**EXPLORING DEVIATION INFORMATION FOR PROACTIVE DECISIONS IN REAL-TIME TRANSPORT PLANNING**

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**Introduction**

There is a desire for sharing real-time information between actors to deal with dynamic nature of operational decisions in transport chains, influenced by constantly changing conditions of activities (AEOLIX, 2017). More available information is important to be able to obtain higher resource utilization and overall efficiency. Inability to be flexible when unexpected changes occurs could affect logistics service providers possibility to deliver to customer in time, customer satisfaction, or generate sub-optimal transport solutions decreasing resource utilization. Real-time operational decisions are further under constrains of time (Schönberger and Kopfer, 2011), generating need for timely and correct available information. To deal with this decision support systems (DSS) have been proposed by literature, including detection of deviation; magnitude evaluation of change (re-plan needed or not); information for re-plan; re-plan decision (Séguin et al., 1997). Literature in supply and transport chains mainly emphasis on models for re-plan stage in DSS and less on the information of a deviation. However, this part is important as the available information can either make the decision makers act in a proactive or reactive way (Mukai et al., 2005). As seen in figure 1, this paper divides information for re-plan into deviation information, regarding information about a change, and support information, regarding information supporting the re-plan decision and this paper focuses on the former. Depending on the deviation information the re-plan decision in a transport chain will have conditions for either reactive or proactive re-plan decisions.

This paper will be focusing on operational deviations (Tang, 2006) in transport chain planning with low impact but high occurrence probability, in comparison with disruptions with high impact but low probability, making them the larges part of the trouble shooting in practical settings and where deviation information can be more applied. Transport chains are dealing with consignment, physical movement and handling connected to transport, as well as planning and control (Woxenius, 2012). These chains differ from logistics chains and supply chains focusing on items or articles respectively a product. This paper focuses on operational planning in transport chains that are exposed to dynamic changes. To cover a broader range of decisions for these activities a case study is executed on an actor acting the transport coordinator, terminal operator and shipper.

More advanced technologies, lead to possibility of having more near real-time information from other actors available. At the same time, logistics service providers are experience challenges to use information from tracking technology for operational control in decisions (Meyer et al., 2014). Further, complex setups between actors in a transport chain (Sternberg et al., 2013) make it hard to share real-time information. Literature has focused on algorithms or optimization models to solve the re-plan issue (Schönberger, 2011) and not on the detection of the change in practice. Even though, advanced technologies have been introduced there seem to be little understanding of deviation information that can better enhance condition for proactive re-planning. This paper therefore investigates deviation information in order to increase understanding on how deviation information influences possibilities for the planning decisions to be of proactive or reactive nature. This paper focuses deviation information in order to explore possibilities to move towards proactive re-plan decisions. Figure 1 presents the purpose of this paper and surrounding context.

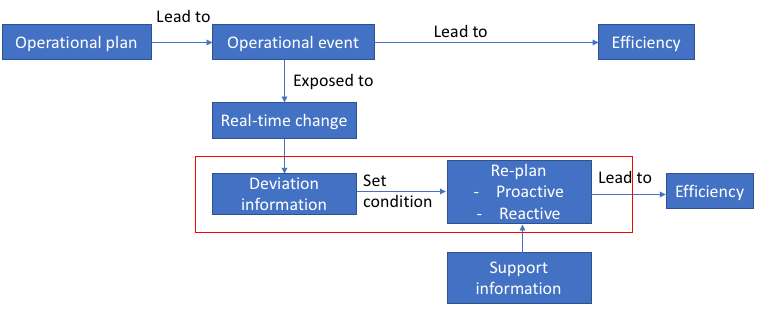


Figure 1: Model representing the context of the purpose of the paper, where the latter is marked with red square.

**Frame of references**

**Proactive and reactive real-time freight transport planning**

Many have raised different phases of dealing with real-time planning. Séguin et al. (1997) introduces a DSS with the steps of detecting changes, analysing data and making predictions, evaluate alternatives, select alternative and monitor environment. Similarly, Feldman et al. (2013) include detection, prediction, decision and act. Further the authors describe proactive in real-time planning as awareness of a change with undesired outcome already at timepoint *t-Δ* to be able to re-plan to a desired outcome at timepoint *t*. The time and relevance of information have also been pointed out of importance for proactive decisions (Mishra et al., 2017). Feldman et al. (2013) configure a proactive software for predicting discrepancies in shipment weights for air transports. Mukai et al. (2005) refer to proactive route planning when a transport vehicle can foresee next destination by providing high reward in order to get learning in the system. The authors add that optimization on not updated information and manual efforts lead to reactive planning approach and difficulties adopting to dynamic changes. From a more strategic and tactical viewpoint Zhalechian et al. (2018) see proactive as having pre-plans for a system to automatically adopt to changes in order to minimize performance consequences. Reactive is referred to as how well a system reacts after a change to minimize performance consequences. The difference of reactive and proactive decisions in this paper is based on the reasoning above and defined as followed. Reactive decisions are performed based on information received after the change has occurred. Proactive decisions get information about the change in advance (*t-Δ*) and can adopt directly. Importantly, the timing of detecting event is important, which is a problem in practice, or as previous research state “unexpected events are often not timely detected” (Meyer et al., 2014, p. 433). Similarly, importance of alertness in supply chains has been pointed out, as timely awareness of change (Xun et al., 2009). The underlying assumption is that a level of overall efficiency for the LSP is obtained at initial state and that this level deviates less with proactive decisions than reactive.

**Dealing with real-time changes**

To deal with real-time changes literature have focused on varies aspects. Roy (2001) goes through real-time decisions with regards to activities connected to LTL (less-than-truckload) or FTL (full-truckload), explaining different tools of EDI, decision support systems (DSS) and GPS for the decisions. DSS is commonly used to deal with real-time changes. The architecture of such system has been broadly discussed (Séguin et al., 1997) and solutions of the DSS with algorithms or heuristics (Schönberger, 2011). A novel study from Meyer et al. (2014) focused on how to use information from tracking technology and building up a support system for freight transport planners. Bock (2010) refers to real-time-oriented control system including one database mapping current situation with input from dynamic events and position and state of vehicle fleet.

Risk management deals with assessing the risks of a change or disruption, typically in regards to the probability that the change occurs combined with the impact it will have (Knemeyer et al., 2009). This is important when dealing with changes to find out probability or impact of risks or mitigation and avoidance strategies in operational activities but is not the focus of this paper. This paper aims only to focus on the deviation information. Zhalechian et al. (2018) defines resilience strategies for hub and spoke network as proactive and reactive. Regarding time point of view, this would be before the change actually happens in order to come up with strategies of mitigation or avoidance. However, it focuses little on information of a change or disruption on an operational level, rather on a tactical and strategic level (Tang, 2006). Indeed, flexibility is included but more from possibility of strategically making decisions to keep a supply or transport chain agile to adopt to changes. Angkiriwang et al. (2014) define reactive and proactive strategies for flexible production of stocks and buffers respectively postponement, agile contracts, routes and lead and setup times. However, also here the deviation information is not the focus. Further, reactive flexibility measures of recovery plans (Sahebjamnia et al., 2015) after change has occurred has been introduced.

**Condition of deviation information**

As previously noted, timing of deviation information is of importance (Meyer et al., 2014),(Xun et al., 2009). Further, no single information component will be able to cover all possible changes, leading to a need of combining information to identify what is going on (Fleischmann et al., 2004). This is also one of the main functions in a DSS (Séguin et al., 1997, Mishra et al., 2017). Taking the example of changes in travel time, many factors can influence (van der Spoel et al., 2017). Distinguishing between data and information can be of valid to understand what is being conditions for information. Following Davenport and Prusak (1998) data can be described as the discrete and objective facts about a change, in comparison to information being the message communicated. The authors further present that information can lead to knowledge and action. However, the two last parts will not be included in this paper as focus is on the deviation information not directly the response of a change. Combining or evaluating data to information can be managed by computer aided or semi-computer aided systems, differing in that computer aided is fully managed by a system and semi-computer aided is where a human is presented with information from a system. Mukai et al. (2005) adds that operational transport planning is often involving completely human evaluation, giving the case of human being source of information. Additionally, Meyer et al. (2014) included the problem of manually analysing the information as unfeasible.

To sum up, considering the timing of deviation information and combination of data four parts can be derived. Firstly, deviation information can be related to detection of a change, referred to as the change has occurred, or prediction of change, referred to indications before a change has occurred. Further, it has been seen that both these two can be achieved by either combining data manually or automatically.

**Methodology**

The study was constructed as a qualitative case study in order to capture and get in-depth understanding of the phenomenon of deviation information in real-time context of operational transport planning.

The chosen case company was based on two main features; (I) Different perspectives and transport modes represented by one case, as the case company is both shipper and plans the studied transport chain, which includes both road and rail transport. The road is assumed to be more flexible in comparison to the rigid schedule of rail transport, which could affect the conditions for deviation information. (II) The case company is using GPS on their own trailers, indicating possible pre-condition to obtain deviation information with conditions for proactive decisions.

Main data source for conducted study was five semi-structured interviews including three transport planners and two logistics business developers. The interviews were based on a question guide including different parts to cover the purpose of the research and second follow up interviews were made with the planners. Initially, the interviews focused on getting a broad overview of the operational planning executed in order to understand what decisions that were mainly in focus. Secondly, more detailed questions regarding deviation information in the planning were covered. The interviews with logistics business developers were aiming to get an understanding of the awareness of deviation information and proactive and reactive decisions from a higher and broader level of the planning. The input from the planners on these topics are including more detailed questions on what changes that occurs and how and what deviation information that is received. The interviews were made in person with the planners and via phone with business developers. During all interviews extensive notes were taken. As a second source of data on-site visits at the central DC were conducted three times by author, in order to do observations on planning and terminal activities. To assure research quality of the conducted case study, the qualitative dimensions of trustworthiness, including credibility, transferability, dependability and confirmability were followed (Halldórsson and Aastrup, 2003). For confirmability, multiple sources of data were used and the question guide was pilot tested on research colleagues to mitigate confusions for that respondents in understanding the questions. Furthermore, extensive notes were taken at all interview and observation sessions. Interpreted answers were shared with the respondents for credibility check. Transferability was treated by comparing case results with previous research. The use of question guide and use of highlighted parts from literature for performing and analysing the interviews are aiming to achieve dependability.

**Case description**

The case company is performing planning on freight flows of around 80 owned and 30 leased trailers and all haulier activities are outsourced. The trailers are going via train from south of Sweden to a Distribution Center (DC) in middle of Sweden, as of now referred to central DC. Trailers destination can either be the central DC or two other DC in middle of Sweden, for which road transport is used. All three DCs are of own regime. The planned freight flows in south of Sweden are combined routes of direct deliveries of trailers from train to stores and pick-up at suppliers for freight going north to the central DC. The train is doing one trip north and return south every day expect Saturdays. The planned deliveries in south of Sweden are direct deliveries of bigger shipments to stores. Activities for smaller deliveries of reloaded and delivered to stores are outsourced to third-party logistics partner and not covered in the planning of the case study. Further, some incoming freight are reloaded into trailers by the same third-party logistics partner and is also not covered in the case study. For delivery and pick up of trailers from and to the train at central DC, the planning revolves around delivery of trailers coming with the train heading to the two other DCs and collection of freight in trailers heading for the train from the same two DCs. The planning executed in the studied case revolves around the three main transport parts; delivering of trailers arriving with train to the two other DCs combined with pick-up of trailers from the other DCs that are going with the train, train transport both heading north and south and finally the delivery to stores and pick-up at suppliers in south of Sweden. Planning revolves around making an initial plan and thereafter performing firefighting re-planning to resolve issues occurring due to changes. The planning is mainly done in excel sheets, which are shared with terminal operators and hauliers. The next sections describe the three main transport chains parts being planned at the planning group at case company and how these parts are dealing with deviations.

**Road delivery and pick up of trailers at two other DCs**

Transport is performed via road through a contracted haulier company. The contracted haulier company has outsourced the transport to a sub-contracting haulier having six truck drivers operating between the three DCs. The truck drivers start early in the morning, one at the central DC and five at one of the other DCs in order to pick up trailers heading for the train going south during the day. Arriving at the main DC in time to collect the first trailers taken from the arriving train to deliver to another DC. Allocation of trailers needing transport are thereafter assigned after finished task. However, some planners plan the whole day at once in comparison to others that only assign the next trailer to see how the status is of other drivers before choosing next task.

Deviation information is mainly revolving around input from drivers or from terminal operators. The communication is made via emails or phone calls, with the drivers a chat program going directly to the mobile devices of the drivers is used. In case of no response from planning group at case company the drivers may contact the contracted haulier, which spreads the information via phone or email. Timepoint for communication is either done at points of interest, as when trailer has been left or picked up. At this point the temperature is manually checked by planner via software connected to the GPS. Transport delays of congestion or breakdowns are communicated by drivers first when the change had occurred, i.e. when the driver is standing still in a queue. The driver may give an estimation of how long the queue is. This setup generates good overview at certain points during the transport but includes few updates for deviation between these points. During observation a new driver took a trailer at a DC and headed for the final destination of the train and not starting point at the main DC. This was first detected when terminal personal was waiting for the trailer and asked planner since it had not arrived. The planner could via GPS data manually get position of trailer and through the contracted haulier get hold of driver to rearrange route. The terminal reports what has been filled in what containers, according to first plan from planners, via excel sheets. No specific combination of data was executed, as it mainly revolved around getting deviation information from driver. One seen data combination was the combination of GPS data with route and experience of traffic situation, to estimate an arrival time to predict deviation. However, no other input than experience was used for traffic information.

**Train transport**

The train transport is executed by an external train operator at fixed time slots. The Swedish transport agency is responsible for the infrastructure and planning of trains in case of delays. The train is filled with trailers in south of Sweden by a third-party logistics partner.The case company receives information from the train operator about reasons for delays after the delay has occurred. Arriving train in middle of Sweden is unloaded by the case company. The planned arrival for this train is 05.10 in the morning, making information about delays to be announced during evening or night. This setup makes deviation information, detection or even prediction, of little interest for operational planning, as terminal personal and truck drivers will not be informed during these times to postpone start of working day. Instead, in case of train delay, the terminal operators need to find other tasks to perform. However, this is not so easy for truck driver waiting on the train to arrive as other tasks risks delaying delivery of these prioritised trailers. Earlier the case company had a jour function of one planner always being available in case something happened. During this time, they used alerts on temperature deviations from GPS software provider directly to the jour mobile phone. However, after taking away the jour the temperature alerts are done manually as mentioned above. The actual sequence of trailers is reported via email and manually compared by planner to identify deviations from plan.

**Road direct delivery to stores and pick-up at suppliers**

In comparison to the road transport from and to DCs, the planers make a route plan covering one day for a driver but the drivers have no fixed points on when to report status. The driver can even change the sequence between pick-up if preferred and possible, as some pick-up and deliveries are limiting with fixed time slots. Deviations can here alter how many shipments the driver is able to complete, which leads to that other drivers may need to take planned shipments from this driver. If demand is high and all available drivers all planned for full days, the options are to either provide more supply in form of getting more drivers or change in assignments. If on top of that changes occur altering the planned routes, it may occur at rare occasions that shipments are left for the next day. One haulier is used for the transport and similarly as previous the deviation information is communicated via phone calls from drivers or emails from haulier. Even though the drivers are good in communicating changes these are mainly done when something unexpected happens leading to reactive behaviour of re-plan decisions. Importantly, changes at other involved actors, as supplier, are not reported by this actor but by drivers. For example, if the supplier only has 29 pallets ready for pick-up instead of planned 33, or the driver has to wait one hour for the remaining pallets, the driver calls the planning to inform. According to interviews this occurs also for suppliers with fixed pick up times. In line with the road transport related to DCs, there are little combination of data, as deviation information is mainly represented by detection after change has occurred.

**Results and discussion**

This section uses the dimensions of deviation information derived in frame of references to analyse and discuss interviews and observations data.

Deviation information in the case study was mainly received after a change had occurred rather than received before the change occurred. Few examples of prediction were found, only in connection to after a changed had occurred to predict next point of interest in transport chain. This makes the deviation information at case company revolve around detection rather than prediction. Deviation was identified when someone in the transport chain is reporting at fixed points or when something expected has not happened, leading to reactive planning with big gap between time of deviation and time for detection. The sub-contracting of activities between hauliers are generating difficulties for efficient information flows adding problems to minimize the gap between deviation and detection. The combination of data for deviation information was primarily executed manually, representing manual detection giving reactive planning possibilities. The combination of data was limited, probably as the case company received data for detection without need for combination and would probably be more of importance for prediction and proactive planning. The train was found not mainly limited by the inflexible infrastructure and schedule but the contextual settings of early arrival time in the morning in the case study show lower potential for detection or prediction information. Giving that flexible activities can give more potential for increased resource utilization compared to better deviation information. However, accurate prediction of magnitude for deviation, i.e. time, could support more options for alternative activities. The case company is not using system support to get from manual detection to automatic detection, even though technically feasible and previously used. The explanation considered no need for constant updates leading to extra work with more notifications. It could be argued that the automatic detection was one module in an otherwise manual system, which not made it suitable for the working settings. However, if the automatic detection had been linked to an automatic module for prediction this might had been more usable. Getting information for detection instead of prediction is generating a reactive re-plan approach, which is seen in the initial planning stage where slack is built in to the routes, comparable to a resilience strategy (Zhalechian et al., 2018), in order to be flexible and manage changes. The overtime of drivers is used as a reactive flexibility measure to deal with unexpected changes or planning for a short day for a driver generating possibilities to help out in other routes in case of changes. One can compare this slack as stocks and buffers in production planning (Angkiriwang et al., 2014) or as a recovery plan (Sahebjamnia et al., 2015).

The activity of planning has no certain rules on how to combine what shipments in a route or what trailers to priorities for transport between DCs. Further are schedules, except some given constraints of fixed time slots, proposals to drivers, who may decide on breaks at other timepoints. This space of freedom for drivers will generate problems to combine data when designing proactive deviation information for prediction. This adds new indications for intelligence needed for prediction systems, i.e. predictive arrival time need to include contextual aspects, adding to the factors identified by van der Spoel et al. (2017). This will be of importance to increase accuracy of prediction as detection is seen more reliable as deviation already happened. Further, to move towards prediction instead of detection, data for deviation information from other actors and data sources need to be considered, to cover contextual aspects and complex actor structures, as seen above. As setup to get this information prediction could be connected to more costs and efforts than detection. This raises the importance of clearly linking prediction to efficiency, in better decisions and less slack in planning, in comparison to detection could influence practitioners to change this view.

**Conclusions**

This paper investigated deviation information in a case company to better understand how deviation information influences possibilities for the planning decisions to be of proactive or reactive nature. Based on literature four main types of deviation information were identified; proactive prediction or reactive detection, depending on timing of identification and both can be achieved via combination of data manually or automatically. The case study illustrates aspects, in comparison to previous literature, when proactive might have little potential or at least to high cost for results. It further points out important contextual issues affecting the possibilities for prediction or detection information to influence the operational planning. How the planning work is structured automatic detection or prediction could be of less interest, i.e. one automatic module deviating from manually structured work in planning was found not suitable. These contextual settings of activities and planning add theoretical implications that could be of importance when developing prediction systems for deviation information in DSS. Reactive planning structures with in-built slack need to be changed, in order to see value in proactive deviation information. Similar as Sternberg et al. (2013), a complex actor structure of hauliers has been seen to limit the possibility of getting proactive prediction information. Technological advancements can change costs for generating data from different sources indicate potential for achieving prediction. Proactive prediction can give potential in using other resources better, rather than having them waiting for arriving transport. However, differing from assumptions in literature, the possible influence was seen varying depending contextual settings as late daytime of arrival and activities possibilities to be flexible and meanwhile waiting do alternative tasks or not.

Limitations of single case study can be addressed by future research to broaden generalizability. The case study shows limitations of available deviation information that could be addressed to develop DSS relevant for practice. Further, the connection between proactive detection information and support information and measured efficiency can be combined for a broader understanding of the complete picture.

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