chave/Documentos transmitidos	Agentes envolvidos	Meio de transmissão	*Timing* "ideal" da transmissão da informação	Pagamentos	Compensações	Responsabilidades		Consequências de falha/atraso	Classificação de atraso
											Perante cliente	Perante transitário		
Transporte C. Distância		Expedidor	Contratos estão estabelecidos e a carga pronta para ser carregada.	Op. de transporte da rota "nacional" vai carregar a carga junto do expedidor. O expedidor ou operador de transporte avisam o transitário do carregamento e da previsão.	Lista da carga carregada e previsão de chegada ao terminal hub.	Operador de transporte nacional ou expedidor informa o transitário de origem.	Telefone, e-mail, software próprio	No momento em que a carga é carregada.	O fluxo de capital pode ser feito de inúmeras maneiras, neste caso temos apenas um exemplo.		Transitário contratado pelo cliente	Empresa transportadora ou transitário de origem	Pode atrasar os processos seguintes por demora na informação do transitário e atraso na reacção deste a essa informação.	Grave
		Operador de transporte c. distância	Carga é carregada, inicia-se a rota e o transitário informado.	Transitário ou op.transporte "nacional" informa o op. terminal de previsão chegada.	Local de origem; Local de destino; Horários a cumprir; Quantidade de carga; Tipo de carga; Requisitos específicos.	Transitário do país de origem informa o operador do terminal.	Telefone, e-mail, software próprio	No momento em que o transitário recebe a informação de previsão de chegada ao terminal.					Pode provocar um atraso na descarga da mercadoria do terminal (hub) por falta de preparação do operador de terminal.	Leve
	Considerando situação de importação.	Operador de transporte c. distância	Carga é carregada, inicia-se a rota e o transitário informado.	Transitário do país de origem informa o transitário no destino do início e estado do serviço.	Confirmação do carregamento e previsão de chegada ao terminal (hub).	Transitário do país de origem informa o transitário de destino.	Telefone, e-mail, software próprio	No momento em que o transitário recebe a informação de previsão de chegada ao terminal.					Pode levar a atraso na reacção do transitário de destino na preparação do restante serviço.	Leve
	Considerando situação de importação.	Operador de transporte c. distância	Carga é carregada, inicia-se a rota e o transitário informado.	Transitário do país de destino informa o cliente do início do serviço.	Confirmação do carregamento e previsão de chegada ao terminal (hub).	Transitário informa o cliente.	Telefone, e-mail, software próprio	No momento em que o transitário de destino recebe a informação do estado do serviço.					Falta de informação.	Pouco Relevante
Terminal de Origem		Operador de transporte/ Terminal	Carga é descarregada no terminal.	Op. do terminal ou op. de transporte informa o transitário na origem da descarga da mercadoria.	Lista de descarga.	Operador de transporte nacional ou operador de terminal informa o transitário na origem.	Telefone, e-mail, software próprio	Após a descarga da carga no terminal (hub).	**Transitário do país de origem paga o serviço de transporte nacional.**	**Em caso de atrasos ou problemas com a carga pode haver lugar ao pagamento de compensações do transportador ao transitário.**		Operador do terminal ou transitário de origem	Pode levar a demora na reacção do transitário de origem e demora na preparação da rota internacional.	Grave
		Terminal (hub)	Carga é descarregada e o transitário de origem informado.	Transitário na origem informa o transitário no destino da descarga da mercadoria.	Lista de descarga.	Transitário na origem informa o transitário no destino.	Telefone, e-mail, software próprio	Após a descarga da carga no terminal (hub).	**Transitário no país de destino paga o serviço ao transitário na origem.**	**Em caso de problemas com a carga pode haver lugar ao pagamento de compensações entre os transitários.**			Pode levar a demora na reacção do transitário de destino e demora na preparação da rota interncaional.	Grave
	Mercado livre não requer informação de alfândega.	Terminal (hub)	Carga é descarregada no terminal (hub) e o transitário de destino informado.	Transitário ou despachante na origem informa a alfândega na origem das mercadorias a transportar.	Local de origem da carga; local de destino da carga; quantidade de carga; tipo de carga; requisitos específicos; Meio de transporte utilizado.	Transitário ou despachante na origem informa a alfândega.	Software próprio ou contacto directo	Após a descarga da carga no terminal (hub).					Atraso na declaração da carga à alfândega provoca atraso no início da rota internacional. Cargas não declaradas não podem ser movimentadas.	Muito Grave
	Pode implicar vistoria à mercadoria.	Terminal (hub)	Alfândega recebe as informações relativas à carga a transportar.	Alfândega na origem autoriza a movimentação da mercadoria.	Autorização para movimentação da mercadoria que conste no pedido feito.	Alfândega informa o transitário ou despachante e os operadores de transporte.	Software próprio	Após verificação da legalidade da mercadoria.					Atraso na declaração da carga à alfândega provoca atraso no início da rota internacional. Cargas não declaradas não podem ser movimentadas.	Muito Grave
		Terminal (hub)	Permissão da alfândega para movimentação da mercadoria.	Agente transportador carrega a mercadoria no terminal.	Local de origem da carga; Local de destino da carga; Carga carregada; Requisitos específicos; Hora de carregamento da carga; Horário previsto de chegada.	Transportador ou terminal envia informação de carregamento ao transitário.	Telefone, e-mail ou software próprio	No momento em que a carga foi carregada.	**Transitário paga ao op. de terminal o serviço o manuseamento e a estadia da carga no terminal.**	**Em caso de atrasos ou problemas com a carga pode haver lugar ao pagamento de compensações do transportador ao transitário.**			Pode levar a demora na reacção do transitário no destino na preparação da recepção da mercadoria no terminal de destino.	Leve
		Operador de transporte	Transitário informado do carregamento da carga.	Transitário no destino informa o cliente do carregamento.	Confirmação do carregamento.	Transitário informa cliente.	Telefone, e-mail ou soft. próprio	No momento em que a carga foi carregada.				Empresa transportadora de rota internacional	Falta de informação.	Pouco Relevante
Transporte Longa Distância		Operador de transporte	Carga foi carregada e o transitário informado.	Transitário no destino ou transportador avisa o terminal do horário de chegada da mercadoria.	Local de origem da carga; Local de destino da carga; Horários a cumprir; Carga transportada; Requisitos específicos.	Transitário ou transportador avisam o operador do terminal.	Telefone, e-mail ou software próprio	No momento em que foi carregada a carga e se iniciou o transporte, mas pode ser feito em qualquer momento durante a "viagem" da mercadoria.					Pode haver um atraso na descarga da mercadoria por falta de preparação do terminal para a chegada da mercadoria.	Leve
	Geralmente já existe contrato c/ despachante.	Operador de transporte	Carga foi carregada e o transitário informado.	Transitário no destino contrata e envia dados para o despachante de forma a legalizar a mercadoria na chegada.	Local de origem da carga; Local de destino da carga; Quantidade de carga; Tipo de carga; Requisitos específicos; Meio de transporte utilizado; Licenças que sejam exigidas; Documentos identificativos.	Transitário contrata despachante.	E-mail, soft. Próprio, correio p/ documentação original.	No momento em que foi carregada a carga e se iniciou o transporte, mas pode ser feito em qualquer momento durante a "viagem" da mercadoria.					Pode provocar um atraso na descarga da mercadoria, a mercadoria não pode ser descarregada antes de estar legalizada.	Grave
		Operador de transporte	Carga foi carregada e o transitário informado.	Transitário no destino, despachante ou transportador avisam a alfândega no destino da carga que vai ser descarregada.	Local de origem da carga; Local de destino da carga; Quantidade de carga; Tipo de carga; Requisitos específicos; Meio de transporte utilizado e rota.	Transitário ou transportador informam a alfândega de destino.	E-mail ou software próprio	No momento em que foi carregada a carga e se iniciou o transporte, mas pode ser feito em qualquer momento durante a "viagem" da mercadoria.					Cargas não reportadas não podem ser descarregadas.	Muito Grave
		Operador de transporte	Carga foi carregada e o transitário informado.	Transitário ou transportador avisa o operador de transporte responsável pela rota no país de destino do horário de chegada.	Local de origem da carga; Local de destino da carga; Quantidade de carga; Tipo de carga; Requisitos específicos; Documentos identificativos da carga.	Transitário (destino) ou transportador avisa o operador de transporte do país de destino.	Telefone, e-mail ou software próprio	No momento em que foi carregada a carga e se iniciou o transporte, mas pode ser feito em qualquer momento durante a "viagem" da mercadoria.					Pode haver um atraso no início da rota no país de destino por falta de preparação do operador de transporte responsável.	Leve
Terminal de Destino	Quando necessário legalizar mercadorias.	Operador de transporte - Terminal	Despachante recebe os dados da mercadoria a legalizar.	Despachante no destino contacta a alfândega para legalizar a mercadoria e pagar as taxas devidas.	Local de origem da carga; Local de destino da carga; Quantidade de carga; Tipo de carga; Requisitos específicos; Meio de transporte utilizado; Licenças exigidas; Pagamentos de taxas alfandegárias.	Despachante no destino legaliza a mercadoria junto da alfândega.	Contacto directo ou software próprio	No momento em que foi carregada a carga e se iniciou o transporte, mas pode ser feito em qualquer momento durante a "viagem" ou na chegada.	**Despachante paga as taxas de legalização da carga junto da alfândega de destino.**				Pode provocar atraso na descarga da mercadoria, a mercadoria não pode ser descarregada se não estiver legalizada, principalmente mercadorias que implicam pagamentos de taxas e/ou vistorias. Pode parar o sistema.	Muito Grave
		Terminal (lado alfândega)	Carga chega ao terminal e é descarregada.	Envio de aviso de descarregamento ao transitário por parte do terminal ou do agente transportador.	Lista de carga descarregada. Documentos identificativos para levantamento da carga.	Operador do terminal e/ou transportador avisa o transitário.	Telefone, e-mail ou software próprio	No momento em que a carga foi descarregada no terminal.	**Transitário paga ao op. de transporte o serviço.**	**Em caso de problemas com a carga pode pagamento de compensações do transportador ao transitário.**			Atraso na reacção do transitário à chegada da carga, podendo atrasar o sistema e reter a mercadoria no terminal por mais tempo.	Grave
	Pode implicar uma vistoria.	Terminal (lado alfândega)	Alfândega recebe os pagamentos devidos e verifica se não há irregularidades.	Alfândega autoriza a descarga da mercadoria.	Local de origem da carga; Local de destino da carga; Quantidade de carga; Tipo de carga; Autorização para descarregar.	Alfândega informa o despachante, os operadores ou o transitário de que a carga pode ser descarregada.	Software próprio	No momento de chegada da carga ao terminal, podendo ser necessário esperar pela vistoria.	**Transitário paga o serviço ao despachante.**			Operador do terminal	Pode parar todo o sistema no caso de haver inconformidades com a mercadoria ou se houver atrasos na vistoria.	Muito Grave
		Terminal destino	Carga legalizada, descarregada e pronta para ser carregada.	Transitário no destino informa o op. de transporte da rota no país de destino que carga está pronta.	Lista da carga a carregar e documentos identificativos do serviço e da carga.	Transitário informa op. de transporte e fornece os documentos necessários.	E-mail, soft. próprio, telefone, correio.	No momento em que a carga está legalizada e pronta a para ser novamente levantada.					Pode atrasar o início do serviço de transporte no país de origem e aumentar o tempo de estadia da carga no terminal (hub da detino).	Grave
		Transporte (rota no destino)	Carga carregada pelo op. transporte de rota "nacional" de destino.	Operador de transporte informa o transitário no destino de que a carga foi carregada.	Lista da carga carregada e previsão de chegada junto do consignatário.	Operador de transporta informa o transitário.	Telefone, e-mail ou software próprio	No momento em que a carga foi carregada novamente.	**Transitário paga ao op. de terminal o manuseamento e a estadia da carga no terminal.**	**Em caso de atrasos ou problemas com a carga pode haver lugar ao pagamento de compensações do transportador ao transitário.**		Operador de transporte (rota destino)	Falta de informação que pode levar a atrasos na recepção da carga por parte do consignatário.	Leve
		Transporte (rota no destino)	Transitário é informado do carregamento e início de serviço.	Transitário informa o cliente e/ou o consignatário de que se iniciou a rota no destino e da previsão de chegada.	Lista da carga carregada, previsão de chegada junto do consignatário e documentos identificativos da carga.	Transitário informa cliente/consignatário.	Telefone, e-mail ou soft.próprio	No momento em que o transitário é notificado do início da rota.					Falta de informação que pode levar a atrasos na recepção da carga por parte do consignatário.	Leve
Destino		Consignatário	Carga descarregada no consignatário.	Operador de transporte ou consignatário informam o transitário do descarregamento da mercadoria.	Lista de carga descarregada. Documentos identificativos para levantamento da carga.	Transitário informado de que a carga foi descarregada pelo consignatário/op. transporte.	E-mail, software próprio ou telefone.	No momento em que a carga foi entregue ao consignatário.	**Transitária paga ao op.de transporte o serviço de rota nacional no país de destino.**	**Em caso de atrasos ou problemas com a carga pode haver lugar ao pagamento de compensações do transportador ao transitário e do transitário ao cliente.**			Atraso nos pagamentos devidos do operador de transporte.	Leve
		Consignatário	Transitário recebe a notificação de fim de serviço	Transitário reporta fim de serviço ao cliente.	Lista da carga descarrega no consignatário.	Transitário reporta o fim do serviço ao cliente.	Telefone, e-mail ou soft. próprio	No momento em que a carga foi entregue ao consignatário.	**Cliente paga o serviço ao transitário no destino.**		Consignatário		Falta de informação e atraso no pagamento ao transitário pelo serviço.	Leve

6. Conclusions and Recommendations

The main goal of this study was to identify all information flows in intermodal freight transport, as well as to evaluate the impact of these flows on chain efficiency. As the literature in this field is scarce and the intermodal business is overly volatile, the adopted methodology was to compare theory with reality as well taking into account some agents' opinions.

During the study, it became clear that freight transport entails many requirements that have to be put in place, and that may also vary. There are different types of cargo with many diverse requirements, different countries have different requirements and the documentation may differ according to the service and contracted mode. Even an import or export situation can change the service requirements. Intermodal increases all these constraints since it involves more agents, more modes, and integration processes will have to be put into place. This means that the more complex a chain is, more critical points will be identified in the information flows

This study reveals that the negotiation and adjudication phase and all processes related to terminal areas are critical steps in any intermodal chain typology adopted.

Documentation flows are key flows in the preparation phase; they can ensure that the service is well prepared. In that regard, it is crucial to know the cargo and its origin/destination requirements.

Terminal areas involve many processes and agents and, in that regard, are more vulnerable to errors and delays. Customs procedures were rated the most critical for international services in all typologies, mistakes and delays can bring the entire chain to a halt, affecting nearly all agents.

Flows in other phases were classified as less important to chain development because they are merely informative or are less prone to reduce chain efficiency.

Currently the transmission media used by chain agents are not standardized and integrated informating sharing systems are uncommon. Agents still seem reluctant to adopt these measures.

The validation phase, prepared based on interviews, showed that even agents with different roles in the chain have identified the same critical points.

Based on expectations and on validation made, it is possible to state that the goals of this study were accomplished. All information flows for the different Woxenius' typologies were classified and the most critical points identified. Furthermore, the aim of embracing the largest possible number of cases and presenting generic chains was also achieved, but one have to take into account that the application of these generic chains to a particular case requires a thorough analysis of the given situation.

This study allows us to understand key data during the chain, the consequences of potential delays or errors, and raises awareness about how important information sharing and cooperation are for intermodal efficiency. The content of this study helps to explain the business and can be used by ITS developers to develop dedicated software or other products.

As future work it is suggested:

- Try a new approach using a modelling methodology;
- Analyse a case study of each type of typology, completing the analysis mentioned in this study;
- Create a standardised communication process and assess its impact;
- Evaluate the impact of communication platforms to integrate information flows;
- Center the study on synchromodality;
- Expand the research to supply chain;

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