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Improvements to Contractor Workload Analysis

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It is challenging to balance work, and family life with an intensive study program such as this Master’s program was. Now, upon completion of the program I find that these challenges have taught me to value all these aspects of life even more than before. The subjects I have had the privilege to learn while studying in this program have proven their value already time and again in and out of working life.

I wish to thank the case company and especially my supervisor M.Sc. Petri Mäkituuli for this valuable opportunity to combine the development of the company’s business processes with my personal journey of learning.

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Thank you, my loved ones, Laura, Väinö, Aino and Hedda for support and understanding and also for just being there for me.

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Abstract

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The objective of this study is to propose improvements to the case company's contractor work load reporting that enable better and less labor intensive measurement and analyses of the contractor's back log. The case company has undergone replacement of its core IT systems in recent years and the reporting of customer initiated grid services has not yet reached maturity.

The study utilizes design research as its research approach. The study is conducted in four stages. The first stage is current state analysis producing the strengths and weaknesses of the current reporting. The second stage is literature research, where concepts from relevant literature were combined into a conceptual framework. The third stage is initial solution development where a list of initial improvement actions is created building on previous stages in addition a development road map is included in this stage as a means of clarifying the capability building phases. In the fourth and final stage the initial improvement actions are validated by senior managers and the improvement actions are finalized based on the feedback from the validation

The outcome of the study is a final list of improvement actions that upon implementation provide measurement tools and visualizations that enable monitoring and predicting the case company's contractor's back log development. Implementation of these tools enable the stakeholders associated in the process to function more efficiently and predict and react to sub-par performance of the contractors ultimately benefitting the whole supply chain.

Keywords: Business analytics, Process management, Supply chain management

Contents

List of Abbreviations

DSO	Distribution System Operator, an electricity grid operator
CIF:	Contractor Interface. The system that delivers messages between case company’s and the contractors work order management systems
ADMS:	Advanced Distribution Management System. A system used to manage the distribution networks current switching state and manage outages.
NIS:	Network Information System. A system where the information regarding network is managed, including component properties, construction plans, electrical properties etc.
CRM:	Customer Relationship Management. A system where the information regarding customer’s is managed, including billing, contacts, orders etc.
SLA:	Service Level Agreement
AMM:	Automatic Meter Management
BI	Business Intelligence
BA	Business Analytics
KAQ	Key Analytic Question
DMU	Decision Making Unit
IQR	Interquartile range in a box plot

UL	Upper limit in a box plot
LL	Lower limit in a box plot
ACK	Technical acknowledgement message in the CIF
NACK	Technical rejection message (not acknowledged) in the CIF

1 Introduction

This study focuses on reviewing and defining improvements to the vendor management and coordination of the case company’s customer initiated grid services. The focus of the study is in the analysis and reporting of the order back log of these vendors. The author of the study works in the case company’s investment program management team.

1.1 Business Context of the Case Company

The case company is one of the Finland’s largest distribution system operators (DSO), with over 700 000 customers. The case company receives annually tens of thousands of customer initiated orders and notifications. The orders range from tasks that require building new grid such as new electricity connections, connection capacity increases and line transfers to simple service tasks that usually require only the work of an electrician such as various switching orders, or tree felling assistance. Customers also send the case company notifications regarding the state of the grid, such as notifications regarding power outages or faulty components. The case company’s customer service receives these orders and notifications and create the necessary work orders to the case company’s contractors who handle the associated field work. The contractors have integrated their ERP systems into the case company’s IT architecture. The work orders are generated in the case company’s CRM system and sent to the contractor’s ERP. All of the reporting and documentation regarding these work orders is delivered to the case company using this integration.

Finnish DSO’s as natural monopolies are subject to regulation under the Electricity Market Act (Finlex, 588/2013). The DSO’s have also additional responsibilities related to the safety of the grid they operate under the Electrical Safety Act (Finlex 1135/2016). The Energy Authority is the supervisory body whose role is to regulate the Finnish electricity and gas markets and monitor the pricing of the network operators. (Energy Authority). The Finnish Safety and

Chemical Agency TUKES is the licensing and supervisory authority that monitors the safety and compliance of electrical products, services and industrial activities (Tukes). The DSO’s also fall under the scope of the Special Procurement Act (Finlex 1398/2016) demanding that all purchases exceeding the national thresholds are to be conducted as public procurements.

The field work associated with the case company’s customer orders are not each separately tendered, but are rather performed under a frame agreement publicly tendered for these kinds of customer initiated grid services. The frame agreement contract periods have usually duration of several years and consist of all of the case company’s customer initiated grid services and fault repair along with other additional services on a specific geographic area. The frame agreement specifies the service level requirements for the contractors and how the performance is measured.

1.2 Business Challenge, Objective and Outcome

In the recent years the case company has undergone replacements of all of its core IT systems and in the wake of these major development projects some aspects of systems have not yet reached their full maturity reflecting on the processes and reporting. The business challenge of this study seeks to overcome is case company’s project manager’s the limited visibility to the customer order handling by the contractors. Currently the available reports focus on whether the orders have been performed on time or not. The result of this limited view to the contractor’s processes is often reactive management. The contractor’s underperformance can go unnoticed for long periods and the ensuing customer complaints cannot be predicted in forehand. The monitoring of the contractors performance requires manual work, which cause risk in form of manual errors in the KPI calculations. In addition even rudimentary analyses to the contractor performance are time consuming and labour intensive, as the process data necessary for these analyses is missing or in a non-utilizable format.

The objective of this study is to propose improvements to the contractor work load reporting that enable better and less labour intensive measurement and analyses of the contractor’s back log. The outcome of the study is a set of specific actions that need to be taken in order to achieve this objective.

1.3 Outline of the Study

The study consists of seven sections. Sections one and two provide an introduction and describe the project plan respectively. Sections three and four treat the current state analysis and literature research. Sections five and six provide the creation of the initial list of proposed actions and its validation. The final section seven include the conclusions and executive summary in addition to the evaluation of the study.

The study was conducted in four stages. In the first stage the case company’s reporting practises and data were analysed in order to gain information on the current state of the reporting processes. The information was gathered in stakeholder workshops and by observing the monthly reporting process. The information was in the end of the first stage compiled into a list of strengths and weaknesses, which was the prioritized and the selected weaknesses were used as the starting point for the next stage.

In the following stage the relevant literature was researched and relevant concepts from the literature research were summarized into a conceptual framework. The weaknesses identified in the current state analysis were used as the focus point for this research and the relevancy of the identified concepts was evaluated on the basis of how well they could address the weaknesses.

The goal of the third stage was to create an initial set of proposed actions focusing on the identified weaknesses and utilizing the concepts from the literature research. The creation of the proposed actions was conducted in three workshops with the key stakeholders involved.

In the fourth stage the list of initially proposed actions were validated by the senior managers of the case company. Adjustments to the proposed actions were made based on the feedback received and the final list of improvement actions was created.

Implementation or the technical specifications of the proposed actions are outside the scope of this study. Next section describes the project plan for the study.

2 Project Plan

The previous section introduced the business challenge, objective and outcome of the study. This section presents the research approach and design and subsequently the plan for collecting and analysing the data.

2.1 Research approach

The defining characteristics of research according to Saunders *et. al.*(2019) are systematic gathering and interpreting of data with a clear purpose. Saunders *et. al* (2019) also argue that the purpose of business and management research cannot solely be to advance the general understanding of the study area, while ignoring the commercial factors. A business research project has to balance the theoretical and methodological rigour with practical relevance of the research to the business issues at hand (Saunders *et. al.* 2019: 39, 43)

For this study a design research approach utilizing qualitative methods was selected. The reasoning behind this approach was that despite the fact that the objective of the study was to create improvement proposals to a very specific business problem in a specific industry the study draws knowledge from existing well researched general professional literature and studies, the knowledge imparted in the form of the outcome of the study is new in the context of the case company.

Design research resembles the normal development activities companies undergo. The aim of design research is to create solutions that have practical applications and improve or help the organizations that are in the focus of the study. The scientific standards are met when proper methodology and documentation is applied to the research. (Kananen,2013: 20-22)

2.2 Research Design

The study was conducted in four stages with the business challenge as the premise of the study. The subsequent actions towards reaching the objective of the study were executed in separate stages with distinct outcomes. Figure 1 illustrates the research design of the study.

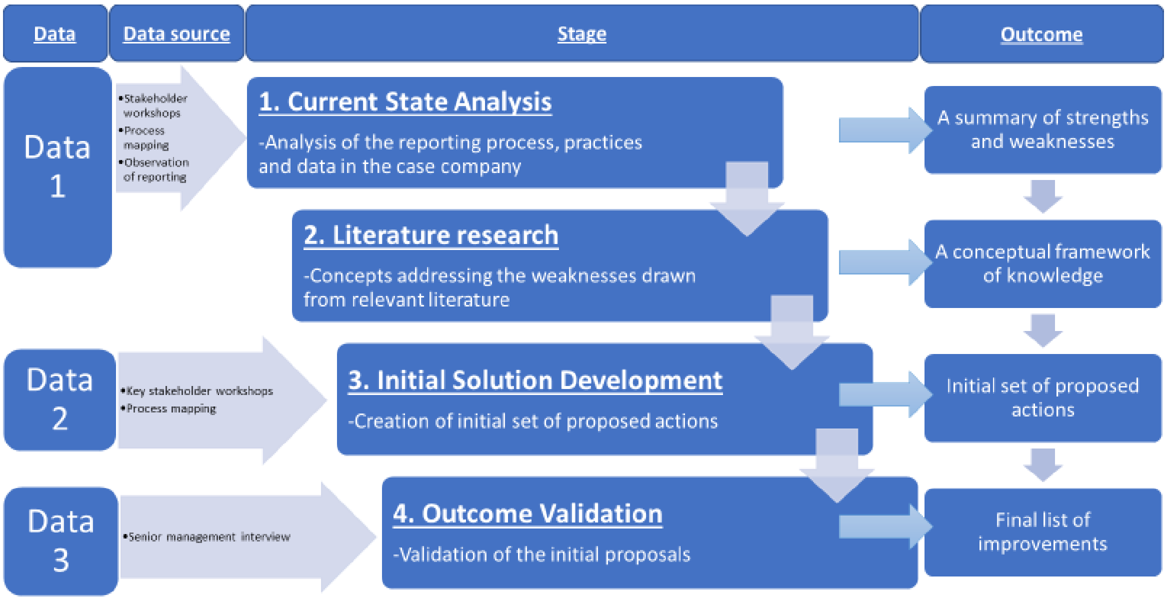

Figure 1The research design of the study

As shown in Figure 1 the study begins with the current state analysis. Following stages are meaningless if the initial state of the reporting processes and data are not analysed. The current state analysis was conducted in two workshops with the key stakeholders. In the first workshop the current end-to-end customer order process was mapped and then more detailed process descriptions were drawn for the field work phases of the sub-processes of the main process. After the initial workshop an email was sent to the participants with detailed instructions on how to prepare for the next workshop where the process visualizations were complemented with a descriptions of the data gathered from the processes. Following the workshops the monthly reporting was observed from the standpoint of how the data was gathered and prepared for the reports and what other actions the data handling entailed. The current state was then analysed and the findings were summarised into a list of strengths and weaknesses, which were then prioritized based on their relevance and impact.

Following stage was the literature research. The prioritized weaknesses identified in the previous stage were used as a premise for the knowledge research from professional literature and studies. The outcome of the literature research stage was the conceptual framework compiling the key concepts found from the literature.

The third stage illustrated in Figure 1 is the initial solution development stage. The initial solution development was executed in three workshops with the key stakeholders. The outcome of the third stage was the list of initial improvement actions addressing the main weaknesses identified in the first stage utilizing the concepts researched in the second stage.

The initial improvement actions were validated in the fourth and final stage of the study. The validation was performed by the case company's senior management involved with the customer initiated field processes. The feedback received from the validation was used to adjust the initial improvement actions thus creating the final list of final improvement actions.

2.3 Data plan

The research data for the study was collected from stakeholder workshops and through observing the reporting process in the absence of documented reporting instructions in the case company. Table one summarises the data gathering plan executed during the study.

Table 1 The data plan for the study

Data	#	Method of collection	Data Source	Data Content	Time of collection	Outcome
DATA 1	1	Workshop 1 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Main process map	January 2022	Summary of strengths and weaknesses
	2	Workshop 1 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Sub-process maps	January 2022	
	3	Workshop 2 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Process status reporting points, format of the reported data	January 2022	
	4	Workshop 2 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	A table of strenghts and weaknesses of the process	January 2022	
	5	Observation	Networks Service Specialist	A list of data collection and preparing for monthly reporting steps	February 2022	
DATA 2	6	Workshop 3	Project Managers	Proposed improvement actions for weaknesses 1 & 2	March 2022	Initial improvement actions

	7	Workshop 4	Project Managers	Proposed improvement actions for weakness 4	March 2022	
	8	Workshop 5	Project Managers, Regional Construction Manager	Proposed process reporting phases	April 2022	
	9	Workshop 5	Project Managers, Regional Construction Manager	Information content of process status messages	April 2022	
DATA 3	10	Outcome validation meeting	Head of Local Network Investment Projects, Regional Construction Managers, Operations Manager	Feeback for the initial improvement actions	May 2022	Final improvement actions

As seen in table 1, the Data 1 consists of five distinct data contents gathered during two workshops and one observation of monthly reporting. The data is formatted as process maps (items 1,2 and 3),as a table (item 4) or as a list (item 5). The strengths and weaknesses were assessed by how strong representation they had in the data and also by their applicability to the study subject.

The Data 2 consists of four distinct data contents gathered in three workshops. The data is formatted as tables (items 6,7 and 9) or as a process map (item 8). The data was gathered in workshop group discussions. Each comment was initially written down and subsequently weighed and analysed by all the participants until the final version was documented as the Data 2.

The third data is a summary of the feedback and comments received in the validation meeting. The feedback received from the validation group members was used to adjust the Data 2, resulting in Data 3.

The next section describes the current state analysis of the case company's reporting process, resulting in the Data 1 outcome illustrated in table 1.

3 Current State Analysis of Contractor Reporting

This section presents the current state of contractor reporting. The findings are categorized into strengths and weaknesses The data plan used in this analysis was presented in the previous chapter.

The section contains an overview of the current state analysis and a top-level end-to-end process visualization with more detailed sub-process visualizations of the field work phase of service task, network construction and fault repair sub-processes.

3.1 Overview of the Current State Analysis

The data collection was organized into two workshops with the process stakeholders and the observation of the reporting process. This was due to the pandemic restrictions and the case company’s telecommuting recommendation in effect at the time the workshops were held remotely.

The observation of the reporting process was conducted by observing the monthly reporting and strategic-level contractor meetings and the preparation of SLA data for these meetings. The frame agreement contract annex regarding the SLA requirements was also consulted for details regarding the measurement.

The stakeholders for the workshops were identified by their roles in the organization regarding the processes. In the first workshop the stakeholders were asked to describe the top-level end-to-end customer order process and then more detailed descriptions of the field work phases of the various sub-processes. This approach was chosen instead of using the case company’s official process descriptions because the official process descriptions lack detail concerning the outsourced parts of the process i.e., the field work performed by the contractors.

After the first workshop the visualizations of the processes were sent to the stakeholders with the instructions to prepare for the next workshop by identifying the process steps where:

- Process status information is collected and utilized by the current process
- Process status information is collected but is not utilized
- Process status information is collected but cannot be utilized

In the second workshop the process visualizations were complemented with descriptions of the process status information and the format of the gathered data as well as the system where it is reported to. Subsequently the participants were asked to describe the problems they were facing with the current contractor reporting model as well as what positive aspects they have observed in the process regarding vendor management.

The following tables 2 and 3 contain the observations made by the participants to the CSA workshops and interviews. The strengths are highlighted in green, and weaknesses are highlighted in red.

Table 2 Summary of the interview responses

Regional Construction Manager		Operations Manager	
Positive	**Negative**	**Positive**	**Negative**
The SLA -model takes the tasks that are not completed into account	Gaming of the KPI is possible, there is no sufficient control implemented	The outsourcing ratio is high. The competence of the contractor can be deducted from the SLA results	Case company has no visibility to the state of the tasks on the field. Are they started? Has the contractor contacted the customer? Is the task done, but not yet reported? Etc.
The contractor can negotiate the task's completion schedule with the customer	There is some information gathered on the contractor's process phases, but the information is not utilized	The contractor communicates directly with the customer	The delay in reporting causes delays in cash flow and in some cases, there is the possibility of double billing
The contractor's and the case company's reporting are very close to each other ~1% difference monthly	There is only information on whether the task is on time or late, not how much there is time left or how late the task is	The contractor has the opportunity to optimize their resource use	There are some vital status messages missing from the contractor interface, most notably the "electricity connected" status is missing

The changes in workload depend on the season and can be predicted somewhat accurately based on the corresponding volume of previous years	No way to predict which tasks are going to be done next week etc. --> No way to predict when the task is done		Contractors do not update the status of the task as agreed
			There is uncertainty over whether there is enough competence in the invoice verification process regarding the invoiced items and documentation

Table 3 Summary of the interview responses continued

Project Manager 1		Project Manager 2	
Positive	**Negative**	**Positive**	**Negative**
The status messages that have incentives or sanctions under SLA are updated frequently	There is no information when the actual field work starts. There exists a field for this information in the contractor interface schema, but it is frequently as the same time as the work order receiving time	Overall results on contractor SLA have improved	Automated orders contain a lot of errors, unnecessary orders etc.

	There is no visual information available the state of the workload, i.e., on a map.	The cooperation between the case company and the contractors is good	Contractor's planners and project managers do not communicate about tasks that are on the same area, resulting in missed combination opportunities, errors etc.
	There is no information on the status of the land-use contracts/permits, when has the permit process started? Are there problems with the permits?		The timetable in smaller tasks has no room for delays, many process phases and each transition has its own delay
			The contractor sends unnecessarily plans to the case company's inspection
			Communication issues with the customer and customer's contractor
			Gaming of the task reporting
			There are indications that some contractors do not have enough resources

			Contractor's planners present sub-optimal designs in order to negate the land-use permitting risk
			Contractor's planners agree to too high land-use compensations (in form of other jobs being done for the customer etc.)

As seen in tables 2 and 3, there are 10 strengths and 21 weaknesses identified in total. Some recurring themes in the responses can be noticed. SLA results can be manipulated or “gamed” by the contractor and that will likely go unnoticed in the case company was identified two times by the workshop participants. Several weaknesses related to the process phase reporting by the contractors were identified with a total of thirteen issues reported. These weaknesses can be roughly categorized under three headings

- Process data is not in a usable format, incorrect or contains errors
- Process reporting cannot be used to assess the contractor’s workload
- The process phases that are reported do not present enough information

The strengths reported by the workshop participants, as seen in tables 2 and 3, can be categorized roughly under three headings.

- In general sense the case company’s SLA model measures the contractor’s performance adequately
- The process steps that can trigger SLA sanctions are reported well
- The contractor can schedule the work order directly with the customer

Some of the identified items such as the quality of contractors work plans fall outside the scope of this study.

3.1.1 Observation of the monthly SLA reporting process

The monthly SLA reporting break for the previous month is in the first business day of every month. The reporting system does not save snapshots of the data, which means the SLA results for especially the “in progress” -category of contractor’s workload will vary from day to day and it is not possible to return to the previous day’s results. For this reason, it is necessary to have an agreed date when the data is extracted from the case company’s and the contractor’s systems to ensure comparability. Regular comparing of system data with the contractor is vital for keeping the situational awareness up to date for both parties. If comparing is not done regularly misreported or work orders otherwise handled in the wrong way start to build up in the reports causing misleading results, more importantly this can cause customer orders to be not performed leading to claims.

The actual SLA results are available in the case company’s reporting system, but in order to eliminate reporting errors due to user or system errors it is necessary to examine the data in line form before locking the results. Below are listed the main phases of SLA data handling. The full list can be found in appendix 1

1 The data is filtered in the reporting system

2 The data is downloaded from the reporting system as three different tables

   a. Low voltage fault task data

   b. Other categories of tasks reported “ready”

   c. Other task categories “in progress”

3 Data is “cleaned up” and consolidated

   a. Irrelevant columns are deleted

b. For network construction type tasks, the “order date” information is missing due to system architecture, data from “created date” column is used instead

c. The data is copied to a separate reporting template

d. SLA result values 0 or 1 are replaced with values “on time” and “late” respectively or “in progress, on time” or “in progress, late” respectively

e. Tasks that have the status “late” with duration value 0,1 days or less are changed to status “on time”

4 The data is then examined for potential reporting errors, e.g., very late tasks

5 In case of reporting errors, the SLA results need to be calculated by hand. Otherwise, the results from the reporting system can be utilized

6 Data is sent to case company’s program manager and the contractor for validation

a. The numerical data by task type is consolidated into a single table

b. The row data is consolidated into another table

Examples of the SLA data table can be found in appendix 2.

According to the person responsible for preparing the monthly SLA data the time it takes to prepare a single report is approximately one to two hours, if there are no major errors in the data. However, the preparing of the report has many manual phases and the possibility for making errors while handling the data is relatively high.

The SLA report is then presented in the monthly operational meeting with the contractor and if there are no issues with the data the amount of sanctions or incentives the contractor receives is decided.

3.1.2 End-to-end Customer Order Process

The end-to-end process has three main phases as shown in figure 2

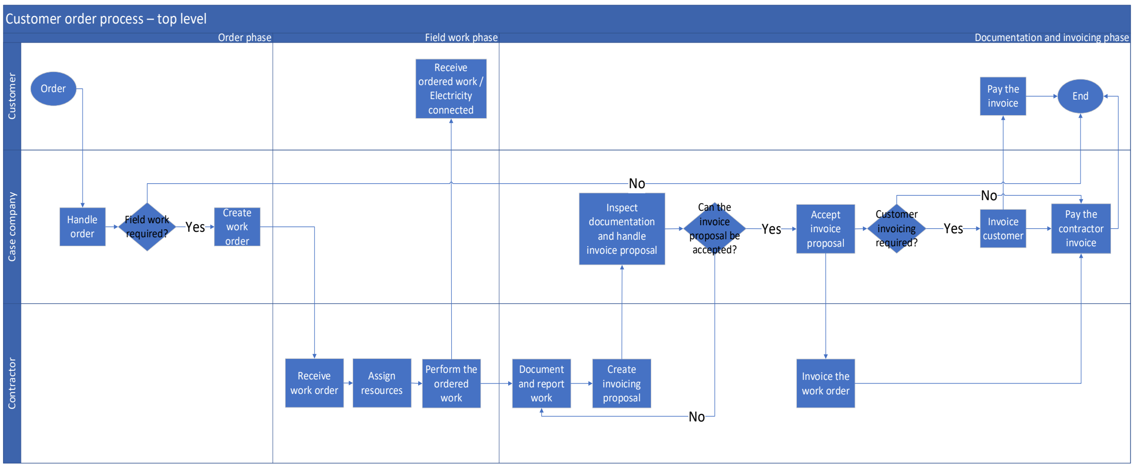

Figure 2. End-to-end customer order process

As seen in figure 2, the order phase, where the customer places the initial order, the case company's network service specialist handles the order and creates the work order for the contractor. The second phase is the actual field work phase, where the contractor performs the actual work that was ordered by the customer. The third phase is the documentation and invoicing phase, where the work performed is invoiced from the case company, the customer and the changes made into the network, or the switching state of the network are documented into NIS and ADMS (Network Information System and Advanced Distribution Management System respectively).

3.1.3 End-to-end Customer Order Process Task Status Reporting

From top level the process status reporting seems superficially sufficient (figure 3). The contractors report status information on all process steps. However, when delved into the sub-processes the deficiencies become more apparent.

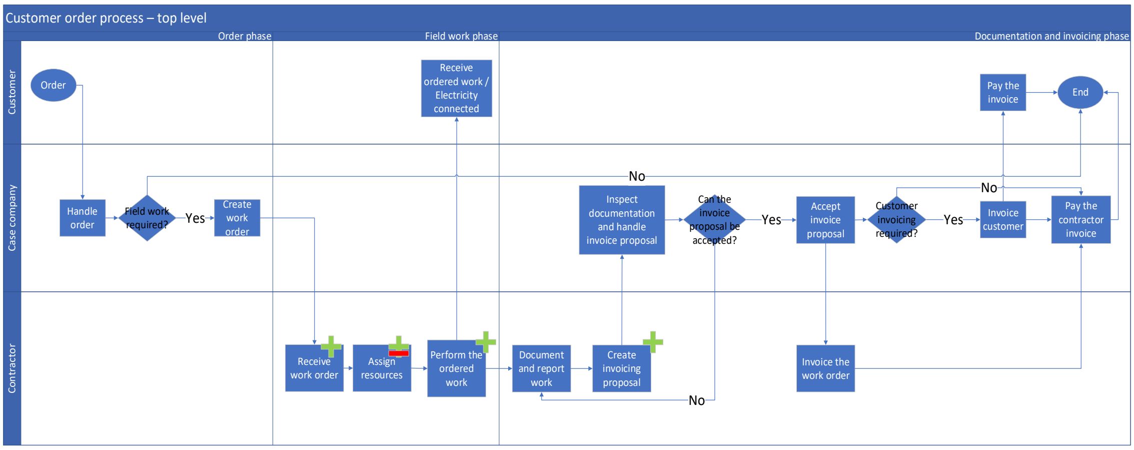

Figure 3 End-to-end customer process reporting steps

As seen in figure 3, the process steps where the contractor sends task status information are marked with a green plus symbol. A red minus symbol represents the process steps where there is the possibility to send task status information but in the current situation

- there is no information sent
- the information is false
- it is in wrong format
- it is sent but not utilized by the receiving end

The only deficiency in status reporting the interviewees noted in the top level concerned the “assign resources” step where there were contractor-specific differences. Only one contractor reported the step status diligently along the reporting guidelines. Other contractors either simply left the step unreported or did not provide accurate information on to whom the task was assigned.

The following sub-processes provide a more detailed look into variations of the field work phase.

3.1.4 Service Task Sub-process

Service tasks are the case company’s most common type of task. The category includes several subtypes e.g., meter installation, or connecting customer’s cable to the grid. Figure 4 illustrates the service task sub-process.

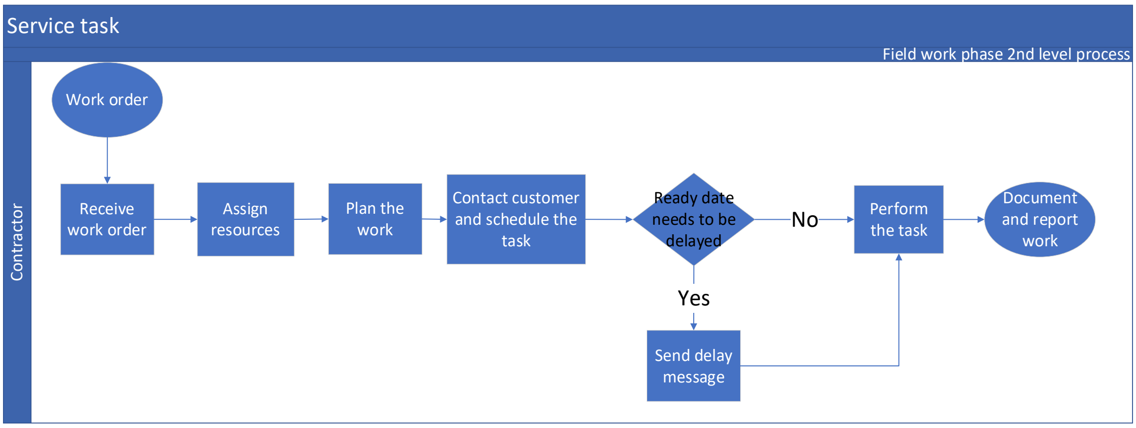

Figure 4. Service task sub-process

Tasks in the service task category typically have a delivery time of one work week and need frequently rescheduling because the customer’s electrician is required to have completed installations on customers end before the connection to the grid. If the customer’s installations are not ready or the customer wishes the task performed on a later date the case company’s contractor has the right to reschedule the task on the condition that the initiative originated from the customer. As seen in figure 4, in these cases, the contractor sends a special message with a task status code “delay due to the customer” and provides a new ready date for the task along with a short explanation of the reason for the delay.

3.1.5 Service Task Sub-Process Status Reporting

Figure 5 illustrates the process steps where reporting currently takes place.

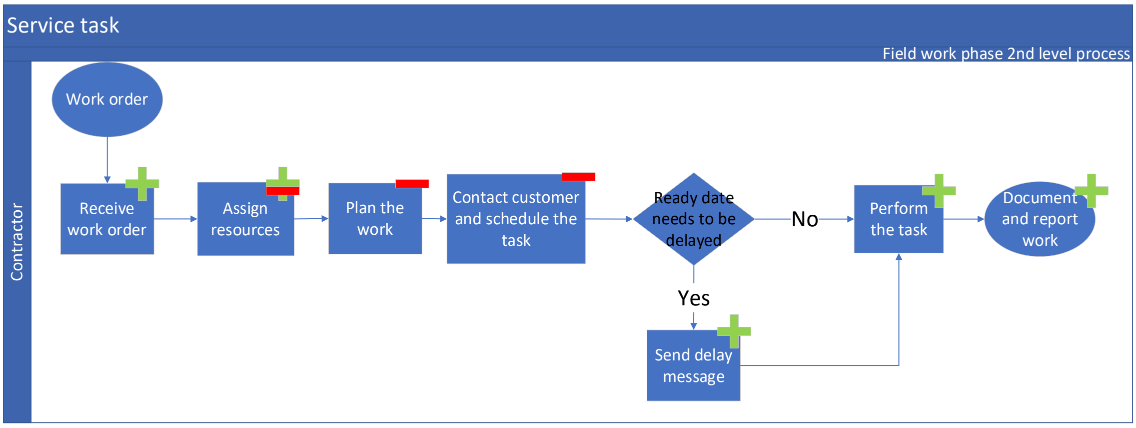

Figure 5. Service task sub process status reporting steps

As seen in figure 5 the process steps where the contractor currently sends task status information are marked with either a green plus symbol or a red minus symbol. The meaning of these symbols is explained in the sub-section 3.1.3.

During the second workshop and subsequent interview three issues regarding the service task sub-process arose. The first issue concerned planning of the work. Similarly, as to the issue regarding assigning resources, only one contractor sends task status information regarding the planned starting date of the work. The second issue was that the information regarding whether the customer has been contacted if sent at all is in non-utilizable form i.e., in free text form. The third issue had to do with the contractor's right to reschedule tasks. The interviewees noted that while the task status reporting functioned technically as intended during this step it is however possible to "game" the SLA metrics. The contractor has the possibility to reschedule the tasks with the task status code "delay due to the customer" and it is very challenging for the case company to verify whether the delay is customer initiated or perhaps due to lack of resources on the contractor's part, thus avoiding SLA sanctions from tasks not completed on time.

3.1.6 Network Construction Task Sub-process

The network construction phase is the most work intensive of the sub-processes. Figure 6 illustrates the network construction sub-process-

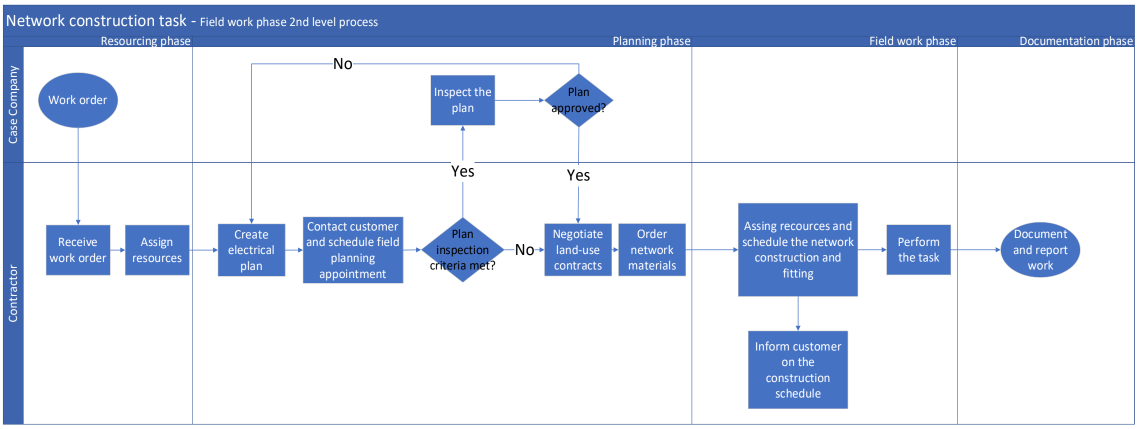

Figure 6. Network construction sub-process

As seen in figure 6, the network construction sub-process can further be divided into four phases. Resourcing phase, where the contractor receives the work order and assigns the correct resources to perform the task. The planning phase where the electrical plans for the task are made and if certain technical criteria are met - also inspected by the case company's project manager. After the plans have been approved the contractor's planner negotiates land-use contracts or applies for construction permits and orders network construction materials such as distribution cabinets or transformer substations. In the field work phase the contractor needs to assign an excavator subcontractor and electricians to the task. After the field work is done the newly constructed network is mapped and documented to NIS.

3.1.7 Network Construction Task Sub-Process Status Reporting

In this subprocess the interviewees reported the highest number of issues. Figure 7 illustrates the network construction sub-process reporting steps. The meaning of the symbols is explained in sub-section 3.1.3.

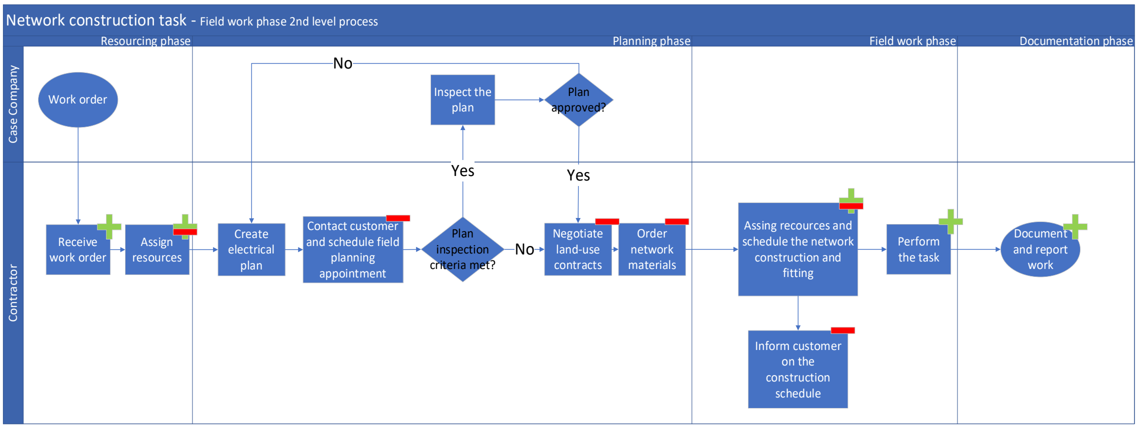

Figure 7. Network construction sub-process reporting steps

As for the service task sub-process, the interviewees noted that there are contractor-specific differences in how the resourcing is reported. As seen in figure 7, all communication with the customer regarding schedule changes or regarding land-use contract negotiations if it is reported at all is in non-utilizable form i.e., free text. The ordering of network is done in a separate system and the status info regarding deliveries is not utilized on any SLA reports. Interviewees also noted that in some special cases network materials are ordered by email and the only way to follow up on the delivery status is to directly call the material vendor.

In addition to the previous issues the project managers reported that the contractors frequently used the “delay due to customer” status message to alter the schedule of the task without reporting sufficient reasons for the delay. The project managers explained that it currently requires continuous manual checking of tasks to detect if there are any tasks that are delayed without sufficient reason, which is not feasible due to the number of tasks.

3.1.8 Fault Task Sub-Process

Fault repair has the fastest lead time of all the processes, the contractor’s performance is measured in hours rather than in days or months. Figure 8 illustrates the fault task sub-process.

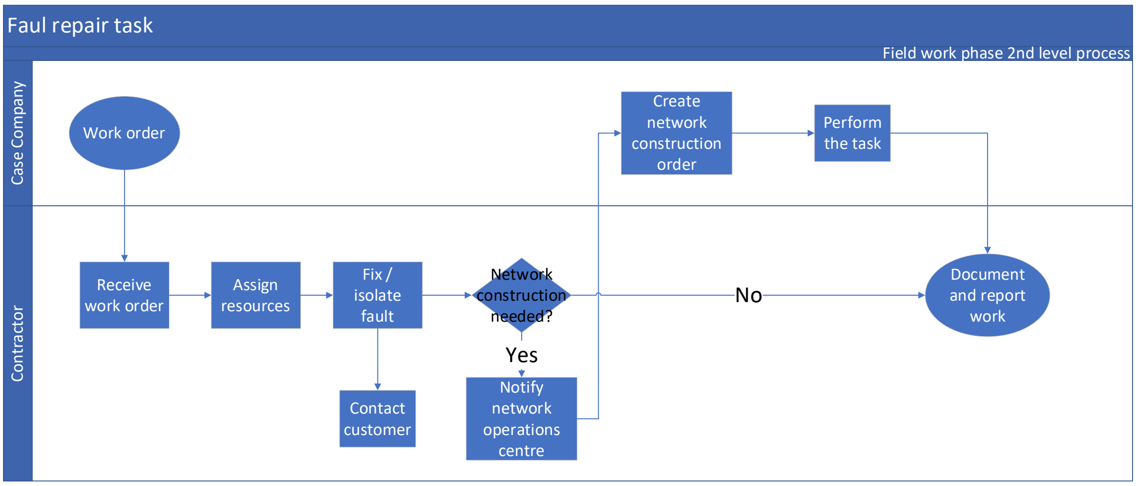

Figure 8. Fault repair sub-process

As seen in figure 8, if the fault repair requires more extensive reconstruction of network due to e.g., storm damages, electricity is restored to customers via temporary measures and the reconstruction is handled in the network construction sub-process.

Fault task sub-process requires the contractor to use two different ordering systems. The commercial work order is sent from the CRM for billing purposes and the technical order is simultaneously sent from ADMS to enable the contractor to report changes in network switching status. The SLA reporting combines information from both systems. The repair time measurement begins when the commercial order is sent to the contractor and the measurement end when the contractor reports that the electricity has been restored to the ADMS.

3.1.9 Fault Task Sub-Process Status Reporting

Figure 9 illustrates the fault repair sub-process reporting steps. The meaning of the symbols is explained in sub-section 3.1.3.

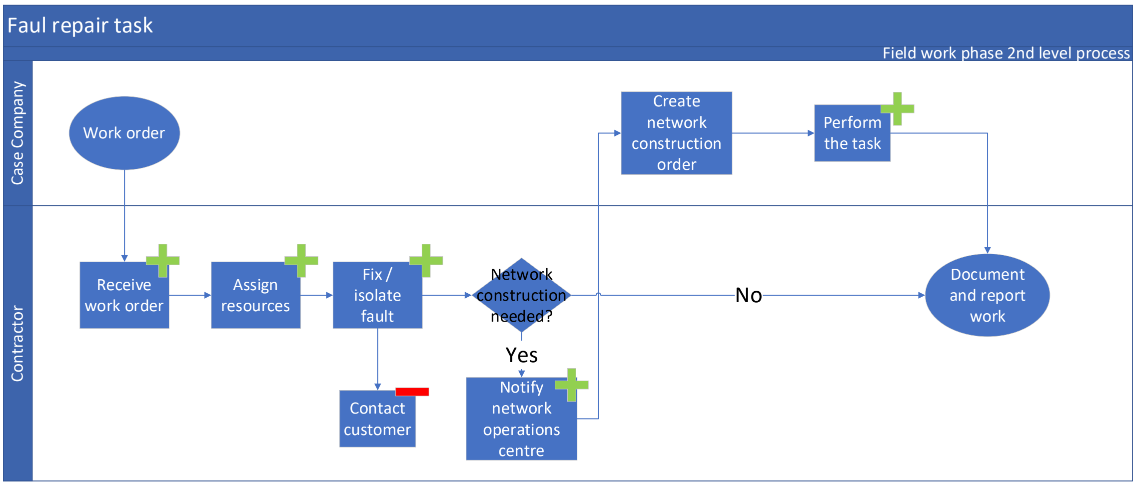

Figure 9 Fault repair sub-process reporting steps

The interviewees reported only one issue regarding the fault task sub-process. The status information regarding customer contact is reported in non-utilizable form i.e., free text, if it is reported at all. According to the interviewees the issue regarding delaying tasks without valid reasons the previous sub-processes is not present in fault task sub-process due to the more accurate information the case company is able to gather regarding the duration of outages utilizing the data from AMM services.

3.2 Current reports and data

Examples of current SLA reports are presented in appendix 3. Current reports hold information regarding order date, completion date, task status and whether the task was completed before the due date, or for tasks in progress whether the due date is in the future or past. Figure 10 illustrates the summary view of the current reporting.

Uusi KARHU Yhteensä

Contract	Valmiit tilaukset ajoissa	Valmiit tilaukset myöhässä	Valmiit Palvelutaso	Kesken tilaukset ajoissa	Kesken tilaukset myöhässä	Kesken Palvelutaso	Yhteensä palvelutaso	Yhteensä tilaukset
Total	**902**	**53**	**96%**	**533**	**370**	**59%**	**77%**	**1858**
Contractor 1	7	2	78%	17	5	77%	77%	31
Contractor 2	6	0	100%	38	5	88%	90%	49
Contractor 3	11	3	79%	63	21	75%	76%	98
Contractor 4	374	37	92%	180	103	64%	80%	694
Contractor 5	504	11	100%	235	236	50%	75%	986

Figure 10. An example of current SLA report summary view

As seen in figure 10 the summary view of reporting does not provide information beyond to what percentage of the work orders have been finished on time. The SLA data is a compilation of system time stamps and user reported time stamps. During the interviews it became apparent that there are contractor-specific differences between reporting different process steps. This is equally true to reporting done by individual users. A CIF system reliant on end users utilizing the system correctly is inherently less reliable than a fully automated one.

In addition to human error there is the matter of reliability of the integration interface between the case company's CRM and the contractor's ERP. These error factors mean that the data gathered in the reports needs constant validation.

3.3 Strengths of current reporting and data

Based on the observation of the reporting process and the interviews three main strengths relevant to the topic could be identified. The identified strengths were:

- The contractor has the right and the obligation to schedule the task with the customer. The contractor communicates directly with the customer
- Current SLA metering measures the contractor's performance reasonably accurately and contractor's poor performance can be deducted from the reports

- The status of the process steps with assigned SLA sanctions or incentives are reported accurately

3.4 Weaknesses of Current Reporting and Data

Four relevant main weaknesses to the current reporting and data can be identified from the interview observations and reporting process. The identified weaknesses were:

- The “gaming” of SLA results is possible and difficult to detect
- The process data needs constant validation
- The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable
- It is not possible to visually or statistically examine the contractor’s order backlog in a concentrated and systematical manner

3.5 Summary of Current Reporting and Data

The case company’s reporting fulfils its main function of measuring the contractor’s overall performance, however the process data is not utilized to its full extent. Table 4 illustrates the summary of the identified strengths and weaknesses.

Table 4The summary of strengths and weaknesses

#	Strength	#	Weakness
1.	The contractor has the right and the obligation to schedule the task with the customer. The contractor communicates directly with the customer	**1.**	The “gaming” of SLA results is possible and difficult to detect
2.	Current SLA metering measures the contractor’s performance reasonably accurately and contractor’s poor performance can be deducted from the reports	**2.**	The process data needs constant validation

3.	The status of the process steps with assigned SLA sanctions or incentives are reported accurately	**3.**	The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable
		4.	It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner

As seen in table 4, the reporting process produces data that is systematically non-utilizable and there are process steps that may have a vital role in the process that do not produce any information. Another important issue is that the process data requires constant monitoring. Errors in the process are detected usually in the following reporting cycle which may lead to a delay of several weeks before resolving the issue

Finally, currently the case company is unable to detect manipulation of the SLA results during the normal reporting cycle. This can lead to user errors and deliberate distorted task go unnoticed until customer complaints are received.

In the following section 4 the Literature Research ideas from relevant academic literature are introduced into the context of the key weaknesses identified in the current state analysis.

4 Literature Research

In section 4 the information found in the reviewed literature is formulated into a conceptual framework based on the findings from the current state analysis. The first sub-section outlines the key findings from the current state analysis described in Section 3 and the subsequent sub-sections describe a relevant idea or concept from literature. The last sub-section summarizes the concepts most relevant to this study into a conceptual framework.

4.1 Overview of Selected Weaknesses from Current State Analysis

Four relevant main weaknesses to the current reporting were selected from the current state analysis.

- The “gaming” of SLA results is possible and difficult to detect
- The process data needs constant validation
- The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable
- It is not possible to visually or statistically examine the contractor’s order backlog in a concentrated and systematical manner.

Existing knowledge from academic literature regarding these specific weaknesses is presented in the following sub-sections.

4.2 Supply Chain Integration SCI

In their article on managing quality in a supply chain, Lo *et al*., present three key areas of effective supplier management. (Victor H.Y. Lo *et al*., 2006)

- Supplier selection
- Supplier development
- Supplier integration

Lo *et al*. (2006) argue that selecting suppliers based on cost or schedule alone in favour of quality oriented long-term partnerships is ultimately detrimental to the continuous improvement of supply quality. To improve the supply quality development activities, such as training and recognizing supplier achievement, should be directed to the supplier’s operations. Finally joint development activities should be taken in cooperation with the supplier to promote integration. (Victor H.Y. Lo *et al*., 2006: 2)

To address the current state main weakness number three (table 4) regarding missing or non-utilizable status data cooperative development measures need to be taken in the supply chain. Both parties, the case company and the supplier, need to implement missing status messages into their ERP systems and convert non-utilizable data into a set format.

As the case company’s current frame agreements are on their final year, it is feasible to implement these changes to the following frame agreements. In the following frame agreement tendering process it is advisable to choose suppliers not entirely based on cost effectiveness, but rather ensure that the agreement model promotes partnership and co-development. Coincidentally the contract period should be sufficiently long in order to facilitate the necessary learning, stabilization of operations and development activities.

4.3 Business Analytics in Supply Chain Management

The terms business intelligence BI and business analytics are often used interchangeably, however the distinction should be made that BI can only answer to the question “What happened?” and BA can answer questions in the manner of “Why something happened?” or “What is going to happen?” (Goodwyn 2019).

El Morr and Ali-Hassan (2019) divide business analytics into four different categories according to how challenging the analytics are to implement and the value they provide. In figure 11 the analytic techniques are illustrated according to the complexicity of the technique and the value gained from it.

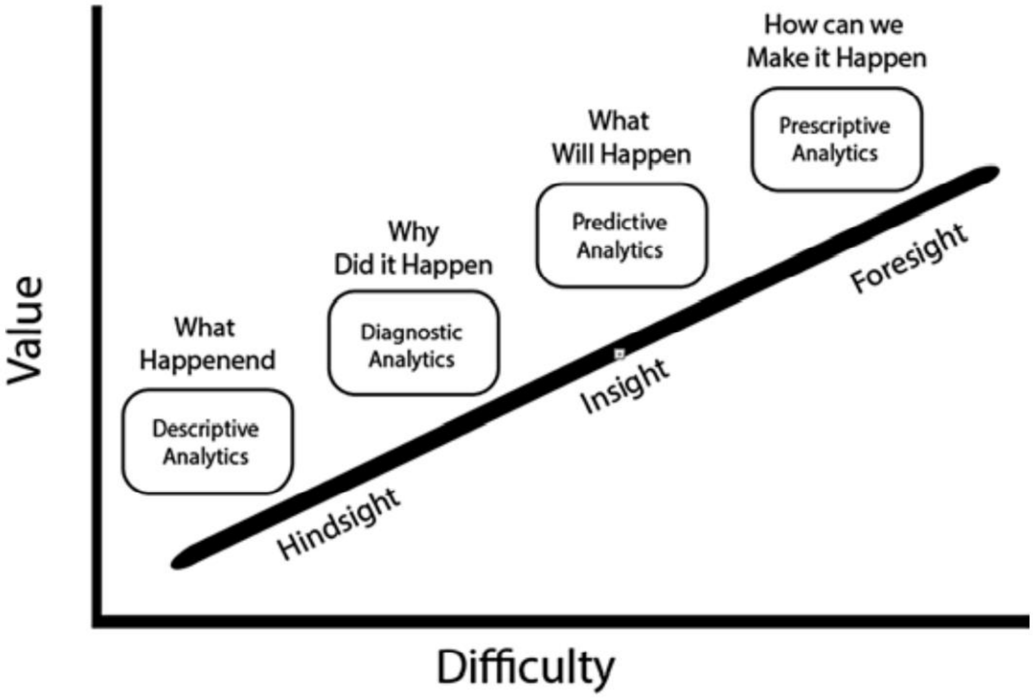

Figure 11 The analytics landscape (El Morr, Ali-Hassan 2019)

As seen in figure 11, the categories from easiest to the most challenging are:

- Descriptive analytics (what happened?)
- Diagnostic analytics (why did it happen?)
- Predictive analytics (what will happen?)
- Prescriptive analytics (how can we make it happen?)

In the following sub-sections, the different types of analytics are presented along with some of the analytic techniques they utilize.

4.3.1 Descriptive Analytics

Descriptive analysis provides insight into current or past data and seek to answer the question “What happened?” by highlighting patterns in the data thus enabling evidence-based decision making. The statistical measures descriptive analysis employs can be e.g., central tendency such as mean, median and mode dispersion, standard deviations, quartiles distribution of variables, histograms (El Morr, Ali-Hassan 2019).

4.3.2 Diagnostic Analytics

The focus of diagnostic analytics is to enable process enhancements by identifying the variable possible causes to events. The analyses used in diagnostics can include e.g., trend, root cause and cause and effect analysis (El Morr, Ali-Hassan 2019).

4.3.3 Predictive Analytics

Predictive analysis utilizes trends in past data in order to derive insight into what is likely to happen in the future. Predictive analytics enable proactive decision making e.g., in resource planning. The tools predictive analytics employ are among others machine learning and neural network algorithms, what-if analysis and predictive modelling (El Morr, Ali-Hassan 2019).

4.3.4 Prescriptive Analytics

Prescriptive analytics seek to increase the possibility of a certain desired outcome by utilizing knowledge acquired by diagnostic analytics. The difference between predictive and prescriptive analytics is that while predictive analysis objectively lists the possible outcomes, prescriptive analytics actively seek to present the actions that ascertain the realization of the desired outcome. The tools include simulations and comparing results of multiple what-if analyses (El Morr, Ali-Hassan 2019).

4.3.5 Utilizing Business Analytics

Goodwyn (2019) suggests a method to begin the utilization of BA.

- Identify problem
- Collect data
- Choose metrics or analytic techniques
- Analyse data
- Interpret results

In the first step, to identify the problem a key analytic question (KAQ) needs to be defined based on the business problem at hand in order to define the required resources. The outcome and complexity of the second step is determined by the amount of needed data sources, where the information is stored and the format of the data. In the third step the appropriate BA techniques are determined by the available data and the KAQ. In the fourth stage the results of the chosen analysis are reviewed. Depending on the results an adjustment of KAQ, data or methods may be required. In the final stage the results are reviewed in the context of the KAQ (Goodwyn 2019)

4.3.6 Relevance to the Business Problem

To address the weakness number one “gaming of the SLA results,” from the CSA described in section 3 changes into the existing BI or descriptive analytics of the case company are needed. These base level modifications to the reporting and the data gathered are also advisable to implement before moving on into more advanced analytic techniques.

To a degree also the CSA issues two “process data needs constant validation,” and four “It is not possible to visually or statistically examine the contractor’s order backlog in a concentrated and systematic manner,” can be addressed with descriptive analytics. For example, a distribution analysis of the contractor’s back log and completed work orders will yield a visual insight into the contractor’s performance as the dispersion of the completed work orders in relation to the due date can be visualized as a normal distribution curve or a boxplot.

As stated in section 3 currently the information regarding contractor’s back log is limited to whether the work orders are late or not. A normal distribution analysis the contractor’s back log in relation to the remaining days until the original due date of each work order is presented in figures 12 and 13. Delays to the due dates by the contractor are not considered. The x-axis of the tables represents the number of days until due date of each work order in the data set. Negative values represent number of days that have passed since the due date and positive values represent number of days remaining until the due date. The y-axis represents the value of normal distribution of the data.

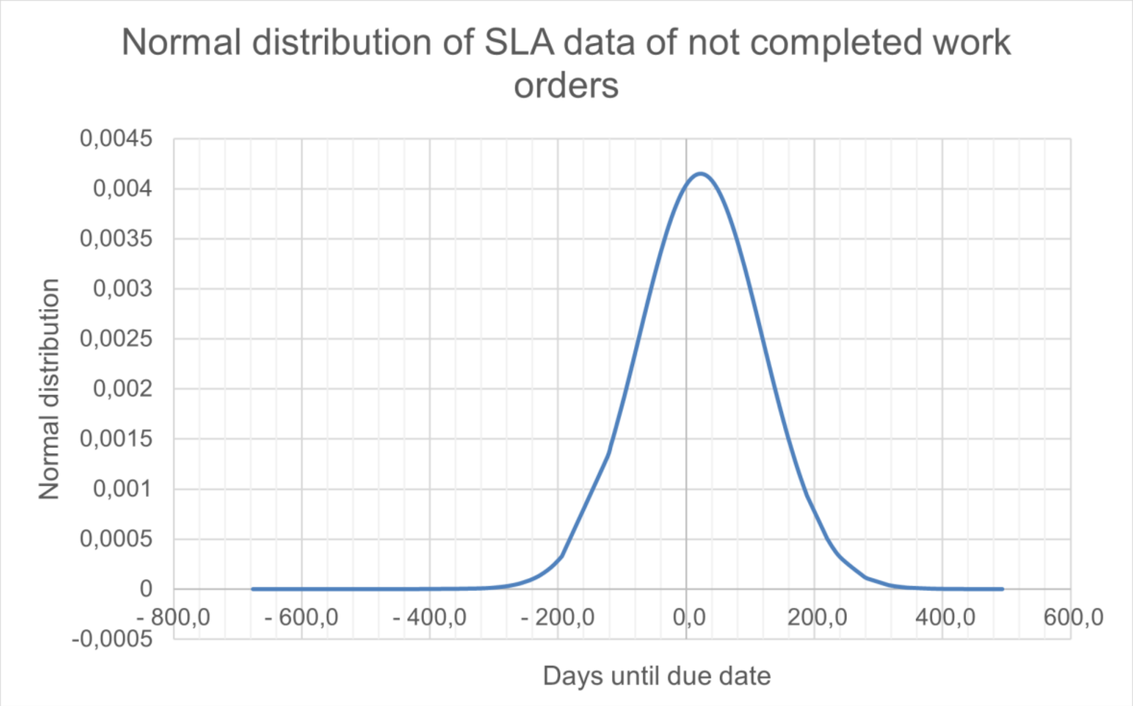

Figure 12 Normal distribution of incomplete work orders

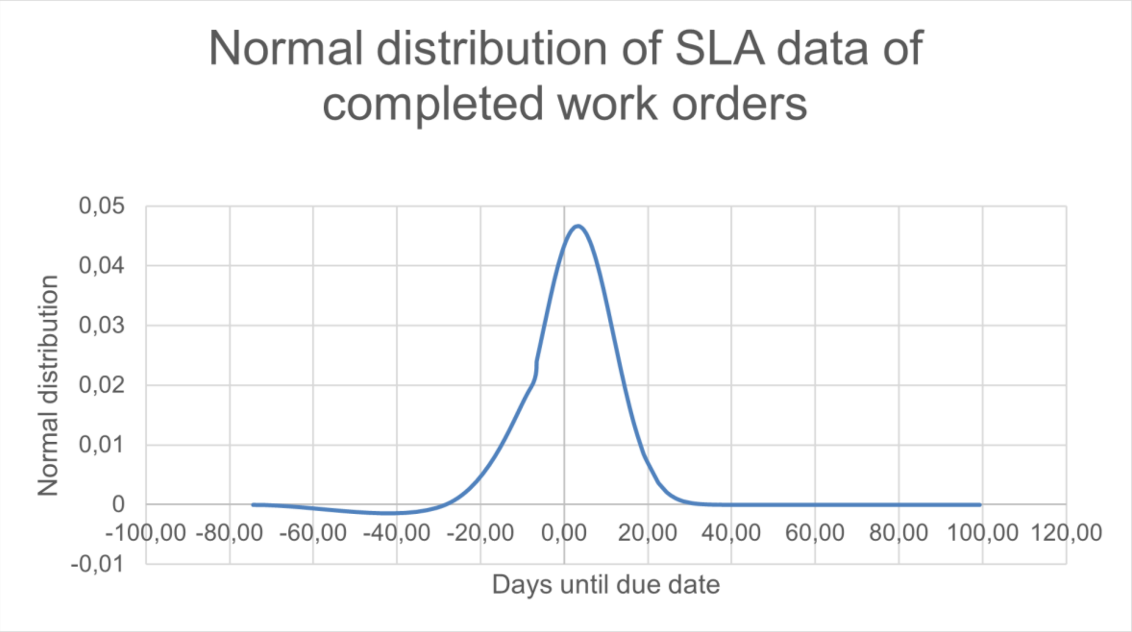

Figure 13 Normal distribution of completed work orders

From the data visualization in tables 5 and 6, it is possible to make the following observations.

- The peak of the normal distribution curve is on the positive side on both graphs meaning that on average the work orders are completed before the original due date

- The slopes of the normal distribution curve run on the both sides of the zero value of x -axis, meaning that there is a significant number of work orders that have been completed after the due date

- Especially in figure 12 but to some extent in figure 13 the tails of the normal distribution curve have very high positive and negative values, which indicates that there are outliers in the data

- Outliers in the data cause inaccuracy in the normal distribution. The data must be validated, and system errors removed.

- Outliers with high positive x-axis value indicate that there are likely user generated errors in the initial work order due dates e.g., wrong month or year in the due date field.

- Outliers with high negative x-axis value are a strong indicator that either the reporting of the work order has failed, or the work order has not been accepted by the contractors ERP. In either case the high x -axis value indicates that the problem has remained unnoticed for a considerable amount of time

From this relatively simple example of utilizing descriptive analysis methods, it is possible to gain decision making enabling insight into the contractors back log that is not available in the current reports.

Another useful way to visualize data features such as the central tendency, dispersion, skewness and outliers through quartiles is the box plot. The features of box the box plot visualization are presented in figure 14. The box represents the interquartile range (IQR). The lower bound of the box represents the first quartile (Q_1) and correspondingly the upper bound of the box represents the third quartile (Q_3). The formulae for calculating the upper and lower limits (UL and LL respectively) are

$$IQR = Q_3 - Q_1$$

$$UL = Q_3 + 1{,}5 \times IQR$$

$$LL = Q_1 - 1{,}5 \times IQR$$

Observations that do not fall within UL and LL are outliers. (Chang *et al.,* 2015, 3) While the core element i.e., the box encompasses 50% of the data, with the line in the middle representing the median. (Krzywinski *et al.,* 2014: 1) Figure 12 illustrates the box-plot visualization technique.

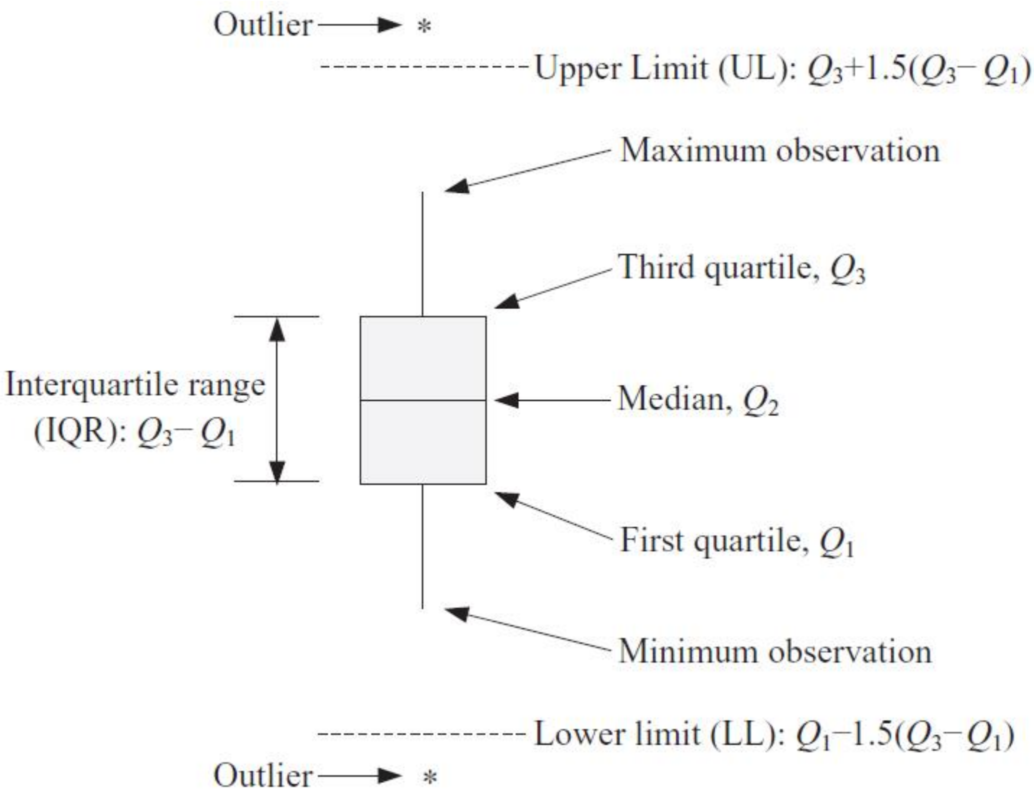

Figure 14 The box plot (Chang *et al.* 2015)

As seen from figure 14, a box plot can provide strong visual clues to the distribution of a contractors back log related to the due dates of the individual task complementing the information gained from normal distribution analysis. It is also an easy way to compare the state of different contractor's back logs. Optimally the UL of the back log should be the due date of tasks with late tasks being the outliers. The frame agreements however allow certain percentage of the total back log to be late, so the UL should be set to that level.

Further insights into the contractor's performance require more complex analysis methods and defining the KAQ's.

4.3.7 Information sharing

Thomas *et al.* (2015) argue that global supply chains whose participants exist in geographically different locations consist of multiple independent decision making units (DMU) and are by nature decentralized. The DMUs of these supply chains are not usually identical or share common objectives, thus it is necessary to share information to effectively coordinate production between DMUs and to improve the overall performance of the supply chain. (Thomas *et al.* 1-2, 2015) The value of information can be described as the difference of performance metric between information-sharing supply chain and non-sharing supply chain. (Davis *et al.* 2011: 3)

According to Thomas *et al.* (2015, 2) false reporting is an issue with information sharing. Thus information sharing must be applied with reporting mechanisms that discourage false reporting. Thomas *et al.* (2015, 10) identify two key metrics in their example study of producer-distribution supply chain, which were production capacity and resource availability.

Case company's supply chain consists of multiple DMUs, the customer service of the case company, the contractor, component suppliers etc. Sharing real time process data i.e., the SLA data or incoming customer order volumes with the suppliers enables each DMU to independently address resourcing, process outliers and exceptions, thus reducing the need for centralized and often very delayed manual validation of the data by the case company employees.

4.4 Conceptual Framework

In this section the findings from literary study presented in previous sections are compiled. In table 5 the weaknesses from the previous section are presented along with the literary study finding, with the findings divided into three columns. In the first column titled "topic" the topic of the study is listed. In the following column "relevant concept" the technique or concept from that particular topic is presented. In the final column, "tool" the particular tools or methods associated with the topic and relevant concept are listed.

Table 5 The conceptual framework

#	CSA Weakness	Topic	Relevant concept	Tool
1.	**The "gaming" of SLA results is possible and difficult to detect**	**Business Analytics** (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Reporting
			Diagnostic Analytics	Trend analysis
		Supply Chain Integration (Victor H.Y. Lo *et al.*, 2006)	Co-development	Data utilization improvements
2.	**The process data needs constant validation**	**Information Sharing** (Thomas *et al* 2015) (Davis *et al* 2011)	Decentralised process coordination	Shared reports
		Business Analytics (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Data visualization
3.	**The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable**	**Supply Chain Integration** (Victor H.Y. Lo et al., 2006)	Co-development	Data utilization improvements
4.	**It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner**	**Business Analytics** (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Data visualization
			Diagnostic Analytics	Trend analysis
			Predictive Analytics	Predictive modelling

As seen in table 5, the conceptual framework is divided into four categories by the CSA weakness each concept addresses. There are topics that address more than one CSA weakness e.g., business analytics. Some topics, such as Supply chain integration or business analytics are already utilized by the case company to a degree-These topics were chosen due to their familiarity and the possibility to enhance and develop existing processes and reporting tools.

In the following section the conceptual framework is used to develop the initial solution. The tools form the conceptual framework are utilized to address the weaknesses identified in the current state analysis to solve the business problem in collaboration with the case company’s key stakeholders.

5 The Initial Solution Development

In section 5 the current state analysis findings from section 3 and the conceptual framework from section 4 are combined to create the initial solution to the business problem. This section starts with an overview of the solution development, a description of the development process and the recommended development roadmap. The section ends with a summarization of the recommendations.

5.1 Overview of the Initial Solution Development

The initial solution development was carried out in three stakeholder workshops and two interviews. The workshops started with introduction to the business problem and previously created material. The objective and desired outcome of the workshops were stated in the beginning of the work shop and the achievements of the workshop were summarized in the end of the work shop.

5.1.1 First workshop

The first workshop started with presenting the weaknesses identified in the current state analysis. The stated objective of the workshop was to address the weaknesses number one, “the gaming” of the SLA results and two, the need to constantly validate the SLA data. The participants were then introduced the relevant concepts identified in the conceptual framework, business analytics and information sharing. The participants of the workshop were the project managers whose responsibility it is to collect and validate the SLA data.

After the briefing the participants were asked to discuss a series of pre-prepared questions. The questions are summarised in the table 6.

Table 6 The first workshop question summary

#	CSA Weakness	#	Question
1	The "gaming" of SLA results is possible and difficult to detect	1.1	What are the specific actions required to make the "gaming" visible?
		1.2	How is this measured?
		1.3	How is this visualized?
2	The process data needs constant validation	2.1	What are the specific actions to make the faulty data visible?
		2.2	How is this measured?
		2.3	How is this visualized?

As seen from table 6, the first three questions concerned the CSA weakness number one, the "gaming" of the SLA results. The following three questions concerned the CSA weakness number two, the process data needs constant validation. The results of the discussions are summarised in the table 7.

For the question number 1.1, what are the specific actions required to make the "gaming" visible? Seven different actions were identified.

- The delayed tasks must be made visible on the reports. The current reports do not differentiate between work orders that have been completed by the initial due date or have been delayed. The work orders with delay codes need to be identified and a separate category must be made in the reports for these work orders.
- The task delay reason is currently reported in a free text format into the same text field with the task reports. The task delay reasons must be in a usable format and in separate field to be utilizable on the reports.
- The reason for the delay is not currently specified as a mandatory field in the supplier ERP user interface. The reason for delay must be made mandatory.
- The reason for delay is in free text format. The most common reasons for delays must be identified and corresponding additional codes are needed to eliminate the need for free text

- Re-delaying work-orders must trigger and alert in the reports, or re-delaying work-orders must be made not possible
- In order to fully utilize the data, the amount of freely written text in the system must be minimized. The delaying of tasks is currently identified with two task result codes, that are “delay due to customer” and “delay due to contractor.” The delay code list must be extended to include the most common reasons for delaying a work order to eliminate the need for written explanations
- The phase of the project where the delay is sent must be included into the reporting

For the question 1.2, how is this measured four actions were identified

- The reports must include a trend analysis of the contractor’s back log in order to determine whether the back log is growing or decreasing. This analysis is beyond the reporting system’s current capabilities as there is no historical data saved on the status of unfinished work orders.
- The number of unfinished work orders must be stored on a day/week/month level into the system
- The number of times a certain work order has been delayed must be stored into the system and displayed on the reports in order to enable automated alerts
- The number of work orders completed by the original due date must be displayed on the report

For the question 1.3, how is this visualized four actions were identified

- The current and historical status of the back log must be visualized in form of a normal distribution curve (see table 6). The normal distribution is determined by the amount of days the work orders have until the designated due date or how many days have passed since the due date. Completed and incomplete work orders must have their own visualizations. There needs to be also the capability to display the visualization for a certain time frame and for selected work order types
- In addition the back log must be visualized in the form of a box plot visualization with similar conditions as to the normal distribution curve
- It was also proposed that a phase-by-phase visualization of the work orders in the back log was implemented to enable further analysis of the back log. See figure 15.

- The dispersion of the work orders in the back log in refence to the work order’s due date must be implemented. The analysis will provide insight into the capabilities of the resource management of the contractor. I.e., high dispersion corresponds with low level of resource management and low dispersion corresponds with high level of resource management. The dispersion can be visualized with a box-plot.

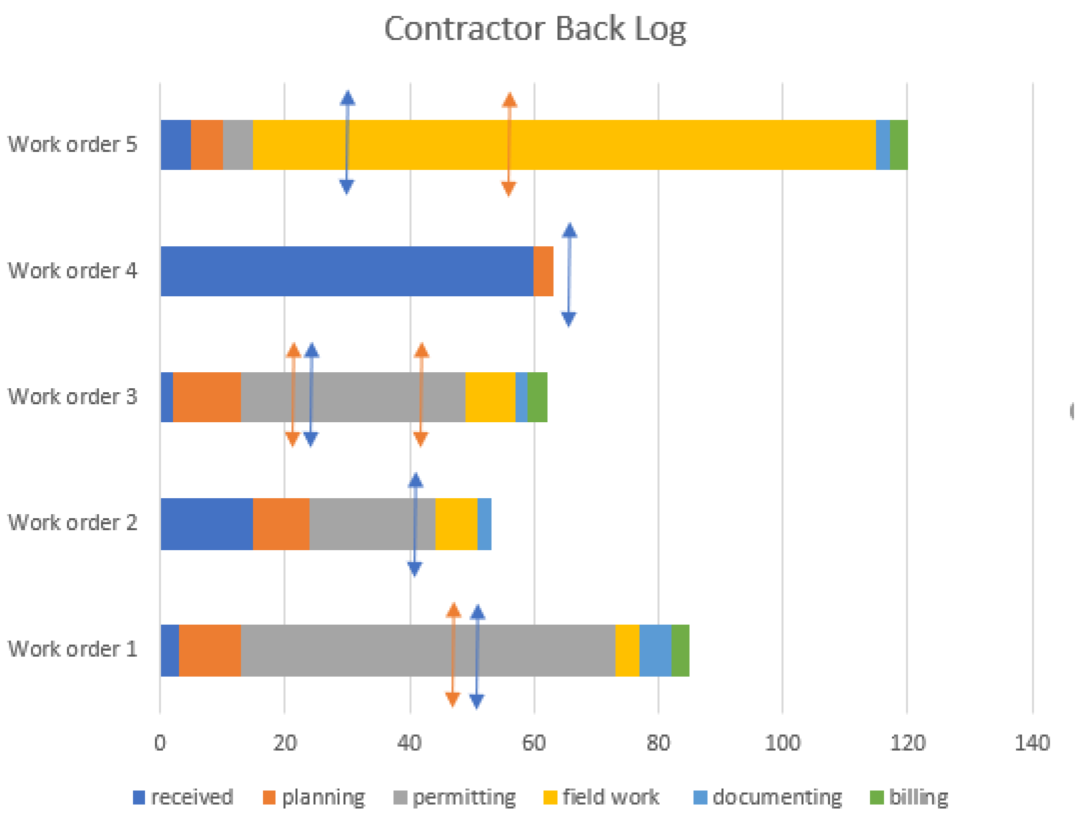

Figure 15 Phase-by-phase visualization of the contractor back log

In the phase-by-phase view of the contractor’s back log each separate work order is visualized as a timeline bar. The timeline bar is divided into separate phases according to the reported work order statuses. The length of each phase represents the duration of the phase in days. Each phase is illustrated by a different color. The work order’s initial due date is illustrated with a blue arrow and the delay messages are illustrated with an orange arrow. The placing of the arrow on the timeline bar is dependent on the number of days that have passed since the placing of the order i.e., day zero.

Such visualization will enable the project managers to identify the work orders that are in need of corrective actions by a glance. Also the project manager can monitor the state of the contractor's capabilities, such as the planning and civil engineering resources the contractor has in use. For example if there are consistently long planning times in the back log, the project manager can raise the issue of planning resources with the contractor.

For the question 2.1, how to make the faulty data visible six actions were identified

- The relevant reports and data must be shared with the contractor in order to enable both parties process monitoring on the basis of same data. The reports must be available on demand. The current once a month sharing of reports and data is insufficient for the needs of the process
- In the interviews it became apparent that work orders that have been advanced beyond the scope of SLA measurements i.e., work orders that are in the billing phase cause also additional need of monitoring and manual work . The billing phase should also be included in the monitoring of the processes to ensure smooth running financial operations
- Work orders with large schedule deviations must trigger an alert. The monitoring must include also certain process phases. For example if the receiving of a work order takes more than the agreed time period of three days an alert must be triggered. The threshold of alerts must also be parametrized to allow the fine tuning of the processes. The parameter can be an absolute time period or a relative to the deliver time e.g., an alert is triggered when 70% of the delivery time has elapsed and the work order has not been advanced to the field work phase
- Work orders that receive a technical rejection by either the case company's or the contractor's ERP should trigger an alert in the system that attempted to send the work order status message
- Work orders that are cancelled either by the case company or the contractor should trigger an alert in both parties systems.
- Work order status messages that do not receive acknowledgement (ACK) or not acknowledged (NACK) message from the receiving system should trigger an alert in the sending system
- The case company's and supplier's ERP's should compare system data at regular intervals automatically and display a list of work orders whose status differs in the ERP's. This comparison should include at least comparison of the work order ID's, statuses and

relevant date information. The comparison can be implement for example by the case company publishing the SLA data on a daily basis and the contractor's ERP ingesting that data and automatically comparing it with its system data

For the question 2.2, how is this measured two actions were identified

- A deviation alert calculation should be implemented in the case company's reporting system. The purpose of the calculation is to enable triggering of alerts in certain process status and elapsed time combinatios e.g., there is less than 30% of the delivery time left and the field work phase has not yet been started
- Thresholds for the deviation alerts need to be specified for each work order type, i.e., for network construction the thresholds can be measured in days or even weeks but fault repair work orders need hourly measurement

For the question 2.3 how is this visualized two actions were identified

- Identified deviations of work orders should be made visible in the reports in a list format
- Triggered alerts should be made visible in the reports. The work orders that have alerts should be identified and displayed e.g., in a list format and also the number of alerts by type in relation to the contractor's back log should be visualized

The summary of discussions in the first workshop is summarised in table 7.

Table 7 The summary of discussion in the first workshop

#	Question	#	Improvement action
1.1	What are the specific actions required to make the "gaming" visible?	1.1.1	The delayed tasks must be visible on the reports
		1.1.2	The task delay reason must be in a usable format and in separate field to be utilizable on the reports.
		1.1.3	The reason for delay must be made mandatory.

		1.1.4	The reason for delay is in free text format. Additional codes are needed to eliminate the need for free text
		1.1.5	Re-delaying work-orders made not possible or triggering an alert
		1.1.6	Dedicated delay codes instead of written explanatations
		1.1.7	The project phase where the delay code is sent displayed on the report
1.2	How is this measured?	1.2.1	Trend analysis of the back log
		1.2.2	The number of unfinished work orders, on a day/week/month level saved into the system
		1.2.3	The number of times a certain work order has been delayed displayed on the report
		1.2.4	The number of work orders completed by the original due date
1.3	How is this visualized?	1.3.1	Normal distribution of the back log
		1.3.2	Box-plot of the back log
		1.3.3	Phase-by-phase visualization of the work orders in the contractor's back log
		1.3.4	Dispersion analysis of the back log
2.1	What are the specific actions to make the faulty data visible?	2.1.1	Shared reports and relevant data
		2.1.2	Billing phase must be added into the ERP process
		2.1.3	Alerts on large deviations
		2.1.4	Alerts on rejected work-orders
		2.1.5	Alerts on cancelled work orders

		2.1.6	Alerts on work orders with no technical acknowledgement from the receiving system
		2.1.6	Automatic system data comparison between case company and suppliers
2.2	How is this measured?	2.2.1	Deviation alert calculation
		2.2.2	Deviation threshold specification
2.3	How is this visualized?	2.3.1	Identified deviations made visible on reports
		2.3.2	Alerts made visible on reports

As seen in the table 7, the first two columns indicate the question presented in the workshop and the following two columns indicate the action that was concluded from the discussion in the workshop.

5.1.2 Second Workshop

The second workshop focused on the weakness number four “It is not possible to visually or statistically examine the contractor’s order backlog in a concentrated and systematical manner” identified in the current state analysis. The objective of the workshop was to identify the key analytic questions (KAQ) for predictive models of the contractor’s back log and also how the back log is analysed and visualized utilizing diagnostic and descriptive analyses. The participants of the workshop were the project managers whose responsibility is to collect and validate the SLA data. Table 8 summarises the questions presented to the workshop participants.

Table 8 Question summary for the second workshop

#	CSA Weakness	#	Question
4	It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner	4.1	What is the key information needed regarding the state of the contractor's back log?
		4.2	How is this measured?
		4.3	How is this visualized?

The first question's objective was to determine what is the key information that was necessary to gain from the contractor's back log. This information can be used at a later stage to formulate the KAQ's for predictive models.

For the question 4.1 the following three questions were formulated

- Is the contractor able to complete the back log in time?

For the case company's project managers to identify and to initiate corrective measures the situations where the contractor is not able to complete the back log in time need to be predicted in advance. Build up in back can create a self-sustaining cycle where the contractor is perpetually performing poorly due to a large back log.

- How work orders that are going to be completed late are identified and predicted

On work order level a method of detecting work orders that are likely to be late is needed to avoid customer complaints.

- How are the disturbances in the supply chain identified?

Disturbances in the supply chain, such as material supply disturbances can have effects on the contractor's SLA that are hard to predict as well as gauge the impact of such disturbances.

For the question 4.2 how is this measured, three actions were identified.

- As a simple method of measuring contractor's back log completion rate the following formula was created

$$\frac{Bl_{30}}{Bl_c * \Delta_c}$$

Where the term Bl_{30} equals the number of incomplete work orders in the contractor's back log with less than 30 days until the due date

The term Bl_c equals the numer of all the completed work orders from this and the previous month

The term Δ_c equals the slope of the average work order completion rate from corresponding time period over last three years. The purpose of this term is to introduce the seasonal variance of customer order volumes into the equation.

- As a way of predicting the work orders that are going to be late the following method was proposed. The process phases of a work order are divided into percentages of the total delivery time. If the progress of the work order does not correspond to the percentages an alert is triggered

In order to fully implement this method two things have to be taken into account. First, currently the process phase reporting by the contractors is not on an adequate level and secondly new process phases should be implemented into the ERP's of all parties. It should also be noted that while this method of triggering alerts takes into account differing delivery times its accuracy decreases with longer delivery times, especially on work orders that have predetermined long waiting periods.

- Task result alert codes

In order to make the effect of supply chain disturbances, or other external disturbances visible and measurable a set of task result codes need to be specified for the most common reasons for these kinds of disturbances, such as major storms causing the need to divert resources into fault repair or component availability issues. These task result codes would enable the contractor to delay the work order and simultaneously triggering an alarm in the case company's reporting system.

For the question 4.3 how is this visualized four actions were identified

- Phase-by-phase visualization of the contractor's back log

A phase-by-phase type of visualization would be a powerful tool for the case company's project manager's to gain overview of the general state of the contractor's back log and to identify performance issues. See figure 15.

- Box-plot visualization

A box-plot visualization of the contractor's incomplete back log as well as similar visualization of the completed work orders over a selected time period with the ability to drill down to work order types. The box-plot visualizes the dispersion of the days remaining until the due date or days that have passed since the due date of the work orders in the contractor's back log.

- Normal distribution of the contractor's back log

The normal distribution is calculated as shown in tables 5 and 6. The normal distribution curve was seen as an alternative or a complementary visualization to the box-plots.

- Work order completion rate / incoming customer order rate

Work order completion rate was identified as a new useful metric to be followed. The completion rate is calculated simply by dividing the number of completed work orders by a chosen time period. I.e., how many work orders were completed in a day. This figure can then be compared to the number of incoming customer orders to gain general insight into the contractor's back log development. Thus the contractor’s back log slope can be calculated by the following formula.

$$\frac{Wo_c - I_o}{t}$$

Where Wo_c is the number of work orders completed in the time period t and I_o is the number of incoming customer orders in the same period.

The discussions in the second workshop are summarised in table 9.

Table 9 The summary of discussion in the second workshop

#	Question	#	Improvement action
4.1	What is the key information needed regarding the state of the contractor's back log?	4.1.1	Is the contractor able to complete the back log in time?
		4.1.2	How work orders that are going to be late identified and predicted?
		4.1.3	How disturbances in the supply chain identified?
4.2	How is this measured?	4.2.1	The contractor's average work order completion rate
		4.2.2	Work order progress analysis
		4.2.3	Alert task result codes
4.3	How is this visualized?	4.3.1	Phase-by-phase visualization of the work orders in the contractor's back log
		4.3.2	Box-plot visualization of the contractor's back log
		4.3.3	Normal distribution of the contractor's back log
		4.3.4	Work order completion rate / incoming customer order rate

As seen in table 9, the first two columns indicate the question presented in the workshop and the following two columns indicate the action that was concluded from the discussion in the workshop.

5.1.3 Third Workshop

The stated objective of the workshop was to address the weakness number three, “the process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable.” The participants of the workshop were the project managers whose responsibility it is to collect and validate the SLA data and two regional construction managers. Table 10 summarises the questions presented in the workshop.

Table 10 Summary of the questions in the third workshop

#	CSA Weakness	#	Question
3	The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable	3.1.	What are the process phases where status information is needed?
		3.2	How should the data be formatted in order to be fully utilizable?

As seen in table 10, for the question 3.1 the sub-process maps that were composed in the current state analysis were used as a baseline of development, see figures 4, 6 and 8. The process phases where status information was deemed necessary were first identified and the what information was required to gather from that process phase and towards what end. Figure 16 illustrates the process steps where a reporting need was identified for the service task sub process.

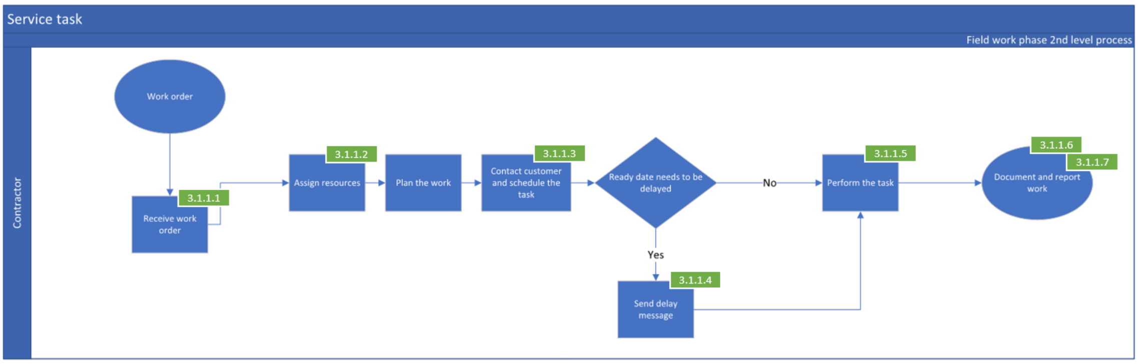

Figure 16 Identified service task sub-process step messages

As seen in figure 16, the new identified process phases where status messages are required are marked with green numbered boxes. The number corresponds to the information content column of table 11.

Figure 17 illustrates the process steps where a reporting need was identified for the network construction sub process

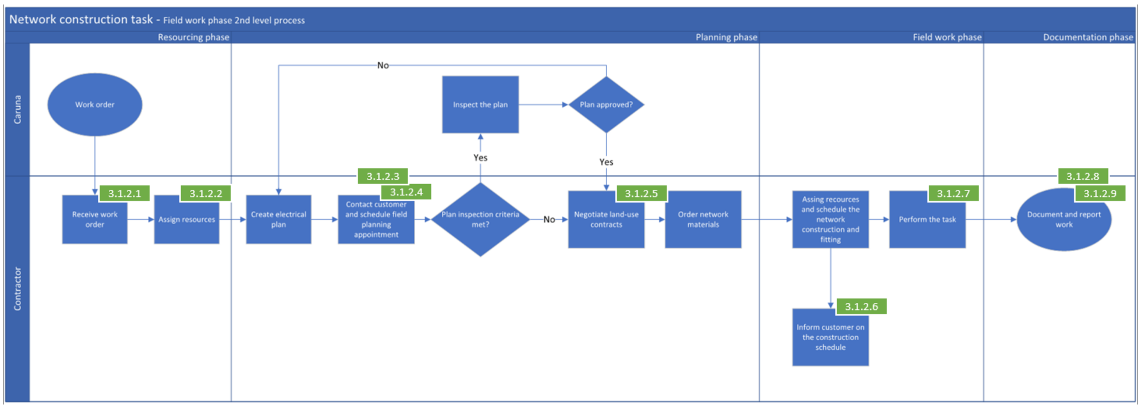

Figure 17 Identified network-construction sub-process phases messages

As seen in figure 17, the new identified process phases where status messages are required are marked with green numbered boxes. The number corresponds to the information content column of table 11.

Figure 18 illustrates the process steps where a reporting need was identified for the fault repair task sub process.

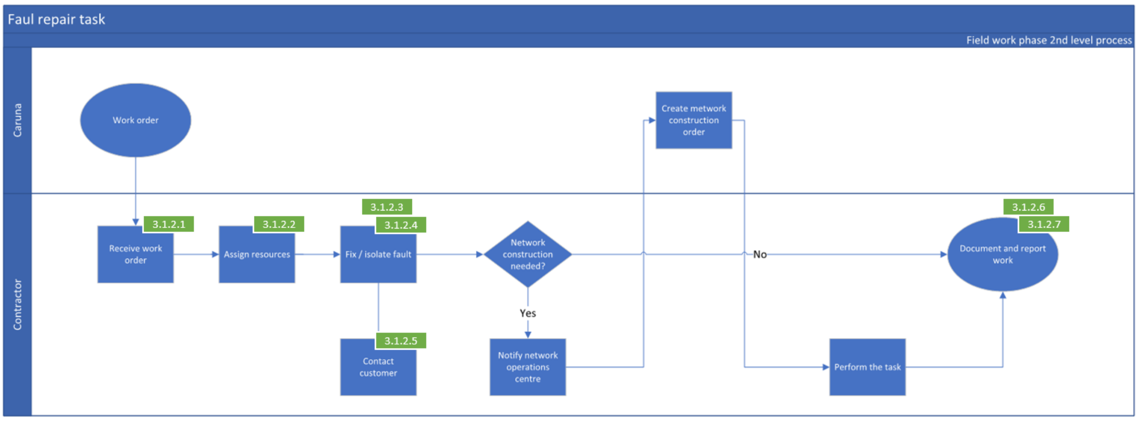

Figure 18 Identified fault repair task sub-process phases messages

As seen in figure 18, the new identified process phases where status messages are required are marked with green numbered boxes. The number corresponds to the information content column of table 11.

Table 11 presents the required information content of the new process status messages.

Table 11 The information content of process status messages

#	Improvement action	#	Information content
3.1.1	Service task phases	3.1.1.1	Work order has been received, the time from placing of order to the receiving of the order
		3.1.1.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-assigning of the work order
		3.1.1.3	All contacts to the customer on separate messages, time of contact and the scheduled time of fitting
		3.1.1.4	Delaying of the work order, the reason for the delay, time of the delay and the amount of delay
		3.1.1.5	Task completed / not completed, time of completion
		3.1.1.6	Documentation ready, time of completing the documentation
		3.1.1.7	Documentation and billing approved by the case company
3.1.2	Network construction task phases	3.1.2.1	Work order has been received, the time from placing of order to the receiving of the order
		3.1.2.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-assigning of the work order
		3.1.2.3	All contacts to the customer on separate messages, time of contact and the scheduled time of field planning visit
		3.1.2.4	Planning ready, time of completion of the plan
		3.1.2.5	Time of applying the land-use permits and time of land use permits received
		3.1.2.6	Task completed / not completed, time of completion

		3.1.2.7	All contacts to the customer on separate messages, time of contact and the scheduled time of construction
		3.1.2.8	Documentation ready, time of completing the documentation
		3.1.2.9	Documentation and billing approved by the case company
3.1.3	Fault repair task phases	3.1.3.1	Work order has been received, the time from placing of order to the receiving of the order
		3.1.3.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-assigning of the work order
		3.1.3.3	Estimated time to restore electricity to end customers
		3.1.3.4	Task completed / not completed, time of completion
		3.1.3.5	All contacts to the customer on separate messages, time of contact
		3.1.3.6	Documentation ready, time of completing the documentation
		3.1.3.7	Documentation and billing approved by the case company

In the table 11 the first two columns indicate the sub-process the status messages concern and the final two columns indicate the information content of the status messages.

The discussions in the third workshop are summarized in table 12.

Table 12 The summary of discussions in the third workshop

#	Question	#	Improvement action
3.1.	What are the process phases where status information is needed?	3.1.1	Service task phases (see table 11)
		3.1.2	Network construction task phases (see table 11)
		3.1.3	Fault repair task phases (see table 11)
3.2.	How should the data be formatted in order to be fully utilizable?	3.2.1	Eliminating the use of "free text"
		3.2.2	Utilization of task result codes
		3.2.3	Principles of using task result codes

As seen in table 12, the first two columns indicate the question presented in the workshop and the following two columns indicate the action that was concluded from the discussion in the workshop

5.2 A Proposed Implementation Road Map

The implementation roadmap can be divided into four different capability building phases.

- Phase 1, develop descriptive analysis based on the current SLA data, with minimal system development.
- Phase 2, implement changes to the process status messages into case company's and supplier's ERP systems. It should be noted that the phase 2 implementation should take place during the tendering of next frame agreements.
- Phase 3, develop predictive analysis capabilities based on the improved data from phase 2.
- Phase 4, develop demand forecast and shared SLA data capabilities to promote supplier operations and further integration.

Figure 19 visualizes a framework for the capability to implement developments activities.

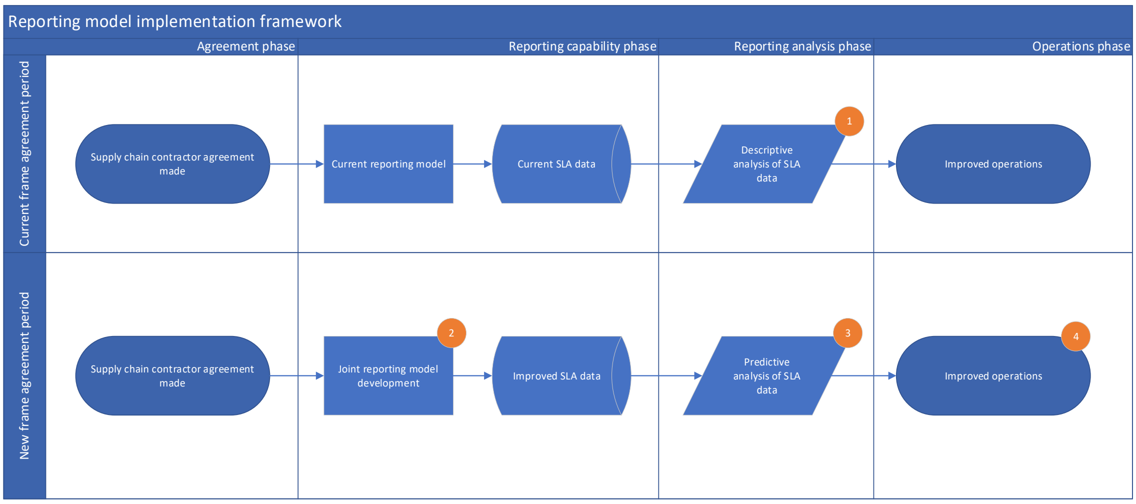

Figure 19 The reporting model implementation framework

As seen in figure 19, the two swim lanes represent development activities that can be taken during the current frame agreement period and the next frame agreement period. The development phases are marked with orange circles on the process phase where they should be implemented.

Figure 20 presents a one possible road map for implementing the improvement actions.

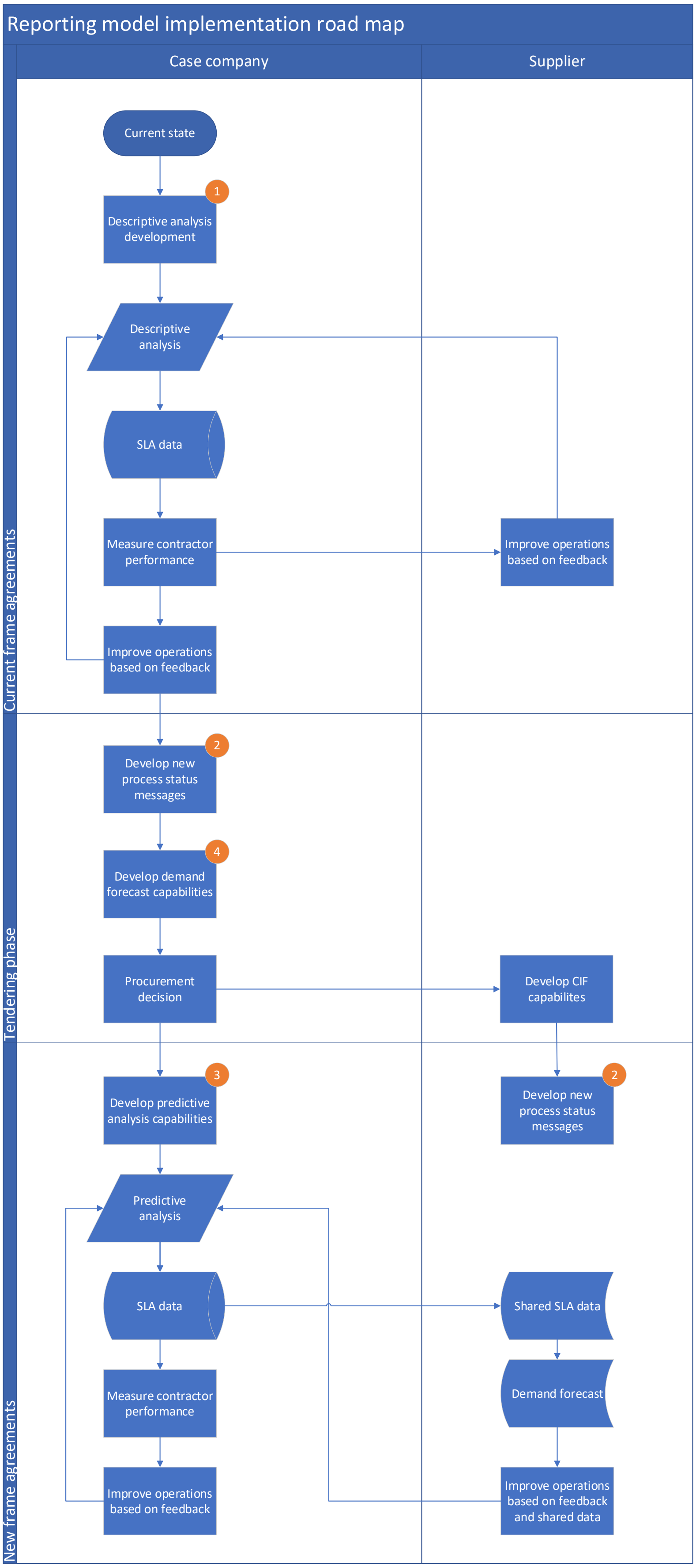

Figure 20 A development road map for contractor work load reporting capabilities

The road map for the development of the SLA reporting tool seen in figure 20, visualizes the development process as a cross-functional flowchart. It should be noted that the illustrated process has no logical end, because the improved operational data and analyses should lead to a cycle of continuous improvement. The flowchart illustrates also the order in which the development activities can take place in the case company's organization and the contractor's organization.

5.3 Summary of Improvements

This sub-section summarizes the proposed development actions from the three solution development workshops. The proposed actions are in a table form. A more detailed description of each development action can be found in the subsections 5.1.1, 5.1.2 and 5.1.3. Each action can be linked to a specific question presented in the workshops and each question in turn can be linked to a weakness identified in the current state analysis.

The proposed development actions can affect more than one CSA weakness, e.g., the phase-by-phase visualization of the work orders in the contractor's back log can be found as action number 1.3.3 and 4.3.1, since the proposed action affects CSA weaknesses one and four, the "gaming" of the SLA results and visual examination of the contractor's back log respectively.

These proposed actions combined constitute the contractor workload analysis tool. However, it should be noted that in order to create the tool not every action needs to be completed, nor the actions need to completed simultaneously. The proposed actions can be implemented in an incremental fashion, in the next section one possible implementation road map is proposed. Table 13 summarises the proposed development actions.

Table 13 Summary of proposed development actions

#	CSA Weakness	#	Question	#	Improvement action
1	**The “gaming” of SLA results is possible and difficult to detect**	1.1	What are the specific actions required to make the "gaming" visible?	1.1.1	The delayed tasks must be visible on the reports
				1.1.2	The task delay reason must be in a usable format and in separate field to be utilizable on the reports.
				1.1.3	The reason for delay must be made mandatory.
				1.1.4	The reason for delay is in free text format. Additional codes are needed to eliminate the need for free text
				1.1.5	Re-delaying work-orders made not possible or triggering an alert
				1.1.6	Dedicated delay codes instead of written explanatations
				1.1.7	The project phase where the delay code is sent displayed on the report
		1.2	How is this measured?	1.2.1	Trend analysis of the back log
				1.2.2	The number of unfinished work-orders, on a day/week/month level saved into the system
				1.2.3	The number of times a certain work order has been delayed displayed on the report
				1.2.4	The number of work orders completed by the origininal due date
		1.3	How is this visualized?	1.3.1	Normal distribution of the back log
				1.3.2	Box-plot of the back log
				1.3.3	Phase-by-phase visualization of the work orders in the contractor's back log
				1.3.4	Dispersion analysis of the back log
2	**The process data needs constant validation**	2.1	What are the specific actions to make the faulty data visible?	2.1.1	Shared reports and relevant data
				2.1.2	Billing phase must be added into the ERP process
				2.1.3	Alerts on large deviations
				2.1.4	Alerts on rejected work-orders

				2.1.5	Alerts on cancelled work orders
				2.1.6	Alerts on work orders with no technical acknowledgement from the receiving system
				2.1.6	Automatic system data comparison between case company and suppliers
		2.2	How is this measured?	2.2.1	Deviation alert calculation
				2.2.2	Deviation threshold specification
		2.3	How is this visualized?	2.3.1	Identified deviations made visible on reports
				2.3.2	Alerts made visible on reports
3	**The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable**	3.1	What are the process phases where status information is needed?	3.1.1	Service task phases (see table 11)
				3.1.2	Network construction phases (see table 11)
				3.1.3	Fault repair task phases (see table 11)
		3.2	How should the data be formatted in order to be fully utilizable?	3.2.1	Eliminating the use of "free text"
				3.2.2	Utilization of task result codes
				3.2.3	Principles of using task result codes
4	**It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner**	4.1	What is the key information needed regarding the state of the contractor's back log?	4.1.1	Is the contractor able to complete the back log in time?
				4.1.2	How work orders that are going to be late are identified and predicted?
				4.1.3	How disturbances in the supply chain identified?
		4.2	How is this measured?	4.2.1	The contractor's average work order completion rate
				4.2.2	Work order progress analysis
				4.2.3	Alert task result codes
		4.3	How is this visualized?	4.3.1	Phase-by-phase visualization of the work orders in the contractor's back log
				4.3.2	Box-plot visualization of the contractor's back log
				4.3.3	Normal distribution of the contractor's back log
				4.3.4	Work order completion rate / incoming customer order rate

As seen in table 13, in the three workshops a total of 42 improvement actions were successfully created in cooperation with the key stakeholders. The improvement actions address each of the initial weaknesses identified in the current state analysis. The validation of the improvement actions is described in section 6.

6 Outcome validation

In section 6 the proposed improvement actions described in section 5 are validated. The validation method is first described in general terms and the feedback from the validation is presented. Finally the changes and additions based on the feedback received to the initial proposed actions are summarised.

6.1 Overview

The validation of the proposed actions was conducted by first briefly outlining the initial business problem and the findings from current state analysis described in section 3. Then the conceptual framework and solution development process were briefly discussed before introducing the summary of proposed actions presented in table 13. The recommendations were presented in four categories arranged by the current state analysis weakness the improvement action was designed to address. After each category the recommendations were assessed. Finally some examples of data visualization, and project phase reporting were presented and the proposed roadmap was discussed.

The participants of the validation meeting were the case company's Regional Construction Managers, Project Management Team Leader, Operations Manager and the Head of Local Network Investment Projects. The meeting was organized in the Teams online meeting application. The feedback was documented in field notes during the meeting and immediately transcribed after the meeting.

6.2 Feedback from Stakeholders

The feedback received from the participants was generally very positive. The importance, scope and timeliness of the study was recognised as the case company's current frame agreement period was nearing its end.

> The timing of this study is correct as we need to determine the reporting and service level specifications to the next frame agrmeement tendering process very soon. (Head of Local Network Investment Projects)

In addition to this the impact the proposed improvements will have to the amount of manual labour the case company's project managers will have to do in the future to perform their tasks was generally seen as a productivity enabling factor.

The phase-by-phase visualization, (table 13, improvement action 1.3.3) was also recognized as potentially useful visualization for the case company's larger investment projects

> This is exactly the kind of visualization our project managers would need in larger investments projects. (Regional Construction Manager)

The phase-by-phase visualization, (table 13, improvement action 4.3.1) and the data gathered by the proposed new process phase reporting improvements outlined in table 12 was also seen as enabler for more fine-grained analyses of the contractor's performance.

> We could calculate for each work order type and process phase the maximum amount the contractor is able to complete each month. This would give us an insight to the contractor resourcing bottlenecks. (Head of Local Network Investment Projects)

There was also two proposed additional analyses proposed by the Head of Local Network Investment Projects based on the data formatting and analyses outlined in the initial proposals

> We could also use this (project phase duration) data to calculate the average or median completion times of each of the project phases and use this to estimate the completion time for each phase. (Head of Local Network Investment Projects)

> We could also use machine learning to process this data for enhanced forecasts. (Head of Local Network Investment Projects)

There was also discussion about the suitability of the box-plot-visualization in the case company's instance. There were some doubts expressed as to the usefulness of the statistical insights enabled by the visualization in the day-to-day operations of the case company.

> I don't see the benefits from this visualization to our business. (Regional Construction Manager)

Finally the proposed development roadmap for contractor workload analysis tool (figure 20) was discussed and the conclusion was that the road map should be taken into consideration in the planning of the next frame agreement tendering.

6.3 Changes Made to the Initially Proposed Improvement Actions

Based on the solution validation meeting a total of four adjustments to the list of proposed improvement actions were identified. The adjustments are presented in table 14.

Table 14 Summary of the adjustments to the initially proposed improvement actions

#	CSA Weakness	#	Improvement action	Adjustment
1	**The "gaming" of SLA results is possible and difficult to detect**	1.3.3	Phase-by-phase visualization of the work orders in the contractor's back log	**Similar visualization implemented for larger investment projects**
3	**The process status information between placing the order and completion of the field work is either absent, inconsistent**	3.1.2	Network construction task phases (see table 13)	**Project phase duration analysis**
				Machine learning forecasts

	or in a format that is non-utilizable			**Contractor resourcing bottleneck analysis for network construction tasks**
4	**It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner**	**4.3.1**	Phase-by-phase visualization of the contractor's back log	
		4.3.2	Box-plot visualization of the contractor's back log	**Removed**

As seen in table 14, two of the adjustments concern the same improvement action project phase-by-phase visualization but from the perspectives of two different initial process weaknesses (table 14, improvement actions 1.3.3 and 4.3.1).

The adjustments may concern multiple improvement actions and weaknesses simultaneously. The first adjustment falls of the scope of this study and will be added to the next step recommendations. The following three adjustments are additional analyses based on presented improvement actions. The more detailed specification of these analyses will be added to the next step recommendations. The final adjustment is the removal of the box-plot analysis from the improvement, as it was seen unnecessary. The list of final improvement actions is presented in table 15.

Table 15 The final improvement actions

#	CSA Weakness	#	Question	#	Improvement action
1	**The “gaming” of SLA results is possible and difficult to detect**	1.1	What are the specific actions required to make the "gaming" visible?	1.1.1	The delayed tasks must be visible on the reports
				1.1.2	The task delay reason must be in a usable format and in separate field to be utilizable on the reports.
				1.1.3	The reason for delay must be made mandatory.
				1.1.4	The reason for delay is in free text format. Additional codes are needed to eliminate the need for free text
				1.1.5	Re-delaying work-orders made not possible or triggering an alert
				1.1.6	Dedicated delay codes instead of written explanatations
				1.1.7	The project phase where the delay code is sent displayed on the report
		1.2	How is this measured?	1.2.1	Trend analysis of the back log
				1.2.2	The number of unfinished work-orders, on a day/week/month level saved into the system
				1.2.3	The number of times a certain work order has been delayed displayed on the report
				1.2.4	The number of work orders completed by the origininal due date
		1.3	How is this visualized?	1.3.1	Normal distribution of the back log
				1.3.2	Box-plot of the back log
				1.3.3	Phase-by-phase visualization of the work orders in the contractor's back log
				1.3.4	Dispersion analysis of the back log

				1.3.5	Phase-by-phase visualization implemented for larger investment projects
2	**The process data needs constant validation**	2.1	What are the specific actions to make the faulty data visible?	2.1.1	Shared reports and relevant data
				2.1.2	Billing phase must be added into the ERP process
				2.1.3	Alerts on large deviations
				2.1.4	Alerts on rejected work-orders
				2.1.5	Alerts on cancelled work orders
				2.1.6	Alerts on work orders with no technical acknowledgement from the receiving system
				2.1.6	Automatic system data comparison between case company and suppliers
		2.2	How is this measured?	2.2.1	Deviation alert calculation
				2.2.2	Deviation threshold specification
		2.3	How is this visualized?	2.3.1	Identified deviations made visible on reports
				2.3.2	Alerts made visible on reports
3	**The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable**	3.1.	What are the process phases where status information is needed?	3.1.1	Service task phases (see table 11)
				3.1.2	Network construction phases (see table 11)
				3.1.3	Fault repair task phases (see table 11)
				3.1.4	Project phase duration analysis
				3.1.5	Machine learning forecasting
		3.2.	How should the data be formatted in order to be fully utilizable?	3.2.1	Eliminating the use of "free text"
				3.2.2	Utilization of task result codes
				3.2.3	Principles of using task result codes
4	**It is not possible to visually or statistically examine the contractor's order backlog in a**	4.1	What is the key information needed regarding the state of the contractor's back log?	4.1.1	Is the contractor able to complete the back log in time?
				4.1.2	How work orders that are going to be late are identified and predicted?

	concentrated and systematical manner			4.1.3	How disturbances in the supply chain identified?
		4.2	How is this measured?	4.2.1	The contractor's average work order completion rate
				4.2.2	Work order progress analysis
				4.2.3	Alert task result codes
		4.3	How is this visualized?	4.3.1	Phase-by-phase visualization of the work orders in the contractor's back log
				4.3.2	Box-plot visualization of the contractor's back log
				4.3.3	Normal distribution of the contractor's back log
				4.3.4	Work order completion rate / incoming customer order rate

As seen from table 15 the validation of the initially proposed improvement actions was performed as planned. The following section summarizes the work performed in this study, presents the recommended next steps and delivers the self-evaluation of this study.

7 Conclusions

The final section of this study contains an executive summary of the work performed in the study and its results, the recommended next steps, a self-evaluation of the study and the closing words.

7.1 Executive Summary

The objective of the study was to recommend improvements to support the case company's vendor management. More specifically improvements to the analysis of the contractor's work load and its development. The outcome of the study is the set of recommendations and a proposal of an implementation road map that enables the development of the improvements in an effective way. In order to fulfil the rising expectations of the case company's customers and to increase the predictability of the field work processes a stronger utilization of the digitized field work reporting is required. In recent years the case company has undergone replacement of all its core systems and in the aftermath of these major changes the field work process reporting is in less than optimal state. The necessary data is not collected or it is in a non-utilizable format and the analysing the data requires extensive manual work.

The study was conducted as a design research consisting of four stages. The research data was gathered utilizing qualitative methods. The research stages were current state analysis, literature research, initial solution development and the validation of the outcome. Current state analysis produced the strengths and weaknesses of the reporting process upon which the following stages were built. In the literature research stage the weaknesses produced in the current state analysis were used as a basis of developing a conceptual framework of knowledge imparted from relevant literature and studies. The third stage consisted of workshops with key stakeholders where the list of initial improvement actions were created. In the last stage the initial improvement actions were reviewed and validated with case company's senior managers.

The feedback from the fourth stage generated the adjustments to the proposed improvements thus creating the outcome of the study.

The current state analysis was conducted as a series of two workshops, an email inquiry and the observation of the monthly reporting. The initial findings were divided into strengths and weaknesses, whereupon a total of four most relevant weaknesses were prioritized into the literature research stage.

The literature research was conducted with the prioritized weaknesses found in current state analysis as premise. Three main topics were chosen for further research, business analytics, supply chain integration and information sharing. From these main topics relevant concepts were chosen which were then in turn refined into specific tools. The research was then conflated into the conceptual framework, which was used as the premise for the initial solution development.

The initial solution development consisted of three workshops with key stakeholders. The workshops were arranged with the individual current state analysis weaknesses as themes. First workshop focused on the first two weaknesses and the following workshops focused on a single weakness respectively. The events were started with an introduction and setting of the workshop goal. The improvement actions gathered from the workshop were then conflated into a list of 42 proposed improvement actions categorized by the initial weakness the actions sought to address.

The proposed solution was validated by the case company’s senior managers responsible for the field work processes, i.e., Regional Construction Managers, Operations Manager, Investment Project Team Manager and the Head of Local Network Investment Projects. The meeting started with an outline of the stages of the study and research methods. The proposed improvement actions were subsequently presented along with examples of particular visualizations and a proposal for the development road map. The actions were evaluated and discussed by the managers. One improvement action was removed and three additional analyses were proposed. In addition to this there was a proposal to implement one of the improvement actions also into other processes outside the scope of the study. In general the response from the managers was positive. After the solution validation the final improvement actions were compiled into a comprehensive list.

The final improvement actions constitute a comprehensive development portfolio designed to improve the reporting and analysis capabilities of the field work processes. The improvement actions will provide benefits in the case company’s operations as reduced need for manual work, reduction and early detection of deviations and potential customer complaints.

7.2 Next step recommendations

When implementing the improvements produced as the outcome of this study, many external factors need to be taken into account. The implementation schedule needs to be synchronized with the case company’s frame agreement periods. An effective way to roll out the improvement actions into the case company’s supply chain is to include the new requirements into the IT specifications of a new frame agreement and develop the internal capabilities during the tendering phase. A proposal for the development road map is presented in figure 20. Some reporting related improvement actions can be taken instantly and others require the co-development of the new process phase reporting capabilities before they are feasible to implement.

Before the implementation of the improvement actions can begin they have to be transformed from functional specifications into technical IT requirements for the case company. The IT development project schedule has to be synchronized with the frame agreement tendering project in order to ensure the undisturbed continuation of operations at the start of the new agreement period. In addition to the technical requirements the case company’s frame agreement contractor’s personnel require training in the reporting requirements, especially if the contractor has no previous experience working with digitized processes.

After the implementation the reporting process and the maturity of the contractors solutions have to be audited. Improved monitoring of the field work processes should lead to a cycle of continuous improvement in the operation and refinement of the reporting processes.

7.3 Self-Evaluation of the Study

The initial business challenge was the limited visibility to the customer order handling by the case company’s contractors, resulting in reactive management as the contractor’s underperformance or customer complaints could not be predicted. In addition to this the monitoring of the contractor’s performance requires constant manual work and even rudimentary analyses of the contractors performance are time intensive. The outcome of the study presented in the section 6, is a comprehensive list of improvement actions aimed to improve aforementioned issues and subsequently validated by case company’s senior managers Objective of the study has been therefore achieved in full.

The correct prioritization of weaknesses identified in the current state analysis can be put into question. However, the number of the strengths and weaknesses identified in current state analysis stage and the repetition of the same themes in the findings lend credibility to the prioritization. The validated improvement actions address a large number of the identified weaknesses. Therefore the results of this study achieve the objective in full.

The author of the study was a member of the case company’s Investment Program Management team, which is responsible for all field operations of the case company. A deep involvement in the process can be considered as an advantage for the purposes of this study as the author was naturally participating in the normal operative activities as a part of normal work. In addition this involvement made identifying the correct key stakeholders and assessing the validity of the stakeholders statements much more effective. The author participated into the workshops also as another stakeholder as well as in the required facilitator role.

The evaluation of the study is conducted in the following sub-sections. The study is evaluated by its validity, credibility, and relevance.

7.3.1 Validity and Credibility

According to Onwuegbuzie *et al.* (2007) a validity of qualitative studies cannot be assessed in absolute terms. The validity is a relative factor to the study purpose and the circumstances of the study. However, the assessment of methods employed in qualitative studies is prerequisite to eliminating rivalling interpretations of data. Onwuegbuzie *et al.* (2007) further describes a set of strategies to ensure the legitimation of a study. Prolonged engagement, triangulation, peer debriefing and rich and thick description are some of those strategies. (Onwuegbuzie *et al.* 2007: 7-12)

Prolonged engagement necessitates that the study is conducted for a sufficient period of time to ensure the representation of the data collected, also understanding the culture and building trust with the study participants. Triangulation as a legitimation strategy necessitates the use of different study methods and sources to the data gathering to reduce systemic bias and chance associations. Peer debriefing on the other hand seeks to provide an evaluative component to the study. Finally rich and thick description provides credibility to the study by the amount and completeness of the data employed in the study. (Onwuegbuzie *et al.* 2007: 7,12)

The internal validity and credibility of this study was assessed and ensured by utilizing the above mentioned strategies. The study was conducted over a period of five months providing a sufficient window to the reporting process and the possibility to assess the data gathered over several reporting periods. On the other hand the study author has been working with improving the processes which constitute the subject matter for the study providing understanding of the culture and the possibility of creating trust with the study participants.

This prolonged exposure to the study subject matter introduces also the risk of creating elements of personal bias into the study. This was sought out to eliminate by utilizing triangulation. The Data 1 was collected for the current state analysis by using as many and as diverse sources as the case company's organization would allow. For the observation of monthly reports historical data exists in the case company's systems spanning several years, enabling the validation of the SLA data set representability. Further the amount of the SLA data employed in the Data 1 analysis consisted of over thousand data points fulfilling the requirement of rich and thick description..

For Data 2 similarly the data collection was conducted in a manner that sought out to employ as many and as diverse sources as the case company's organization would allow.

Finally for Data 3, the peer debriefing method was employed in the study's final stage the outcome validation

7.3.2 Relevance

According to Stefano Mizzaro (1997) relevance can described as "a relation between two entities." One such pair of entities is the relevance of a information need i.e., a problem to the information received i.e., a solution. (Mizzaro, 1997: 2). Thomas et al. (2011) expand the definition relevance in supply chain management research context as ability to communicate the research findings to the business representatives and asking the right type of research questions before initiating research (Thomas et al. 2011: 3)

In this study's context the relevance stems from the value that can be produced by solving the business challenge. The business challenge presented in this study affects the core business, accountability and customer perception of the case company. The study subject is therefore internal, important for the case company and based on an actual problem.

In the course of the study the relevance is verified in each stage by the involvement of the stakeholders whose daily work is connected to the associated processes and therefore also affected by the study outcome and secondly by utilizing actual production data from the case company's reporting system.

In the literature research stage the relevance was pursued by introducing only relevant concepts from the professional literature to the study. Further the study's relevance was validated by the case company's senior management in the solution validation phase. Only one improvement action of the initial list of 42 proposed improvement actions was removed as irrelevant. Based on the validation feedback the improvement actions were adjusted thus increasing the relevancy on the final outcome.

7.3.3 Closing words

The demand for information from industrial processes has been steadily growing over the past decades. The process information can not only be utilized in improving the cost efficiency and quality of production but also for value adding services to the end customer. The process information gathering is a necessary element of process planning and in many cases the value of a process depends on the information that can be extracted from it. Industrial Management Master's Thesis projects have well defined and pragmatic objectives. The outcome of this project should bring concrete benefits to the case company in form of process accountability and predictability. Contractor work load analysis enables many capability enhancing improvements in the case company as it is implemented.

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SLA Data Handling

Table 1. SLA data manual handling

Step	Action
1.	The SLA data is downloaded from the reporting system. a. First LV-fault data from one report b. Second phase other tasks that have been reported as ready c. Third phase the tasks that are not yet ready The system does not store history of the data --> the "not ready" status tasks displays the current date's status
2.	3. The data downloaded is first filtered in the reporting system by following paremeters a. Year b. month c. Contractor d. contract region e. Contract f. Status "ready" or "not ready"
3.	5. The data for ready tasks is downloaded to excel where further filtering is done and unncessary columns are deleted a. w_o id b. Contractor name c. Region d. Workorder type e. Orginal task due date f. Process status in CRM g. Reported on h. Row result code i. Row completed
4.	The data is then sorted by SLA_category and then by order date a. Network construction tasks don't have order date in CRM, the task creation date is copied to order date column
5.	The data is then copied to a excel table template row by row
6.	8. The SLA result values "0" and "1" are replaced with values "ajoissa" and "myöhässä" respectively a. If there are no data corrections to be made, the current SLA result can be observed from the report b. The update cycle on the report is done daily, starting every day @ 18:30, if there's heavy load on the CRM servers the update can take over 20 hours which can introduce errors into the report as the source data is updated during the load cycle
7.	9. The data for not ready tasks is downloaded to excel similarly but with following exceptions a. Metering tasks are filtered out b. All the time filter are removed --> all not ready tasks are thus included in the data set c. The SLA results are labeled "not ready, on time" and "not ready, late" d. Tasks that are late 0,1 days or less are considered as not late e. If there are any suspicious tasks in the data (for example very late tasks) they need to be checked one by one i. This is very time consuming and can lead to very large investigations ii. There is no other way to weed out user errors etc. iii. For example orders that have errors are easy to miss by the orderer and if they are not noticed in this analysis they are left "hanging" --> customer complaints iv. It is very importont to regularly compare data with the contractor, especially in the contract stabilisation period, when CIF is not yet fully functional
8.	If there are any corrections to the data the SLA calculation needs to be done by hand -> the user has a ready excel table with formulas for weighted average calculation
9.	LV fault data is gathered similarly as previous a. Only ready tasks are included (due to short due date time) b. LV -fault data comes from ADMS some more manual filtering is required to consolidate the data
10.	The numerical data is then consolidated into the calculation table a. A short written analysis is made about the state of the work load and changes to previous month b. The calculation table and the task list information is then sent to contractor with notes c. The contractor compares the data to similar data in their system d. Necessary error adjustments are made (for example new order to replace one that is not reportable)
11.	Data is compared with corresponding data from the contractor's ERP

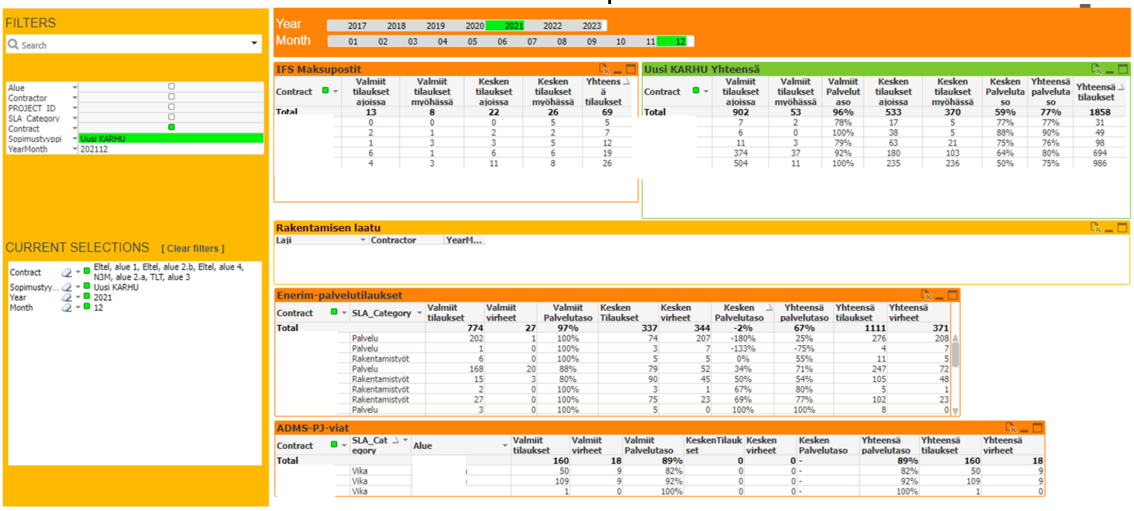
Current SLA Row Data

Table 1 An excerpt from an SLA row data table

Työtilaus ID	Alue	SLA-luokka	Työtyyppi	Kommentti	Tilauspäivä	Vastaanotettu	Arv. Valmist.	Työ valmis	Eräpäivä SLA	koodi	SLA Tulos	ajoissa tai myöhässä / vrk
CR19177744	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		11.3.2019 11:39:15		17.2.2022 23:59:00	Kesken	17.2.2022 23:59:00	300	Kesken/Ajoissa	24,9
CR19204572	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		22.5.2019 10:45:14	23.5.2019 13:02:00	4.2.2022 23:59:00	Kesken	4.2.2022 23:59:00	300	Kesken/Ajoissa	11,9
CR19204559	Alue 1	Palvelu	LKT Liittymän kytkentätyö		29.5.2019 11:26:29	29.5.2019 11:28:00	11.2.2022 23:59:00	Kesken	11.2.2022 23:59:00	300	Kesken/Ajoissa	18,9
CR19283674	Alue 1	Palvelu	VLT Valvontatyö		6.12.2019 8:42:15	6.12.2019 8:46:27	17.9.2020 22:59:00	Kesken	17.9.2020 22:59:00	300	Kesken/Myöhässä	-493,1
CR19290553	Alue 1	Palvelu	PAT Palvelutyö		31.12.2019 10:13:45	7.5.2020 14:50:25	14.1.2022 23:59:00	Kesken	14.1.2022 23:59:00	300	Kesken/Myöhässä	-9,1
CR20291348	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		3.1.2020 14:03:49	19.2.2020 14:50:32	25.2.2022 23:59:00	Kesken	25.2.2022 23:59:00	300	Kesken/Ajoissa	32,9
CR20299071	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		24.1.2020 15:34:47		21.3.2022 23:59:00	Kesken	21.3.2022 23:59:00	300	Kesken/Ajoissa	56,9
CR20307435	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		17.2.2020 9:47:02	12.3.2020 10:18:43	14.1.2022 23:59:00	Kesken	14.1.2022 23:59:00	300	Kesken/Myöhässä	-9,1
CR20307544	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		17.2.2020 12:04:42	19.2.2020 10:36:18	14.1.2022 23:59:00	Kesken	14.1.2022 23:59:00	300	Kesken/Myöhässä	-9,1
CR20315065	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		9.3.2020 12:30:41	9.3.2020 15:18:15	21.2.2022 23:59:00	Kesken	21.2.2022 23:59:00	300	Kesken/Ajoissa	28,9
CR20315148	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		9.3.2020 15:09:03		11.11.2021 23:59:00	Kesken	11.11.2021 23:59:00	300	Kesken/Myöhässä	-73,1
CR20316054	Alue 1	Palvelu	MIT Mittarointityö		11.3.2020 13:12:47	11.3.2020 13:43:37		Kesken	19.3.2020 0:00:00		Kesken/Myöhässä	-676,1
CR20318616	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		18.3.2020 15:31:47		12.12.2022 23:59:00	Kesken	12.12.2022 23:59:00	300	Kesken/Ajoissa	322,9
CR20324026	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		7.4.2020 13:22:46	14.4.2020 13:04:52	21.1.2022 23:59:00	Kesken	21.1.2022 23:59:00	300	Kesken/Myöhässä	-2,1
CR20326658	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		15.4.2020 12:19:48		11.3.2022 23:59:00	Kesken	11.3.2022 23:59:00	300	Kesken/Ajoissa	46,9
CR20335747	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		14.5.2020 7:01:00			Kesken	7.9.2020 23:00:00		Kesken/Myöhässä	-503,1
CR20337027	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		18.5.2020 13:43:17	23.12.2021 7:48:47	14.1.2022 23:59:00	Kesken	14.1.2022 23:59:00	300	Kesken/Myöhässä	-9,1
CR20340112	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		28.5.2020 12:25:00			Kesken	28.11.2020 0:00:00		Kesken/Myöhässä	-422,1
CR20340748	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		30.5.2020 15:44:39	12.6.2020 14:09:51	18.1.2022 23:59:00	Kesken	18.1.2022 23:59:00	300	Kesken/Myöhässä	-5,1
CR20346136	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		10.6.2020 12:12:10	12.6.2020 12:24:46	20.1.2022 23:59:00	Kesken	20.1.2022 23:59:00	300	Kesken/Myöhässä	-3,1
CR20350341	Alue 1	Puutteellinen raportointi	PRA Puutteellinen Raportointi		22.6.2020 15:19:56			Kesken	25.6.2020 23:00:00		Kesken/Myöhässä	-577,1
CR20356664	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		3.7.2020 7:10:32	3.7.2020 7:32:45	7.1.2022 23:59:00	Kesken	7.1.2022 23:59:00	300	Kesken/Myöhässä	-16,1
CR20359680	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		7.7.2020 12:04:15		19.5.2022 22:59:00	Kesken	19.5.2022 22:59:00	300	Kesken/Ajoissa	115,9
CR20363704	Alue 1	Palvelu	KUK Kunnossapito- tai korjaustarve		16.7.2020 10:39:46	16.7.2020 13:37:56	14.1.2022 23:59:00	Kesken	14.1.2022 23:59:00	300	Kesken/Myöhässä	-9,1
CR20375024	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		12.8.2020 15:33:00	27.1.2021 13:12:46	4.2.2022 23:59:00	Kesken	4.2.2022 23:59:00	300	Kesken/Ajoissa	11,9
CR20380359	Alue 1	Palvelu	PAT Palvelutyö		27.8.2020 9:02:04	27.8.2020 9:05:34	7.1.2022 23:59:00	Kesken	7.1.2022 23:59:00	300	Kesken/Myöhässä	-16,1
CR20384092	Alue 1	Rakentamistyöt	VRA Verkostorakentaminen		6.9.2020 15:43:56	29.9.2021 13:42:10	31.3.2022 22:59:00	Kesken	31.3.2022 22:59:00	300	Kesken/Ajoissa	66,9

Current SLA Reports

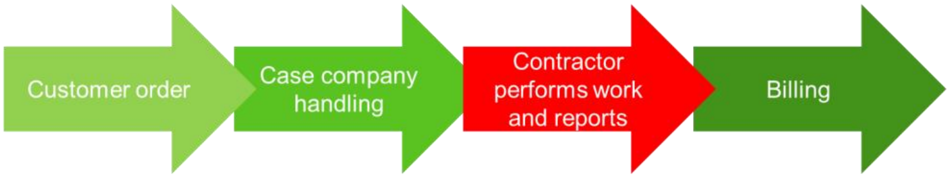
Table 1 A screenshot of the current SLA report



Workshop 1 Tasks

Current process

- Process map drawing, time 30 min



Sub-processes

Sub-processes

- Process map drawing, time 45 min
  - Service task
  - Network construction task
  - Fault repair task

Only the process steps from creating the work order to billing phase are mapped

Workshop 2 Questions

Mark into the previously created process maps the process steps where:

- Contractor sends process status information (use green plus symbol)
- There is a possibility to send process status information, but the contractor does not send the information, or the information is false or unusable (use red minus symbol)

Make a list of the strengths and weaknesses of the current state

- By yourself (time 15min)
- Compare your findings in pairs (time 15min)
- The findings of the whole group are listed (time 30min)

Workshop 3 Questions

The “gaming” of SLA results is possible and difficult to detect

- What are the specific actions required to make the "gaming" visible?
- How is this measured?
- How is this visualized?

The process data needs constant validation

- What are the specific actions to make the faulty data visible?
- How is this measured?
- How is this visualized?

Workshop 4 Questions

It is not possible to visually or statistically examine the contractor’s order backlog in a concentrated and systematical manner

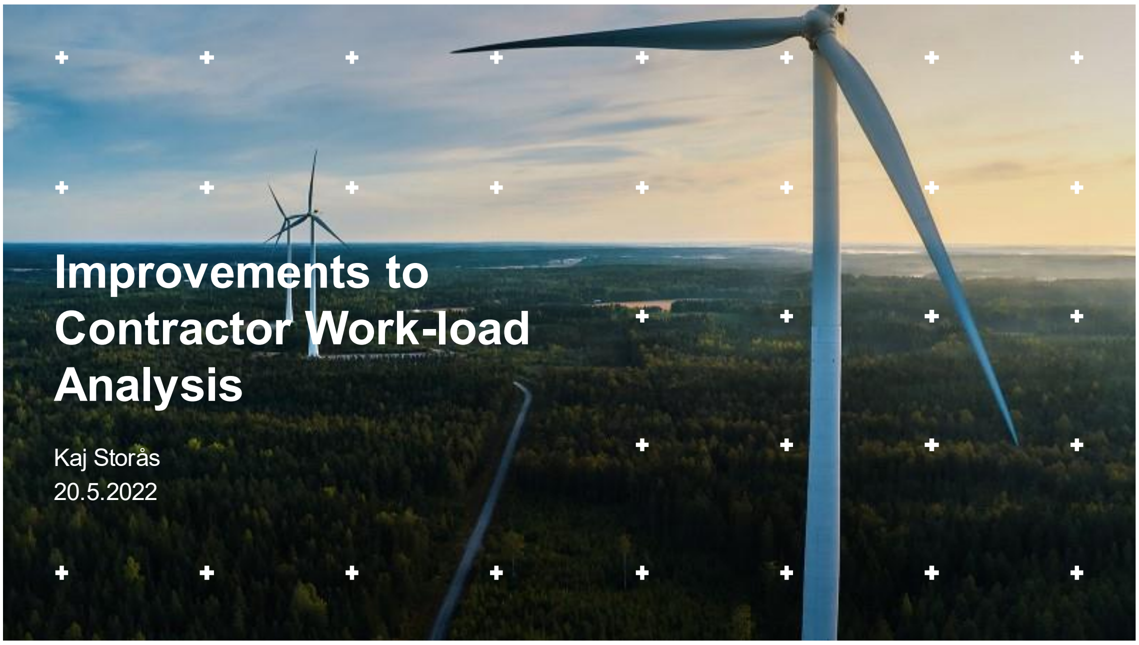
- What is the key information needed regarding the state of the contractor's back log?
- How is this measured?
- How is this visualized?

Workshop 5 Questions

The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable

- What are the process phases where status information is needed?
- How should the data be formatted in order to be fully utilizable?

Solution Validation Presentation



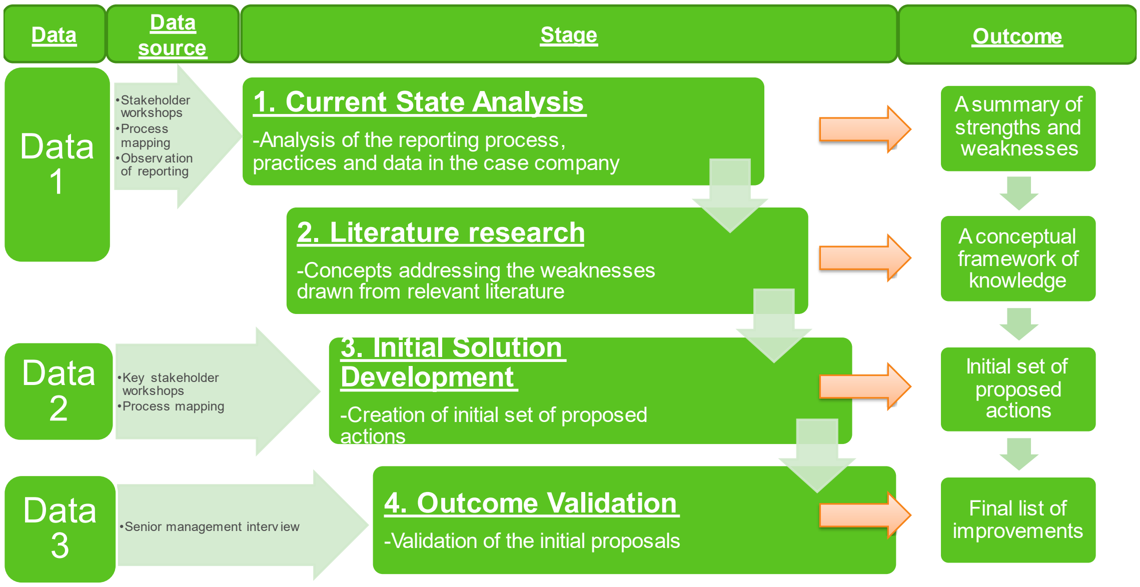
Improvements to Contractor Workload Analysis

Business context:
- Case company is one of the Finland's biggest electricity distribution company with over 700 000 customers
- Company receives annually tens of thousands of customer orderds, connection orders, line transfers etc. The related field work is handled by frame agreement contractors

Business challenge:
- The visibility to customer order handling by contractors is currently limited to whether the task was performed on time or not
- Customer complaints and contractor underperformance "comes as a surprise"
- Forecasting and monitoring contractor performance need manual analysing

Objective:
- Create improvement actions to workload analysis

Outcome:
- Improvements to workload analysis



Data plan

Data	#	Method of collection	Data Source	Data Content	Time of collection	Outcome
DATA 1	1	Workshop 1 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Main process map	January 2022	Summary of strengths and weaknesses
	2	Workshop 1 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Sub process maps	January 2022	
	3	Workshop 2 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	Process status reporting points, format of the reported data	January 2022	
	4	Workshop 2 (online / teams)	Project Managers, Regional Construction Manager, Operations Manager	A table of strenghts and weaknesses of the process	January 2022	
	5	Observation	Networks Service Specialist	A list of data collection and preparing for monthly reporting steps	February 2022	
DATA 2	6	Workshop 3	Project Managers	Proposed improvement actions for weaknesses 1 & 2	March 2022	Initial improvement actions
	7	Workshop 4	Project Managers	Proposed improvement actions for weakness 4	March 2022	
	8	Workshop 5	Project Managers, Regional Construction Manager	Proposed process reporting phases	April 2022	
	9	Workshop 5	Project Managers, Regional Construction Manager	Information content of process status messages	April 2022	
DATA 3	10	Outcome validation meeting	Head of Local Network Investment Projects, Regional Construction Managers, Operations Manager	Feeback for the initial improvement actions	May 2022	Final improvement actions

Results of Current State Analysis

Maintain

#	Strenght
1.	The contractor has the right and obligation to schedule the task with the customer. The contractor communicates directly with the customer
2.	Current SLA metering measures the contractor's performance reasonably accurately and contractor's poor performance can be deducted from the reports
3.	The status of the process steps with assigned SLA sanctions or incentives are reported accurately

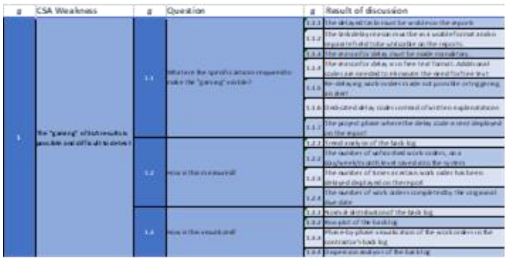
Focus

#	Weakness
1.	The "gaming" of SLA results is possible and difficult to detect
2.	The process data needs constant validation
3.	The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable
4.	It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner

Conceptual Framework from Relevant Literature

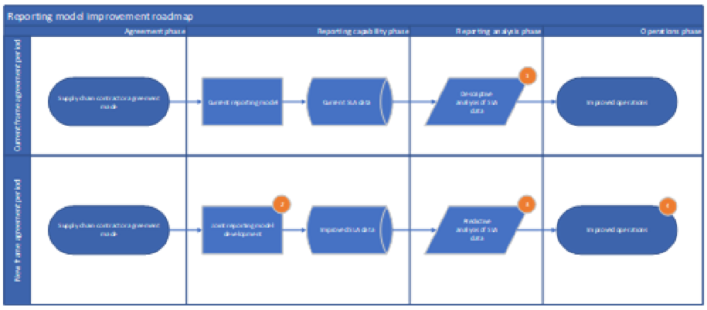
#	CSA Weakness	Topic	Relevant concept	Tool
1.	The "gaming" of SLA results is possible and difficult to detect	**Business Analytics** (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Reporting
			Diagnostic Analytics	Trend analysis
		Supply Chain Integration (Victor H.Y. Lo *et al.*, 2006)	Co-development	Data utilization improvements
2.	The process data needs constant validation	**Information Sharing** (Thomas *et al* 2015) (Davis *et al* 2011)	Decentralised process coordination	Shared reports
		Business Analytics (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Data visualization
3.	The process status information between placing the order and completion of the field work is either absent, inconsistent or in a format that is non-utilizable	**Supply Chain Integration** (Victor H.Y. Lo et al., 2006)	Co-development	Data utilization improvements
4.	It is not possible to visually or statistically examine the contractor's order backlog in a concentrated and systematical manner	**Business Analytics** (Goodwyn 2019) (El Morr and Ali-Hassan 2019)	Descriptive Analytics	Data visualization
			Diagnostic Analytics	Trend analysis
			Predictive Analytics	Predictive modelling

Summary of Proposed Actions



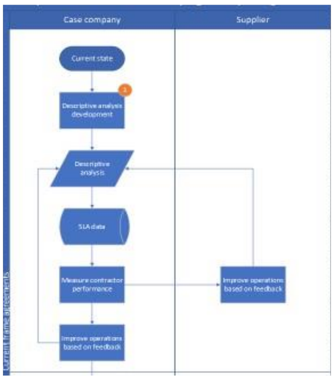
Proposed actions

- Actions can be implemented incrementally
- Thesis proposes one possible road map for implementation

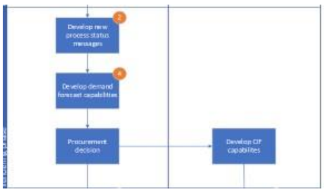


Implementation road map

Current agreements

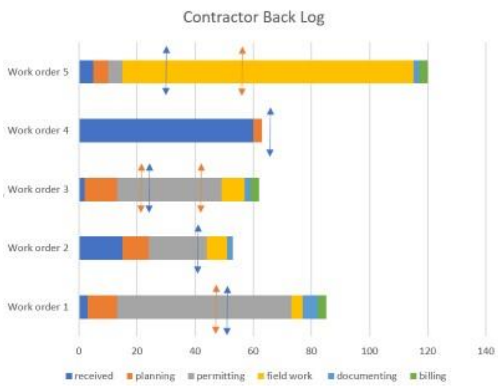


Tendering phase



New agreements

Examples of Back Log Visualizations



+ Project phase -by-phase view

"In the phase -by-phase view of the contractor's back log each separate work order is visualized as a timeline bar. The timeline bar is divided into separate phases according to the reported work order statuses. The length of each phase represents the duration of the phase in days. Each phase is illustrated by a different colour. The work order's initial due date is illustrated with a blue arrow and the delay messages are illustrated with an orange arrow. The placing of the arrow on the timeline bar is dependent on the number of days that have passed since the placing of the order i.e., day zero."

Examples of Back Log Visualizations

From the data visualization it is possible to make the following observations.

- *The peak of the normal distribution curve is on the positive side on both graphs meaning that on average the work orders are completed before the original due date*
- *The slopes of the normal distribution curve run on the both sides of the zero value of x-axis, meaning that there is a significant number of work orders that have been completed after the due date*
- *Especially in the table 5 but to some extent in the table 6 the tails of the normal distribution curve have very high positive and negative values, which indicates that there are outliers in the data*
- *Outliers in the data cause inaccuracy in the normal distribution. The data must be validated, and system errors removed.*
- *Outliers with high positive x-axis value indicate that there are likely user generated errors in the initial work order due dates e.g., wrong month or year in the due date field.*
- *Outliers with high negative x-axis value are a strong indicator that either the reporting of the work order has failed, or the work order has not been accepted by the contractors ERP. In either case the high x-axis value indicates that the problem has remained unnoticed for a considerable amount of time*

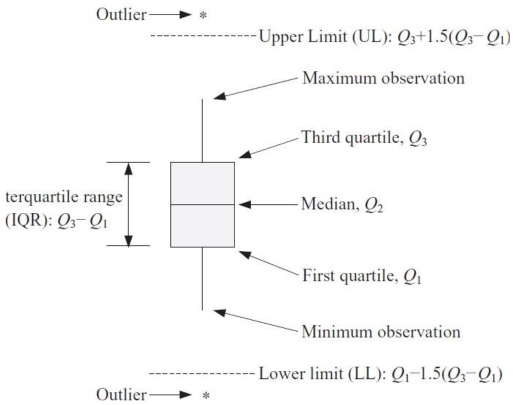
From this relatively simple example of utilizing descriptive analysis methods, it is possible to gain decision making enabling insight into the contractors back log that is not available in the current reports.

Examples of Back Log Visualizations

Another useful way to visualize data features such as

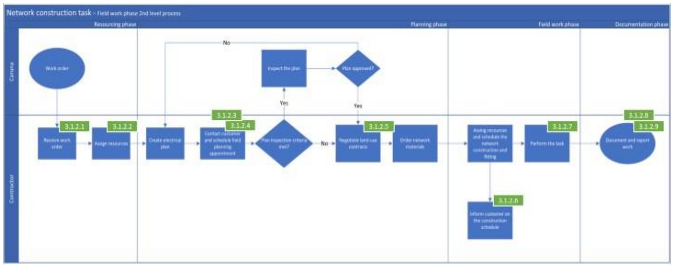
- *the central tendency,*
- *dispersion*
- *skewness*
- *outliers*

through quartiles is the box plot. The features of box the box plot visualization are presented in figure 11. The box represents the interquartile range (IQR). The lower bound of the box represents the first quartile (Q_1) and correspondingly the upper bound of the box represents the third quartile (Q_3)



Process phase reporting and alerts

#	Result of discussion	#	Information content
3.1.1	Service task phases	3.1.1.1	Workorder has been received, the time from placing of order to the receiving of the order
		3.1.1.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-assigning of the work order
		3.1.1.3	All contacts to the customer on separate messages, time of contact and the scheduled time of fitting
		3.1.1.4	Delaying of the work order, the reason for the delay, time of the delay and the amount of delay
		3.1.1.5	Task completed / not completed, time of completion
		3.1.1.6	Documentation ready, time of completing the documentation
		3.1.1.7	Documentation and billing approved by the case company
3.1.2	Network construction task phases	3.1.2.1	Workorder has been received, the time from placing of order to the receiving of the order
		3.1.2.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-assigning of the work order
		3.1.2.3	All contacts to the customer on separate messages, time of contact and the scheduled time of field planning visit
		3.1.2.4	Planning ready, time of completion of the plan
		3.1.2.5	Time of applying the land-use permits and time of land use permits received
		3.1.2.6	Task completed / not completed, time of completion
		3.1.2.7	All contacts to the customer on separate messages, time of contact and the scheduled time of construction
		3.1.2.8	Documentation ready, time of completing the documentation
		3.1.2.9	Documentation and billing approved by the case company
3.1.3	Fault repair task phases	3.1.3.1	Workorder has been received, the time from placing of order to the receiving of the order
		3.1.3.2	Who is the work order assigned to, the time from receiving of the order to resourcing and the possible re-
		3.1.3.3	Estimated time to restore electricity to end customers
		3.1.3.4	Task completed / not completed, time of completion
		3.1.3.5	All contacts to the customer on separate messages, time of contact
		3.1.3.6	Documentation ready, time of completing the documentation
		3.1.3.7	Documentation and billing approved by the case company



- Identified process phases where reporting is critical
- Phase reporting guidelines established
  - Task result codes
  - No “free text”
- Enables automated alerts and analysis

Solution Validation Notes

This is exactly the kind of visualization our project managers would need in larger investments projects. (Regional Construction Manager)

(Discussion regarding the phase-by-phase visualization)

We could calculate for each work order type and process phase the maximum amount the contractor is able to complete each month. This would give us an insight to the contractor resourcing bottlenecks. (Head of Local Network Investment Projects)

(Discussion regarding the phase-by-phase visualization)

We could also use this (project phase duration) data to calculate the average or median completion times of each of the project phases and use this to estimate the completion time for each phase. (Head of Local Network Investment Projects)

(Discussion regarding the proposed list of improvements)

We could also use machine learning to process this data for enhanced forecasts. (Head of Local Network Investment Projects)

(Discussion regarding the proposed list of improvements)

I don’t see the benefits from this visualization to our business. (Regional Construction Manager)

(Discussion regarding box-plot visualization)

The timing of this study is correct as we need to determine the reporting and service level specifications to the next frame agrmeement tendering process very soon. (Head of Local Network Investment Projects)

(Discussion regarding the proposed development road map)