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Faculty of Industrial Engineering and Innovation Science
Data2move Community Project

# Real-Time Data Use in Improving End-to-end Supply Chain Delivery Visibility

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# Forewords

The importance of data for general use in the industry as of 1980s surged in average up to 40% until 2007 (Hilbert & López, 2011). This attested that ever since then, data availability is believed to be a crucial factor for any industries, or organization to survive in such tempestuously competitive business environment (Devine, Srinivasan, & Zaman, 2004). In their article, Hilbert and López showed that this number is determined not only by referring to the number increase of bytes in data storage or capacity but also data transferred through broadcast, telecom, and data and used for general and specific computation application. Additional staggering fact is that there are around 28,381 Mega Instruction per Second (MiPS) increase merely within 7 years for the use of application-specific computation. This amount does not yet include the open source data availability and other general-purpose computation (Hilbert & López, 2011). The data has indeed become abundant and available everywhere.

The use of data is no longer only important for the data scientists. Currently, business and management player are paying more to attention to acknowledging and implementing the right tools to analyze and get a better translation of market to support their business decision (Lebied, 2017). This data is become very crucial in the implementation of supply chain visibility along with customer's demand, such as: on-time or same-day delivery, dynamic product trend, etc. For example, specific to the logistic industry, the use of real-time traffic data is believed to reduce their lead time, hence cost. From the customer's side, it is important for them to be convinced that their purchase is being delivered to the right address at the time as scheduled. Thus, the need of data is not only perceived by traders but the whole chain, including the end customer. This highlights that market leads all business player to play their role in data-driven manner.

Researchers, industrial experts and other have put their eyes on increasing supply chain visibility for decades. At times, the technology capability is limited. The existence of cloud and internet has introduced companies to the use of EDI, IoT, etc. Currently, as the interest of Big data increased, the tools for data analysis started as well to heave in sights. They compete to get along with the company's need, and provide the ease for the company to be able to create an optimized decision by only a push of a button. However, creating such system needs a concrete and specific information system architecture. Searching the extant technology solution in the market provided by one technology provider company can also be a fast choice. Because it is indeed simple, easy and does not cost as much as the self-tailored technology solution. However, knowing that the competitiveness among logistics industry is never receding, these type of solution tools (general) can be also used by the competitor.

The interest of creating tools for making use such real-time data and paced information arrival is what enforces many companies to start measuring their own capability to develop their technology or looking at technology provider that can create a self-tailored solution. However, to start on such greenfield project, companies are curious of what would happen once this innovation is implemented. Will it give more benefits and profits? Will they need more time to prepare? If so, what kind of preparation should be done? Is the running system or the owned technology capability compatible to operate with the real-time and resulting real-time decision making? And are the people inside the company ready for the change? This investigation is necessary to create the baseline of stepping further to implementation and operation. Creating an investigation tools as a decision support tools will give a visualization of the impact on the running system. Wherefore, the KPI can be used to measure the extent of one company's preparedness to the this "new system".

# 1. Data2move

Data2move community is established to grasp the opportunity of the immense increase of data availability in the open source. The community consists of not only the academia from several universities, but also companies located in the Netherlands. Companies that are the members, along with the goal of Data2move community, see these open and real-time data with high valuable information as the key enabler to hoist their service quality in such a competitive market. By combining the expertise in both fields (academia as the researcher in theoretical manner and industrial players as the challenge provider in practical manner), it is expected that the exchange of needs and knowledge within the community can be altered into platform where solution and innovation related to data are born.

The industrial sectors in data2move community come from various types of Industries. The events that are yet held, provide opportunity for companies to share their current data-related challenge and issue. The probability of gaining a solution out of the challenge is then high as meeting the other companies from different industry will allow them to build and design collaboration with the technological providers or the supporting companies. Other than that, companies may also get inspired by the other company with the same industrial field that have already been advanced in the technology application.

The data2move board then provides selected students as the research assistants to be assigned to the company according to the project in which each student finds it interesting. The company also has a right to choose which students they find the best for the project. Under the supervision from the university (data2move board) and the company, the students must be able to meet the project expectation under the agreed period of internship or project.

# 2. H&S Group B.V.

H&S Group is a bulk food liquid transport provider. The market reaches throughout Europe and Russia. H&S has been working on this field for 65 years and they are specialist in road tanker transport and tank container services. H&S group organizes numbers of business line, such as Intermodal Solutions, Warehousing (Coldstores) and Supply Chain Solution (Logistic services). In addition, as of 1 November 2017 H&S (H&S foodtrans) and HOYER have signed joint venture agreement, known as H&H foodlog. Their aim is to combine the knowledge and assets of H&S and HOYER to provide innovative solutions and best service to the customers.

The intermodal solution in H&S aims to transport the liquid food safely, in an efficient way and economical way in accordance to the customer's order including the time window of arriving and/or picking up the product. For accommodating transportation services in the liquid food sector, they provide various type of transport, such as: Road transport, rail transport, shortsea transport, inland waterway transport (barge). On the other hand, H&S coldstores as a subsidiary of H&S group, they handle the storage of various products (fruit juice, concentrate and puree). The services include temperature controlled storage, Juice handling facilities with advanced blending, customs services and fully integrated quality system. These services will be conforming to the customer's request, recipe, etc. Other business line, H&S Logistic services is specialized in various transportation area (road transport and Intermodal transport). Based on many years of experience in various logistic function, H&S logistic can provide specific advice and solution to customer's request and activities. including reconstruct the customer's supply chain, optimize and reduce the cost of customer's supply chain.

Despite these business lines are organized under one industrial group, they operate on their own. This means that it is possible to use one service of one business line without involving the other business line. For example, if one company uses the service of H&S coldstore to blend and prepare the product to be delivered it does not mean that Foodtrans will be the one who will receive the order to deliver the product.

## 2.1 H&S Foodtrans

As an intermodal solution provider for transporting bulk liquid food stuff, foodtrans has the biggest network in the business specific to their market region. However, it is Foodtrans' strategy to further expand their market, not in terms of breaching a new region but in terms of increasing customer and supplier trust and consolidating their network. Customer here stands for another company that places an order of transporting their product to another factory in the different address, it can be under the same company, or even different company. Foodtrans thus in this case plays an important role to make sure that the product (in the container) is delivered in the right time, and right place.

Determining the right price level is then what matters the most. Many factors must be considered, such as: the shortest travel time in a way of economic wise. It is an obligatory to define whether the product is categorized in ADR (dangerous goods) or not. Specific to the bulk-food liquid business, there are even more things to be taken into account such as: the allergy information, concentrates, etc. These details are used to determine the whole operation; which container should be assigned? whether the delivery will be postponed or not due to weather or some road maintenance? what type of treatment or handling should be executed to the product during the delivery? and so on. The container is transported through ocean, railways, and/or road using different types of transportation modes. The exchange of data and information within an executable period is crucial to achieve the within-time window delivery.

Up to this point, the company has been able to generate the route using the developed and automated system including the charter booking procedure. The EDI system which they implement within the system has supported most of the planning and execution operation in the intermodal planning. However, modality planning is still manually executed. The automated system cannot anticipate the unexpected events or commonly named real-time information and data if it occurs the current planning.

## 2.2 End-to-end Supply Chain Process Flow

The end-to-end supply chain visibility, in the case of H&S Foodtrans, highlights the whole process of delivering the product from point A to B. This includes the administration and the planning activity. However, as mentioned earlier, this research will focus on the planning activity, in which the supply chain visibility can be very much improved.

### 2.2.1 Organizational Terms

There are several units of departments that will be mentioned in this proposal. The mentioned departments are those who are involved and responsible in the end-to-end supply chain of all the orders. However, the mentioned departments below are not limited by the classification of planning or administrative functions. They are:

a. Customer: One company that has signed a contract to use H&S Foodtrans service.
b. Commercial Manager: Contacting a potential customer, keep the customer relation.
c. Pricing: create and update quotation if there is an extra cost
d. Account Manager: Input order, keep the customer relation and the first person to receive the complaint.
e. MMP: Planning an intermodal route (ferry port – railway terminal).
f. MMP – Routing: Book the chartered vehicle.
g. TCP: Truck, driver and container planning; Pick-up and deliver the product from/to door.

### 2.2.2 Planning Activity Map

The general overview of the business process flow can be seen in Figure 1. This overview is provided to help us to see how planning process becomes very crucial besides the fact that delivering the product is their core business service. Any improvement in the planning phase will give a big impact to those surrounds it even it is suspected to affect to the organizational structure as well.

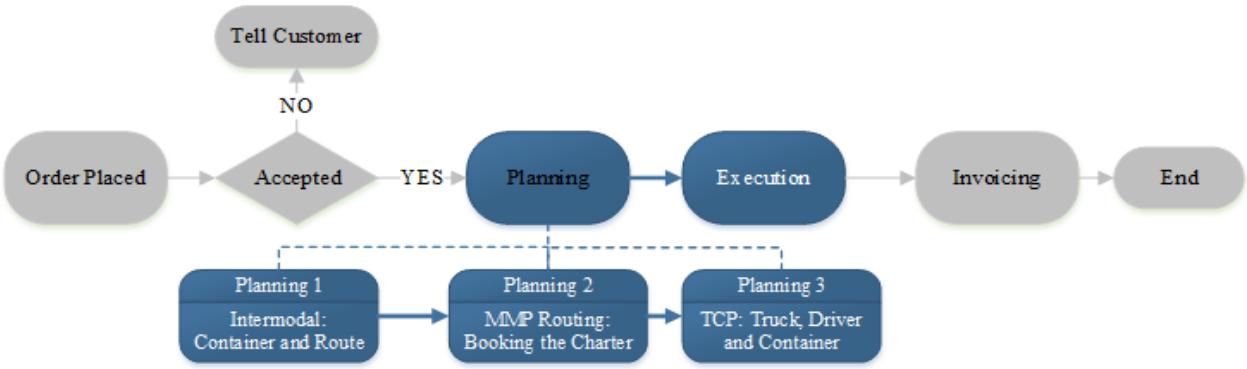


Figure 1 General Overview of Business Process Flow

Figure 1 shows there are three sub-process within the planning phase. This phase surely affects the process post-planning. Therefore, in this case it is important to highlight that what is decided after the planning phase is of what would happen in the execution phase. To obtain more pre-knowledge regarding the specific activity during the planning and see a clearer image of this phase, the author decided to classify two types of flow. These flows are made based on the two questions:

1. What is being exchanged? What is being transferred within the flow?
2. What are the platform, the mounts, the vehicles that move it?

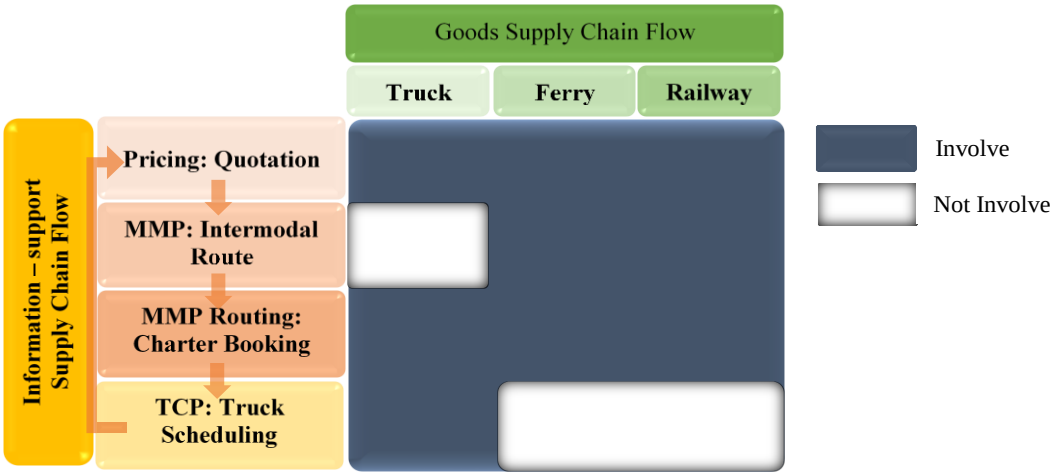


Figure 2 Matrix of Supply Chain Planning Activity

Based on two above questions, the two classifications are termed: Goods Supply Chain Flow (GSCF) and Information-Support Supply Chain Flow (ISSCF). These two terms will be often used in the latter report.

The matrix shows that in GSCF, the goods or the product as written in the order template are the one who is being exchanged. The mounts that moves the product are 3 possible transportation modes that H&S Foodtrans uses, they are: Truck, Ferry and Railway. Whereas in the ISSCF, the transporter are the departments or functions in which the information is being exchanged. For example: to plan the movement of product using ferry and railways, the process that is involved is everything but TCP planning.

# 3. Project Background

"Reaching ahead" has been the way H&S approaches the market as of late. H&S sees that by being integrating both GSCM and ISSCM it will be able to use real-time data to supplement decision-making. The demand of information update regarding the location and the expected time of the arrival of their product is starting to emerge frequently. This is not along with the pace of information receivable from the sub-contractors (ferry, truck, or train service provider).

The transparency then becomes what causes the company's performance to either go up or down. The information cycle and the content itself are seen to be what matters the most for the next one or two years. Reaching this opportunity; that is by involving real time information and data from the open source or the specific supplier to the specific process; is seen to be implementable and beneficial for the company's life cycle in their market.

# 4. Project of Real-Time Data Use for Supply Chain Visibility

Supply Chain Visibility is said to be a key enabler to reach market driven efficiency (Rusch, 2014). Through a collaborative supply chain across trading partner, the company will be able to respond to a sudden demand changes or market behavior and minimize the risk of disruption occurrence that can happen during the execution of the operation. This visibility needs more than just trust among the partners within the supply chain process, but also a willing to provide transparency as mentioned above.

The company believed by first building a concrete architecture of supply chain visibility in terms of information exchange across department that involves in the planning phase will result to an efficient planning and execution, hence the better KPI. However, in the practical world, the logistic flow is as dynamic as the arrival of the information itself. During the execution it is often found the change of planning due to delay, weather, traffic, etc. (For the remainder of the report, traffic data, weather, etc. will be known as the real-time information or data.). This occurrence might lead to a late delivery time, whereas longer lead times is a key indicator of delivery performance.

As the company focuses on providing logistic solution through multimodal transportation use (excl. airways), H&S Foodtrans understands that these real-time data will not only affect the planning that has been created by their own planner, but also the planning of its partner. Using ferry and train means that the planner needs to do the booking to reserve a spot for their container. Despite the booking is already accepted, sometimes during the operation, it is possible that the train exceeds the capacity or under maintenance, etc. To respond to such circumstances, the company is required to make a sudden action. The partners are not only those who are owning intermodal transportation modes. Currently, H&S Foodtrans owns approximately 30 trucks and 1300 containers. The containers are the material that is being exchanged in the GSCF and container's availability can still fulfill the customer's demand. However, it is important to know that the trucks used during the execution of the delivery are not always the ones which belong to the company. Therefore, many truck charter providers are also involved as their partner of delivery and these partners are across Europe and Russia.

In their record, the mentioned occurrence frequently happened. However, the real-time information itself is not received immediately. The platform of such information is still manually written through email. The one who is responsible for keeping the partners information up-to-dates are the TCP Planner and the MMP-Routing, even sometimes the account manager. How the information exchanges are crucial to keep pace with the dynamicity of logistic. Whereas the real-time data is useful to help the planner immediately redirect the plan from the source available.

There are always probabilities for the real-time information and data to interfere the delivery plan during execution, even though not every order delivery has one. But the company wants to migrate their response from reactive to be proactive. This means that they are curious of what will be affected when real-time data and information arrives. How to respond to such interference? Is there any way to minimize the risk of disruption upon the delivery execution? These reasons are then what leads this project to existence.

Many technology providers are ready to embed the feature of handling real-time information. However, H&S Foodtrans does not want to merely implement the sophisticated system into their operation. The company understands very well that there should be any effect that will happen to their strategical, tactical and/or operational planning stage. The fact that the company focuses on bulk food-liquid transportation, adds even more constraints to the treatment requirements. Therefore, the self-tailored solution is believed will be able to facilitate these constraints.

H&S Foodtrans sees this as an opportunity to develop their current system and train their own resource to be able to do so. The further questions in this regard then emerges. If the company was to focus on implementing the system in which all the real-time information and data are considered as the sudden additional constraints for the planning decision making, the company would have to firstly evaluate their resource and technology capability. Must all the real-time data and information that are available on the market be considered for making decision? Will these variables (real-time data and information), once it is involved, give benefits to the pace of decision making? Are all available data necessary to be taken into account? If not, then which of these should be embed? In terms of technology, how is the condition of their data warehouse? Will the system capacity be able to tackle the big wave arrival of data? What to prepare during the transition? Are they capable of implementing this by themselves? Lastly, will there be any change occurred in terms of organizational structure in order to support the cycle of exchanging information?

## 4.1 Research Boundaries

Measuring the current supply chain visibility in the multimodal transport planning activity is a broad topic, yet it is not impossible to search further. The project is considered as a master thesis project, where time also matters to determine the extent of the expected result of the research and the scope of the research.

Firstly, as mentioned in the early section, the research will only focus on the delivery planning activity. In subsection 2.2, it is explained that since the company is a logistic provider, the end-to-end supply chain will be narrowed to highlight the activity of delivering a product from location A to location B. Whereas, between administrative and planning activity, the research will narrow to the delivery planning activity due to the aim of improving the supply chain visibility. This means that the whole order process flow that relates to any administrative matter such as: when the commercial manager must be looking for more customers or what to sign in the contract is out of the research scope. There are several processes involved prior to delivery execution as seen in the Figure 1. The mentioned departments will be the focus of seeing the impact of what would happen when an information or data arrives during the execution.

Secondly, it is affirmed to state that the real-time information will be the main variable that is suspected to enable the delivery behavioral change. This change can affect to the time of the delivery and extra cost. This research will only use the real-time information that will arrive during **the execution of the order**. This is because the real-time information or data that arrive during the planning period is an anticipative action and it is basically why it is called planning phase. However, the real-time information or data that arrive during the execution will create a responsive action both to the planners in the planning desk or the invoicing in its desk. To alter this responsive action become proactive actions is wherefore this project is established. In addition, it is also important to highlight that the order that will only be considered in the research is the order that combines intermodal and modal transportation to transport the product.

Thirdly, due to time limitation of the project, it is important to bridge the expectation of both company and the university standard. In order to do so, the map that can be seen in Figure 2, is proposed to the Director of the Business Unit such that the process which is in urgent of improvement according to the company needs can be selected as the scope. The project itself is highly prioritized. Therefore, it is important to validate the mapping of the process. Additionally, the deliverable of the research will be used for the further project.

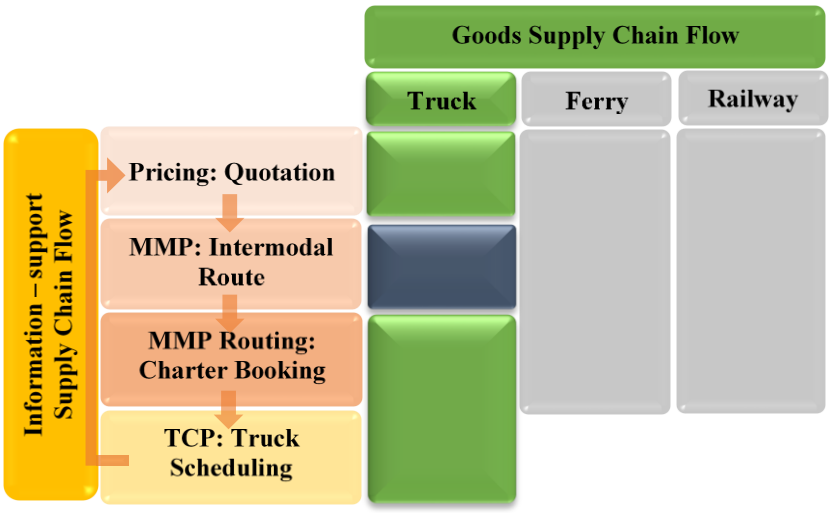


Figure 3 Information-support Focus on Truck Movement Map

To determine which process is most prioritized, the author proposes two types of focus. Focusing in GSCF means that the scope will be one of the horizontal line. This will emphasize the movement of goods with the consideration of variable (potential real-time information) that will arrive during one process in the ISSCF line. After several meetings and discussions including observations and revisions, the research will focus on the ISSCF that is how the ISSCF will respond to the arrival of real-time information and how it will impact the performance of GSCF specific to truck movement.

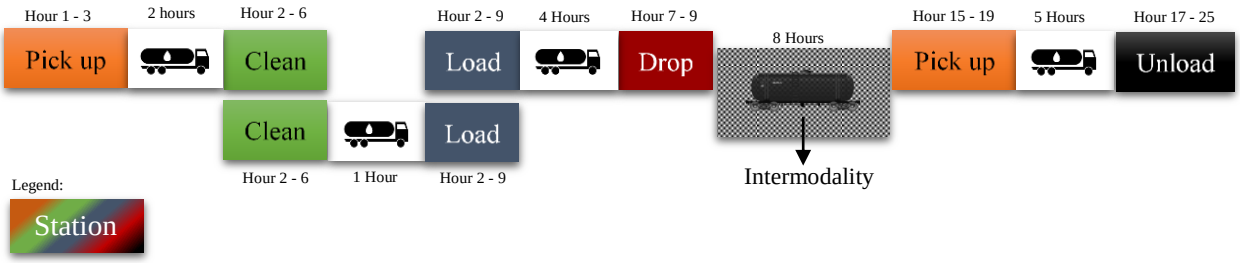


Figure 4 Truck Movement

However, note that in the figure 3, the box in the MMP: Intermodal Route is filled. This means the real-time information that is received by the MMP department which in regards with the movement of ferry and railway (intermodal) will be taken into account. If to deliver one product requires such multi-modality: truck – railway – truck respectively, then if there is a delay of the train arrival, it will impact the time of a truck picking up or unloading the product, then the whole process is disrupted (see Figure 4). This the reason why the company is interested to investigate deeper onto this area. The number of inputs for real-time data and information would be greater for the modal parts (Trucking). There are two perspectives (1) the customer wants insight in the entire process from e.g. Cleaning to delivery; (2) H&S wants more insight in the entire process i.e. which truck will pick up which container? Where is the truck at a certain time? Will the truck be on time? And so on. H&S Foodtrans believed that the difficult part is that the truck that initially picks up the container, usually is not the same truck as the one that will pick the container up after arriving at the terminal. This is where the subcontract (truck charter partner) plays the role.

See it from how the focus is being scoped, it is therefore important to set assumptions that will be used to create a standard tool. These assumptions will be used according to its frequency of occurrences, such as: the type of product (ADR, or kosher, etc.), the road regulation of different

countries. Refer to Figure 4, each of the station will have its time windows. This time windows shows the availability or the office hours of the station. Time spent in each station will be determined by its regularity per location. To ease the investigation, hourly time unit will be used to define the expected and actual time. Later, there should be any other factors that can affect the entire visualization besides the mentioned above. Therefore, the assumption will have to be stated clearly during designing the visualization.

## 4.2 Research Questions

The big question that the company expects to obtain from the research is "are they ready for implementing the new system? And what do they need to prepare to implement the *new system*?". To be able to answer to the big question, the investigation question is then emerged. These questions are also based on the observation that has been performed for 5 weeks. The detailed information about the methodology will be outlined in the section 6. The research questions are as mentioned below:

1. The current planning activity and the execution process.
    a. How is the information being exchanged for every order in planning the delivery prior to execution according to the SOP (Standard Operation Procedure)?
    b. What departments is authorized to do which process?
2. Current system learning
    a. What types of tools that are used to exchange the information within the company in specific to planning activity?
    b. Up to what extent these tools support the planners to have an efficient decision making? Both in terms of performance and the pace of making the decision itself?
    c. How is the collaboration across the supply chain? How do charters integrate information of delays or unavailability with H&S Foodtrans?
3. Resource availability
    a. What type of information that is available and not available?
    b. Has any of the outside information ever disrupted the process? What is it? What is the time regularity of this type information arrival?
    c. How can it help our decision making?
4. Designing implementable investigation tools
    a. What type of visualization that suits best to the current company operation?
    b. What type of tools are available?
    c. How real-time information will change the behavior of delivery in the execution?
    d. How should each planning department respond on the sudden behavior change?
    e. Is the current tool to run the current system capable of involving the real-time data? If not, what to do to improve the pace and capacity of information exchange within the department?
    f. What to do to have an integrated information exchanged across the supply chain in order to build an extensive collaboration?

These investigation questions need to be answered to reach the main objective of the research. That is to **design the decision support tools by visualizing the effect of real-time data implementation to the current operation, to make a better decision making and improve the supply chain visibility.**

## 4.3 Future Research

As mentioned above, research scope has been made. As seen in figure 3, the scope is limited by one vertical line which is agreed by both the company and the author that the process selected for the research is the most crucial one. However, the other vertical line in the matrix is also important to support the whole delivery process (as seen in figure 4), since the company is an intermodal solution provider as well. If the further research should be performed, the author hopes that the

result and the tool that are designed to investigate the impact of real-time data involvement from this research, can be used to support and/or as the baseline for the future research.

### 4.4 Project Management

This section is outlined through the project plan as seen in the Appendix 2. The project is expected to be finished within 21 weeks starting from 5 February 2018 until the 1st of July 2018. Each step is determined to be completed on the specific week (period). This must be executed as is in order to keep the target on track.

## 5. Literature

Data analysis is identified as the collaborative knowledge from several disciplines, such as: statistics, mathematics, computer science, artificial intelligent, etc. (Hand D. , 1997). It is the process of how a data is cleansed, examined, or transformed, in order to extract and exploit the useful information that was implicit in the data. Therefore, Judd et al (1995) simplify the definition into a term, that is:

$$Data = Model + Error$$

Interpreting data in proper manner matters to result a good model. Therefore, each process of treating data is very important to obtain fit and minimize error. Finding a general statement or interpretation of the data to make the data value become more sensible often involves some sort of form of logic to the research (Schwandt et al., 2007). The process of the data treatment is also distinctive. Briefly, Berthold (2010) in his book stated that it is frequent to link data analysis with statistics. The terms that are widely known and used in many literatures such as: Exploratory Data Analysis (EDA), hypothesis testing, etc. However, due to the evolution of data behavior: volume, velocity, and other 5 v's (Cano, 2014) in this era, the pace of data cultivation must also be adjusted.

Berthold, M. & Hand, D.J. (2010) believed that statistics and machine learning are two disciplines that becomes the root of intelligent data analysis. The terms intelligent was then used by many researchers due to awareness of how the data these days are treated automatedly. The involvement of machine learning in this case is indeed becoming a major contribution of the data analysis evolution arrive in a large set within seconds. Mutlu et al. (2014) finds visualization as a method to handle their project. That is to provide a tool to automatically extract value out of a messy and big data; and propose the appropriate means consisted of facts and data therein (Mutlu, et al., 2014). Therefore, data visualization is known as one of the methods to perform data analysis (Vartak et al., 2016).

Even though data visualization is commonly linked to data analysis, some experts (Samsel, 2013) believed that data visualization is a combination of art and science, whereas van Wijk (2005) concluded that visualization itself is an ambiguous term. This means that it does not matter which discipline gave birth to visualization, but what matters is that the application can refer to technology, to a specific technique or to the research discipline. It is noted that in 2009, Friendly argued that the root of statistical thinking is a rise of visual thinking e.g. how diagrams is used to illustrate functions, nomograms and several other graphs that enables the data to explicitly show its value: trends, tendencies, etc (Friendly, 2009). In the more specific view, Vartak et al. (2016) emphasizes how data visualization plays in important roles to summarize data that is providing an overview of the data distribution, correlation attributes, an understanding of what is "typical" in the dataset and enabling users to contextualize trends and advanced statistics.

Stuart Card (2012) succinctly metaphorized information visualization as what automobile do for the feet. As mentioned earlier, therefore there are numbers of ways to translate and transform both qualitative data and quantitative data into picture. However, Goebel (2014) affirmed that exposing data relationship is rather difficult due to data complexity or the volume. "The real practical challenge of visualization is making choices: how should one select within the data to focus the quest for implicit relationships, and what kind of visual vocabulary should those data be mapped

to?" (Goebel, 2014). This is a conspicuous manner of saying that not every data visualization technique can fit to certain data set.

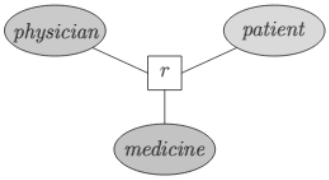


Figure 5 Entities and Relations Map (van der Corput et al., 2014)

Transforming must be conformed with the data behavior. Therefore, there is no standard theory or methodology of how to compress the (big) data and visualize it. It is also possible to include the cognitive process of human perception to make the data more sensible (Patterson et al., 2013; Goebel, 2014). It is also common to see the relationship between visualization manipulation and analytics (May et al., 2010; Goebel, 2014). Van der Corput (2014) creates an *entities-relationship* map as the basic methodology of creating the 3 tables visualization for the prescription data. This methodology marks the ground of how to visualize data in a simplified manner. The result of how the visualization looks varies in accordance to the data behavior. It is important to again note that he main idea of visualizing data is to allow the user to obtain information

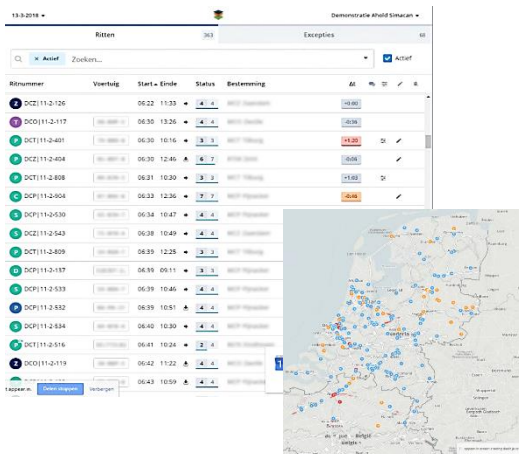

Figure 6 Track and Trace Data Visualization
(https://integration.telematics.tomtom.com/en_gb/solutionDetails/2701/control-tower)

# 6. Methodology

Designing the investigation tools as the decision support tools in this case is the best choice. Referring to the literature mentioned above, to determine which type of tools best suits the current operational data, observation on the current process and the execution performance needs to be performed. Comparing the internal resource availability, the external resource availability must also be learned. This must be performed to pursuit the more acknowledgement regarding what potential real-time data and information are available out there and could interfere the entire process. The knowledge about the existence technology or tools that can handle the all requirements is also important such that the visualization can be aligned to the company's current situation.

After the data visualization is designed, the next step would be creating the possible scenario. These scenarios are the also the result from the system learning. It can be taken by unexpected events that already frequently occurred in the current operation and also by any other case that can be found during external resource learning, of which has not ever occurred in the company but potentially interfere the operation.

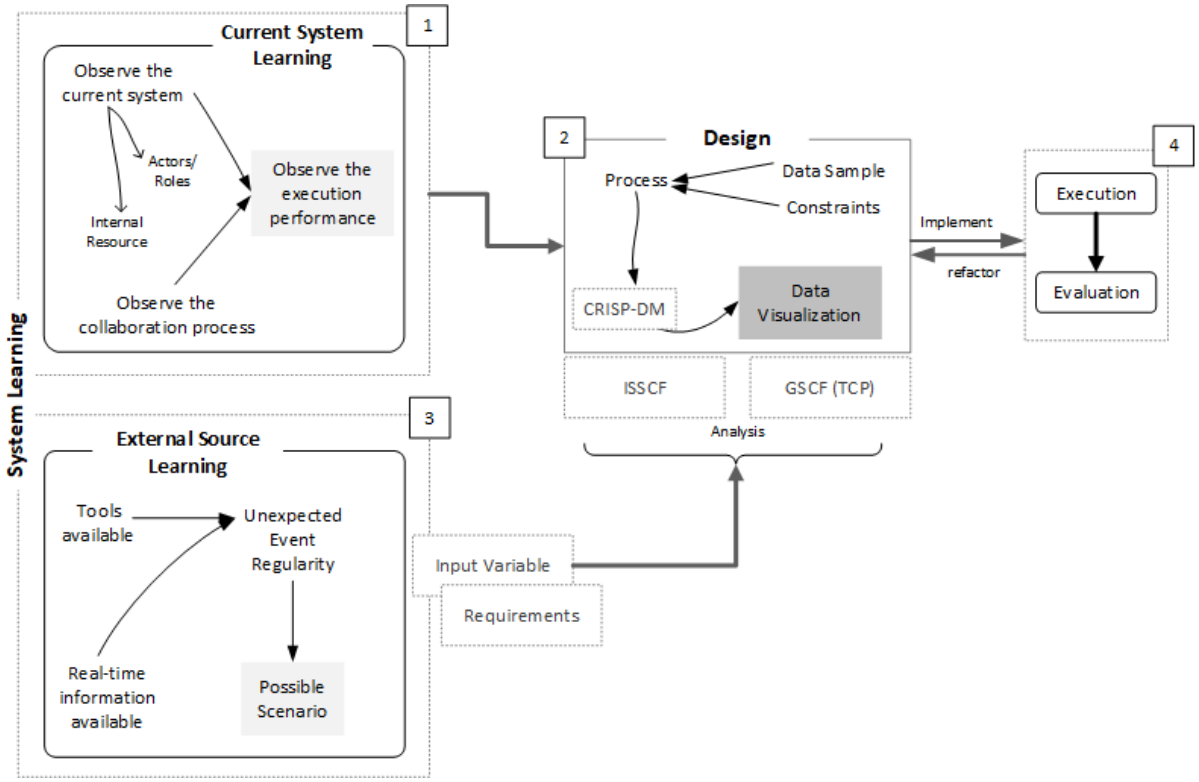


Figure 7 Procedure of Research

The investigation tools will then be tested to several trials to see whether the tools are implementable and general for the company to be used for their further research on the project. This is performed by executing the visualization with different scenarios, then record the behavior. This behavior helps the company to see what to respond on such behavior and leads to a decision of direct planning. The performance of the new decision will be compared with the current KPI level, specific to the lead time quantitatively. If the decision that is made from new system creates a worse performance, then layered evaluation would have to be performed in order to see whether the variable (real-time information and data) is not necessary to be taken into account, or the current planning indeed suits best in the certain type of situation, or there is something wrong with the visualization. To ensure which one of these shows the correct indication of the issue, then refactoring would have to be done. Every possible scenario (variable) that is input into the visualization and its specific result must always be recorded during the trials.

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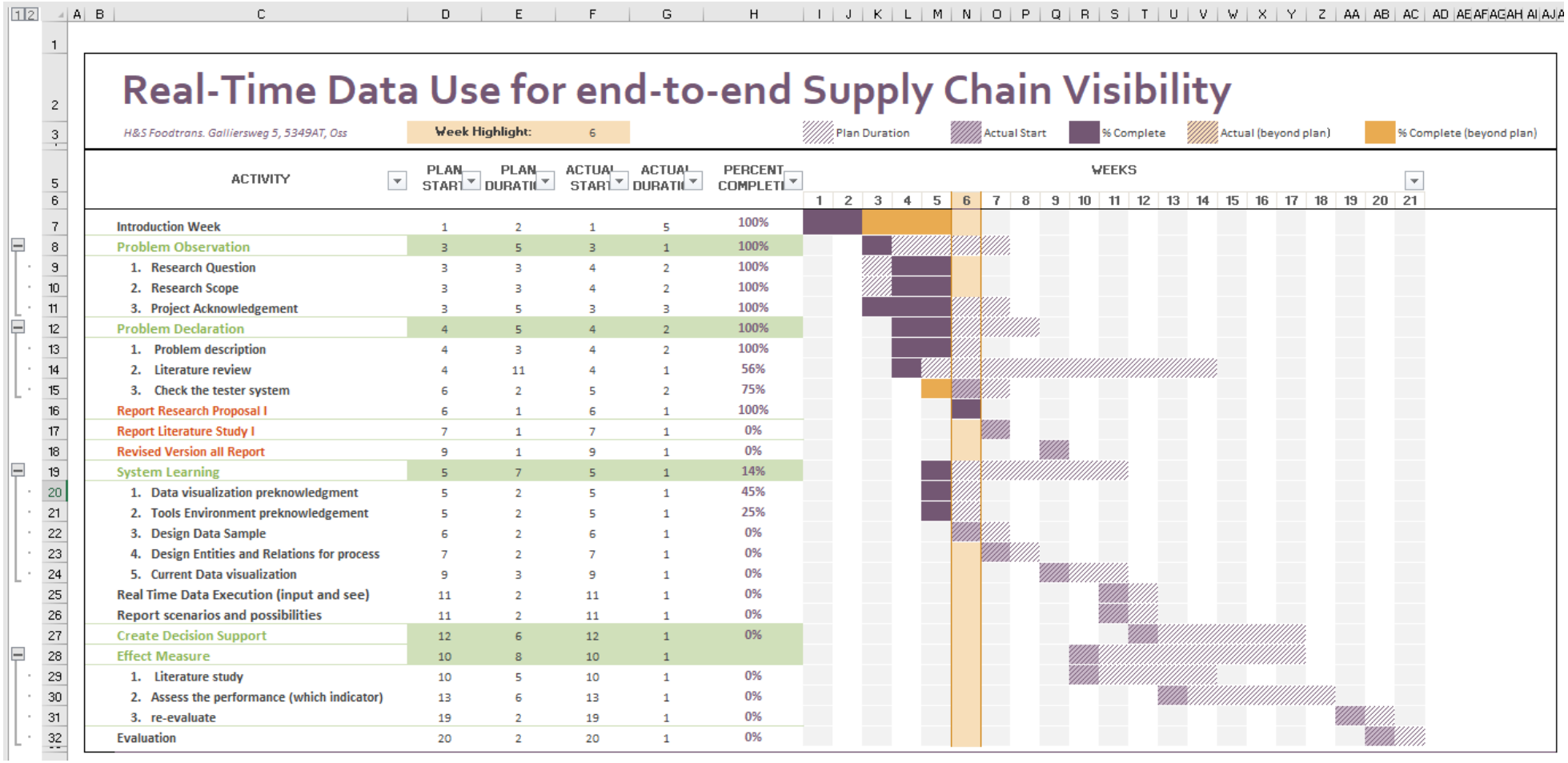
# Appendix 1:Real-Time Data Use in Improving End-to-end Supply Chain Visibility Project Planning



## Real-Time Data Use for end-to-end Supply Chain Visibility

H&S Foodtrans. Galliersweg 5, 5349AT, Oss

Week Highlight: 6

Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

| ACTIVITY | PLAN START | PLAN DURATION | ACTUAL START | ACTUAL DURATION | PERCENT COMPLETE |
|---|---|---|---|---|---|
| Introduction Week | 1 | 2 | 1 | 5 | 100% |
| Problem Observation | 3 | 5 | 3 | 1 | 100% |
| 1. Research Question | 3 | 3 | 4 | 2 | 100% |
| 2. Research Scope | 3 | 3 | 4 | 2 | 100% |
| 3. Project Acknowledgement | 3 | 5 | 3 | 3 | 100% |
| Problem Declaration | 4 | 5 | 4 | 2 | 100% |
| 1. Problem description | 4 | 3 | 4 | 2 | 100% |
| 2. Literature review | 4 | 11 | 4 | 1 | 56% |
| 3. Check the tester system | 6 | 2 | 5 | 2 | 75% |
| Report Research Proposal I | 6 | 1 | 6 | 1 | 100% |
| Report Literature Study I | 7 | 1 | 7 | 1 | 0% |
| Revised Version all Report | 9 | 1 | 9 | 1 | 0% |
| System Learning | 5 | 7 | 5 | 1 | 14% |
| 1. Data visualization preknowledgment | 5 | 2 | 5 | 1 | 45% |
| 2. Tools Environment preknowledgement | 5 | 2 | 5 | 1 | 25% |
| 3. Design Data Sample | 6 | 2 | 6 | 1 | 0% |
| 4. Design Entities and Relations for process | 7 | 2 | 7 | 1 | 0% |
| 5. Current Data visualization | 9 | 3 | 9 | 1 | 0% |
| Real Time Data Execution (input and see) | 11 | 2 | 11 | 1 | 0% |
| Report scenarios and possibilities | 11 | 2 | 11 | 1 | 0% |
| Create Decision Support | 12 | 6 | 12 | 1 | 0% |
| Effect Measure | 10 | 8 | 10 | 1 | |
| 1. Literature study | 10 | 5 | 10 | 1 | 0% |
| 2. Assess the performance (which indicator) | 13 | 6 | 13 | 1 | 0% |
| 3. re-evaluate | 19 | 2 | 19 | 1 | 0% |
| Evaluation | 20 | 2 | 20 | 1 | 0% |

WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21