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Requirements on Supply Chain Visibility: a case on inbound logistics

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Abstract. Events such as Covid-19 have revealed the vulnerabilities that companies face due to low visibility. Consequently, companies experience impact on their supply chains in terms of disruptions of material supply, deliveries, productivity and revenue. Thus, the importance of Supply Chain Visibility (SCV) in global and competitive markets with increasing sustainability demands has received widespread recognition. Yet, the literature provides limited understanding of requirements to consider when developing a SCV system. Addressing the gap, this study presents the findings from a case study during the first months of 2021 at a global manufacturing company developing a SCV system to improve their inbound flow. Using a system engineering perspective, this study presents requirements highlighted during early stage for a SCV system. The results indicate the importance of ensuring SCV system requirements to enable data collection, handling and usage for decision making leading to both supply chain sustainability and resilience. This study contributes to the understanding of SCV by presenting and categorizing requirements considered for real-time case at a manufacturing company when developing a SCV system.

Keywords: Supply Chain Visibility, Digitalization, Real-time data, Logistics

1 Introduction

In recent years, the importance of Supply Chain Visibility (SCV) has received widespread recognition. The literature provides numerous suggestions for defining SCV. Key characteristics of visibility is the accuracy, accessibility, availability, timeliness and usefulness of information [1], [2], [3],[4]. Visibility is also considered to play an important role in the transition towards industry 4.0 by enabling real-time data and support decision making[5]. Despite its relevance, the level of SCV perceived by supply chain practitioners within the manufacturing industry is rather low. The study conducted by Srinivasan and Swink [6] revealed that industrial leaders conveyed the need

to increase SCV. Events such as Covid-19 pandemic have shown the vulnerabilities that companies face due to low SCV [7]. Companies experienced disruptions in their material supply affecting deliveries, productivity and revenue [8], [9], [10]. In addition to affecting business performances, low SCV is mentioned restrict the ability to achieve supply chain resilience [11]. Thus, handling supply chain disruptions, a global supply base, operations and markets, have increased the attention on SCV in order to attain sustainable and resilient supply chains [12], [13], [14]. Although previous research accentuated the importance and expected benefits of SCV, the requirements to consider when developing and implementing a SCV system in practice are fuzzy [15] [16]. This is problematic since failing to develop understanding of requirements may result in inadequate implementation leading to financial and reputational loss [10]. Addressing the gap, the objective of this paper was formulated as investigating the following research question: how are requirements on SCV formulated within manufacturing industry? This study presents the findings from a case study at a manufacturing company developing a SCV system to improve their inbound flow. This study contributes to the understanding of SCV by analysing and categorizing requirements considered by a manufacturing company when developing a SCV system. The requirements can be considered as a support for further research on how to plan, develop and implement SCV systems.

2 Methodology

In order to address the objective, this research is based on a single case study within the manufacturing industry. Given the complexity of supply chains, adopting a case study method can be beneficial in order to understand specific problems [17]. This can in turn contribute to development of more generic solutions. In addition, case studies are stated to support in-depth understanding which in turn can contribute to development of theory in exploratory research [18] [19].

The selected case company is in the top-three in terms of revenue in its business, has a global manufacturing presence and is considered to be world-class in its industry. They have approximately 50 000 employees in 100 countries. In order to improve their supply chains in terms of performance and sustainability aspects, they have identified areas where they want to improve SCV. They also experienced SCV challenges in recent covid-19 pandemic through supply chain disruptions of material supply and uncertainties leading to production issues. Therefore, they can be considered as suitable representative of a manufacturing company on a digitalization journey, facing number of SCV challenges.

The study has followed a project, run from the company's headquarter in Northern Europe, which started at the case company in January 2021. Data collection occurred between January and March 2021. It included participation in six project meetings, three semi-structured interviews and analysis of project documents. The project team was cross-functional and consisted of members with responsibilities for supply chain development and data & mobility services. In total, three semi-structured interviews and participation in seven project meetings took place. The collected data was discussed

and reviewed by the authors (consisting of three professors, one postdoc, and one PhD student) to establish a detailed picture.

In order to categorize requirements from the collected data, a system engineering perspective was adopted. System engineering, well recognized to enable the engineering of complex system, support to understand requirements needed to successfully implement a system [20], [21]. Here four categories of requirements were used. *Business requirements* can support to understand the general aim with the system describing what the system should do and desired features. *Functional requirements* describe what functions a system should deliver. *Nonfunctional requirements* refer to the behavior of and constraints placed upon the system. *Stakeholder's requirement* support to understand the expectations and needs from stakeholders. It also increases the possibility for project success and acceptance [22],[23]. It is important to ensure that the requirements are verifiable, realistic, consistent and understandable by stakeholders [22].

3 Results

The results from the data gathering and analysis is presented according to Current state, (detailing the process steps, flow of goods, IT-system as well as pain points) and Expressed requirements on the SCV system (mapped to the four categories of Business, Functional, Non-functional and Stakeholder requirements).

3.1 Current state

Semi-structured interviews were conducted with the project member with experience in supply chain development. This helped in understanding and visualizing the current state and related pain points in the inbound flow.

Inbound flow. A general representation of the inbound flow at the case company is presented in Fig. 1, which depicts the main process steps, flow of goods & packaging and overview of the IT-systems. Orders to suppliers are predominately sent by EDI (Electronic Data Interchange) using the ERP (Enterprise Resource Planning) system at the case company. This is followed by order confirmations sent by the suppliers. Consecutively, suppliers will send an order for packaging, as they are normally required to use the packaging material produced by the case company. Once the parts are packed and ready for delivery, the suppliers send delivery confirmations to the company. Certain percentage of deliveries from suppliers are sent to cross-docks, called x-dock at the case company. The parts from suppliers arrive in pallet or box level as indicated in Fig. 1. Operations performed at the x-docks are mainly unloading, sorting and loading. No extensive verifications of parts delivered from suppliers are performed. The pallets are eventually loaded at the x-dock, picked-up and delivered to logistic centers. Once the deliveries to the logistic centers arrive, there is an arrival confirmation at gate unloading confirmation, storing confirmation, booking confirmation and stock status update in the WMS (Warehouse Management System). Eventually, the arrival confirmation can be seen by the production site in order to place an order to the logistic center.

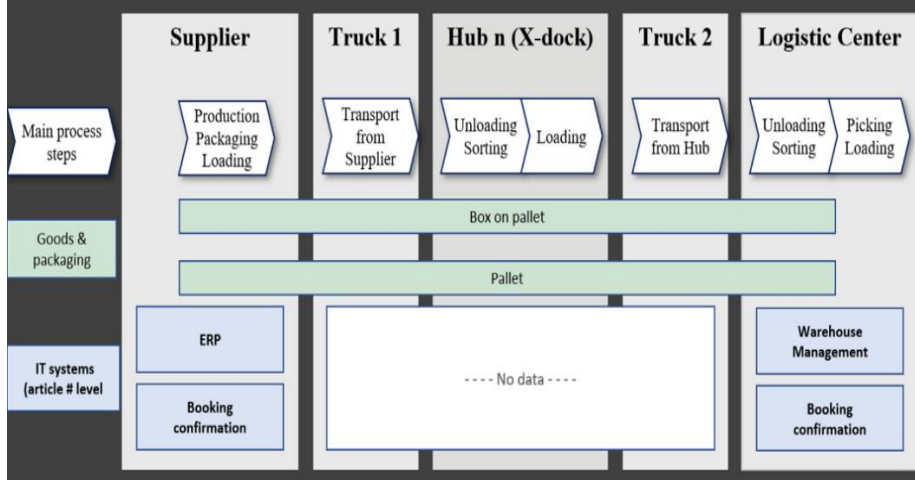


Fig. 1. Current state of the inbound flow in terms of main processes, flow of goods & packaging and IT system used.

Current pain points. Primarily the pain points (summarized in table 1) consist of factors affecting operations but are also related to restricted capabilities to control, plan and analyze the inbound flow. 90-95% current deliveries are one time, so one challenge with current approach is that there is no-real time information from the supplier at the point of loading (Truck 1 in Fig. 1). Despite the fact that information exchange occurs using IT systems, this approach is in essence trust based. Consequently, the deliveries cannot be checked and verified in real-time. This has in turn led to choosing speed transports to solve deviations leading to additional costs. Together with lack of ability to verify deliveries in real-time, the complexity of the supply base forces the company to keep additional stock to ensure material availability for production. The lack of visibility pointed out in Fig. 1 causes blind spots in the flow. Thefts have occurred in certain blind spots causing issues. As production rate is planned to increase, additional investments are required to increase the storage capacity if the current delivery situation remains. The study also revealed that there is no unified visualization of the connection between article number, pallet, truck and hub. This leads to reduced ability to monitor, plan and act proactively. The importance of these abilities for both current and future operations were further realized during the covid-19 pandemic when the company suffered from lack of SCV resulting in restricted capabilities to plan and be proactive.

Table 1. Summary of expressed pain points.

Pain point	Description
Speed transports	No real-time information causes speed transports
Additional inventory levels	The complexity of the supply base forces the company to keep additional stock to ensure material availability for production
Blind-spots	Lack of SCV causes difficulties to identify spots of deviations in the flow
Additional investments	Additional investments in storage capacity due to the lack of SCV
Lack of unified view	No unified visualization of article number, pallets, truck and hub
Limited proactivity	Difficulties to identify deviations in time and take appropriate actions

3.2 Requirements on SCV system

As explained in the previous chapter, the identified requirements were categorized into business, functional, non-functional and stakeholder requirements.

Business requirement. Business requirement included both short term and mid-long-term goals describing both desired states and effects of implementing SCV system. Summary of the business requirements are presented in table 2.

Short term. Real-time monitoring was expected to result in improved resource utilization by reducing manual work spent on deviation handling. Flow optimization reduced inventory levels and unnecessary investments in logistics centers were stated to be anticipated effects. In addition, reducing the environmental impact by reducing speed transports and optimizing transports were other desired outcomes.

Mid-long term. Improved forecast and planning abilities are expected to be the outcome of implementing a SCV system. This was in turn expected to enable virtual stock across the supply chain. It was also clear that going forward, a SCV system should support the case company to become more autonomous in the supply chain. Having a SCV system is considered to support automation of processes and flows.

Table 2. Business requirements

Business requirement	Description
Real-time monitoring	Enable real-time monitoring from point of loading at supplier till delivery required
Improve forecast and planning accuracy	Utilize real-time data to further improvement of forecasts
Virtual stock	Implement virtual across the supply chain
Autonomous flows	Attain more autonomous flow and processes

Functional requirement. The functional requirements identified describes the high level functions the SCV system is expected to perform. They were based on supporting operations and improve the ability to work proactively. The functional requirements are listed in table 3.

Table 3. Functional requirements.

Functional requirement	Description
Deliver digital view of article number, boxes and pallets	The ability to have unified view of deliveries in real-time for the inbound flow
Provide continuous updates regarding Estimated Time of Arrival (ETA) upon for deliveries	This function was crucial for operations and for instance support the reduction of speed transports
Deliver a track and trace function	The function was needed to support deviations
Deliver measurement of fill rate	This function will enable actual measurement of fill-rate in real-time
Deliver measurement of CO2 consumption	This function will enable higher accuracy of the measurement and the sharing of information

Non-functional requirements. The non-functional requirements indicated the expected characteristics of SCV system. They were based on the data collection, connectivity, analysis, handling and security. In addition, the importance of integration and

interface with the current systems was identified. The non-functional requirements are listed in table 4.

Table 4. Non-functional requirements

Non – functional requirement	Description
Data collection and connectivity through registration of events in real-time	Important to capture key steps such as departure, vehicle on road position, arrival cross-docks and logistics centers. The data collection and connectivity should be used to visualize order number, supplier shipping confirmation, pallet ID, Vehicle ID, Vehicle position, Site information, Production unit need and stock status
Data analytics for the measurement's calculations	Data analytics should be applied to utilize the components of digital thread in order to provide performance indicators and reports
Set up data security to ensure data protection	To ensure data protection
Integration and interface with related systems	Critical to make sure integration and interfaces with related system which includes ERP, WMS, and TMS (Transport Management System)

Stakeholder requirement. No explicit goals describing stakeholder requirements on the SCV system could be identified in the project during the time period for data collection. One stakeholder requirement, which is related to business requirements, pointed out that the system should deliver alerts and notifications regarding deviations of deliveries in order to timely provide stakeholders with information to take appropriate actions.

4 Discussion and conclusion

Supply Chain Visibility has received widespread attention from both researchers and practitioners. This paper strengthens the view that SCV is considered to be crucial for performance and decision making in both current and future operations in global manufacturing [6],[7].

This case study has identified and categorized the requirements expressed during early phases of a new SCV system for inbound logistics within a global manufacturing company, known to be a leader in their business. The current state of inbound flow confirms that the company suffers from lack of SCV [6] and the related pain points accentuates the consequences in terms of disruptions in material supplies [10]. Also, this study highlights that sustainability is a key driver for SCV [13].

From a systems engineering perspective, the requirements can be categorized into mainly business, functional and non-functional requirements. It can be noted that some of the requirements (both functional and non-functional) can be further detailed. For instance, the track and trace function might at this stage be insufficient, exposed for

multiple interpretations and lack stakeholder input [22]. Even though the project is still in its early phase, the study indicated that stakeholders' requirements are not specified. Not including stakeholders' requirements and inputs might limit the utilization of the SCV system for future large-scale implementation.

Previous literature already highlighted the importance of gathering real-time data for SCV[5]. However, this study underlines additional points to consider. For manufacturing companies on a digitalization journey with complex supply chains facing SCV challenges, this study indicates the importance of developing SCV systems requirements for collecting, connecting, analyzing, securing and applying real-time data for decision making, which incorporates both the goals for the company as well as external supply chain challenges. This can in turn enable both sustainable and resilient supply chains.

The study contributed to the existing body of knowledge on SCV by presenting and analyzing early-stage requirements set within a large global manufacturing company, in the midst of external supply chain challenges and digitalization journey. Future studies will include analyzing further realization steps for the case, in relation to this initial requirement data. It can also include incorporating various stakeholders' requirements for specifying and testing a SCV system. Such a study will support to identify additional requirements to consider for a large-scale implementation of SCV systems.

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