Delft University of Technology

FACULTY MECHANICAL, MARITIME AND MATERIALS ENGINEERING
Department Maritime and Transport Technology

Mekelweg 2
2628 CD Delft
the Netherlands
Phone +31 (0)15-2782889
Fax +31 (0)15-2781397
www.mtt.tudelft.nl

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Author: A. Nuur

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Initiator (company): ir. D. Wagenaar (Siemens Netherlands N.V., The Hague)
Supervisor (company): ir. N. Jongbloed (Siemens Netherlands N.V., The Hague)
Supervisor: Dr. V. Reppa

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Preface

This thesis presents the development of a new developed ship-to-shore crane performance prediction model which takes parallel movements, accelerations/decelerations, container weight and automation systems into account as modeling parameters for an automated ship-to-shore crane. This is report is my graduation thesis for the master program Mechanical Engineering, for the track Transport Engineering and Logistics (TEL), at the Delft University of Technology.

I would like to thank Douwe Wagenaar for initializing and giving me the opportunity to do this research assignment at Siemens Cranes N.V. the Hague. I would like to thank Niek Jongbloed for being my supervisor and always supporting me though this project. I would also like to thank Johan Visser and Ashvant Mahibar for always keeping the door open for me when I had questions.

I want to thank Vasso Reppa for being my daily supervisor from the Delft University of Technology . The continuous support, meetings and critical feedback helped me tremendously for completing the assignment. I would also like to thank Rudy Negenborn for his critical constructed feedback.

Amersfoort, July 2020

Summary

There is a need for more accurate crane models for container handling operations. The degree of automation keeps on increasing in container terminals, this has not yet been included into existing crane models. The automated ship-to-shore crane is the most important equipment on an automated container terminal. Semi-automated ship-to-shore cranes operate on the quay area and load/unload containers from or to the ship. The performance of the automated container terminal is measured by its throughput in cycle time and is overall influenced by the ship-to-shore crane performance. Present performance prediction models do not take automation systems into consideration for predicting the throughput of automated container terminals. Furthermore these current models do not consider the parallel movements of the different components. These factors influence the performance of the ship-to- shore crane heavily, thus are indispensable for crane modelling. Current performance prediction models do not suffice. To prevent serious logistical and financial consequences, the automation systems and the parallel movements of the ship to shore crane components should be included.

In the literature review there are many parameters for container terminal modelling, but all they were not enough for modelling a new ship-to-shore crane model. A ship-to-shore crane model was found that uses the velocity of the different components when there is a load or not, also the locking and unlocking times of the container were included. The cycle path, which is the path that the different components move in relation to each other, was modelled in sequence whereas in other literature it was stated that the cycle path is parallel in reality. The accelerations/decelerations of the different components were not used in all the models. Automation systems were found in literature and different types were described on how they operate, but they were not used as crane modelling parameters in the reviewed literature.

A new ship to shore crane model has been developed for predicting the performance based on the literature and the expertise of Siemens Cranes. The new model has a new cycle path which is parallel was found by analysing real data of the reference crane. The cycle path was described by in velocity patterns including automation systems which are present in the corresponding crane. Accelerations/decelerations of the different components of the ship-to-shore crane were also considered. The new model takes also the weight of the container into account. The new ship-to-shore crane model was verified by comparing it to the reference crane.

For determining the accuracy of the new ship-to-shore crane model it was compared to a model found in literature. This model does not consider automation systems, accelerations/decelerations while the cycle path was modelled in sequence. A total of 99 jobs categorized in three datasets that were analysed, executed by the automated ship-to-shore crane for the comparison test. The new developed ship-to-shore crane has a smaller sum squared error for all the different datasets compared to the model in literature. This means the new ship-to-shore crane model predicts the performance output

more accurately. Moreover sensitivity analysis was also performed for the two ship-to-shore models to analyse how they will react to parameter change.

From the comparison test results we can conclude that for deriving a new ship-to-shore crane model for an automated ship-to-shore crane, automation systems, parallel movements of the cycle path and accelerations/decelerations of the different crane components should be included for deriving a model. The new developed model can be used for different ship-to-shore cranes by changing the crane specifications or adding/removing process blocks and automation systems.

Summary (in Dutch)

Er is behoefte aan nauwkeurigere kraanmodellen voor container handelingen. De mate van automatisering blijft stijgen in containerterminals, dit is nog niet opgenomen in bestaande kraanmodellen . De geautomatiseerde ship-to-shore kraan is het belangrijkste onderdeel op een geautomatiseerde containerterminal. Semi-automatische ship-to-shore-kranen werken op de kade en laden/lossen containers van of op het schip. De prestaties van de geautomatiseerde containerterminal worden gemeten aan de hand van de doorvoer in cyclustijd en worden in het algemeen beïnvloed door de ship-to-shore kraan.

Huidige prestatie voorspellingsmodellen maken niet gebruik van automatiseringssystemen om de doorvoer van geautomatiseerde containerterminals te voorspellen. Bovendien houden deze huidige modellen ook geen rekening met de parallelle bewegingen van de verschillende componenten. Deze factoren hebben veel invloed op de prestaties van de ship-to-shore kraan, deze zijn dus onmisbaar voor kraan modellering. De huidige prestatievoorspellingsmodellen voldoen niet aan de eisen. Om ernstige logistieke en financiële gevolgen te voorkomen, moeten de automatiseringssystemen en de parallelle bewegingen van het ship-to-shore kraancomponenten worden meegenomen.

Uit literatuuronderzoek is gebleken dat er verscheidene parameters zijn voor het modelleren van containerterminals. Deze werden gebruikt in containerterminal modellen, maar alle parameters werden verspreid uit over de verschillende literatuur, dit was niet voldoende voor het modelleren van een nieuw ship-to-shore kraan model. Een ship-to-shore kraanmodel was gevonden in het literatuur dat gebruik maakt van de snelheid van de verschillende componenten afhankelijk of er lading aanwezig is of niet, ook de sluit en ontgrendel tijden van de container zijn meegenomen. De cyclus baan, is het baan hoe de verschillende onderdelen bewegen met betrekking tot elkaar, is achtereenvolgens gemodelleerd in het literatuur terwijl in andere literatuur staat dat de cyclus baan in werkelijkheid uit parallelle bewegingen bestaat. De versnellingen / vertragingen voor de verschillende componenten werden niet in alle modellen gebruikt, maar deze zijn nodig om een nauwkeuriger kraanmodel te ontwikkelen. Automatiseringssystemen werden gevonden in de literatuur en verschillende typen werden beschreven over hoe ze werken, maar ze werden niet gebruikt als parameters voor kraanmodellering in het literatuur.

Een nieuw ship-to-shore kraanmodel is gerealiseerd voor het voorspellen van de prestaties met behulp van literatuur en de expertise van Siemens Cranes. Het nieuwe model heeft een nieuw cyclus baan dat parallel is. Deze is gevonden door echte gegevens van de referentiekraan te analyseren. Het cyclus baan is in snelheidsvormen gezet met daarbij ook de automatiseringssystemen die in de bijbehorende kraan aanwezig zijn. Versnellingen / vertragingen van de verschillende componenten van de ship-to-shore kraan zijn ook meegenomen. Het nieuwe model houdt ook rekening met het gewicht van de container. Het nieuwe ship-to-shore kraanmodel werd geverifieerd door het te vergelijken met de referentiekraan.

Voor het bepalen van de nauwkeurigheid van de nieuwe ship-to-shore kraan model, werd het vergeleken met het model uit het literatuur. Het model in het literatuur maakt geen gebruik van automatiseringssystemen, het cyclus baan is achtereenvolgend gemodelleerd en maak geen gebruik van versnellingen/vertragingen. 99 jobs onderverdeeld in drie datasets werden geanalyseerd die uitgevoerd werden door de geautomatiseerde ship-to-shore voor de vergelijkingsproef . De nieuw ontwikkelde ship-to-shore-kraan heeft een kleinere sum squared error voor de verschillende datasets vergeleken met het model in het literatuur. Dit betekent dat het nieuwe ship-to-shore kraanmodel de prestatie output nauwkeuriger voorspelt . Bovendien werd voor de twee ship-to-shore-modellen ook eens sensitiviteit analyse uitgevoerd om te analyseren hoe ze zullen reageren op parameterwijzigingen.

Uit de vergelijkingstestresultaten kunnen we concluderen dat voor het afleiden van een nieuw ship-to-shore kraanmodel voor een geautomatiseerde ship-to-shore kraan, automatiseringssystemen, parallelle bewegingen van het cyclus baan en versnellingen/vertragingen van de verschillende kraancomponenten moeten worden meegenomen voor het ontwikkelen van een model . De nieuw ontwikkelde model kan worden gebruikt voor verschillende ship-to-shore kranen door de kraan specificaties te veranderen of procesblokken en automatiseringssystemen toe te voegen of te verwijderen.

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List of symbols

Symbol	Description	Units
$a_{sp,acc}$	Spreader acceleration	m/s^2
$a_{sp,Load}$	Spreader acceleration with container load	m/s^2
$a_{Tr,acc}$	Trolley acceleration	m/s^2
s_{sp}	Spreader position	m
$s_{sp,0}$	Initial spreader position	m
$s_{sp,a}$	Distance covered by the spreader when it accelerates	m
s_{TR}	Trolley position	m
$s_{TR,0}$	Initial trolley position	m
$s_{TR,a}$	Distance covered by the trolley when it accelerates	m
$s_{TR,AGV}$	Trolley position above AGV	m
$s_{sp,AGV}$	Spreader position above AGV	m
$s_{sp,PF}$	Spreader position above platform	m
$s_{TR,PF}$	Trolley position above platform	m
w	Container load	MT
$s_{SP,bh}$	Boom height	m
$s_{SP,h1}$	Maximum spreader hoisting height for deck operations between the platform and AGV	m
z	Distance between boom and spreader	m
S_{HC}	Hatch cover location on vessel	m
v_{sp}	Spreader velocity	m/s
$v_{sp,0}$	Initial spreader velocity	m/s
$v_{SP,max}$	Maximum spreader velocity	m/s
v_{TR}	Trolley velocity	m/s
$v_{TR,0}$	Initial trolley velocity	m/s
$v_{TR,max}$	Maximum trolley velocity	m/s
$v_{sp,Load}$	Load dependent spreader speed	m/s
v_x	Spreader speed percentage	%
$t_{tr,a}$	Time duration of the trolley acceleration	s
$t_{tr,c}$	Time duration of the trolley	s

	travelling with constant velocity	
$t_{sp,a}$	Time duration of the spreader acceleration	s
$t_{sp,c}$	Time duration of the spreader hoisting with constant velocity	s
t_{cyc}	Performance time	s
$t_{ref,cyc}$	Reference crane performance time	s
$t_{A,cyc}$	Model A performance time	s
$t_{B,cyc}$	Model B performance time	s
$\Delta t_{A,cyc}$	Difference performance time of model A and the reference crane	s
$\Delta t_{B,cyc}$	Difference performance time of model B and the reference crane	s
t_{SW}	Stochastic sway control time duration	s
t_{TL}	Stochastic twistlock time duration	s
$t_{TL,PF}$	Stochastic manual twistlock time duration on the platform	s
t_{LM}	Load measurement time duration	s

List of abbreviations

Abbreviations	Meaning
ACT	Automated container terminal
STS	Ship to shore
TEU	Twenty-foot equivalent unit
APS	Automated positioning system
TOS	Terminal operating system
TPS	Truck positioning system
AGV	Automated guided vehicle
IAV	Intelligent autonomous vehicle
ECT	European container terminal

Contents

1. Introduction

The Automated Container Terminal (ACT) shown in Figure 1 is an indispensable link in the global supply chain. The ACT consists of the Ship to shore cranes (STS), yard cranes and Automated Guided Vehicles (AGVs). The STS cranes operate on the quay area and load/unload containers from or to the ship. The yard cranes operate on the container storage area and store the containers in the intermediate storage facilities before they are transported to their final destinations. The AGVs operate on the quay, transportation and container storage area, enabling horizontal transport of the containers between these different areas. Furthermore, trucks or trains operate in the hinterland for external transportation. Container trade increased significantly over the years. The container handling sector is very competitive and terminals attract high volumes of containers. Due to these high volumes, prices of container handling decrease while labour costs increase. To tackle these challenges various studies of automation of container terminals have been conducted (Hoshino et al.,2006).

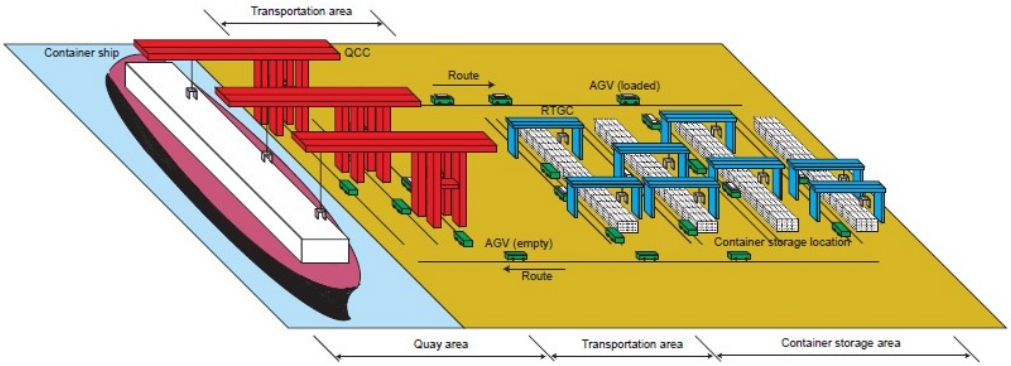


Figure 1 Automated container terminal (ACT) (Hoshino et al., 2006)

1.1 Ship to shore crane

The STS crane, shown in Figure 2, consists of three main dynamic mechanisms, the gantry, trolley and spreader. The Gantry travels along the x-axis, the trolley traverses the spreader in the Y-axis and the spreader which hoists and lowers the container in the Z-axis. Currently STS cranes are semi-automated. Since STS cranes are required to be larger, quicker, safer and more efficient, some handling processes have been automated (Zrnić et al, 2010). In fact most of the crane movements are automated except for the last steps of the process. These steps are grabbing or releasing the container from source or destination. This is done by the operator who is not located close to the crane but operates the crane remotely from a control station.

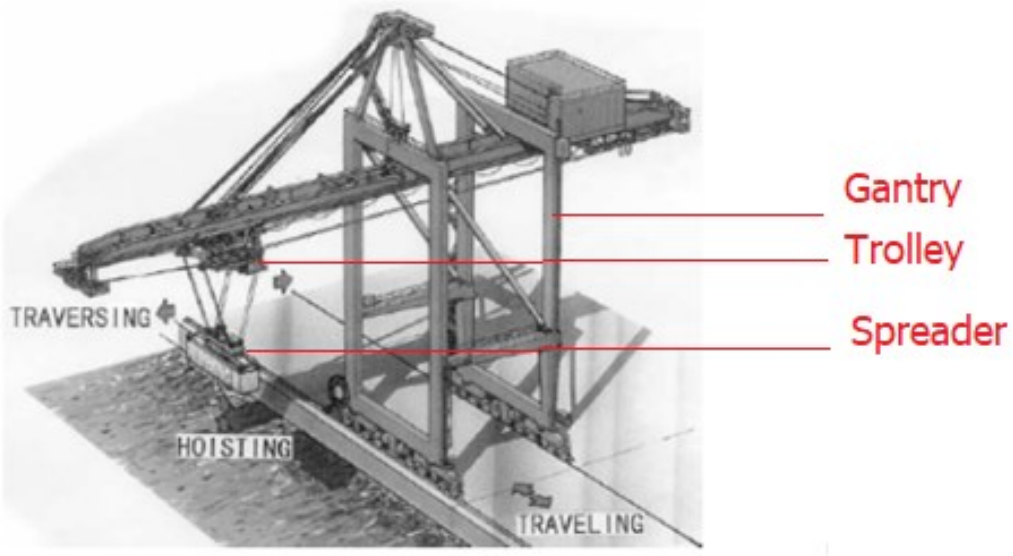


Figure 2 A STS crane with its possible movements (Zrnić et al., 2005)

Automation continues to evolve for increasing the productivity of container terminals (Zrnić et al, 2010). Full automation is a step closer to autonomous control of STS cranes and other port equipment. This makes it possible in the near future to completely replace the operator with an intelligent controller (control agent) without major changes in the existing cranes. In Figure 3 the current and future state of quay cranes is shown by their degree of automation (Zrnić et al, 2010).

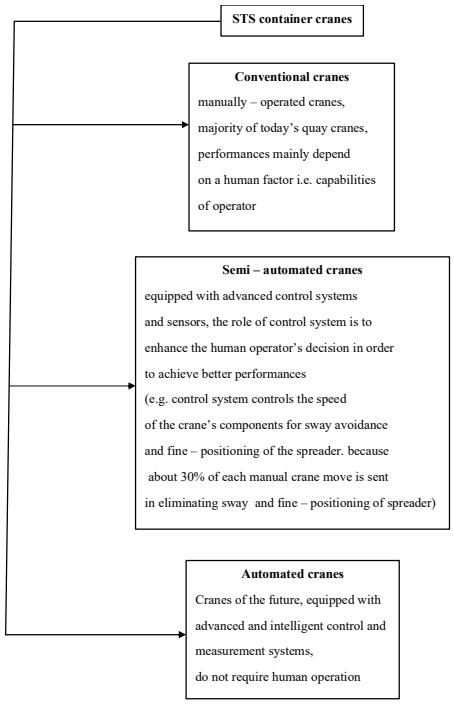


Figure 3 Classification of STSs by their degree of automation (Zrnić et al, 2010)

1.2 Problem definition

The Department Cranes of Siemens Netherlands is in the process of developing a simulation model for calculating the container throughput of terminals. Simulation is often used in the designing process of container terminals during the tendering phase. Different requirements are demonstrated such as the preferred performance or design layout of the terminal that is achievable before building the actual port during the offer phase. This step provides crucial insight in the economic cost and benefit of the terminal realization.

The current automation advances made in container terminals have not been implemented yet in STS crane models. Current simulation models found in literature do not take automation systems into consideration for predicting the performance of automated container terminals. These systems influence the performance of the STS crane, therefore automation systems are indispensable for crane modelling. Furthermore current models do not take in account the parallel movements of the different components of the STS crane. In reality the trolley and spreader which are components of the crane, move parallelly but in literature the crane motion is simplified and the components are operated in sequence. When these factors are not considered, the predicted performance model does not describe the actual system behaviour, which makes these model output less accurate. Moreover the STS crane is the most important equipment in the Automated Container Terminals (Tang, 2010). The rate at which containers are handled through the terminal is a key performance indicator. Especially the productivity of the STS crane notably influences the overall performance of the container terminal (Jonker et al, 2019). Implementing current performance prediction models for semi-automated cranes can have deviations when the predicted performance output is compared to the actual output. As a result this can have serious logistical and financial consequences for the container terminal.

1.3 Research Questions and Scope

The objective of this research is to build a simulation model of a STS crane to predict the performance with the automation systems incorporated. The goal of this research is to deliver a prediction model including automated systems, evaluated based on the cycle-time, i.e. the time for handling of a container from source to destination.

This thesis addresses the following research questions:

What is the impact on the performance prediction model when acceleration/deceleration, automation systems and parallel movements are considered?

This main question is answered by answering the following

1. How can the performance of an STS crane be characterised?
2. What are the important parameters for modelling/predicting the performance?
3. How can the performance model be more realistic and accurate?
4. How can we assess the accuracy of the new model compared to the state-of-the-art models?

1.4 Research scope

This section describes framework within which the research questions are addressed. The research aims to investigate the performance of an STS crane only, other transport systems are not taken in account. A performance prediction model an STS crane is made.

The research scope is defined by the reference model assuming:

- The vessel is already located at the berth and that the AGV is available when the container is loaded.
- The AGV has one fixed designated lane under the STS crane.
- Different spreader types are not taken into account.
- The parameters of the reference model will be used for modelling the crane ,since there is a lack of literature regarding performance modelling of an STS crane.
- The STS crane scheduling is out of the scope, since only one STS crane is used for this research.
- Only loading or unloading of the vessel will be considered, dual cycling is out of the scope.

1.5 Thesis Outline

1.5.1 Approach

Each research sub-question will be respectively answered by conducting a literature review on the mentioned topic and by making use of the expertise within Siemens. A performance prediction model will be developed for the semi-automated crane, and the results of this research will be evaluated in a report. The model will be described, experimented with and the results will be evaluated. The results of the semi-automated crane model will be verified using existing data. When each sub-question is evaluated with respect to the main research question an advice will be given as well as some recommendations for further research.

1.5.2 Structure of the report

In chapter 1 the research subject is explained, the problem definition, its objective and its scope of the research.

Chapter 2 addresses the following research questions:

- How can the performance of an STS crane be characterised?
- What are the important parameters for modeling/predicting the performance?

Literature review is conducted in this chapter to explain how an Automated Container Terminal works and its function. Different automated container terminal models and STS Crane models are discussed and compared to assess the determinative parameters of the simulation models. Only one STS crane model was found which is used for comparing it with the new crane model. Also the cycle path of the crane is discussed. The STS crane model uses sequential movements, but in practice parallel movements occur.

Chapter 3 addresses the following research questions:

How can the performance model be more realistic and accurate?

In this chapter new crane model is described for calculating the cycle time for the STS crane. A new cycle path has been defined by analysing the terminal operation system data of Siemens for describing the actual crane motion characteristics which also will be implemented in the new crane model. The new model is verified and validated against measured data of an actual STS crane.

Chapter 4 addresses the following research question:

How can we assess the accuracy of the new model compared to the state-of-the-art models?

The two different performance prediction models are compared in this chapter. One model that uses the general cycle path which operates in sequence only and without the automation system and one model with the new cycle path which has parallel movements with the automation systems taken in account. Sensitivity analysis has been conducted as well. This has been done to check if the model behaves accordingly when the inputs are changed.

Chapter 5 addresses the main research question:

How can a prediction model be derived for an automated Ship to Shore crane?

Here the conclusion of the research can be found including the recommendations.

An overview of the topics covered in this research are given in Figure 4.

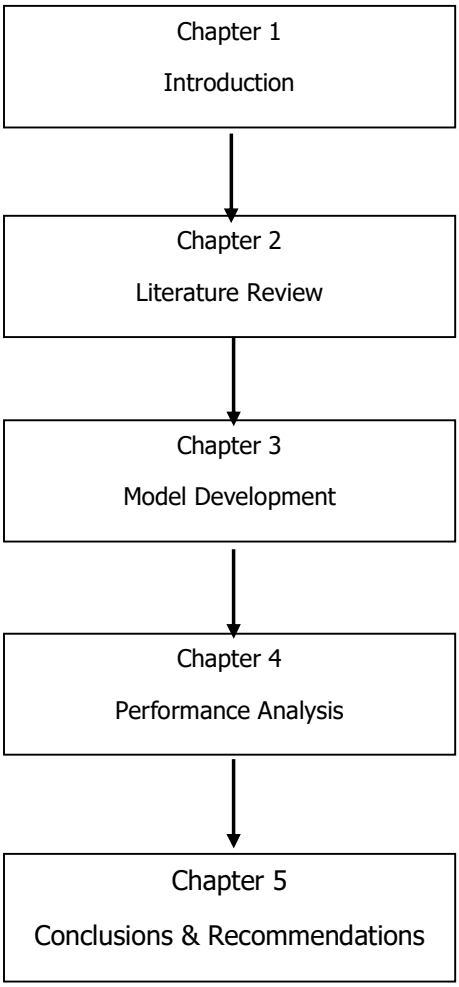


Figure 4 Overview of chapters covered in this research

2. Literature Review

Before designing a new performance prediction model we analyse the literature on this topic of the state of the art STS crane addressing the questions on how the performance of the STS crane can be characterised, and which parameters are important for modelling the in the next chapter. In this chapter the container terminal operations and its trends are briefly described. Then the STS crane is explained and its main function. The STS crane's cycle time is described and its performance influencers are researched. Furthermore different automation systems that can be found in automated STS cranes are described and their purposes. Finally a conclusion is given of the found literature.

2.1 Container terminal operations

The ACT commonly consists of the following container handling equipment operating on the terminal: Automat-ed Guided Vehicle (AGVs), yard canes, STS canes and straddle carries, as shown in Figure 5 (Gharehgozli et al, 2014). This equipment makes transhipment possible between ship and barges and also trucks and trains, and vice versa. The mode of transport is used in logistics to differentiate various modes of transportation such as air, land (rail & road) and water. Containers can be transhipped from one mode to another and also can be temporally stored in the stack area, before transferring to another mode. The ACT consists of different areas, including: seaside, landside, stacking and internal transport areas for horizontal transport for seaside and landside operations portrayed in Figure 6 which describes the layout of a typical container terminal. STS cranes have the function loading and unloading from ships berthed along the quay at seaside. STS cranes grab and place containers on AGVs which move the containers from the seaside to the stacking yard where the yard cranes stack and store the container. At the end the straddle carrier transports the container from the yard crane and places the container on the external truck or train at the landside.

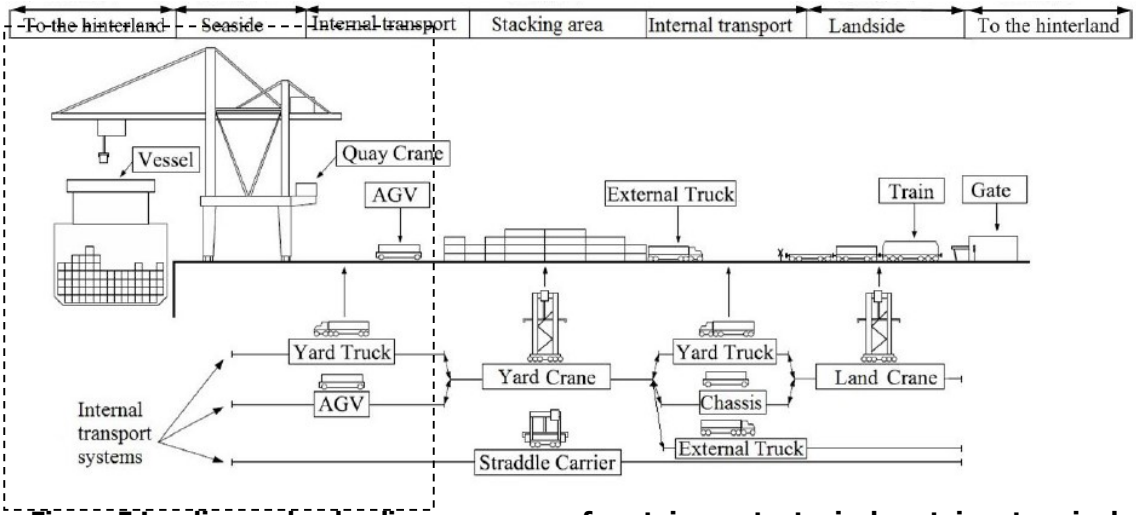


Figure 5 Loading and unloading processes of containers at a typical container terminal (Gharehgozli et al., 2014)

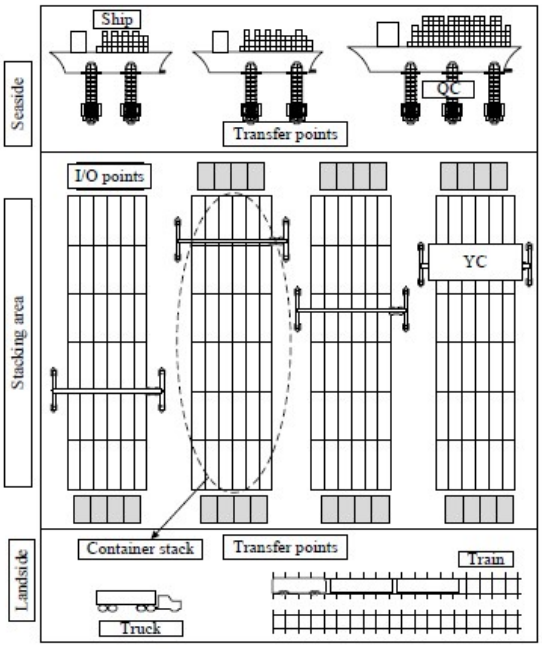


Figure 6 Schematic representation of a container terminal layout (Gharehgozli et al, 2014)

2.2 Trends in container operations

Gharehgozli et al.(2014) described that large container terminals handle millions of containers yearly. Vessels increased in size significantly over the decades. Nowadays these vessels carry 15000 TEU compared to 400 TEU with last generations ships. With this increase efficient terminal handling systems are essential.

Saanen (2004) described that due to trend of increasing in scale of maritime shipping and price drop of ocean freight over the years, automation is of great importance for replacing manually controlled transportation with reliable automated equipment alternatives. An important factor of this automation trend is the costs, especially labour costs. Labour costs decrease by 40% while overall cost reduction is 15%-25% (including capital costs of automated equipment) compared to manually equipment operating in the terminal.

Furthermore the benefits of automation are:

- Being less depended of operators such as crane and carrier drivers
- Capable to handle last-minute modifications such as late arrivals
- Capable to modify operational priorities
- Track and trace improvements for containers and equipment, this gives the accurate status of the cargo and handling equipment
- Reduced preparation costs for future operations (housekeeping).
- Automated feedback loop generated with monitored key performance parameters.

Computer technology also helped with the improvement of automation in container terminals over the years in the areas such as sensor technology, decentralized systems, software and information network (Saanen, 2004).

2.3 STS cranes

STS cranes (also called quay cranes) load or unload vessels at container terminal. STS cranes have various sizes, handling capacity, logistical concept and other characteristics. There are two main types of STS canes, the rail mounted gantry cranes and mobile harbour cranes. The mobile harbour crane is more flexible due to rubber tires instead of moving on a rail. But nowadays rail-mounted cranes are mainly used for container handling because they have higher productivity meaning higher handling speeds, and can be used for steadily increasing vessel sizes. Three moving components of an STS crane are required for the three-dimensional loading and unloading of vessels, which are the gantry, trolley and spreader shown in Figure 7. The gantry can move on the rail perpendicular to the quay wall and unload containers to or from different bays or vessels. The trolley can move along the beam of the STS crane and transports the container between the ship and shore. The containers can be either handled in the back-reach or in the portal/gauge, this depends on the kind of horizontal transport, hatch covers position of the vessel and the organizational workflow. The spreader picks up the container, it has pins that fit precisely into the corner castings. The spreader is lowered and hoisted with cable winches, so that the spreader is able to pick up or place the container.

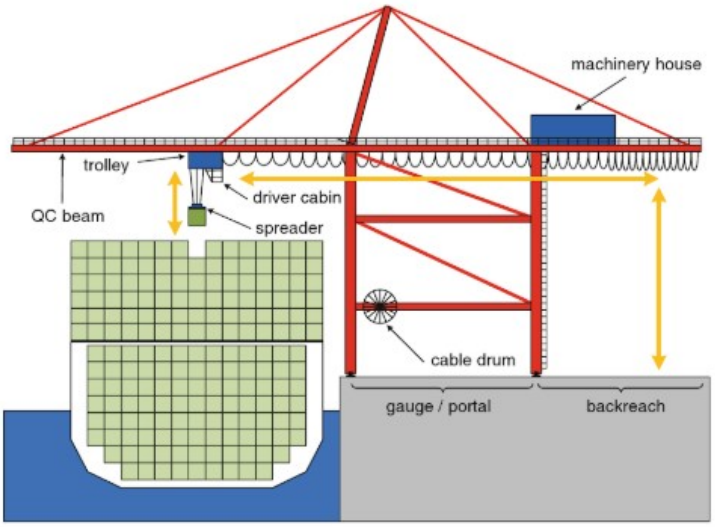


Figure 7 Schematic illustration STS crane (Kemme, 2013)

2.4 Ship to shore cycle-time

The performance of an STS crane is measured in terms of cycle time, this is the time of completing a container movement. In literature cycle times are based on operational sequence processes (Galle et

al, 2018). The operational sequence of an yard crane is described in Figure 8, STS cranes and yard cranes models have similar operational sequences and consist of the same components, such as the gantry trolley and spreader. Moreover they have the same function, however STS cranes operate between the water and landside while the yard crane only operates on the landside. The operational sequence starts with an empty drive where the previous job has ended, which is also now the starting location for the new job. The spreader picks up the container, the trolley moves it along the beam and the spreader lowers the container again to its destination.

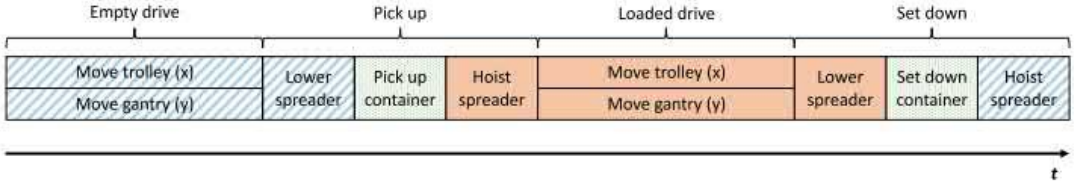


Figure 8 Typical operational sequence of a yard crane container handling cycle (Galle et al.,2018)

Speer and Fischer also described the operational sequences for a yard crane Figure 9, which also is the same for the STS Crane (Speer & Fischer, 2018). These are divided in two movements; inbound and outbound movement. Also the resizing of the spreader is incorporated this operational sequence. Furthermore crane has to wait for the transfer area (TA), horizontal transport and remote operation.

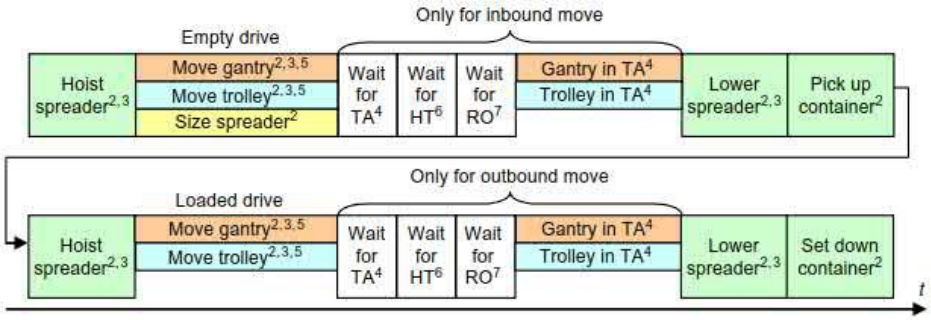


Figure 9 Operational sequence of a yard crane handling cycle where the transfer area (TA), the horizontal transport and remote operation is taken into account (Speer and Fischer,2017)

Jordan (2002) described that crane productivity is one of the critical components of the overall container terminal and predicted that vessels carrying over 12000 TEU can lead to the quay crane becoming the limiting factor of the terminal's productivity and that the productivity of terminals can be improved by automation. This was not discussed, however an insight is given in Table 1 showing the quay crane productivity and vessel turnaround time of various vessels.

Table 1 Turnaround times various vessels and lifts/hour

Vessel Turnaround Time vs. Lifts per Hour

Vessel Size TEU	6,000	8,000	10,000	12,000
Cranes	4.0	5.0	6.0	6.0
Lifts per Hour	Vessel Turnaround Time, Hours			
20	96	103	107	129
30	64	69	71	86
40	48	51	54	64
50	39	41	43	51
60	32	34	36	43
Parameters: 1.75 TEU per lift. Turnover 75%. Two eight hour shifts/day.				

The general processes of the STS Crane for completing a container handling cycle are similar to the yard crane process described by Jongbloed (2018) is shown in Figure 10, the sum of these processes is the total cycle time of the STS Crane. The subprocesses also have been mentioned for executing the main processes.

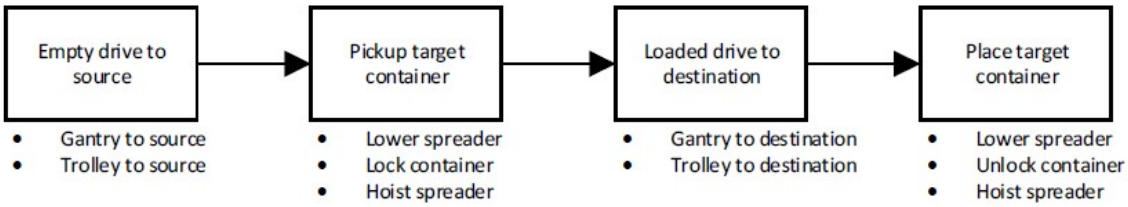


Figure 10 The four basic yard crane processes and subprocesses to complete a container handling cycle (Jongbloed, 2018)

Also using Cranesim Jordan (2002) generated the half-cycle time from the wharf to the inside from the ship's hold showing in Figure 11. Here it is noticeable that the hoist and Tolley times are parallel and that the dwell times are in series. The travel times vary due to the different locations of the containers.

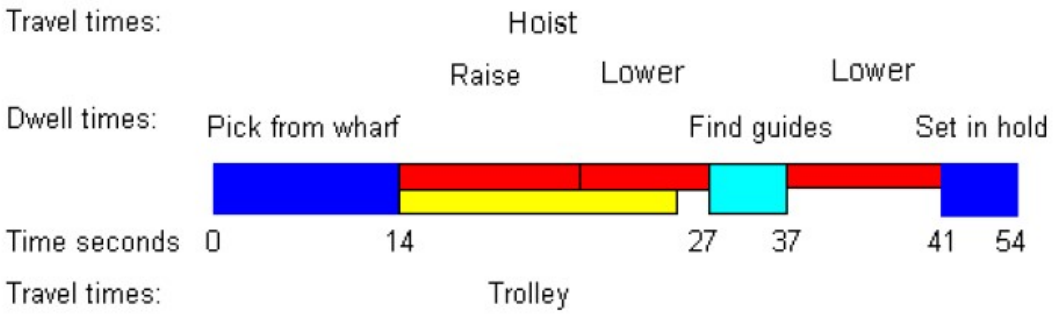


Figure 11 An example of half-cycle timeline of an STS crane in the hold of a vessel (Jordan, 2002)

2.5 Performance influencers

Several performance models are researched in literature to find out which parameters for the STS Crane are of importance for influencing the performance. Performance metrics that are commonly used in literature for simulation models are defined for the STS crane as cycle time, moves/h and container/h.

Liu et al.(2002) designed, simulated and evaluated an automated container terminal to make existing facilities more efficient. Four different concepts of the ACT's were compared and their performance was evaluated with respect to the number of movements per hour. The design considerations for the speed of the quay crane were 50 moves/h for single mode (i.e. only loading or unloading) and for double mode 42 moves/h (i.e. loading and unloading combined).

Vis and Harika (2004) made a comparison study of automated guided vehicles and automated lifting vehicles. When designing an automated container terminal, the type of equipment must be taken in consideration. The two vehicle types are compared with a simulation model considering only unloading of a ship, the number of vehicles needed and occupancy degrees. The type of equipment is chosen by a performing a feasibility and economic analysis. The STS crane's cycle time is the time from unloading the container from the ship to positioning it on the AGV. Cycle time depends on the crane specifications, experience of the crane operator and the ship type. The STS crane cycle time is empirically distribution seen in Table 2. Large disturbances such as downtimes are not considered. The simulation generated an average cycle time of 65.9 seconds of the distribution of Table 2. The unloading time of a STS crane is 55 containers/h on average. In this simulation four cranes were used where the containers were evenly distributed on the vessel.

Table 2 Cycle time STS crane empirical distributed (Vis and Harika, 2004)

Fraction	Cycle time in seconds
0.05	30–40
0.15	40–50
0.25	50–60
0.20	60–70
0.17	70–80
0.11	80–90
0.04	90–120
0.02	120–150
0.01	150–180

Fraction: Fraction of observations

Yang et al.(2004) also compared automated lifting vehicle (ALV) to an automated guided vehicle. In this simulation-based performance model the number of ALVs were increased instead of AGVs to see how this would affect the productivity and efficiency of the ACT, because AGVs are unproductive under the quay crane and in the blocks of the storage yard because of costly waiting time compared to an ALV which is able to lift containers by itself. In the model there are three cranes and with a trolley speed of 3m/s and a cycle time of 30s for loading/unloading.

Xin et al.(2014) made a simulation study on how the performance of automated container terminals can be improved in an energy efficient way by improving the handling capacity. In the model the STS crane has a maximum speed of 4m/s, a maximum acceleration of $4m/s^2$ and the weight of the trolley is 10T. The quayside transport area dimensions are 150m x 200m. Vessel's stowage width is 8 TEU. The distance between the furthest container and interchange point is 100m. Service times of all cranes are ignored in this model.

Kavakeb et al.(2015) designed a simulation model of a European container terminal layout using real data from this terminal as a case study to see the effects of new intelligent vehicle types called intelligent autonomous vehicles (IAVs) on the performance and total cost. Three quay cranes are located in the terminal with a cycle time of 160 seconds which is retrieved from actual data. Its cycle time consists of locating the container, hoisting it up and placing it on its destination.

Choi (2004) studied the container terminal resources by making as simulation whereby the different processes are modeled. Cranes have the processes idle, wait, move and work. In the model the quay crane has a speed of 0.75 m/s and has as a normal distribution N(112.8, 31.2) operating time.

Bielle et al.(2006) made an object oriented simulation model of an container port distribution for giving more insights for improvement. The simulation was realised using the real data of an existing container terminal in Casablanca Morocco and compared these values found in its database with the simulation runs. These runs were achieved by trying different calibration parameters combinations each time of the quay crane, yard crane and shuttle truck for improving the results to get close to the real data of the port. Calibration parameters for the STS crane have a mean time of 108 container/h and 216 container/min for moving a container from the STS crane to the shuttle truck.

Taner et al.(2014) made a simulation model of four common terminal layouts, which have been modelled and compared to investigate how the layout influences the performance of the terminal. Also the various dispatching rules and allocation strategies have been taken into consideration for their influences on the port. The simulation parameter for the handling time of the STS crane is triangular distributed, the probability density function of a triangular distribution which is a continuous probability function, is shaped like a triangle with a minimum value of 0.9 min a maximum value of 1.35 min and a peak value of 1.8 min.

Lin et al.(2013) made a simulation model which considers the cost for investing in designing of the Humen Port container terminal for different cranes and ship types. The efficiency of the crane operation depends on the ship size. In Table 3 it can be seen that the operational efficiency for smaller ships is twice as large as for big vessels. Furthermore the assumptions for the simulation that have been made are that the crane operates always perfectly, it has no downtimes and ships are never left unserved. Also the operation efficiency is always considered constant and movement times are disregarded.

Table 3 Operation efficiency cranes (Lin et al.,2013)

Ship Type	Operational Efficiency (minutes per box)	
	Quay crane	Gantry crane
Big_150	1.5	–
Big_200	1.5	–
Small_60	3	3

Sauri et al.(2014) developed a simulation model where horizontal handling equipment is analysed. In this paper data of the Port of Barcelona has been used to design a small model of part of the terminal to get a view of the financial costs of unmanned vehicles (AGVs) compared to manned ones (straddle carriers) for transporting containers from ship to the stack yard. In Figure 12 the service time distribution of the quay crane is displayed. The performance of the STS crane is 40 moves/h for peak conditions and 30 moves/h on average.

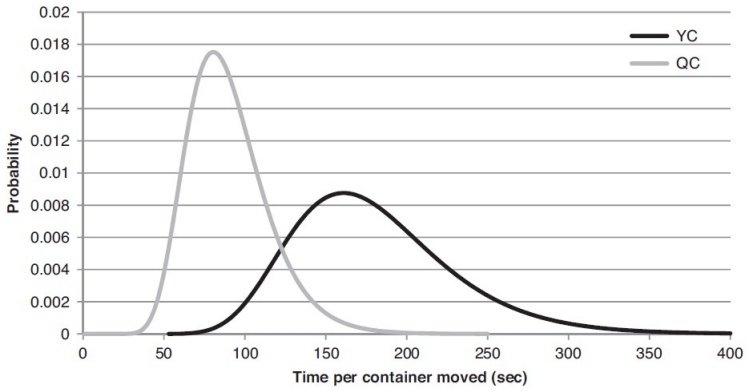


Figure 12 Service time distribution (STS crane Sauri et al.,2014)

Ha and Choi (2005) compared the effect of four different STS cranes (single trolley/ dual trolley/ double trolley/ supertainer) on the productivity of the terminal process. A simulation-based performance model was made by gradually increasing the vehicle fleets velocity. These different STS cranes load and unload differently by following a different cycle path. The cycle path is shown in Figure 13. The primary working path for each STS crane can be found in Table 4. It is assumed that the cranes have the same crane specifications these can be seen in Table 5. The cranes' productivity is given in cycle time is given in Table 6.

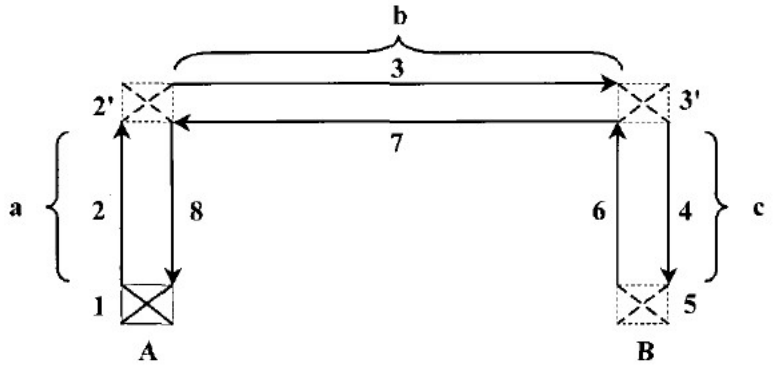


Figure 13 Cycle path (Ha and Choi, 2005)

Single trolley STS cranes are the most common STS cranes used in container terminals. One trolley is used for unloading and loading operations and it is also has the primary working path of the crane.

Dual trolley STS crane uses two trolleys for completing unloading/ loading operations. The first trolley operates between the quays side and the platform of the crane and the second trolley operates between the platform and the landside. The first trolley has the primary working path of this crane.

The double trolley STS cranes is a concept which uses two trolleys for crane operations. Both trolleys can operate simultaneously when loading or unloading the container from the ship to the AGV or the other way around. Both trolleys have the primary working path

The supertainer is also an STS crane concept which uses a traverser for horizontally moving the container and one trolley on the quayside and one trolley on the landside for vertical movements. The traverser can hold more than one container. The transvers has the primary working path of this crane.

Table 4 Path direction (Ha and Choi, 2005)

Crane type	Applies to	Primary working path
Single	Trolley	1 (lane)→2→3→4→5→6→7→8
Dual	1st trolley	1 (platform)→2→3→4→5→6→7→8
Double	1st, 2nd trolley	1 (lane)→2→3→4→5→6→7→8
Supertainer	Traverser	2 '→3→3'→7

Table 5 STS crane specification (Ha and Choi, 2005)

Division	With load	Without load
Hoist speed	2.40m/s	2.40m/s
Trolley speed	1.50m/s	3.00m/s
Locking / Unlicking Time spreader	2s	2s
Distance a	Dual 1st: 14m, others: 18m	
Distance b	Dual 1st: 43m, others: 74m	
Distance c	17m	

Table 6 Cycle time productivity (Ha and Choi, 2005)

Division	Cycle Time	Mechanical productivity
Single	75.00s	48.00 lifts/hr
Dual	56.50s	63.72 lifts/hr
Double	76.00s	94.74 lifts/hr
Supertainer	41 .00s	87.80 lifts/hr

The container models examined showed several parameters, speeds, accelerations and decelerations, and various times such as cycle, handling and operating time. The gantry, trolley, hoisting speeds and their accelerations and decelerations are of importance for the STS crane. The trolley acceleration and deceleration, the hoisting speed and acceleration were not found in the researched literature. Furthermore, there are no papers found in literature that contain all relevant parameters. Performance models found in literature model the whole container terminal instead of separately modelling the transport equipment. This fact questions the reliability of these models. Also two comparative performance models of a STS crane were found. Only one paper contained the important parameters, whereas the other model used only statistical data of different process times.

The various important parameters and their values of the models found in literature are organized in tables. In Table 7 the parameters of the STS cranes in the literature of automated terminal models are given and in Table 8 the parameters of the STS crane model is given. Transport modes of the STS crane are also described; single mode means only loading or unloading the vessel; double mode means loading and unloading the vessel simultaneously so that the crane movements are not wasted. Additionally the unloading and loading were assumed to be the same in the container models. Furthermore in the table headers, the accelerations/decelerations and velocities of the different STS crane components and the modelling times that were used such as the cycle, handling and operating time can be found for each paper.

Table 7 Parameters found in ACT models

Paper	*Mode*	*Unloading/ Loading*	*Gantry Veloc.*	*Gantry Acc/Dec*	*Trolley Veloc.*	*Trolley Acc/Dec*	*Hoist Veloc.*	*Hoist Acc/Dec*	*Time*	*Comments*
Liu et al.(2002)	Single/ Double	U/L	✗	✗	✗	✗	✗	✗		50 moves/h single mode 42 moves/h double mode
Vis & Harika (2004)	Single	U	✗	✗	✗	✗	✗	✗	Cycle time empirical distributed	
Yang et al.(2004)	Single	U/L	✗	✗	3m/s	✗	✗	✗	Cycle Time 30s	
Xin et al.(2014)	Single	U	4m/s	4m/s^2	✗	✗	✗	✗		
Kavakeb et al.(2015)	Single	U	✗	✗	✗	✗	✗	✗	Cycle Time 160s	
Choi (2004)	Single	U/L	0.75m/s	✗	✗	✗	✗	✗	Operating time normal distribution N(112.8, 31.2)	
Bielli et al.(2006)	Single	U/L	✗	✗	✗	✗	✗	✗	Mean time (108/126) cont/h	
Taner et al.(2014)	Single	U/L	✗	✗	✗	✗	✗	✗	Handling time triangular distribution (0.9, 1.35, 1.8) min	
Lin et al.(2013)	Single	U/L	✗	✗	✗	✗	✗	✗	Operational efficiency time (90,90,180) cont/h	
Sauri et al.(2014)	Single	U/L	✗	✗	✗	✗	✗	✗	Service time distribution (Real case)	40 moves/h peak, 30 moves/h average

Table 8 Parameters found in STS crane models

Paper	*Mode*	*Unloading/ Loading*	*Gantry Speed*	*Gantry Acc/Dec*	*Trolley Speed*	*Trolley Acc/Dec*	*Hoist Speed*	*Hoist Acc/Dec*	*Time*	*Comments*
Ha & Choi(2005)	Single	U/L	✗	✗	1,5m/s 3m/s no load	✗	2.4m/s	✗	Cycle time 75s, for single trolley	Mechanical productivity 48.1 lifts/h, Locking/unlocking container 2s

2.5 Automation in STS cranes

Zrnic et al.(2010) analysed the crane developments of quay cranes from 1959 to 2009 for predicting the future trends. The evolution from structural mechanical design and automation of the quay crane such as anti-sway which balances out the sway of the load, automated positioning system and smart spreaders were described.

2.5.1 Sway Control

When the trolley moves it causes the load that hangs underneath to swing around the vertical position. This is called sway. For the sway problem bang-bang control is mostly used that will be explained further in text. When the motion of the pivot is under control, it is possible to disregard the sway at both ends of the acceleration. Velocity increases step wise in this technique, the pivot is accelerated to half the velocity then one half time-step later it accelerates to as velocity. In Figure 14 from top to down the lines describe the trolley velocity reference, trolley velocity reference through velocity pattern system and sway angle. When this is done accurately the load should be straight beneath the pivot. This is exactly in the reversed order for stopping the sway movement. Decreasing the velocity to half and wait one and a half times-step then the velocity can go to zero for stopping the sway movement. Acceleration and deceleration are in two pulses, making it the load possible to catch up with the trolley during acceleration and during deceleration the trolley to catch up with the load. The load is lowered quickly at the end of the movement. Because quay crane dynamics are nonlinear a simple pendulum doesn't suffice. Due to its non-linearity and operator's unpredictable input to the system the anti-sway operation may not work properly or not even at all. For this reason, operators switch off anti-sway to cancel out the negative effects of the system. Using simple control methods as Bang-bang for nonlinear systems, uncertainties and undesired outcomes may be produced.

To counter act these effects, reshaping the trapezoidal velocity pattern is of importance. Reducing the trolley's crossing time considerably is a must, also the swinging motion of the spreader must stop at the end. To meet these requirements, the crossing interval is split in three sections these are accelerating interval, constant velocity interval and the decelerating interval.

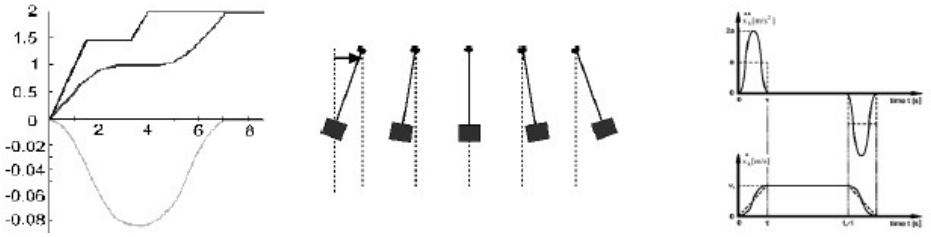


Figure 14 Velocity reference pattern Bang-bang sway Modified standard trapezoidal velocity pattern (Zrnic et al.,2010)

Appropriate velocity patterns are given in Figure 15.

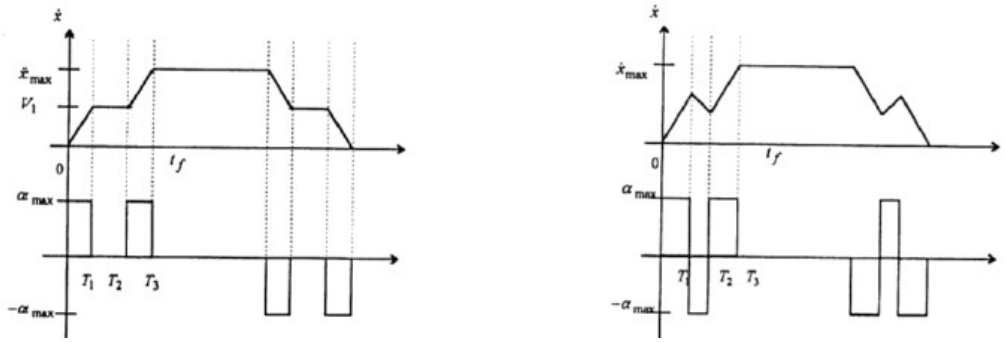


Figure 15 Stepped velocity pattern Notched velocity pattern (Zrnic et al.,2010)

Values such as velocity and accelerations of large container crane examples where given also in this paper in Table 9. These parameters were also distinguished with or without any load, and also hosting a load with a 40 t container, only the gantry parameters were not given. This paper contained more information on the parameters than the papers about the container models.

Table 9 Large STS crane performances (Zrnic et al.,2010)

Mode	Speed	Acceleration times	Deceleration times
Hoisting with rated load	70 m/min	2,0 s	1,5 s
Hoisting with 40 t container	100 m/min	2,0 s	1,5 s
Hoisting with spreader only	180 m/min	4,0 s	3,0 s
Trolley drive	250 m/min	5,0 s	5,0 s

2.5.2 Automated positioning system

Automated positioning system aligns the container and the truck's chassis during loading and unloading of the container. The system uses sensors which are located on the trolley and visual aided design to make this possible.

2.5.3 Automated smart spreaders

Automatic spreaders, automatically rotate the twist locks by 90 degrees to lock the spreader with the container. This system uses various sensors which are located on the spreader to detect objects and gaps between containers. Information of the sensors is processed and the spreader adjusts to the container accordingly. Furthermore, these spreaders avoid collision with the help of the automated positioning system. It automatically adjusts the height of the spreader when it approaches and object to avoid collision.

2.6 Conclusion

In this chapter, the questions on how the performance of an STS can be characterised and what parameters are important parameters modelling/predicting the performance are answered.

The performance metric is characterised as cycle time for an STS crane (Ha and Choi, 2005). Important parameters for an STS crane in literature are the trolley and spreader velocity (Ha & Choi,2005).

When we want to achieve a more accurate model, the accelerations/decelerations, parallel movements and automation systems should be taken into account. All the papers on ACT models in literature did not use accelerations/decelerations for the trolley and spreader hoist components and additionally did not use the velocity for the spreader. Some papers did not use velocities or accelerations/decelerations at all and instead used moves per hour instead for modelling or used the cycle time in a certain distribution which in fact the cycle time is how the performance should be characterised. Ha and Choi(2005) was the only paper which only focused solely on different STS crane models compared to other models which focus on ACT's. In this paper the different velocities of the trolley and spreader were used and also distinguished the different velocities for these components when they are carrying a load or not. Furthermore the container locking/unlocking times for were also considered, however in the study of Ha and Choi(2005) the accelerations/decelerations were not used. It is important to add the accelerations/decelerations since this can have a negative accuracy on the output performance of the simulation model. Moreover the cycle path was modelled in sequence, while Jordan(2002) clearly states that crane operations for trolley and spreader are parallel. This can also influence the performance out negatively.

In the following chapter we look into on how the model of Ha and Choi(2005) can be improved. With the findings of the literature, a new model is made considering accelerations/decelerations of the different components, a cycle path with parallel movements an automation systems.

3. Model Development

For addressing the question on how the performance model can be more realistic and accurate, we look into this chapter on how the model of Ha and Choi(2005) can be improved. A new semi-automated STS crane model is developed. This model also considers automation systems. To achieve this, information acquired from literature and also from Siemens Cranes is used, a reference case from European container terminal STS crane will be used to develop the model. Further he design criteria that the model has to meet are also described. The mathematical model consists of process blocks for determining the cycle time of the STS crane. These process blocks are divided in subprocesses to achieve a more detailed cycle time and for developing a performance prediction model of the cycle time. Verification and validation is accomplished by comparing the new developed model with existing data of the reference crane. Finally conclusion is given of the findings.

3.1 Reference case

The reference case from an STS crane project of Siemens is used to verify and compare the new STS crane model. Actual performance data is used from unloading a vessel from the cargo hold to the AGV, from the deck to the AGV and loading a vessel from the AGV to the deck. Each crane is assigned to one lane, therefore the crane has one destination and other lanes are not taken in account during the calculation. Operational data of the STS crane is given by the terminal operational system (TOS).

3.1.1 STS crane specifications

In **Fout! Verwijzingsbron niet gevonden.** a schematic view of the reference crane is portrayed. Here we can see the STS cane components. The spreader (1) moves in the z-axis and the trolley (2) moves in the y-axis. The container location on the vessel which is on the deck or in the hold is also shown. These are defined as container spreader position (s_{SP}) and trolley container position (s_{TR}). Other locations such as the platform and the AGV lane position are also defined as spreader and trolley position. The platform defined as $s_{TR,PF}$ and $s_{SP,PF}$ is the location from where the twistlocks are removed or attached manually when containers are loaded/unloaded from the deck. For crane operations in the hold the platform is not used. The containers go straight from the vessel to the AGV and vice versa. The AGV lane position 1 defined as $s_{TR,AGV}$ and $s_{SP,AGV}$ is where the AGV delivers or receives containers from or to the STS crane. The boom height ($s_{SP,bh}$) is also given and is the maximum height the spreader can reach. Furthermore the maximum spreader hoisting height ($s_{SP,h1}$) for deck operations between the platform and AGV is also shown.

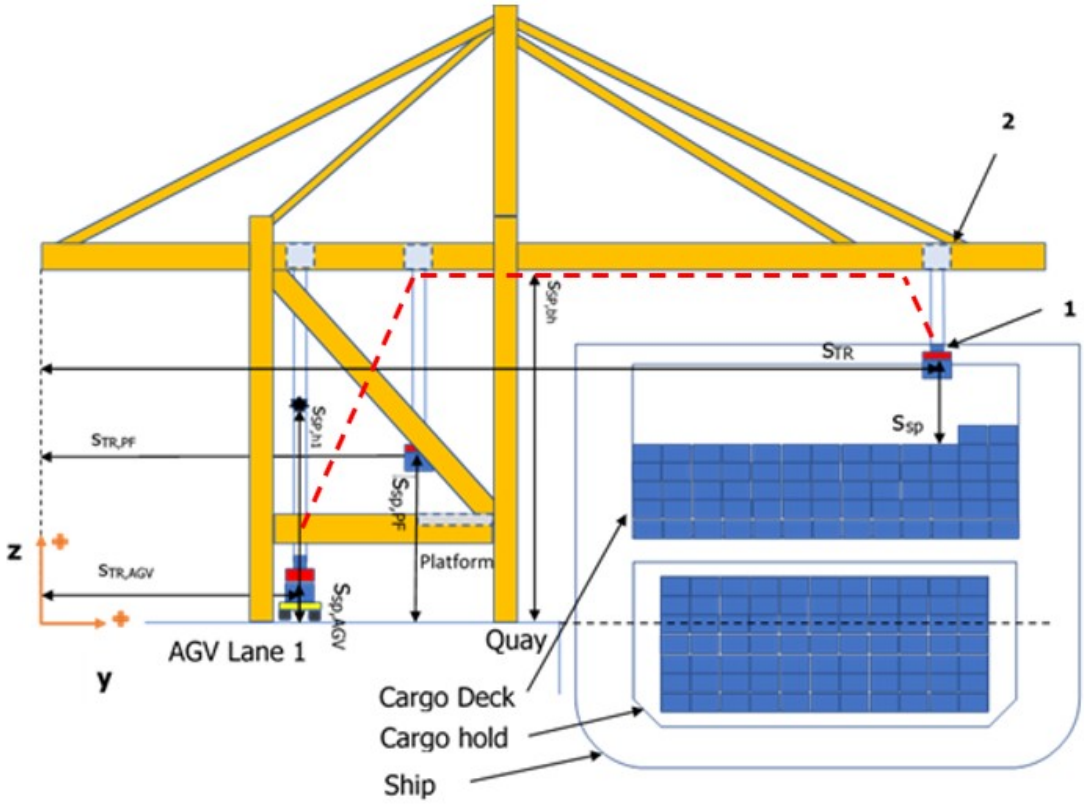


Figure 16 Schematic side view reference case

The values of the distances relating to the trolley and spreader components are given in Table 10.

Table 10 Distances relating to trolley and spreader components

Distance	Value
$S_{SP,bh}$	50.06m
$S_{SP,PF}$	18.20m
$S_{SP,h1}$	25.60m
$S_{SP,AGV}$	4.30m
$S_{TR,AGV}$	30.20m
$S_{TR,PF}$	59.20m

The technical specifications of the crane are given in
Table **11**, where it is highlighted that the spreader velocity depends on the container. The calculation method for different spreader velocities for different container loads will be used in the mathematical modelling.

In

Table 12 the spreader's load dependent curve table is shown, here can be seen which velocity the spreader should operate with which load, also the load dependent curve is shown in Figure 17.

Table 11 STS crane specifications

COMPONENT	VELOCITY	ACCELERATION
1 SPREADER	2.5 m/s (25 ton)	0.6 m/s^2

	1.25 m/s (90 ton)	0.6 m/s^2
2 TROLLEY	4 m/s	0.9 m/s^2
3 GANTRY	0.75 m/s	0.15 m/s^2

The velocity is defined as percentage of the maximum spreader velocity. The spreader velocity can use 100% of its maximum velocity when load is up to 25 MT and 50% of the maximum the velocity when the load is carrying is 90 MT and.

Table 12 Spreader Curve table

Load W (MT)		**Velocity V (%)**	
X1=	25.00	**Y1=**	100.00
X2=	30.00	**Y2=**	88.46
X3=	40.00	**Y3=**	74.04
X4=	55.00	**Y4=**	62.24
X5=	70.00	**Y5=**	55.49
X6=	90.00	**Y6=**	50.00

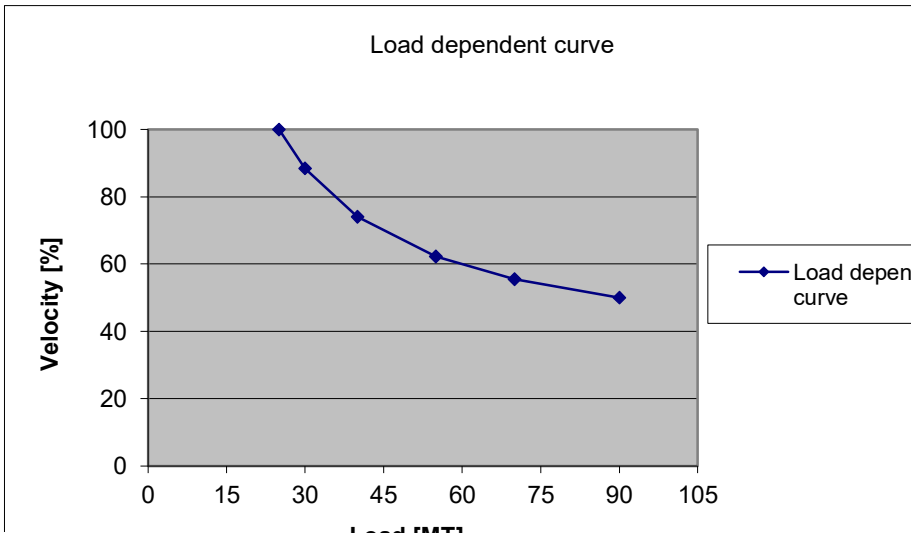


Figure 17 Load dependent curve

The calculation method of the load dependent velocity is as followed:

$$v_{SP,Load} = f(w)$$

$$v_{SP,Load} = V_x = \frac{1}{W_x} \cdot a + b \quad (1)$$

where, V_x *is Velocity (%) of the maximum velocity Fig.(16)*

W_x *is Load(MT)*

$$a = \left(V_{x,\max} - V_{x,\min}\right) / \left(1/W_{x,\min} - 1/W_{x,\max}\right) \quad (2)$$

$$b = V_{x,\max} - \left(1/W_{x,\min} \cdot a\right) \quad (3)$$

3.1.2 Automation systems

3.1.2.1 Siemens sway control

In the literature the sway control previously found in literature is only for counteracting the sway during the acceleration/deceleration of the trolley. The operator defines the cycle path manually of the crane with sway control assistance. However not only does Siemens' sway control automation system counteract the swinging motion during crane operations, it also defines the cycle path. The cycle path from the source to destination and back is partly automated. The operator remotely grabs the container and lifts the container from the AGV, thereafter the sway control system defines the cycle path until the lashing bridges of the vessel are reached. When the lashing bridge is reached the operator engages the manual operation of the crane and lowers the container till it reaches destination and releases the container. Afterwards the operator hoists the spreader until the lashing bridge is reached again, and from there the sway control system defines the cycle path which moves the trolley and spreader right above the source.

3.1.2.2 Load measurement

The load measurement is also an automation system. Cables which are attached to the spreader measure the load from four different points. When the spreader locks to the container, it automatically lifts the container up to a certain height and weighs the load so that the STS crane can determine the maximum spreader velocity it can operate with.

3.1.3. Spreader system

The spreader system in the reference case is a twinlift spreader. This spreader can lift two 20ft containers, one 40ft or 45ft container. This can be achieved by a telescoping motion of the spreader, where the spreader adjusts its length for the desired container handling operation.

The spreader uses also flipper guides which help to locate the container's corner castings. They flip down when the spreader is going to the source and flip up when the container is locked by the twistlocks.

When the spreader is landed on the container, the twistlocks lock the container spreader and release it when the destination has been reached.

3.1.4 Reference data analysis

Data from the reference crane stored in the Terminal Operation System(TOS) is used for modelling the crane movement, the velocities and positions. Considering several different jobs were also

compared with each other, to analyse the differences. The position and speed data over time were collected for the trolley and spreader. Furthermore the positions of the containers on the ship and their load were also collected. These can be found in Appendix B.1. A total of ten jobs is analysed for unloading a ship from the cargo hold to the AGV.

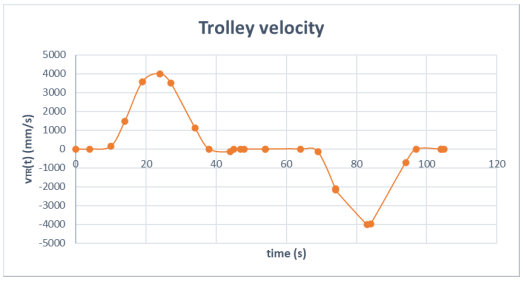
Table 13 TOS data from 1 job

w (MT):4.9 s_{TR}(mm):96084 s_{SP}(mm):6526 s_{GA}(mm): 80585

t(s)	s_{TR}(mm)	v_{TR}(mm/s)	$s_{SP,bh}$ (mm)offset	z(mm)	s_{sp}(mm)	v_{sp}(mm/s)
0	30150	0	50056	45860	4196	0
4	30150	0	50056	45100	4956	251
10	30160	145	50056	37320	12736	2411
14	33710	1482	50056	28070	21986	2380
19	46070	3566	50056	21170	28886	0
24	66030	4001	50056	21180	28876	0
27	79210	3521	50056	21180	28876	-85
34	94480	1119	50056	30050	20006	-1672
38	96450	0	50056	36610	13446	-939
44	96380	-142	50056	39420	10636	-421
45	96090	0	50056	39850	10206	-431
47	96080	0	50056	40300	9756	0
48	96080	0	50056	40310	9746	-98
54	96080	0	50056	43320	6736	-502
54	96080	0	50056	43520	6536	-51
64	96070	0	50056	37320	12736	2099
69	96060	-145	50056	26690	23366	2099
74	90830	-2098	50056	18480	31576	478
74	89150	-2176	50056	18290	31766	0
83	59110	-4010	50056	18290	31766	-88
84	55560	-3990	50056	18610	31446	-629
94	31110	-720	50056	36170	13886	-2101
97	29940	0	50056	42650	7406	-1506
104	30190	0	50056	45550	4506	-247
104	30200	0	50056	45680	4376	-251
105	30200	0	50056	45880	4176	0

Table 13 presents the data collected from job 1. The gantry does not move and the variable s_{Ga} will not change. Time (t) shows the total process time of a container handling cycle, the trolley position (s_{TR}), velocity (v_{TR}), spreader velocity (v_{SP}) and position (s_{SP}) over time. The boom height ($s_{SP,bh}$), is an offset included from the boom in the data. Also data that was included, which measures the distance from the boom to the spreader(z).

The positions and velocities of the trolley and spreader based on the data shown in Table 13 are shown in Figure 18 and Figure 19. In Figure 18 the trolley and spreader is velocity are plotted over time. The trolley makes two movements which can be explained by one positive and one negative peak in the plot, positive means a movement to the right and negative a movement to the left. For the spreader it can be seen that it makes four movements, with two positive and two negative peaks, where a positive peak means an upper hoist movement and a negative a downward movement. The small negative peak in the middle describes the pick-up process of the container.



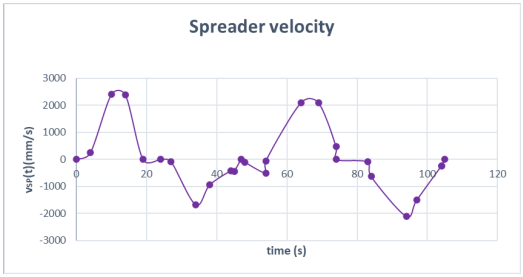


Figure 18 Trolley & spreader velocity Job 1

In Figure 19 it can be seen how the position changes over time for the trolley and spreader and that the spreader changes positions more frequently than the trolley.

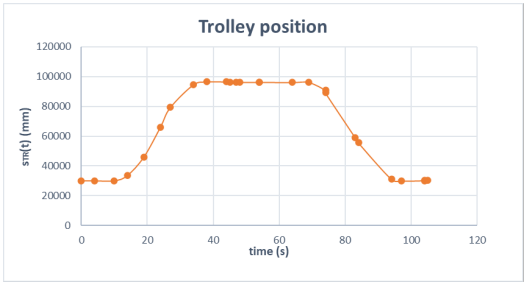


Figure 19 Trolley & spreader positions Job 1

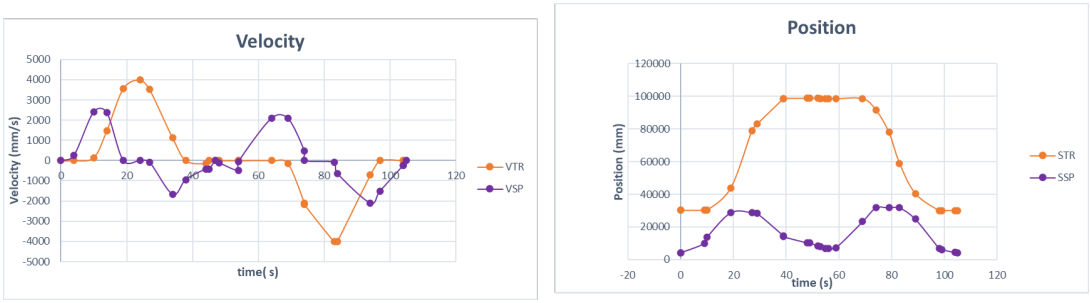


Figure 20 Trolley & hoist positions combined Job 1

In Figure 20 the velocities and positions were combined for the two components. It can be seen from the data analysis shown in Figure 20 that the operational cycle is not rectangular when the v-t graphs analysed compared to the paper from Ha and Choi(2005). Parallel movements occur for completing a handling cycle. The cycle path found from data analysis is as followed:

1. The crane starts to operate firstly with hoisting the spreader which starts to accelerate from the source.
2. When the spreader is at its maximum velocity the trolley starts to accelerate.
3. When the spreader stops moving the trolley is at its maximum speed.
4. When the trolley starts to decelerate, the spreader resumes moving downwards.
5. The trolley stops moving when the spreader is approximately at its maximum or minimum velocity.
6. Then the spreader decelerates, lands on the container and locks the container.
7. The spreader hoists upwards and starts to accelerate again hanging the container hanging underneath.
8. When the spreader reaches it maximum velocity the trolley starts to accelerate to the opposite direction.
9. When the spreader stops hoisting, the trolley is at its maximum velocity.
10. When the trolley starts to decelerate, the spreader continues, moving downwards.
11. The trolley stops moving when the spreader is approximately at its maximum or minimum velocity.
12. The spreader with the container decelerates until it reaches its destination.

This gives the following operational cycle path shown in Table 14. Describing the detailed subprocesses for the STS crane. The sway control and accelerations/decelerations are also taken into account. These subprocesses are based on the operational cycle path found in the reference case and data analysis which was conducted in Appendix B.1 from several jobs.

Table 14 Operational cycle path from crane analysis with parallel movements

1	Job start		
2	Job received from TOS		
3	**Acc.Spr hoist to boom**		
4	Con.Spr hoist to boom		
5	Dec.Spr hoist to boom	**Acc.Tr to source**	Sway.Ctrl
6	**Acc.Spr lower to source**	Con.Tr to source	
7	Con.Spr lower to source	Dec.Tr to source	Sway.Ctrl
8	Dec.Spr lower to source		
9	Lock container (Twistlock)		
10	Load measurement		
11	**Acc.Spr hoist to boom**		
12	Con.Spr hoist to boom		
13	Dec.Spr hoist to boom	**Acc.Tr to destination**	Sway.Ctrl
14	**Acc.Spr lower to destination**	Con.Tr to destination	
15	Con.Spr lower to destination	Dec.Tr to destination	Sway.Ctrl
16	Dec.Spr lower to destination		
17	Unlock container (Twistlock)		
18	Send completed job to TOS		
19	Job finish		

Acc = Acceleration, Dec= Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

The same patterns for these ten jobs were mostly similar and differences could be explained. These differences were due to corrections made by the operator during container handling movements for example hoisting too low or too high which means to adding another movement for correction. The scatterplot of these ten reference jobs for the trolley and spreader hoist are shown in Figure 21 and Figure 22.

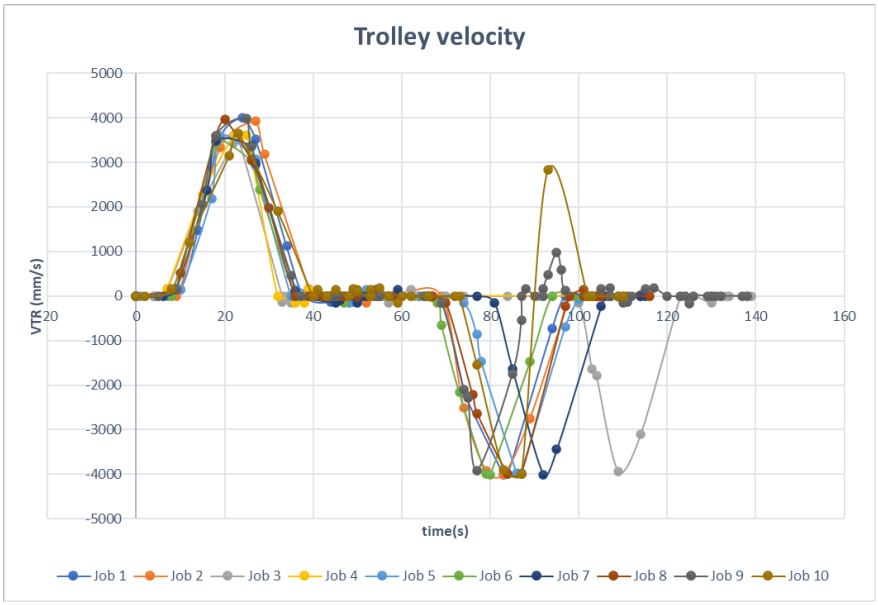
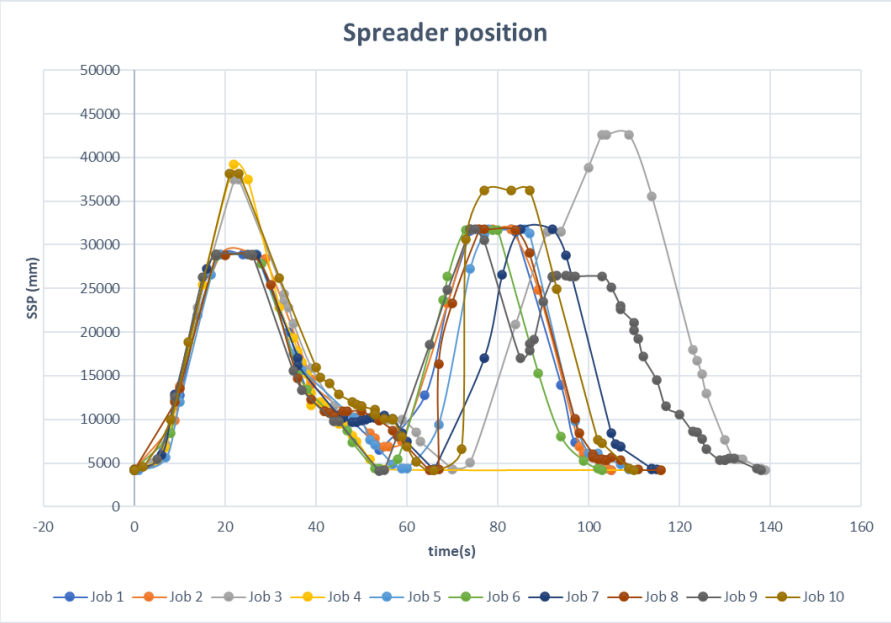


Figure 21 Scatter plot trolley of the 10 reference jobs



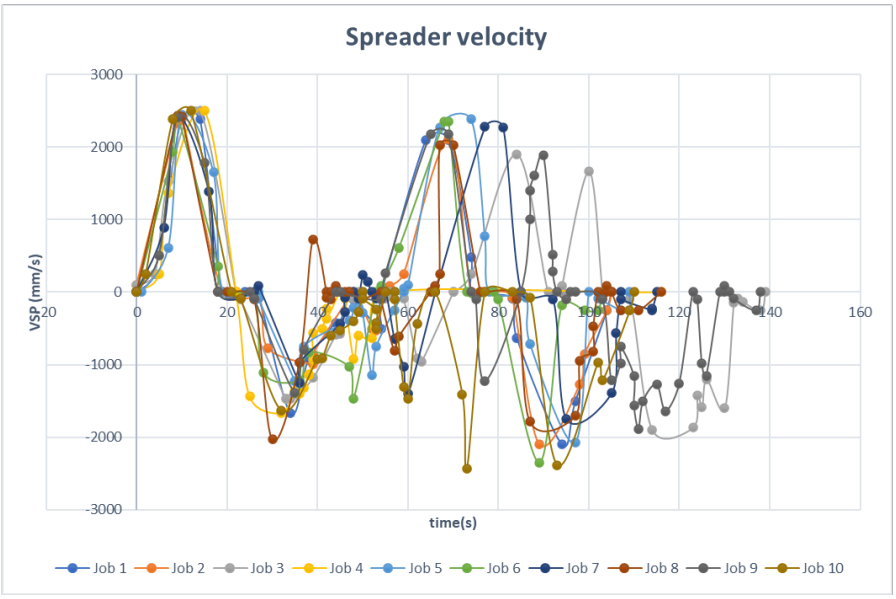


Figure 22 Scatter plot spreader hoist of the 10 reference jobs

3.2 Design criteria

The design criteria for developing a new STS crane model of the cycle time based on **Fout! Verwijzingsbron niet gevonden.**, come from literature found in chapter 2 and from experience from Siemens Cranes. These are summarised as the following:

- Vessel dimensions
    - The length, width and height of the ships are important. This also defines the size of the crane and also the specifications of the different components should have. For example the s_{TR} depends on the width of the vessel, and s_{SP} depends on the height. Vessel dimensions also have an effect on the cycle time. When larger ships are handled the cycle time is longer. The trolley and spreader have to travel a longer distance. For smaller vessels the cycle time is shorter. The cycle path also depends on whether the container is on the deck or in the hold.

- Crane specifications
    - The crane dimensions, such as the length height and width but also the acceleration/ deceleration and velocity values of the spreader and trolley have an impact on the performance.
- The cycle path of the crane.
    - The operational cycle path that the trolley and spreader follows from the source to the destination should be considered.
- The transfer points location
    - AGV lane locations
- The automation systems used in the crane operations
    - The automated systems also influence the performance of the crane. Not all automation systems are used for each project. For a truck, truck positioning system (TPS) and auto skew is used to align the spreader with the truck's chassis. For an AGV the TPS and auto skew is not needed because the AGV is more precise when it parks at the transfer location. The sway control which counter acts the swinging motion of the spreader due to the container and wind is always used.
- Horizontal transport.
    - According to literature and Siemens Cranes, the type of horizontal transport used influences the throughput. For example, the loading/unloading time on a truck takes longer than an AGV, because the truck is manually driven extra automation systems are needed for aligning the tuck with lane position of the STS crane such as the truck positioning system (TPS).

3.3 Mathematical modelling cycle time

To determine the handling cycle time of one container movement for the STS crane, the different components are modelled in process blocks. Gantry movement is out of the scope, because gantry movements does not occur between jobs.

3.3.1 Component operation time

The performance indicator for an STS crane is the cycle time is the output of the model. The cycle time is influenced by the trolley acceleration and velocity, the spreader hoisting acceleration and velocity and the position of the container in the trolley and spreader hoist direction. The spreader hoisting velocity is load dependent which means that container load also effects the performance. The time duration of the sway control which counteracts the swinging of the container is also considered. Also the twistlock time duration is taken into account, this locking mechanism which connects the spreader with the container. Furthermore the load measurement time has an effect on the performance. The mathematical modelling is based on Jongbloed (2018) modelling approach, it is based on the kinematic equations of each crane component.

The parameter inputs and output are defined as:

Inputs:
s_{TR}: trolley container position
s_{SP}: spreader container position

w: container load

Output:
t_{cyc}: cycle time

The velocity pattern is shown for the performance prediction with its inputs and outputs in Fig.22 and will be elaborated in the next subparagraphs.

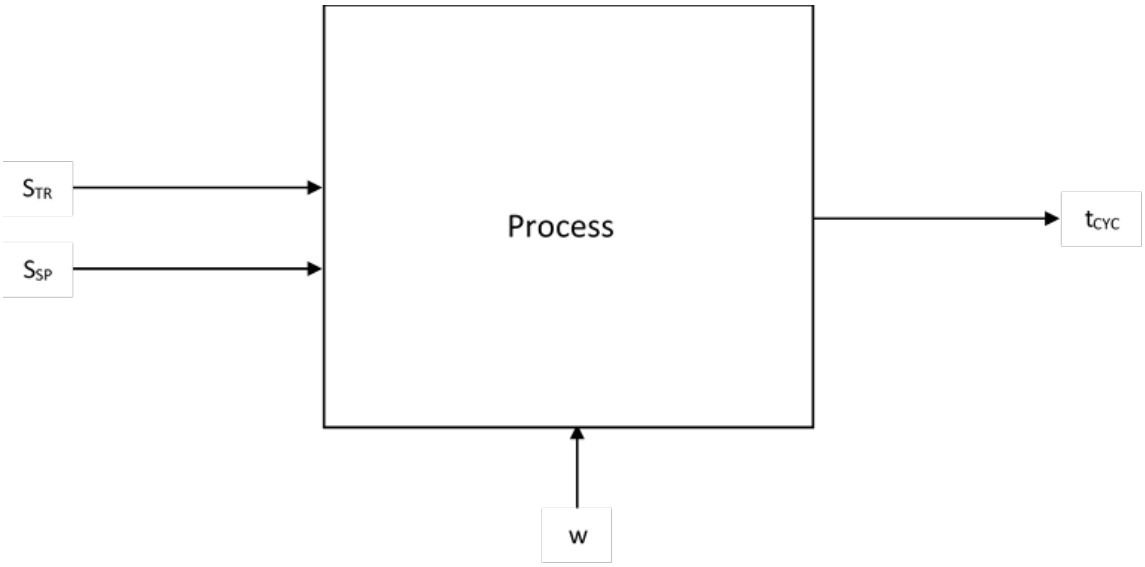


Figure 23 Process block

Trolley

The trolley follows a fixed horizontal path along the boom travelling over the land and waterside. For modelling it is assumed that the trolley moves with maximum speed when the spreader is not hoisting. The trolley movement to right which has a positive velocity profile, is modelled as the graph portrayed in Figure 24 and consists of a constant acceleration/deceleration and a maximum velocity. When the maximum velocity is reached, the velocity stays constant, and the trolley has no delays. The trolley movement to the left has a negative velocity profile and will be portrayed in the total cycle time later on.

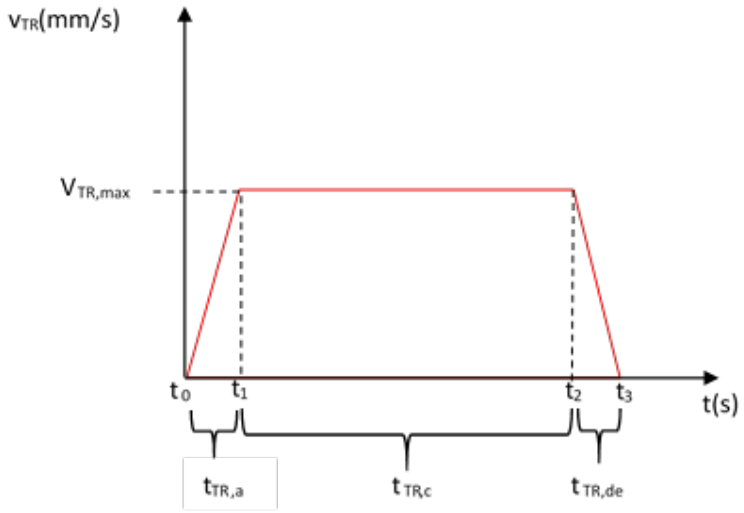


Figure 24 Velocity Pattern trolley for one trolley movement

For the cycle time calculation, the trolley accelerates from zero to maximum velocity and decelerates from maximum velocity to zero with the same value so we have:

$$a_{TR,dec} = -a_{TR,acc} \tag{4}$$

The maximum trolley velocity is calculated as followed:

$$v_{TR} = v_{TR,\max} = v_{TR,0} + a_{TR,acc} \cdot t_{TR,a} \tag{5}$$

Given that $v_{TR,0} = 0$, we have

$$v_{TR,\max} = a_{TR,acc} \cdot t_{TR,a} \tag{6}$$

The time duration of the trolley acceleration starting from standstill is:

$$t_{TR,a} = \frac{v_{TR,\max}}{a_{TR,acc}} \tag{7}$$

The time duration of the trolley acceleration starting with an initial speed is:

$$t_{TR,a} = \frac{v_{TR,\max} - v_{TR,0}}{a_{TR,acc}} \tag{8}$$

It is assumed that $t_{TR,a} = t_{TR,de}$ (9)

The distance covered by the trolley when it accelerates with an initial velocity and initial position:

$$s_{TR,a} = s_{TR,0} + v(0) \cdot t_{Tr,a} + \frac{1}{2} \cdot a_{TR,acc} \cdot t_{TR,a}^2 \tag{10}$$

The distance covered by the trolley when it accelerates with an initial velocity and initial position equal at timestep zero seconds:

$$s_{TR,0} = s_{TR,AGV}$$

$$v_{TR}(0) = 0$$

$$s_{TR,a} = s_{TR,AGV} + \frac{1}{2} \cdot a_{TR,acc} \cdot t_{TR,a}^2 \tag{11}$$

It is assumed that $s_{TR,de} = s_{TR,a}$ (12)

The time duration of the trolley travelling with constant velocity:

$$t_{TR,c} = \frac{(s_{TR} - s_{TR,AGV}) - 2 \cdot s_{TR,a}}{v_{TR,\max}} \tag{13}$$

The total cycle time for one trolley movement is defined as:

$$t_{tr} = 2 \cdot t_{TR,a} + t_{TR,c} \tag{14}$$

Spreader hoisting

The spreader is moving vertically. The hoist movements of the spreader which are positive are shown in Figure 25 consists of a constant acceleration/deceleration and a maximum velocity. When the maximum velocity is reached, the velocity stays constant, and the spreader has no delays. The

lowering movement of the spreader has a negative velocity profile and will be portrayed in the total cycle time later on.

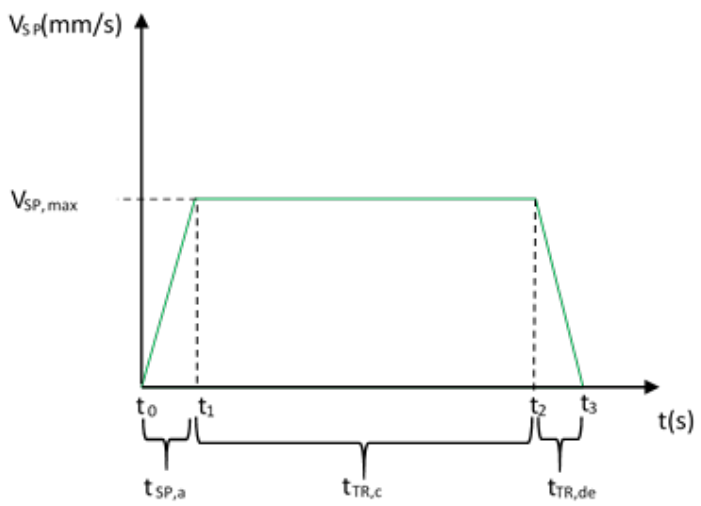


Figure 25 Velocity Pattern spreader hoisting for one spreader movement

From the operational cycle path, it is known that the spreader starts at first with its hoisting movement of the total crane movement. It has also no delays.

For the cycle time calculation, the spreader hoist accelerates from zero to maximum velocity and decelerates from maximum velocity to zero with the same value so we have:

$$a_{SP,dec} = -a_{SP,acc} \tag{15}$$

The maximum spreader velocity is calculated as followed

$$v_{SP} = v_{SP,max} = v_{SP,0} + a_{SP,acc} \cdot t_{SP,a} \tag{16}$$

Given that $v_{SP,0} = 0$, we have

$$v_{SP,\max} = a_{SP,acc} \cdot t_{SP,a} \tag{17}$$

The time duration of the spreader acceleration starting from standstill is:

$$t_{SP,a} = \frac{v_{SP,\max}}{a_{SP,acc}} \tag{18}$$

It is assumed that $t_{SP,a} = t_{SP,de}$ (19)

The time duration of the spreader acceleration starting with an initial speed is:

$$t_{SP,a} = \frac{v_{SP,\max} - v_{SP,0}}{a_{SP,acc}} \tag{20}$$

The distance covered by the spreader when it accelerates with an initial velocity and initial position:

$$s_{SP,a} = s_{SP,0} + v_{SP}(0) + t_{SP,a} \cdot \frac{1}{2} \cdot a_{SP,acc} \cdot t_{SP,a}^2 \tag{21}$$

The distance covered by the spreader when it accelerates with an initial velocity and initial position equal at timestep zero seconds to or from the vessel:

$$s_{SP,0} = s_{SP}$$
$$v_{SP}(0) = 0$$

$$s_{SP,a} = s_{SP} + \frac{1}{2} \cdot a_{SP,acc} \cdot t_{SP,a}^2 \tag{22}$$

It is assumed that $s_{SP,de} = s_{SP,a}$ (23)

The time duration of the spreader travelling with constant velocity:

$$t_{SP,c} = \frac{(s_{SP,bh} - s_{SP}) - 2 \cdot s_{SP,a}}{v_{SP,\max}} \tag{24}$$

The distance covered by the spreader when it accelerates with an initial velocity and initial position equal at timestep zero seconds to or from the AGV:

$$s_{SP,0} = s_{SP,AGV}$$
$$v_{SP}(0) = 0$$

$$t_{SP,c} = \frac{(s_{SP,bh} - s_{SP,AGV}) - 2 \cdot s_{SP,a}}{v_{SP,\max}} \tag{25}$$

The total cycle time for one spreader movement is defined as:

$$t_{SP} = 2 \cdot t_{SP,a} + t_{SP,c} \tag{26}$$

Sway control

The sway control process time is considered stochastic and normally distributed, since the sway control parameter of the reference crane is a machine performance process with random output. This automation system engages only during the acceleration and deceleration of the trolley. The acceleration or deceleration process is stopped and a constant velocity is engaged (sway control), after this constant velocity step is completed, the acceleration/deceleration is reengaged. This constant velocity's process time is found when load deflection is at maximum or minimum. This is because the angle that the load makes in relation to the trolley is equal to zero. Eleven measurements were used defining the process time acquired from the PLC file and can be found in Appendix D, Table 39. Based on a confidence interval level of 95%, the margin of error of the eleven measurements is ±0.242s. The mean and standard deviation are shown in Table 15.

Table 15 Sway control duration

Parameter	Mean μ(s)	Standard deviation σ(s)
t_{SW}	1.000s	0.4090

Twistlock

The twistlock process time is considered stochastic and normally distributed, because twistlock parameter of the reference crane is a machine performance process with random output. From the spreader system only the twistlock is used for the crane model, because it has impact on the cycle time. The telescoping and flipper guide operation engage parallelly where moving to the source. The twistlock process time is the time difference found when the twistlock unlocks and locks again. Four measurements were found in the PLC file and can found in appendix D Table 40. With a confidence interval level of 95%, the margin of error of the four measurements is ±0.244s. The mean and standard deviation are shown in Table 16.

Table 16 Twistlock process parameter

Parameter	Mean μ(s)	Standard deviation σ(s)
t_{TL}	2.3520	0.2487

Load measurement

The cables which the spreader hangs on measure from four different points the total load. When picking up a container, the spreader hoists the container to a height of 1 meter with a speed of 10% of the maximum hoisting speed of 2.5m/s. This gives a constant load measuring time of t_{TL}= 4s.

Twistlocks platform

The twistlock platform process time is a considered stochastic and normally distributed for the reason that this parameter of the reference crane is a human performance process with random output. When containers are being handled on the deck of the vessel, twistlocks are manually placed or removed in the corners of the container at the platform, so that the containers can be stacked on each other and do not fall. To describe this process, the time duration of removing or placing the twistlocks is determined by using ten measurements from PLC-traces and can be found in appendix D Table 41. Based on a confidence interval level of 95%, the margin of error of the ten measurements is ±4.709s. The mean and standard deviation are shown in Table 17 and is considered stochastic.

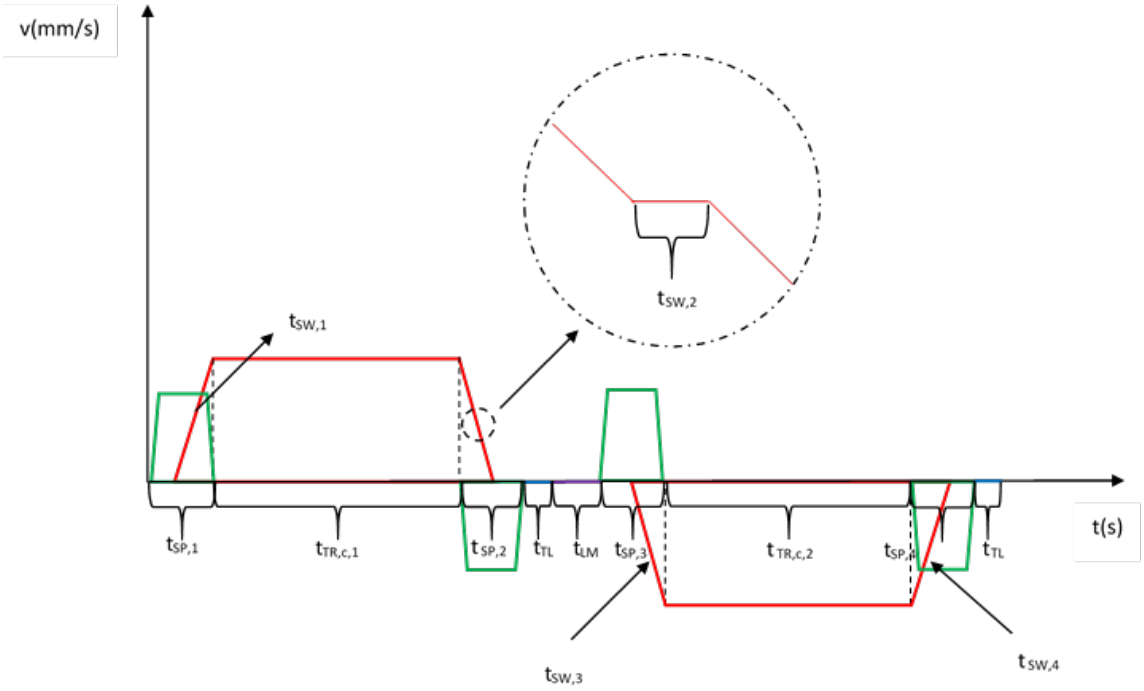
Table 17 Twistlock platform parameter

Parameter	Mean μ(s)	Standard deviation σ(s)
$t_{TL,PF}$	13.2	7.597

3.3.2 Mathematical model

Cycle time when the container is in the cargo hold with parallel movements

In **Fout! Verwijzingsbron niet gevonden.** we can see that the cargo hold of the ship is located in the bottom part of the vessel. Containers in the cargo hold are directly loaded/unloaded between the vessel and the AGV. The total cycle time consists of four spreader hoisting movements and two trolley movements for in cargo hold operations. The spreader contains two movements with a positive velocity for hoisting upwards and two movements for lowering which have a negative velocity. The trolley contains two movements which have one positive velocity for a movement to the right and a negative velocity for a movement to the left, However only the constant movements are used for calculating the total cycle time, because from data analysis we saw that trolley accelerations do not have an impact on the cycle time. The sway control automation system occurs four times and the twistlock mechanism engages two times. The time for load measuring occurs once. The total cycle time is shown in Figure 26. Note that the cycle time in Figure 26 describes the evolution of the cycle path shown in Table 14.



Trolley

Spreader

Twistlock

Load measurement

Figure 26 Velocity Pattern for the total crane with parallel movements for unloading containers from the cargo hold with sway control

Cycle time for when the container is on the deck

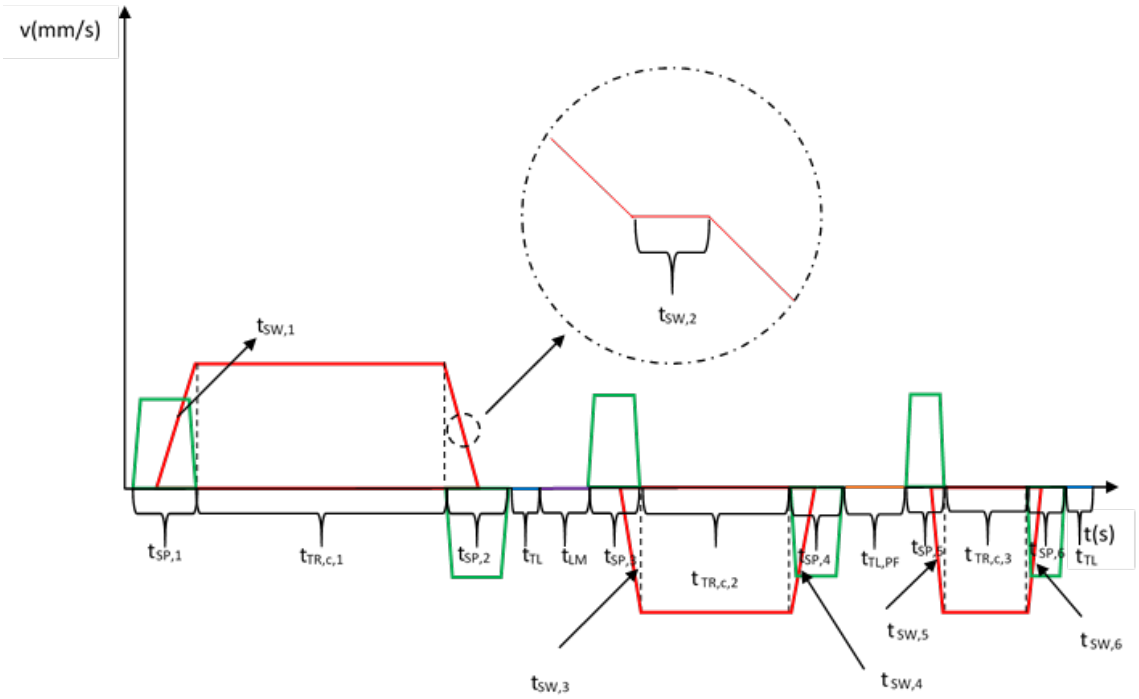
In **Fout! Verwijzingsbron niet gevonden.** we can see that the deck of the ship is located in the top part of the vessel. Containers on the deck are not directly loaded/unloaded between the vessel and the AGV, but in this case the container is placed above a platform which is between the vessel and the AGV. The twistlocks are manually placed or removed in the corners of the container at the platform. This gives a considerably larger cycle time compared to cargo hold operations. From the PLC-traces time traces can be seen used in appendix B2 how the process of unloading a container on the deck to the AGV is executed. The spreader and trolley collect the container from the deck of the ship and move it above the platform where it hovers (see **Fout! Verwijzingsbron niet gevonden.**). The twistlocks which are attached under the container are removed by hand. When this is completed the container moves to the AGV. The operational process is described in Table 18.

Table 18 Operational cycle path on deck with parallel movements

1	Job start		
2	Job received from TOS		
3	**Acc.Spr hoist to boom**		
4	Con.Spr hoist to boom		
5	Dec.Spr hoist to boom	**Acc.Tr to source**	Sway.Ctrl
6	**Acc.Spr lower to source**	Con.Tr to source	
7	Con.Spr lower to source	Dec.Tr to source	Sway.Ctrl
8	Dec.Spr lower to source		
9	Lock container (Twistlock)		
10	Load measurement		
11	**Acc.Spr hoist to boom**		
12	Con.Spr hoist to boom		
13	Dec.Spr hoist to boom	**Acc.Tr to platform**	Sway.Ctrl
14	**Acc.Spr lower to platform**	Con.Tr to platform	
15	Con.Spr lower to platform	Dec.Tr to platform	Sway.Ctrl
16	Dec.Spr lower to platform		
17	Remove Twistlocks		
18	**Acc.Spr hoist to pos.1**		
19	Con.Spr hoist to pos.1		
20	Dec.Spr hoist to pos.1	**Acc.Tr to destination**	Sway.Ctrl
21	**Acc.Spr lower to destination**	Con.Tr to destination	
22	Con.Spr lower to destination	Dec.Tr to destination	Sway.Ctrl
23	Dec.Spr lower to destination		
24	Unlock container (Twistlock)		
25	Send completed job to TOS		
26	Job finish		

Acc = Acceleration, Dec = Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

The total cycle time of the process block for handling containers on the deck consists of six spreader hoisting movements and three trolley movements, whereby only the trolley constant movements have an impact on the total cycle time. The sway control automation system occurs six times and the twistlock mechanism engages two times. On the platform the twistlocks for stacking the container are placed or removed, this happens only once per container handling. The load measuring occurs once. The total crane movement is shown in Figure 27.



Trolley

Spreader

Twistlock

Load measurement

Twistlock platform

Figure 27 Velocity Pattern for the total crane with parallel movements for unloading containers from the deck with sway control

**In Figure 27 Velocity pattern for the total crane with parallel movements for unloading containers from the deck with sway control can be seen that the total cycle time operation is much longer and consists of more spreader and trolley movements and has also the parameter t_{TL} compared to Figure 26. Table 18 has 26 steps for finishing a job for on deck operations, 7 steps more compared to 19 steps for cargo hold operations shown Table 14.*

This gives the following equation for calculating the cycle time for one container handling movement:

$$t_{cyc} = \begin{cases} f_1\left(s_{TR}, s_{SP,}, w; \sigma\right) \text{ , if } \; s_{SP} < s_{HC} \\ f_2\left(s_{TR}, s_{SP,}, w; \sigma\right), \text{ if } \; s_{SP} > s_{HC} \end{cases},$$

$\sigma \in \{0,1\}$

$\sigma = 0 \Rightarrow$ *no sway control*

$\sigma = 1 \Rightarrow$ *sway control with parallel movements*

This gives the following equation for calculating the cycle time for one container handling with parallel movements with sway control in the hold:

$$f_1 = (t_{SP,1} + t_{TR,c1} + t_{SP,2} + t_{SP,3} + t_{TR,c2} + t_{SP,4}) + 4 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} \tag{27}$$

$$f_1 = \left(2 \cdot \frac{\left(v_{SP,\max} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP,AGV}) - \frac{v_{SP,\max}^{\;2}}{a_{SP}}}{v_{SP,\max}} \right) + \left(2 \cdot \frac{\left(v_{SP,\max} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP}) - \frac{v_{SP,\max}^{\;2}}{a_{SP}}}{v_{SP,\max}} \right)$$
$$+ \left(2 \cdot \frac{\left(v_{SP,Load} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP}) - \frac{v_{SP,Load}^{\;2}}{a_{SP,Load}}}{v_{SP,Load}} \right) + \left(2 \cdot \frac{\left(v_{SP,Load} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP,AGV}) - \frac{v_{SP,Load}^{\;2}}{a_{SP,Load}}}{v_{SP,Load}} \right)$$
$$+ 2 \cdot \left(2 \cdot \frac{\left(v_{TR,\max} - v_{TR,0}\right)}{a_{TR,acc}} \cdot (1 - \sigma) + \frac{s_{TR} - s_{TR,AGV} - \frac{v_{TR,\max}^{\;2}}{a_{TR}}}{v_{TR,\max}} \right) + 4 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} \tag{28}$$

$$v_{SP,Load} = \frac{1}{W_x} \cdot a + b$$

where a nd b are defined in (2) & (3)

This gives the following equation for calculating the cycle time for one container handling with parallel movements with sway control on the deck:

$$f_2 = (t_{SP,1} + t_{TR,c1} + t_{SP,2} + t_{SP,3} + t_{TR,c2} + t_{SP,4} + t_{SP,5} + + t_{TR,c3} + t_{SP,6}) + 6 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} + t_{TL,PF} \tag{29}$$

$$f_2 = \left(4 \cdot \frac{\left(v_{SP,\max} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP,AGV}) - \frac{v_{SP,\max}^2}{a_{SP}}}{v_{SP,\max}} + \frac{(s_{SP,bh} - s_{SP}) - \frac{v_{SP,\max}^2}{a_{SP}}}{v_{SP,\max}} \right)$$

$$+ \left(4 \cdot \frac{\left(v_{SP,Load} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,bh} - s_{SP}) - \frac{v_{SP,Load}^2}{a_{SP}}}{v_{SP,Load}} + \frac{(s_{SP,bh} - s_{SP,PF}) - \frac{v_{SP,Load}^2}{a_{SP,acc}}}{v_{SP,Load}} \right)$$

$$+ \left(4 \cdot \frac{\left(v_{SP,Load} - v_{SP,0}\right)}{a_{SP,acc}} + \frac{(s_{SP,h1} - s_{SP,PF}) - \frac{v_{SP,Load}^2}{a_{SP,acc}}}{v_{SP,Load}} + \frac{(s_{SP,h1} - s_{SP,AGV}) - \frac{v_{SP,Load}^2}{a_{SP,acc}}}{v_{SP,Load}} \right)$$

$$+ \left(\frac{12 \cdot \left(v_{TR,\max} - v_{TR,0}\right)}{a_{TR,acc}} \cdot (1 - \sigma) + 2 \cdot \frac{\left((s_{TR} - s_{TR,AGV}) - 2 \cdot \frac{v_{TR,\max}^2}{a_{TR,acc}} \right)}{v_{TR,\max}} + 2 \cdot \frac{\left((s_{TR} - s_{TR,PF}) - 2 \cdot \frac{v_{TR,\max}^2}{a_{TR,acc}} \right)}{v_{TR,\max}} + 2 \cdot \frac{\left((s_{TR} - s_{TR,AGV}) - 2 \cdot \frac{v_{TR,\max}^2}{a_{TR,acc}} \right)}{v_{TR,\max}} \right)$$

$$+ 6 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{IL} + t_{LM} + t_{IL,PF}$$

(30)

3.4 Verification

The model is tested by gradually increasing the different inputs s_{TR}, s_{SP} and w one at a time. Here is expected that the output also increases. The verification tests done are for positions in the hold. These tests are shown in Table 19, Table 20and

Table 21.

Table 19 Verification trolley position

s_{TR}(m)	s_{SP}(m)	w(MT)	t_{cyc}(s)
82.500	4.027	24.0	126.867
84.938	4.027	24.0	128.260
87.376	4.027	24.0	129.653
89.814	4.027	24.0	131.046
92.252	4.027	24.0	132.440
94.690	4.027	24.0	133.833
97.128	4.027	24.0	135.226
99.566	4.027	24.0	136.613

Trolley position is gradually increased by one container width verify that the cycle time increases. This is related to the width of the vessel.

Figure 28 Trolley position verification

Table 20 Verification spreader position

s_{TR}(m)	s_{SP}(m)	w(MT)	t_{cyc}(s)
82.500	**11.800**	24.0	120.649
82.500	**9.209**	24.0	122.721
82.500	**6.618**	24.0	124.794
82.500	**4.027**	24.0	126.867
82.500	**1.436**	24.0	128.940
8.2500	**-1.155**	24.0	131.013
82.500	**-3.746**	24.0	133.085
82.500	**-6.337**	24.0	135.158

Spreader position input is gradually decreased by one container height to verify that the cycle time increases. This is related to the height of the vessel.

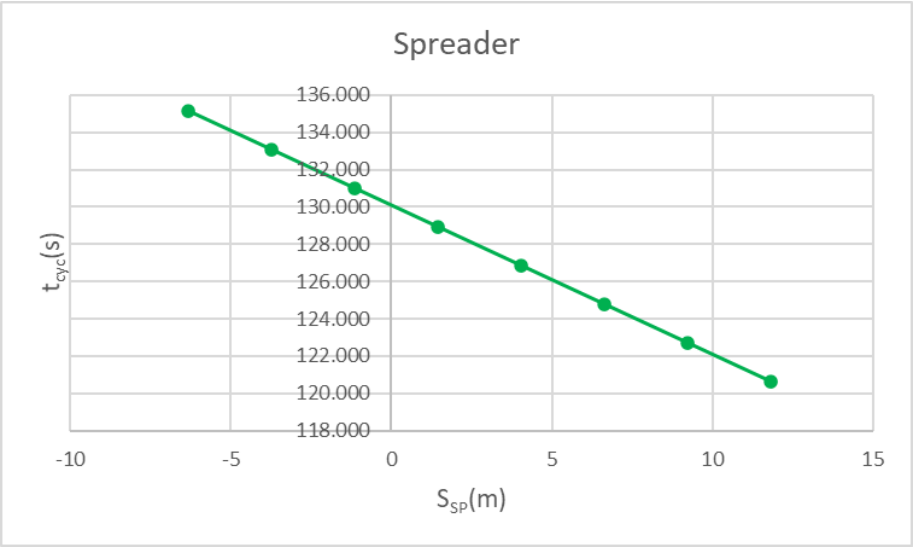


Figure 29 Spreader position verification

Table 21 Verification container load

s_{TR}(m)	s_{SP}(m)	w(MT)	t_{cyc}(s)
82.500	4.027	**16.0**	126.867
82.500	4.027	**18.0**	126.867
82.500	4.027	**20.0**	126.867
82.500	4.027	**22.0**	126.867
82.500	4.027	**24.0**	126.867
8.2500	4.027	**26.0**	127.650
82.500	4.027	**28.0**	129.191
82.500	4.027	**30.0**	130.695

The load input is gradually increased by 2 metric tons to verify that the cycle time increases.

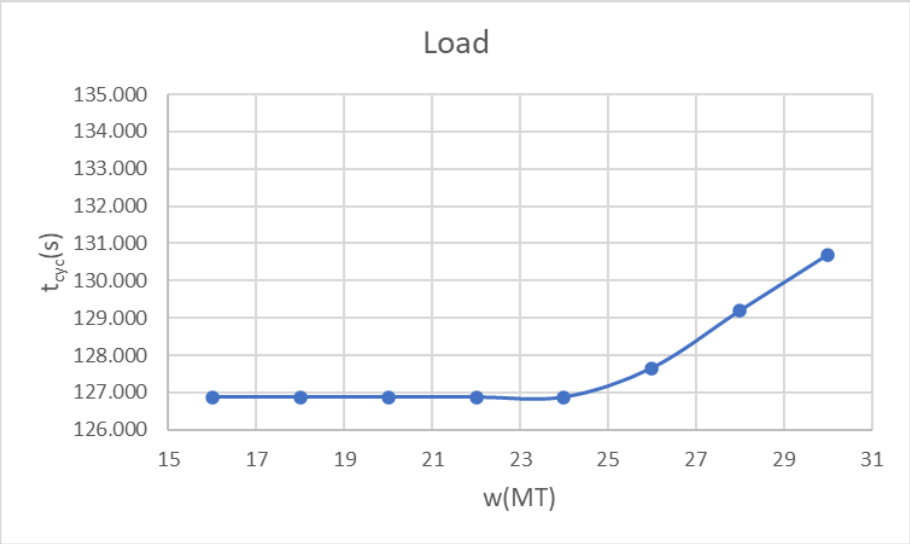


Figure 30 Container load verification

Increasing the trolley position, means that the distance between the trolley and spreader increases. This gives an increased cycle time as expected shown in Figure 28. Container operations in the hold operate below the hatching covers (S_{HC}). When the spreader position is decreased, the spreader lowers into the vessel's hold. This increases the distance between the hatching covers and the spreader. The cycle time also increases as expected and is shown in Figure 29. The cycle time also increased as expected when the load of the container is increased. In Figure 30 the spreader operates with maximum velocity when the load is does not exceed 25 metric tons as formulated in Table 12. Containers on the deck are above the hatching covers and it is also expected the same output reaction, because the model consists of the same velocity patterns but with more steps.

Furthermore In chapter 3.1.3 the new cycle path of the crane was defined from conducted data analysis. The data acquired by TOS have large timesteps, also the new cycle path still needs to be verified. Therefore PLC-traces of the trolley and spreader velocity patterns have been analysed. The data analysed from PLC traces of the movements of the spreader and trolley correlates with the new

cycle path that was obtained from data analysis. This can be seen in Appendix B.2. In Figure 40 half-cycle times are shown of the reference crane's components. This concludes that the cycle path that is used for modelling the performance output follows the same velocity pattern as the reference crane.

3.4.2 STS crane model verification and validation

The results of the process output of the new STS crane model for unloading from the deck is verified and validated by comparing it with the reference case of the automated STS crane. A total of nine jobs is used where the trolley position and container load vary, were obtained from PLC-traces for unloading from the deck and are displayed in Table 22 for the verification and validation process.

Table 22 PLC jobs for unloading of deck

Job	*Job Time*	*Weight*	*Source*		*Destination*	
		W(MT)	S_{TR}(m)	S_{SP}(m)	$S_{TR,AGV}$(m)	$S_{SP,AGV}$(m)
1	07-10-2018 12:46:00	17	80.919	24.967	30.200	4.200
2	07-10-2018 12:48:36	10	83.981	24.609	30.200	4.200
3	07-10-2018 12:50:49	7	85.594	24.558	30.200	4.200
4	07-10-2018 12:52:50	20	88.589	25.599	30.200	4.200
5	07-10-2018 12:57:52	18	94.132	25.421	30.200	4.200
6	07-10-2018 12:57:52	7	96.263	24.735	30.200	4.200
7	07-10-2018 13:00:09	9	98.697	25.061	30.200	4.200
8	07-10-2018 13:02:26	9	101.094	24.925	30.200	4.200
9	07-10-2018 13:04:26	8	103.274	24.637	30.200	4.200

For verifying the model, the mean output of every job is calculated by ten repetitions, because stochastic values were used for the automation systems and locking mechanisms. The actual output of the reference crane and predicted output of the model were compared. This is done by plotting them against each other to find the correlation seen in Figure 31. Furthermore the predicted results are compared to the actual results in Table 23. Here is the error defined as Δt_{cyc} and the error squared

as Δt_{cyc}^2. The sum of the error squared is calculated for defining the accuracy. The reason for this is that the mean error cannot be used because we have different jobs in a dataset.

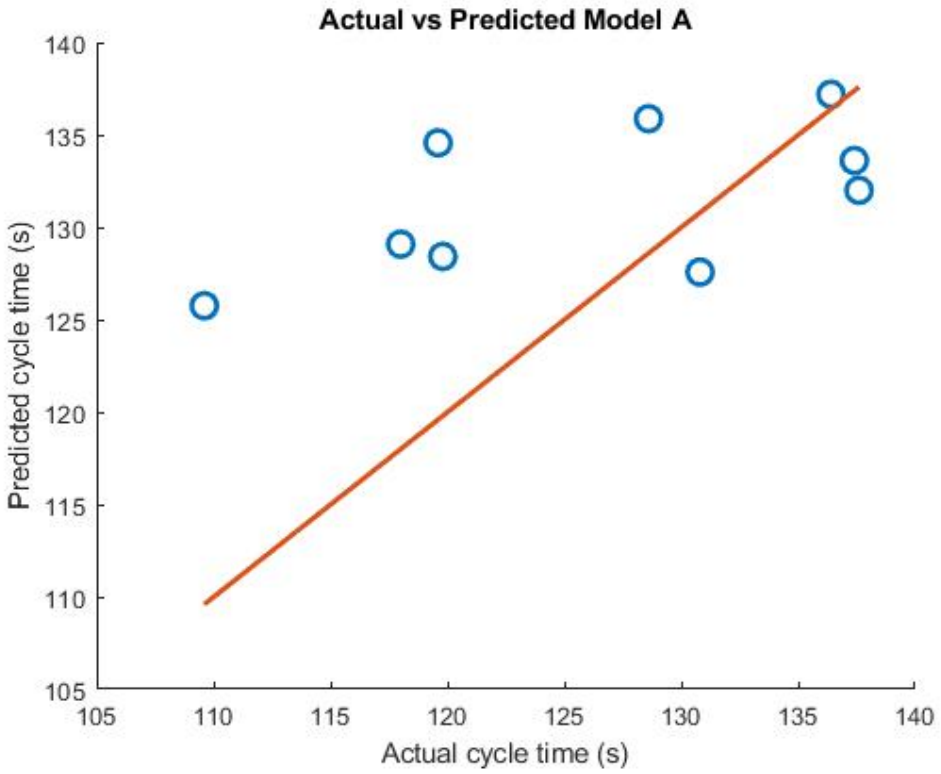


Figure 31 Actual vs predicted plot of PLC Data

Table 23 Process block output results compared to the reference case

Job	s_{TR}(m)	s_{SP}m)	w(MT)	Crane t_{cyc}(s)	Model A t_{cyc}(s)	Δt_{cyc}(s)	Δt_{cyc}^2(s)
1	**80.919**	**24.967**	**17**	**109.6**	125.760	-16.160	261.130
2	**83.981**	**24.609**	**10**	**130.8**	127.577	3.223	10.388
3	**85.594**	**24.558**	**7**	**119.8**	128.424	-8.624	74.377
4	**88.589**	**25.599**	**20**	**118**	129.089	-11.089	122.964
5	**94.132**	**25.421**	**18**	**137.6**	132.003	5.597	31.328
6	**96.263**	**24.735**	**7**	**137.4**	133.617	3.783	14.310
7	**98.697**	**25.061**	**9**	**119.6**	134.573	-14.973	224.201
8	**101.094**	**24.925**	**9**	**128.6**	135.881	-7.281	53.008
9	**103.274**	**24.637**	**8**	**136.4**	137.201	-0.801	0.642

The equation used for the calculation of the error is given in Equation 31.

$$SSE = \sum_{i=1}^{n} \left(t_i - \hat{t}_i \right)^2$$

where t_i is the actual time (31)

$\hat{t}_i$ is the predicted time

This gives the following sum error squared value of 792.349 for the analysed PLC traces output values vs the predicted output values of the new crane model A. When job 3 and job 6 are compared, we can see that they have the same load. In this case the actual results vary by around 5 seconds and the predicted results vary also around 5 seconds. This is a good approximation of the reality. However when we compare job 7 and job 8, where they also have the same load, we can see that the actual results vary around 9 seconds, while the actual results vary around 1 second. This can be explained when we look more closely into the job movements. In Appendix C the time differences is shown per process of the nine jobs. In Table 36 and Table 37 we can clearly see that biggest difference occurs in the spreader movement processes. This can be explained because the spreader is partially manually operated which results into varying cycle time outputs for the reference crane. Table 32 we see that the smallest time difference occurred during the trolley movement to its destination which was 0.003s and in Table 36 we have the biggest time difference was during lowering the spreader to the source which was 13.605s.

3.5 Conclusion

In this paragraph the question on how the performance model can be more realistic and accurate will be answered.

A New STS crane model, with automation systems and locking mechanisms is realised. Also the acceleration/deceleration of the trolley and spreader hoist have been added to the model. The sway control, twistlocks and manual twistlock placement on the platform are modelled as stochastic parameters. Data was used from the reference crane for producing these stochastic parameters, also was the reference crane used for data analysis that was conducted for defining the cycle path, this will give a more complete model compared to the model in literature.

The new model was verified and the output reacted as expected when the parameters were gradually increased. For the validation of the model a reference case attained from PLC trace analysis was used. The error between the output from the reference case and the new crane model was calculated with the sum square error(SSE). This gave an SSE 792.349, but it has to be proven if the new improved STS crane model produces a more accurate performance prediction compared to the model from Ha and Choi(2005). This will be researched in the following chapter.

4. Performance Analysis

This chapter addresses the question on how we can assess the accuracy of the new model compared to the state-of-the-art models. The cycle path and the mathematical model of the crane model in literature is described. The results of the performance prediction of the new STS crane model with parallel movements and automation systems and the model with the cycle path in sequence without accelerations/decelerations which is found in the paper of Ha and Choi(2005) is compared to find the accuracy of the new crane model. The results are verified by using the reference cranes' dataset. Furthermore sensitivity analysis is conducted to test the model's reliability and a conclusion is given

4.1 Crane model in literature

The crane model found in literature is described in this paragraph. The cycle path found in Figure 13 is used which does not contain any parallel movements between the trolley and spreader. Furthermore the crane movement is described for this particular case, using the reference crane's specifications. Ha and Choi(2005) used twistlocks operating times as well but these are fixed. However they do not consider manual operating times for placing/removing the twistlocks when container operations are on the deck. Since that is the case we use the process time from the new crane model but it will be a fixed parameter.

Cycle path

The operational cycle path found in literature is described in Table 24. This table describes the detailed subprocesses for the STS crane. These subprocesses are based on the operational cycle path found in Ha and Choi(2005), the reference case and data analysis. Clearly here can be noticed that the different handling operations are in sequence. Furthermore the trolley and the spreader hoisting velocity are considered constant and the automation subsystems are not taken in account.

Table 24 Operational cycle path from crane analysis in sequence

1	Job start
2	Job received from TOS
3	Con.Spr hoist to boom
4	Con.Tr to source
5	Con.Spr lower to source
6	Lock container (Twistlock)
7	Con.Spr hoist to boom
8	Con.Tr to destination
9	Con.Spr lower to destination
10	Unlock container (Twistlock)
11	Send completed job to TOS
12	Job finish

Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

Cycle time with movements in sequence in the case of containers on the cargo hold

In Figure 32 the velocity pattern of the crane movement for uloading a vessel is displayed. The total cycle time still consists of four spreader hoisting movements and two trolley movements, but now the trolley and spreader hoisting movements are both considered constant compared to Figure 26 which has parallel movements where only the trolley constant movements is considered constant for the calculation of the total cycle time and has the sway control system included

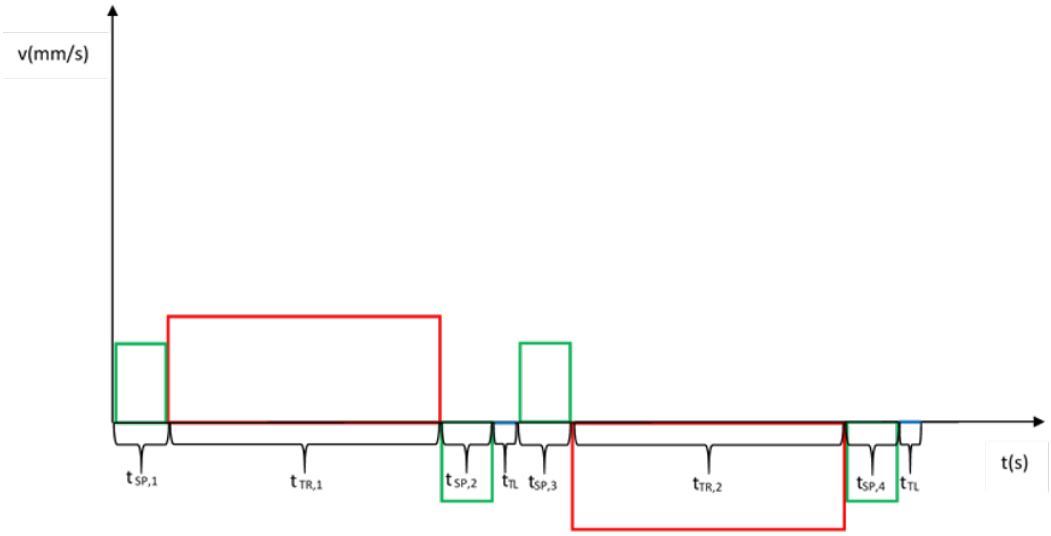


Figure 32 Velocity pattern for the total crane movement with sequential movements for unloading containers from the cargo hold

**In Figure 32 Velocity pattern for the total crane movement with sequential movements for unloading containers from the cargo hold can be seen that the total cycle time operation is much shorter and the accelerations/decelerations for the spreader and also the parameter t_{sw} are not included compared to Figure 26. Table 14 has 19 steps for finishing a job for on deck operations, 7 steps more compared to 12 steps for cargo hold operations shown Table 24.*

Cycle time with movements in sequence for on the deck

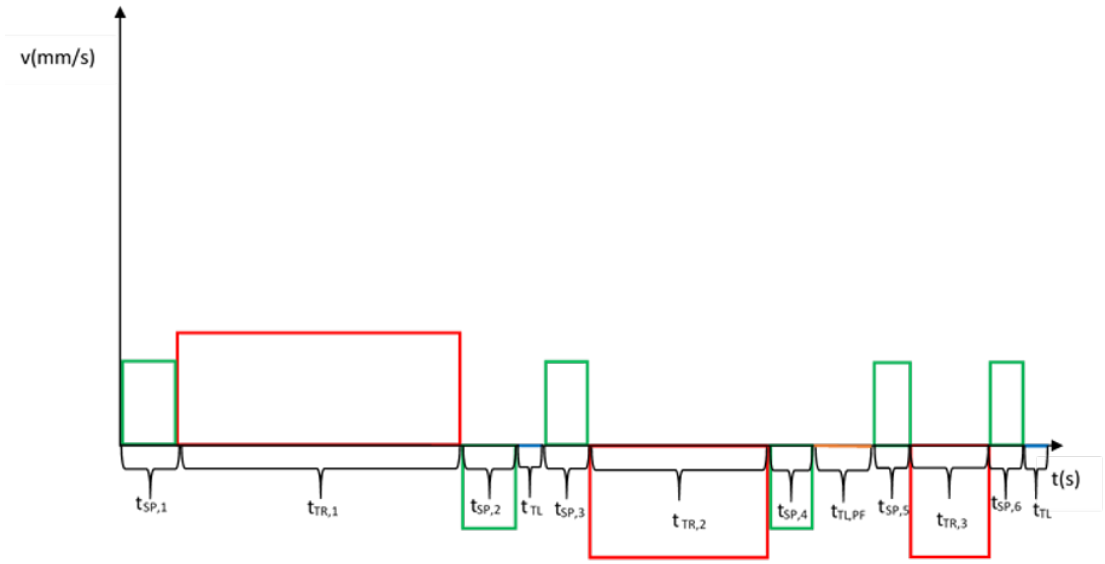
The operational process only uses constant velocities for the trolley and spreader hoist compared to the parallel movement on the deck explained previously but now the movements are in sequence and the operational process is described in Table 25.

Table 25 Operational cycle path on deck in sequence

1	Job start
2	Job received from TOS
3	**Con.Spr hoist to boom**
4	**Con.Tr to source**
5	**Con.Spr lower to source**
6	Lock container (Twistlock)
7	**Con.Spr hoist to boom**
8	**Con.Spr lower to platform**
9	Remove Twistlocks
10	**Con.Spr hoist to pos.1**
11	**Con.Tr to destination**
12	**Con.Spr lower to destination**
13	Unlock container (Twistlock)
14	Send completed job to TOS
15	Job finish

Acc = Acceleration, Dec= Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

In Figure 33 velocity pattern of the total crane movement of the total crane movement for unloading the vessel from the deck with sequential movements is shown. The total cycle time of the process block for handling containers on the deck consists now of six spreader hoisting movements and three trolley movements. Compared to Figure 27, it can be seen that the different components do not have accelerations/decelerations and the sway control system is not included. The twistlock mechanism engages two times. On the platform the twistlocks for stacking the container are placed or removed, this happens only once per container handling.



Trolley

Spreader

Twistlock

Twistlock platform

Figure 33 Velocity pattern for the total crane with sequential movements for unloading from deck

**In Figure 33 Velocity pattern for the total crane with sequential movements for unloading from deck can be seen that the total cycle time operation is also much shorter and the accelerations/decelerations for the spreader and also the parameter t_{SW} are not included compared to Figure 27 .Table 18 has 26 steps for finishing a job for on deck operations, 11 steps more compared to 15 steps for cargo hold operations shown Table 25.*

This gives the following equation for calculating the cycle time for one container handling movement:

$$t_{cyc} = \begin{cases} f_1\left(s_{TR}, s_{SP,}, w, \sigma\right) \text{ , if } \quad s_{SP} < s_{HC} \\ f_2\left(s_{TR}, s_{SP,}, w, \sigma\right), \text{ if } \quad s_{SP} > s_{HC} \end{cases}$$

$\sigma \in \{0,1\}$

$\sigma = 0 \Rightarrow$ *no sway control*

$\sigma = 1 \Rightarrow$ *sway control with parallel movements*

This gives the following equation for calculating the cycle time for one container handling with sequential movements in the hold:

$$f_1 = (t_{SP,1} + t_{TR,1} + t_{SP,2} + t_{SP,3} + t_{TR,2} + t_{SP,4}) + 4 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} \quad (33)$$

$$f_1 = \left(\frac{s_{SP,bh} - s_{SP,AGV}}{v_{SP,\max}} \right) + \left(\frac{s_{SP,bh} - s_{SP}}{v_{SP,\max}} \right) + \left(\frac{s_{SP,bh} - s_{SP}}{v_{SP,Load}} \right) + \left(\frac{s_{SP,bh} - s_{SP,AGV}}{v_{SP,Load}} \right) + 2 \cdot \left(\frac{s_{TR} - s_{TR,AGV} - \frac{v_{TR,\max}^2}{a_{TR}}}{v_{TR,\max}} \right) + 4 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} \quad (34)$$

This gives the following equation for calculating the cycle time for one container handling with sequential movements on the deck:

$$f_2 = (t_{SP,1} + t_{TR,1} + t_{SP,2} + t_{SP,3} + t_{TR,2} + t_{SP,4} + t_{SP,5} + + t_{TR,3} + t_{SP,6}) + 6 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} + t_{TL,PF} \quad (35)$$

$$f_2 = \left(\frac{s_{SP,bh} - s_{SP,AGV}}{v_{SP,\max}} + \frac{s_{SP,bh} - s_{SP}}{v_{SP,\max}} \right) + \left(\frac{s_{SP,bh} - s_{SP}}{v_{SP,Load}} + \frac{s_{SP,bh} - s_{SP,PF}}{v_{SP,Load}} \right) + \left(\frac{s_{SP,h1} - s_{SP,PF}}{v_{SP,Load}} \cdot \alpha + \frac{s_{SP,h1} - s_{SP,AGV}}{v_{SP,Load}} \right) + \left(2 \cdot \frac{(s_{TR} - s_{TR,AGV})}{v_{TR,\max}} + 2 \cdot \frac{(s_{TR} - s_{TR,PF})}{v_{TR,\max}} + 2 \cdot \frac{(s_{TR} - s_{TR,AGV})}{v_{TR,\max}} \right) + 6 \cdot t_{SW} \cdot \sigma + 2 \cdot t_{TL} + t_{LM} + t_{TL,PF} \quad (36)$$

The differences between Equation 27 and 34 is that in Equation 27 we have the acceleration and deceleration time duration of the spreader defined and in Equation 34 we only defined the constant time duration of the spreader and the trolley. This is also the case when we compare Equation 30 and 36.

4.2 Model comparison

For determining the performance prediction accuracy, the two STS crane models are used for comparison. To distinguish the two separate models they are each labelled Model A and B. Model A is the new developed crane model and Model B is the crane model based on the literature.

Model A is based on the new STS crane model which uses parallel movements and also automation systems seen in table 13 and table 18 found in Chapter 3 and is defined through Equations (26)-(30). Model B is based on the operational sequence of the crane movement which is rectangular as shown in Figure 13 described in (Ha and Choi, 2005) and discussed in Section 2.4. In this model the automation systems and accelerations/decelerations are not considered and is defined through Equations (33)-(36). Both models use the crane specifications of the reference crane for the comparison test.

The actual and predicted results are visualized in plots and are compared. These are shown in Figure 37-Figure 39. We compare the different models with the sum of the square errors (SSE) Equation 31 also used in 3.4.2 during the verification process. This will give an insight on which model is more accurate.

In Table 26 an overview of the differences is given.

Table 26 Comparison of Model A to Model B

	Model A	Model B
Automation systems	✓	×
Parallel movements	✓	×
Acceleration/deceleration	✓	×

*Model A defined in Equations (26)-(30) and Model B defined in Equations (33)-(36)

4.2.1 Comparison

To compare the models, three datasets were used: Dataset 1 is arisen from unloading the cargo hold, dataset 2 is collected from unloading containers the deck and dataset 3 of loading containers onto the deck. The different datasets inputs such as the container trolley position Y, container spreader position Z and the container weight W are also portrayed and their results of the performance prediction can be found in appendix E. Both models, A and B make use of stochastic values. Model A uses stochastic values for the automation systems, twistlock mechanisms and manually locking/unlocking the twistlocks. While model B uses only stochastic values for the manually locking/unlocking of the twistlocks. The performance prediction output results of the models mentioned in this paragraph are now approximated with the mean of thousand repetitions compared to the ten repetitions which were used for the verification process discussed in 3.4.2. Increasing the number of repetitions increases the reliability of the approximated mean.

A result comparison of Model A and B with the use of only dataset 1 is made a for automation systems, parallel movements accelerations/decelerations and parallel movements each to find out which has the most influence.

The results for only automation systems is given in Figure 34.

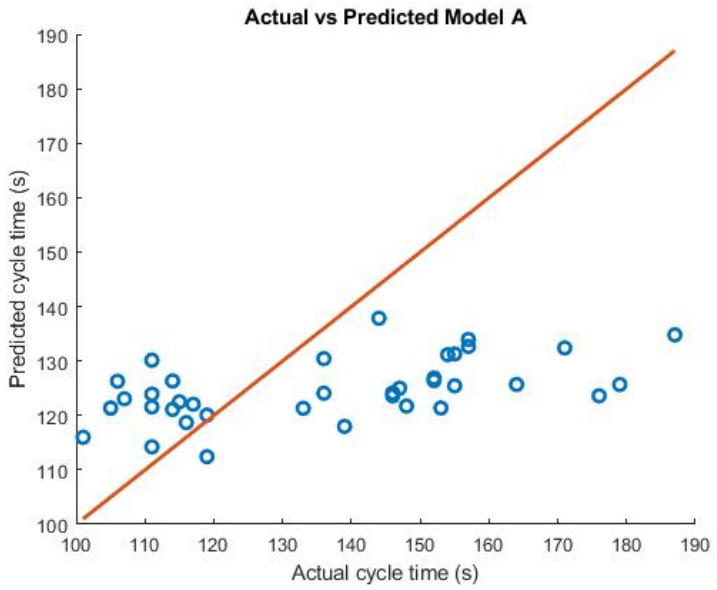


Figure 34 Model A with only automation systems

Model A only with Automation systems gives an SSE of 2.1996e+04.

The results for only parallel movements is given in Figure 35.

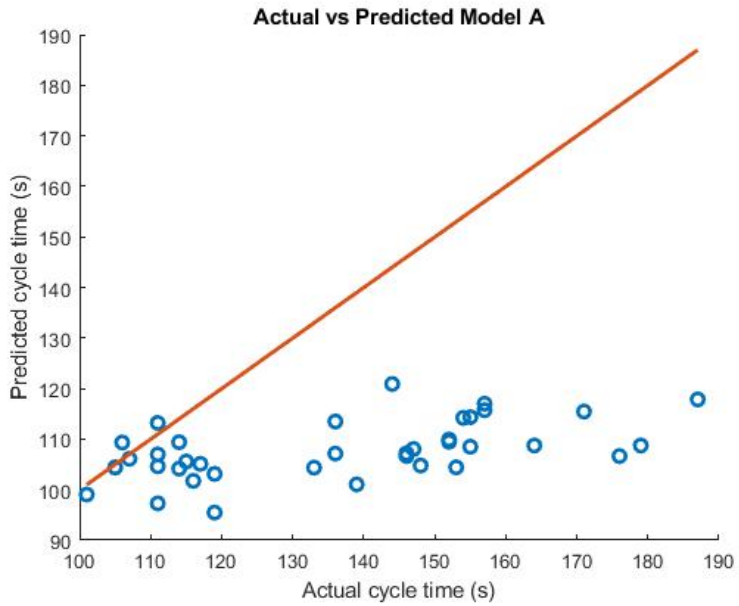


Figure 35 Model A with only parallel movements

Model A with only parallel movements has an SSE of 4.7485e+04.

The results for accelerations/decelerations is given in Figure 36.

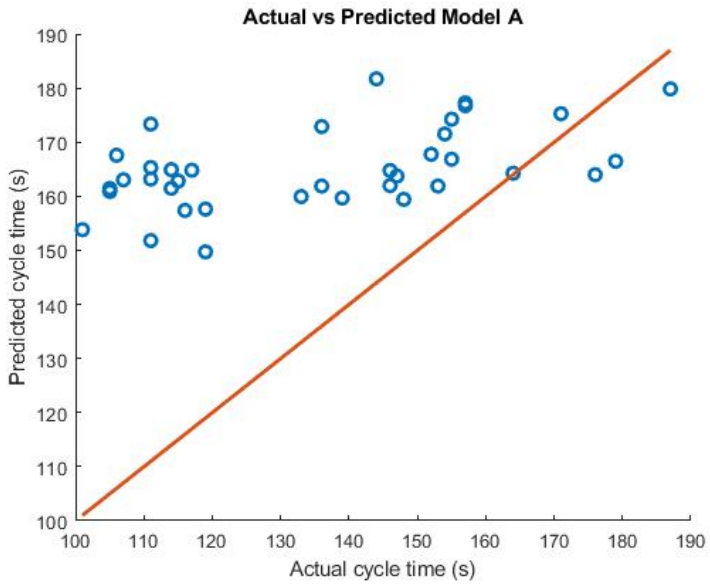


Figure 36 Model A with only with accelerations/decelerations

Model A with only with accelerations/decelerations has an SSE of 4.9008e+04

The Automation systems has the most influence which has a smaller sum squared error when compared to the parallel movements or accelerations/decelerations. When compared to model B, where the results can be seen in Figure 35 when only parallel movements or only accelerations/decelerations is considered, their SSE is larger. When only Automations systems is considered model A's SSE is smaller compared to model B. In Figure 37 can be seen when all three are combined the SSE is smaller compared to when only Automation systems is considered.

The results for dataset 1 are given in Figure 37.

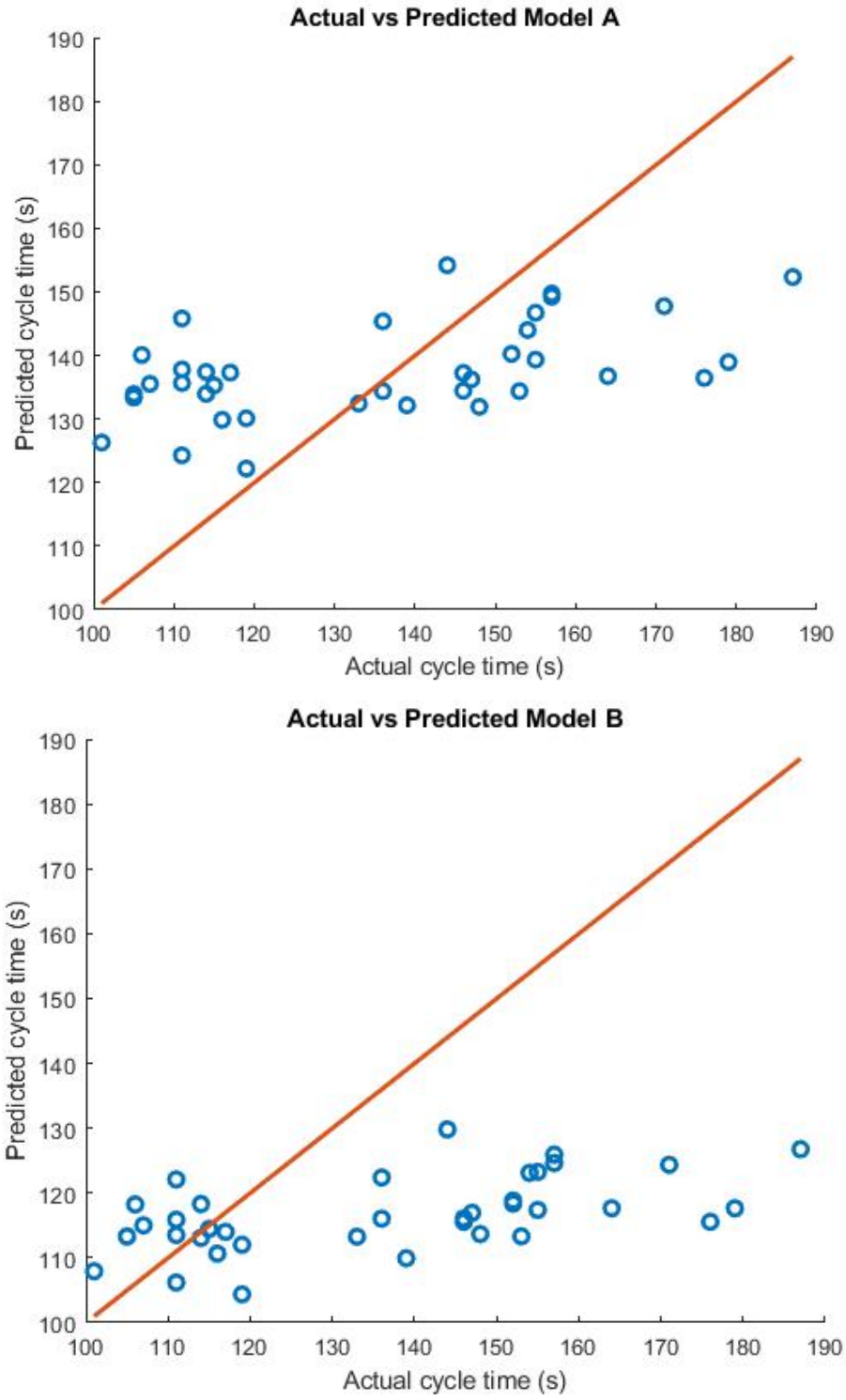


Figure 37 Actual vs predicted plots dataset 1

The sum squared error (SSE) of the thirty-eight jobs of dataset 1 for model A of is 1.67e+04 and for model B SSE 3.14e+04. This means that Model A for unloading from the cargo hold is 88.02% more accurate compared to model B, it predicts an output closer to the reference crane used in this research

For dataset 2 the results of the comparison model are given in Figure 38.

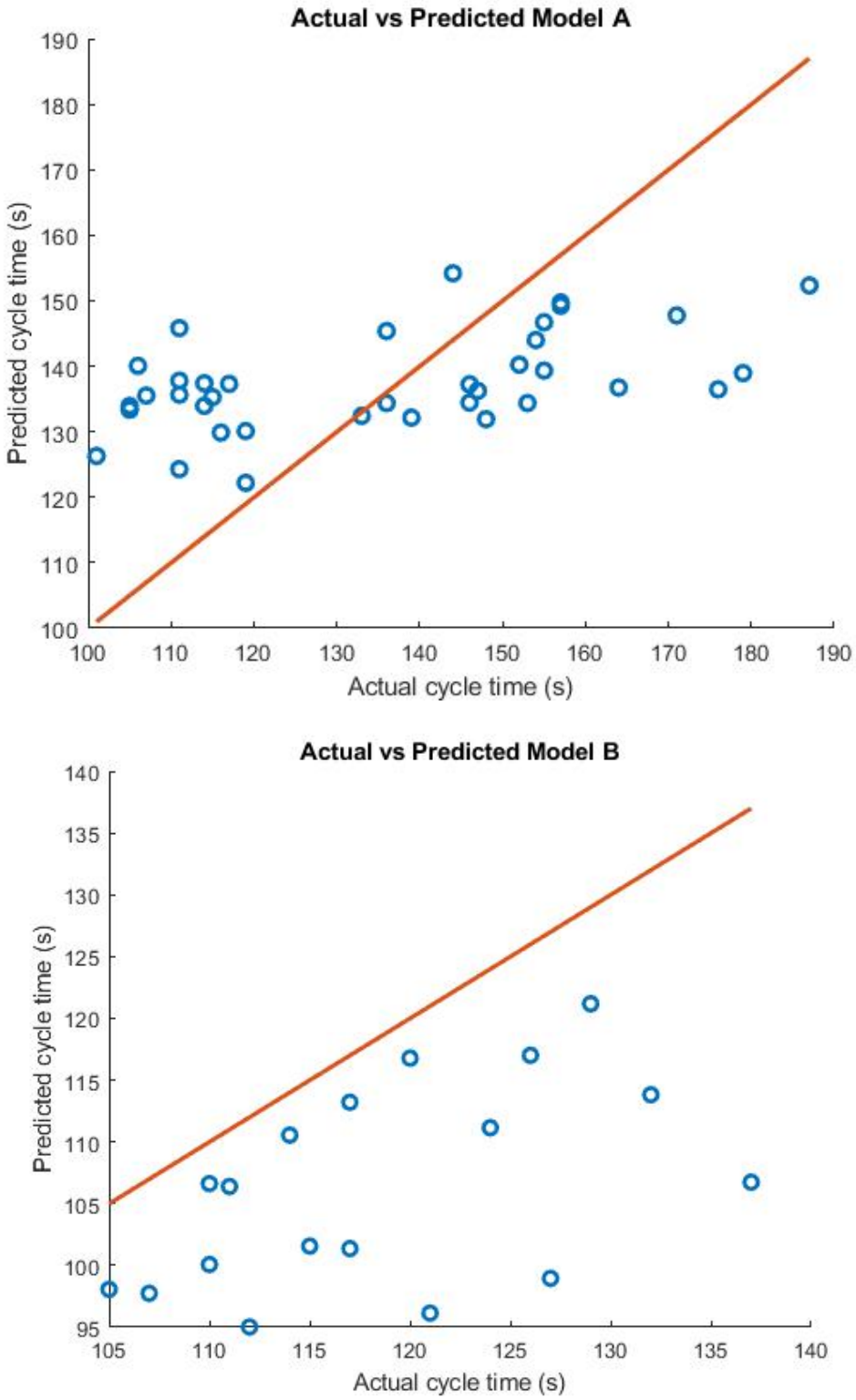


Figure 38 Actual vs predicted plots dataset 2

Model A has an SSE of 1.80e+03 for the total of eighteen jobs of dataset 2 and model B has an SSE 3.97e+03 this means that Model A for unloading from the cargo deck is 120.56% more accurate compared to model B, it predicts an output closer to the reference crane used in this research.

For dataset 3 the results of the comparison model are given in Figure 39.

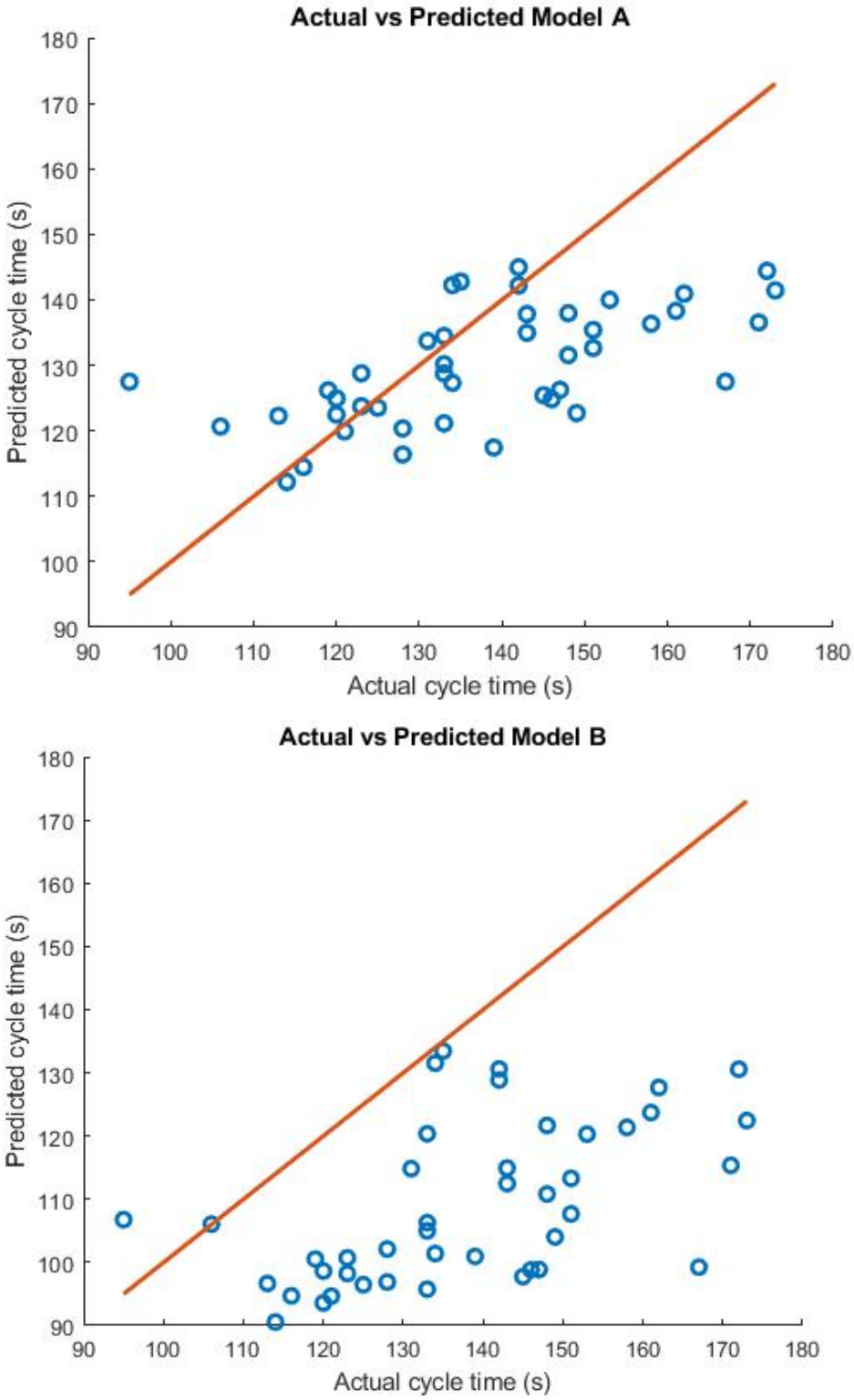


Figure 39 Actual vs predicted plots dataset 3

Model A has an SSE of 1.16e+04 for the total of forty-three jobs for dataset 3 and model B has an SSE of 4.61e+04. This means that Model A for loading from the cargo deck is 297.41% more accurate compared to model B, it predicts an output closer to the reference crane used in this research. The results of the individual jobs per datasets can be found in Appendix E.

4.2.2 Discussion

The results of the three different datasets show that Model A is more accurate compared to Model B, it predicts an output closer to the reference crane model used in this research. From the correlation plot in Figure 37, Figure 38 and Figure 39 we can see that Model A's outputs are closer to the linear line which are the actual values compared to model B's outputs for all datasets. We can see that the Model A has more values closer to the x-axis compared to model B for all datasets. Moreover the sum squared error (SSE) of all datasets is smaller for model A compared to model B. The error between model A and the reference crane can be explained when looked at the different datasets of the reference crane, jobs where the performance prediction model ought to be smaller are in fact larger. This can be explained since the crane is partially operated manually during the lifting and lowering of the load but also during on deck operations where the twistlocks are attached/removed on the platforms. Other factors that play a role are external factors like weather disturbances for example the wind. The external and the operators human factors were not taking in account in model A.

Model B has a considerably larger performance prediction for all datasets compared to model A and the reference crane. This is due to the factor that model B does no take the sway control into account which also defines the cycle path with parallel movements of the different components of the crane. Also there the external and human factor of the operator were not taken in account.

4.3 Sensitivity analysis

The output of the performance prediction model is studied by conducting a sensitivity analysis. This is done by checking how the model behaves by changing the parameters. The approach that has been used is one-at-a-time (OAT). One parameter is changed while keeping the other at their values, then the value is returned to its value. Then this step is repeated for changing each other parameter the similar method

A sensitivity analysis is done for Model A and Model B. The jobs from dataset 1 used in the performance prediction model are also used for this experiment. The trolley speed and spreader hoisting speed are used for the sensitivity analysis. The increments for the trolley velocity is 0.5s and spreader hoist velocity 0.25. Are shown in Table 27.

Table 27 Increments for sensitivity analysis

Trolley velocity increments (m/s)	*0.5*	*1*	*1.5*	*2*	*2.5*	*3*	*3.5*	*4*	-	-
Spreader velocity increments (m/s)	0.25	0.50	0.75	1	1.25	1.50	1.75	2.00	2.25	2.50

4.3.1 Results

The results of the sensitivity analysis for the trolley velocity parameter and the spreader hoist velocity parameter with their respective velocity increments are shown in Table 28 and Table 29.

Table 28 Sensitivity analysis Trolley velocity

Trolley velocity increments (s)	*0.5*	*1*	*1.5*	*2*	*2.5*	*3*	*3.5*	*4*
Model A $t_{A,cyc}$ SSE (-)	1.85e+06	3.86e+05	1.43e+05	6.70e+04	3.73e+04	2.42e+04	1.87e+04	1.67e+04
Model B $t_{B,cyc}$ SSE (-)	1.4056e+06	2.1110e+05	5.5273e+04	2.3024e+04	1.8177e+04	2.1029e+04	2.5998e+04	3.1372e+04

Model A and Model B both show an increase of the performance of the model when the trolley velocity is increment is increased. Also the error rate decreases when the velocity increment is increased

Table 29 Sensitivity analysis Spreader hoisting velocity

Spreader velocity increments (s)	*0.25*	*0.50*	*0.75*	*1*	*1.25*	*1.50*	*1.75*	*2.00*	*2.25*	*2.50*
Model A SSE (-)	2.50e+07	4.80e+06	1.60e+06	6.50e+05	2.91e+05	1.36e+05	6.49e+04	3.29e+04	2.015e+04	1.67e+04
Model B SSE (-)	1.98e+07	3.66e+06	1.14e+06	4.24e+05	1.64e+05	6.24e+04	2.50e+04	1.61e+04	2.06e+04	3.1403e+04

Model A shows an increase of the performance of the model when the spreader hoisting velocity is increment is increased. Also the error rate decreases when the velocity increment is increased. For model B showed an increase of performance till the last two parameters. The SSE started to increase from there on.

4.3.2 Discussion

For model A the SSE decreased as expected when the velocity of trolley and spreader parameter increments were increased, but for model B the SSE started to increase for the last two parameter increments for the trolley and spreader velocity parameters. This was not expected to happen for model B. This means model B is more sensitive to parameter change compared to Model A.

4.4 Conclusion

From the performance prediction results comparison for three different datasets we can conclude that Model A is more accurate than model B. Model A is the new improved STS crane model and model B is the crane model from Ha and Choi(2005) found in literature. The accuracy was determined by which model has the smaller sum squared error (SSE). Model A has a SSE which is 46.82%, 54.66% and 74.84% smaller for the different datasets compared to model B. For the sensitivity analysis, model A's SSE would decrease when the velocity parameter increments for the trolley and spreader are increased, but this was not the case for model B which was more sensitive to these changes compared to model A.

5. Conclusions and recommendations

5. 1 Conclusions

This research aimed to develop new performance prediction model for automated STS cranes. For semi-automated STS cranes automation systems should be considered to predict the performance, which are in this case the load measurement and sway control. Besides by counter acting the swaying motion caused by the load, Siemens' sway control automation system from the reference crane also defines the trajectory i.e. cycle path. However STS cranes have parallel movements but in literature the cycle path is modelled in sequence. The cycle path of the new STS crane model was determined by conducting data analysis of the operational data. Furthermore the accelerations/decelerations of the crane components are also not taken into account in literature. The accuracy of the new STS crane model is defined by comparing it with the reference crane's operational data from several real events. Different tests cases were conducted which gave the sum squared error of 1.67e+04, 1.80e+03 and 1.16e+04 respectively from the semi-automated crane's operational performance from the reference case. On the other hand when the model found in literature with no automation systems and parallel movements taken in account, predicted a performance with an sum squared error of 3.14e+04, 3.97e+03 and 4.61e+04 compared to the reference crane, which is higher than the new developed model. Model A has a SSE which is 88%, 121% and 297% smaller for the different datasets compared to model B. This shows that the developed STS crane is more accurate than the current model found in literature.

To answer the research question, it can be concluded that for deriving a new STS crane model for an automated STS crane, automation systems, parallel movements of the cycle path and accelerations/decelerations should be included when deriving a model.

The productivity of the STS crane is a key indicator and a critical component of the overall productivity of container terminals. A more complete and accurate model is now generated compared to current models in literature. This makes Siemens now able to predict a more accurate performance for automated container terminals during the offer phase. Furthermore the model can be used for different STS cranes by changing the crane specifications or adding/removing process blocks and automation systems.

5.2 Recommendations

Further research is required for determining the input of the crane operator. The human factor by the crane operator was not taken in account the development of the new STS crane model. In the different cases it was obvious that the performance output varies considerably of the reference crane. For example certain jobs that should have a shorter cycle-time tend to take longer and vice versa. This causes different performance outputs for the prediction model when compared to the actual

performance of the reference crane. The new crane model can be more accurate if the human factor and the environmental disturbances (e.g. wind) are taken into consideration.

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Appendix A: Scientific Research Paper

Performance prediction model for automated Ship-to shore cranes

A. Nuur[1], ir. D. Wagenaar#[2] , dr.V. Reppa*[3],prof. Dr. R.R. Negenborn*[4]

[1]A.Nuur@student.tudelft.nl

#Cranes, Siemens Netherlands N.V.
Pr. Beatrixlaan 800, 2595 BN Den Haag, the Netherlands
[2]Douwe.Wagenaar@siemens.com

*Department of Marine Transport Technology, Faculty of 3ME
Mekelweg 3, 2628 CD Delft, the Netherlands
[3]V.Reppa@tudelft.nl
R.R.Negenborn@tudelft.nl

Abstract: *This paper presents the design of a performance prediction simulation model for an ship-to-shore crane. Current STS crane models do not take new trends in container terminal operations into account like automation. These models do not predict the performance accurately. This can lead to logistical and financial consequences. Automation systems that are present in the cranes should be taken into account when modelling. State-of-the-art models do not model the cycle path of the crane accurately, crane components are modelled in sequence while in real life the movements between the crane components are parallel. Moreover what is not included in these models are the accelerations/decelerations of these different components of the STS cranes. A new STS crane model is developed that consists of process blocks and all the lacking points. Data was used from a reference crane to verify and validate the new model. To evaluate the performance of the proposed prediction model, a comparison has been made with existing prediction models.*

Keywords: Ship-to-shore container cranes, performance prediction modelling, automation, cycle path, cycle time

I. INTRODUCTION

The Automated Container Terminal (ACT) shown in Fig.1 is an indispensable link in the global supply chain. The ACT consists of the Ship to shore cranes (STS), yard cranes and Automated Guided Vehicles (AGVs). The STS cranes operate on the quay area and load/unload containers from or on the ship. The yard cranes operates on the container storage area and store the containers in the intermediate storage facilities before they are transported to their final destinations. The AGVs operate on the quay, transportation and container storage area, enabling horizontal transport of the containers between these different areas. Furthermore, trucks or trains operate in the hinterland for external transportation. Container trade increased significantly over the years. The container handling sector is very competitive. Terminals attract volumes as high as they can handle. Due to these high volumes, prices of container handling decrease while labor costs increase. To tackle these challenges various studies of automation of container terminals have been conducted (Hoshino et al.,2006).

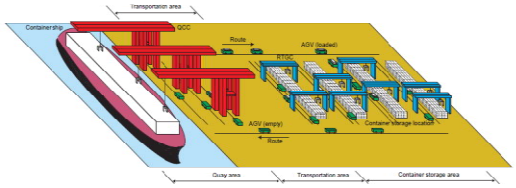

Figure 1 Automated container terminal (ACT) (Hoshino et al., 2006)

The current automation advances made in container terminals have not been implemented yet in STS crane models. Current simulation models found in literature do not take automation systems into consideration for predicting the performance of automated container terminals. These systems influence the performance of the STS crane, therefore automation systems are indispensable for crane modeling. Furthermore current models do not consider the parallel movements of the different components of the STS crane. In reality the trolley and spreader which are components of the crane, move parallelly but in literature the crane motion is simplified and the components are operated in sequence. When these factors are not considered, the predicted performance model does not describe the system in practice, which makes these model output less accurate. Moreover the STS crane is the most important equipment in the Automated Container Terminals (Tang, 2010). The rate at which containers are handled through the terminal is a key

performance indicator. Especially the productivity of the STS crane notably influences the overall performance of the container terminal (Jonker et al, 2019). Implementing current performance prediction models for semi-automated cranes show deviations of the predicted performance output is compared to the actual output. As a result this can have serious logistical and financial consequences for the container terminal.

The STS crane, consists of three main dynamic mechanisms, the gantry, trolley and spreader. The Gantry travels along the x-axis, the trolley traverses the spreader in the Y-axis and the spreader which hoists and lowers the container in the Z-axis. STS cranes in the current state are semi-automated. Since STS cranes are required to be larger, quicker, safer, more efficient and to save costs, some handling processes have been automated (Zrnić et al, 2010). In fact most of the crane movements are automated except for the last steps of the process. These steps are grabbing or releasing the container from source or destination. This is done by the operator who is not located close to the crane but operates the crane remotely from a control station. Automation continues to evolve for increasing the productivity of container terminals (Zrnić et al, 2010). Fully automation is a step closer to autonomous control of STS cranes and other port equipment. This makes it possible in the near future to completely replace the operator with an intelligent controller (control agent) without major changes to the existing cranes. Zrinc et al discussed the current and future state of quay cranes is shown by their degree of automation. We have the conventional cranes which are manually operated and the performance depends mainly on the human factor. The semi-automated cranes, this is the state-of-the-art crane which is equipped with advanced control systems and sensors to enhance the performance. For example the sway control is automated so that the operator can focus on other parts of the process. Finally the automated crane. These are cranes of the future and are autonomous. They use intelligent control and measurement systems to operate (Zrnić et al, 2010).

The objective of this paper is to derive a prediction model of the performance of an STS crane with respect to cycle time. This is done by incorporating the automation systems and parallel movements between the different components of the STS crane.

II RELATED WORK

A Current ACT models

There have been numerous studies conducted on automated container terminal modelling. Liu et al.(2002) designed, simulated and evaluated an automated container terminal to make existing facilities more efficient. Vis and Harika (2004) made a comparison study of automated guided vehicles and automated lifting vehicles. Yang et al.(2004) also compared automated lifting vehicle (ALV) to an automated guided vehicle. Xin et al.(2014) made simulation study on how the performance of automated container terminals can be improved in an energy efficient way by improving the handling capacity. Kavakeb et al.(2015) designed a simulation model of an European container terminal layout using real data from this terminal as a case study to see the effects of new intelligent vehicle types called intelligent autonomous vehicles (IAVs) on the performance and total cost. Choi (2004) studied the container terminal resources by simulating the different modeled process. Bielle et al.(2006) made an object oriented simulation model of an container port distribution using real data of an existing container terminal in Casablanca for giving more insights for improvement. Taner et al.(2014) made a simulation model of four common terminal layouts, these have been modeled and compared to research on how the layout influences the performance of the terminal. Lin et al.(2013) made a simulation model which considers the cost for investing in designing of the Humen Port container terminal for different cranes and ship types

B Current STS crane model

Ha and Choi (2005) conducted a study on STS crane modeling. They compared the effect of four different STS cranes (single trolley/ dual trolley/ double trolley /supertainer) on the productivity of the terminal process. A simulation-based performance model was made by gradually increasing the vehicle fleets velocity. These STS cranes load and unload following a different cycle path shown in Fig.2 which is rectangular and in Table 1.

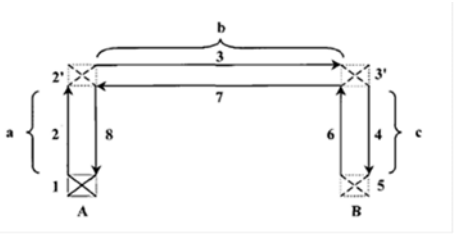

Figure 2 Cycle path(Ha and Choi, 2005)

Table 1 Path direction (Ha and Choi, 2005)

Division	Applies to	Primary work path
Single	trolley	1 (apron)→2→3→4→5→6→7→8
Dual	1st trolley	1 (buffer)→2→3→4→5→6→7→8
Double	1st, 2nd trolley	1 (apron)→2→3→4→5→6→7→8
Vertical circulation	Traverser	2 '→3'→3'→7

C Performance Influencers

The parameters used in modelling these ACT models found in literature did not use accelerations/decelerations for the trolley and spreader hoist components and additionally did not use the velocity for the spreader hoist.. Some papers did not use velocities or accelerations/decelerations at all and instead used moves per hour instead for modeling or used the cycle time in a certain distribution which in fact the cycle time is how the performance should be characterized. Ha and Choi(2005) was the only paper which only focused solely on different STS crane models compared to the other models which focus on ACT's where the different velocities of the trolley and spreader were used and moreover distinguished different velocities for these components when they are carrying a load or not, however in the study of Ha and Choi(2005) the accelerations/decelerations were also not used and the cycle path was modeled in sequence, while Jordan(2002) clearly states that crane operations for trolley and spreader are parallel. When we want to achieve a more accurate model, the accelerations/decelerations, parallel movements and automation systems should be taken into account. In Table 2 the parameters found in literature is given.

Table 2 Overview parameters found in literature

STS crane	Parameter
Trolley	Velocity
Spreader hoist	velocity
Locking/unlocking container	Time

D Process handling cycle

The general processes of the STS Crane for completing a container handling cycle are similar to the yard crane process described by Jongbloed (2018) is shown in Fig.3, the sum of these processes is the total cycle time of the STS Crane. The subprocesses also have been mentioned for executing the main processes.

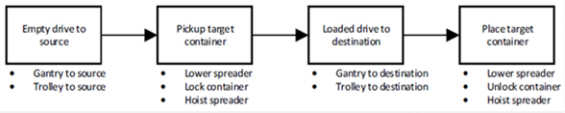

Figure 3

II. PROBLEM STAEMENT

The reference case from an STS crane project of Siemens is used to verify and compare the new STS crane model. Actual performance data is used from unloading a vessel from the cargo hold to the AGV, from the deck to the AGV and loading a vessel from the AGV to the deck. Each crane is assigned to one lane, therefore the crane has one destination and other lanes are not taken in account during the calculation. Operational data of the STS crane is given by the terminal operational system (TOS). The goal is to design a prediction performance model based on the following design criteria:

- Vessel dimensions
- Crane specifications
- The cycle path of the crane.
- The transfer points location
- The automation systems that are located on the crane.
- Horizontal transport.
- Job scheduling

Technical specifications crane are shown in Table 3, the hoisting velocity is load dependent, for the trolley this not the case. The spreader system used in the reference case uses is a twinlift spreader. This spreader can lift two 20ft containers, one 40ft or 45ft container. A schematic view of the reference crane is portrayed in Fig.4. The AGV lane 1 position (only lane which the AGV's of this crane operated on), the platform where the twistlocks are removed or attached manually and the location on the ship which is located on the deck or in the hold are shown.

Table 3

COMPONENT	VELOCITY	ACCELERATION
1 SPREADER	25 ton at 2.5 m/s	0.6 m/s^2
	90 ton at 1.25 m/s	0.6 m/s^2
2 TROLLEY	4 m/s	0.9 m/s^2
3 GANTRY	0.75 m/s	0.15 m/s^2

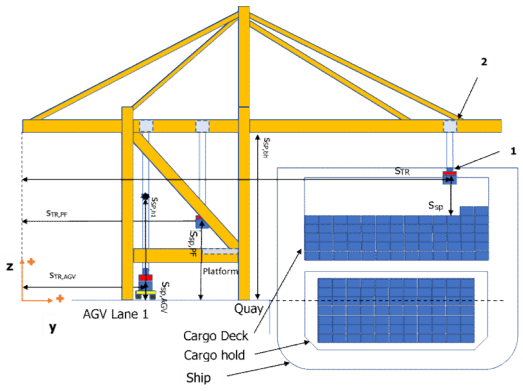

Figure 4 Schematic side view reference case

The automation systems of the reference crane are:

- Sway control is used to counter act the swaying motion of the container load and also defines the cycle path.
- Load measurement is used for weighing the load on the spreader hoist component

III. STS CRANE MODELING

The performance indicator for an STS crane is the cycle time, which also is the output of the model. This cycle time is influenced by:

1. the trolley acceleration and velocity
2. the spreader hoisting acceleration and velocity
3. the position of the container in the trolley and spreader hoist direction

The spreader hoisting velocity is load dependent which means that container weight also influences the performance. The time duration of the sway control which counteracts the swinging of the container is also considered. The twistlock time duration, this locking mechanism which connects the spreader with the container is considered as well. Furthermore the load measurement time has an effect on the performance.

The parameter inputs and output are defined as see(Fig.5):
Inputs: s_{TR}: trolley position container(horizontal position of the container in the ship)
s_{SP}: spreader position container(vertical position of the container in the ship)
w: weight of the container
Output: $t_{cyc:}$ cycle time

The process block is shown for the performance prediction with its inputs and outputs in Fig.5 and will be elaborated in the next subparagraphs.

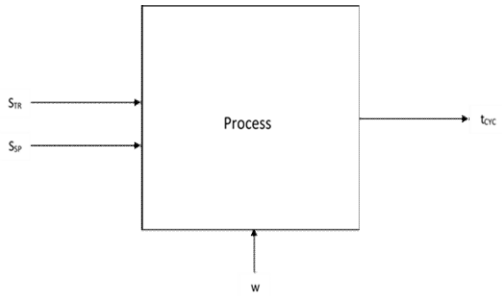

Figure 5 Process block

The trolley follows a fixed horizontal path along the boom travelling over the land and waterside. For modelling it is assumed that the trolley moves with maximum velocity when the spreader is not hoisting. The trolley movement cycle time portrayed in Fig.6 is calculated as the sum of the constant velocity ($t_{,TR,c}$) and acceleration/deceleration ($t_{TR,a}$, $t_{TR,de}$) process times. The trolley has no delays.

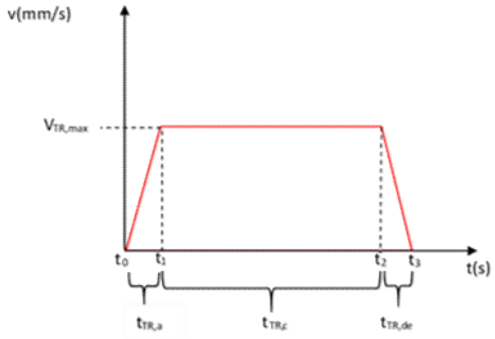

Figure 6 Velocity Pattern trolley for one trolley movement

The spreader is hoisted and lowered vertically. These movements cycle time shown in Fig.7 is calculated as the sum of the constant velocity ($t_{,SP,c}$) and acceleration/deceleration ($t_{SP,a}$, $t_{SP,de}$) process times. The spreader also has no delays.

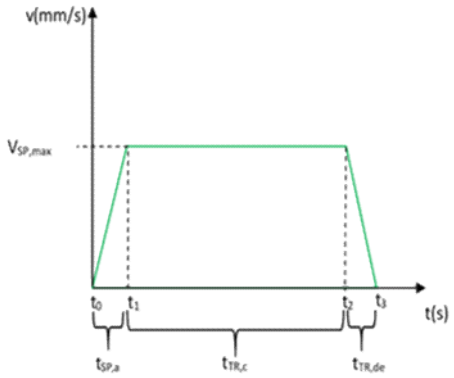

Figure 7 Velocity Pattern spreader hoisting for one spreader

The automation systems and locking mechanisms measurements were acquired from the terminal operational system and PLC trace files were used. The sway control, twistlocks and manual twistlock placement on the platform are modeled as stochastic parameters. The automation systems are shown in Table 4, the process time of the sway control is normally distributed and. For the locking mechanisms, the process time of the twistlocks is normally distributed and the twistlocks on the platform are also normally distributed. The load measurement process time is constant and is shown in Table 5.

Table 4 Sway control parameter

Parameter	Mean μ(s)	Standard deviation σ(s)
Sway control	1.000s	0.4090
Twistlock	2.3520	0.2487
Twistlocks platform	13.2	7.597

Table 5 Load measurement

Parameter	Time (s)
Load measurement	4

The operational cycle path of the STS crane was acquired by data analysis of the TOS. This gives the operational cycle path for crane operations in the cargo hold shown in Table 8. The table describes the detailed subprocesses for the STS crane. The sway control, accelerations/decelerations and parallel movements are also taken into account.

Table 6 Operational cycle path in the hold from crane analysis with parallel movements for Model A

1	Job start		
2	Job received from TOS		
3	Acc.Spr hoist to boom		
4	Con.Spr hoist to boom		
5	Dec.Spr hoist to boom	Acc.Tr to source	Sway.Ctrl
6	Acc.Spr lower to source	Con.Tr to source	
7	Con.Spr lower to source	Dec.Tr to source	Sway.Ctrl
8	Dec.Spr lower to source		
9	Lock container (Twistlock)		
10	Load measurement		
11	Acc.Spr hoist to boom		
12	Con.Spr hoist to boom		
13	Dec.Spr hoist to boom	Acc.Tr to destination	Sway.Ctrl
14	Acc.Spr lower to destination	Con.Tr to destination	
15	Con.Spr lower to destination	Dec.Tr to destination	Sway.Ctrl
16	Dec.Spr lower to destination		
17	Unlock container (Twistlock)		
18	Send completed job to TOS		
19	Job finish		

Acc = Acceleration, Dec= Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

The total cycle time of the process block consists of four spreader hoisting movements and two trolley movements. The spreader contains two movements which have a positive velocity for hoisting upwards and two movements for lowering which have a negative velocity. The trolley contains two movements which have one positive velocity for a movement to the right and a negative velocity for a movement to the left, whereby only the trolley constant movements have an impact on the total cycle time. The sway control automation system occurs four times and the twistlock mechanism engages two times. The time for the load measuring occur once. The total crane movement is shown in Fig.10. The cycle path for container operations on the deck is described in Table 9.

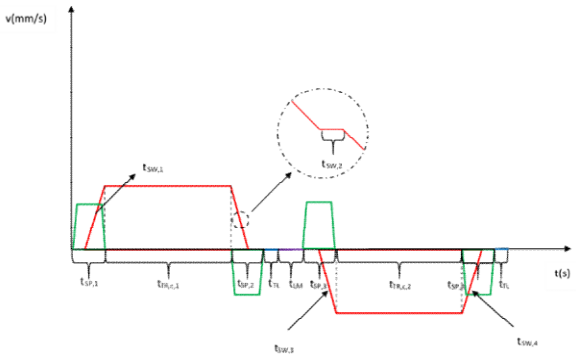

Figure 10 Velocity Pattern for the total crane with parallel movements for unloading containers from the cargo hold with sway control

Table 7 Operational cycle path on deck with parallel movements for Model A

1	Job start		
2	Job received from TOS		
3	Acc.Spr hoist to boom		
4	Con.Spr hoist to boom		
5	Dec.Spr hoist to boom	Acc.Tr to source	Sway.Ctrl
6	Acc.Spr lower to source	Con.Tr to source	
7	Con.Spr lower to source	Dec.Tr to source	Sway.Ctrl
8	Dec.Spr lower to source		
9	Lock container (Twistlock)		
10	Load measurement		
11	Acc.Spr hoist to boom		
12	Con.Spr hoist to boom		
13	Dec.Spr hoist to boom	Acc.Tr to platform	Sway.Ctrl
14	Acc.Spr lower to platform	Con.Tr to platform	
15	Con.Spr lower to platform	Dec.Tr to platform	Sway.Ctrl
16	Dec.Spr lower to platform		
17	Remove Twistlocks		
18	Acc.Spr hoist to pos.1		
19	Con.Spr hoist to pos.1		
20	Dec.Spr hoist to pos.1	Acc.Tr to destination	Sway.Ctrl
21	Acc.Spr lower to destination	Con.Tr to destination	
22	Con.Spr lower to destination	Dec.Tr to destination	Sway.Ctrl
23	Dec.Spr lower to destination		
24	Unlock container (Twistlock)		
25	Send completed job to TOS		
26	Job finish		

Acc = Acceleration, Dec = Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

The total cycle time of the process block for handling containers on the deck consists now of six spreader hoisting movements and three trolley movements, whereby only the trolley constant movements have an impact on the total cycle time. The sway control automation system occurs six times and the twistlock mechanism engages two times. On the platform the twistlocks for stacking the container are placed or removed, this happens only once per container handling. The load

measuring occurs once. The total crane movement is shown in Fig.11.

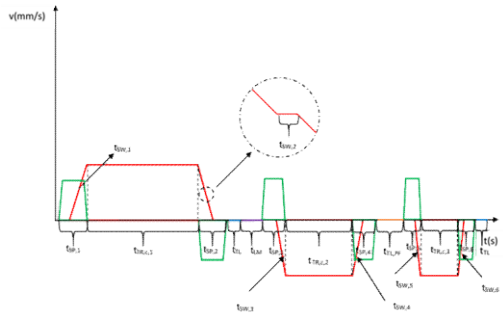

Figure 11 Process block for the total crane with parallel movements for unloading from deck

IV PERFORMANCE ANALYSIS

The new model of the STS crane cycle time, with automation systems, locking mechanisms, the acceleration/deceleration of the spreader hoist and parallel movements is from now on called Model A.

The cycle time predicted using model A is compared to the reference crane cycle time and the cycle time based on the model found in literature by Ha and Choi(2005) which we will call from now on model B. Model B uses only constant velocities for the crane components, which operate in sequence. Additionally model B does not include automation systems. The operational cycle path in sequence is described in Table 10.

Table 1 Operational cycle path on deck in sequence Model B

1	Job start
2	Job received from TOS
3	Con.Spr hoist to boom
4	Con.Tr to source
5	Con.Spr lower to source
6	Lock container (Twistlock)
7	Con.Spr hoist to boom
8	Con.Tr to destination
9	Con.Spr lower to destination
10	Unlock container (Twistlock)
11	Send completed job to TOS
12	Job finish

Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

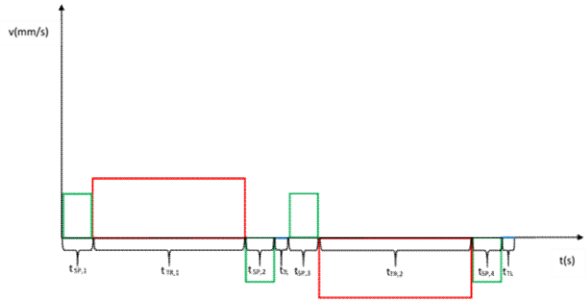

Figure 12 Process block for the total crane for unloading containers from the hold with sequential movements

In Fig.12 the crane movement of the total crane movement for unloading containers from the cargo hold in the ship with sequential movements is shown. The total cycle time of the process block for handling containers on the deck also consists of six spreader hoisting movements and three trolley movements. It can be seen that the different components do not have accelerations and decelerations. The twistlock mechanism engages two times. On the platform the twistlocks for stacking the container are placed or removed, this happens only once per container handling.

The cycle path for container operations on the deck is described in Table 11.

Table 9 Operational cycle path on deck in sequence for Model B

1	Job start
2	Job received from TOS
3	Con.Spr hoist to boom
4	Con.Tr to source
5	Con.Spr lower to source
6	Lock container (Twistlock)
7	Con.Spr hoist to boom
8	Con.Spr lower to platform
9	Remove Twistlocks
10	Con.Spr hoist to pos.1
11	Con.Tr to destination
12	Con.Spr lower to destination
13	Unlock container (Twistlock)
14	Send completed job to TOS
15	Job finish

Acc = Acceleration, Dec= Deceleration Con = Constant, Tr = Trolley, Spr = Spreader, Pos = Position, Ctrl = Control

In Fig.13 the crane movement of the total crane movement for unloading the vessel from the deck with sequential movements is shown. The total cycle time of the process block for handling containers on the deck consists now of six spreader hoisting movements and three trolley movements. Here can be seen that the different components also do not have accelerations and decelerations. The twistlock mechanism engages two times. On the platform the twistlocks for stacking the container are placed or removed, this happens only once per container handling.

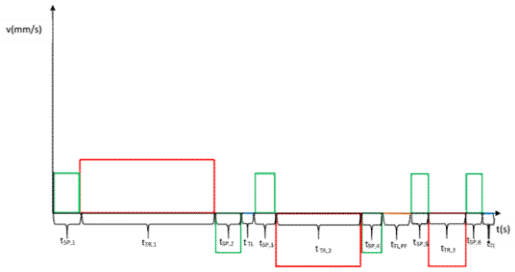

Figure 13 Process block for the total crane with sequential movements for unloading from deck

An overview is given in Table 13 of the parameter differences between model A and model B.

Table 10 Comparison differences crane models

	Model A	Model B
Automation systems	✓	×
Parallel movements	✓	×
Acceleration/deceleration	✓	×

IV. Model VERIFCATION & VALIDATION

Model A was verified by increasing the different inputs one at a time to see if the model reacts appropriately. A total of eight increments were used for the weight, spreader location and trolley location of the container for testing the model. Verification tests were executed for container operations in the hold. The model reacted as expected, the output also increased when the different inputs were increased. The cycle path was verified with five PLC traces from container operations on the deck. This gave the same cycle path that was defined with data from the TOS.

The results of the process output of the new STS crane model for unloading from the deck is verified and validated by comparing it with the reference case of the automated STS crane. A total of 10 jobs is used, obtained from PLC-traces for unloading from the deck for the verification and validation process. The accuracy of the performance prediction of model A can now be compared to the reference crane and the crane model of Ha and Choi(2005) which will be called from now on model B.

Model comparison

For determining the performance prediction accuracy model A is compared to model B. Both models use the crane specifications of the reference crane. A total of three different datasets are extracted from the reference's crane TOS data. The operation scenario of datasets is as followed:

- Dataset 1 is unloading the ship from the cargo hold
- Dataset 2 unloading the ship from the deck
- Dataset 3 is loading onto the deck.

Dataset 1 contains thirty-eight jobs, dataset 2 eighteen jobs and dataset 3 forty-seven jobs.

The Actual output of the reference crane and predicted output of the model A and B are compared to find the correlation residuals of the actual and predicted outputs of both models. The sum of the error squared is calculated for the different jobs for both model A and model B. The reason for this is that the mean error cannot be used because the datasets consist of different jobs.

V. Results

The results of the actual versus the prediction comparison plot are displayed in Fig. 14, 15 and 16.

Dataset 1

The sum squared error (SSE) of the 38 jobs of dataset 1 for model A is 1.67e+04 and for model B is 3.14e+04.

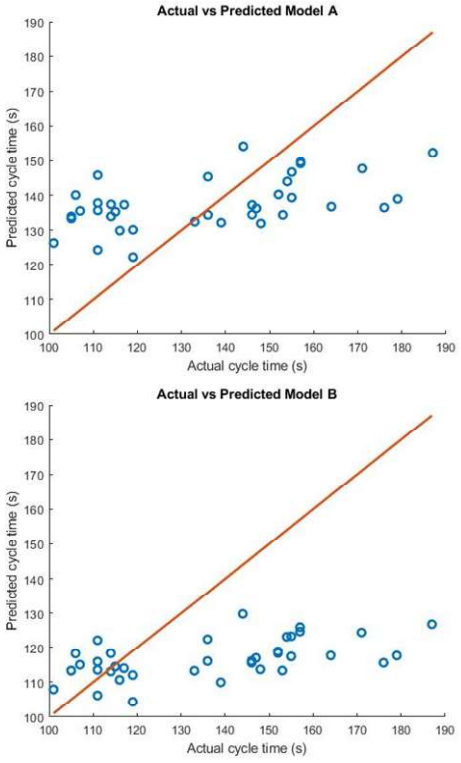

Figure 14 Actual vs predicted plots dataset 1

Dataset 2

Model A has SSE of 1.80e+03 for the total of 18 jobs of dataset 2 and model B has SSE 3.97e+04.

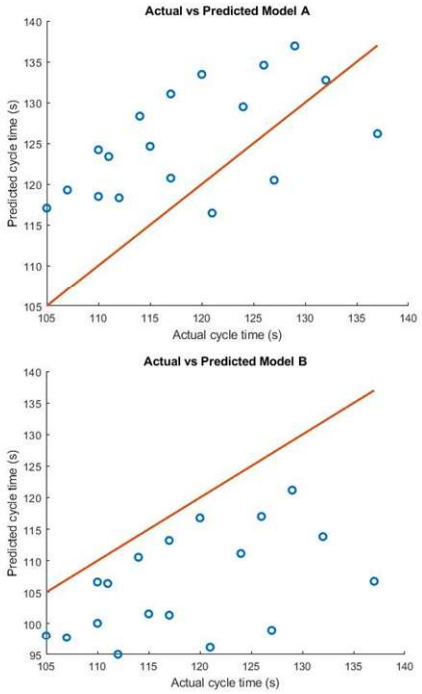

Figure 15 Actual vs predicted plots dataset 2

Dataset 3

Model A has SSE of 1.16e+04 for the total of 47 jobs for dataset 3 and model B has SSE of 4.16e+04.

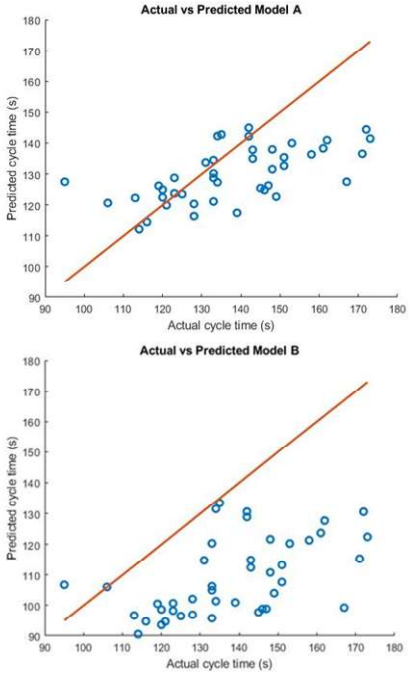

Figure 16 Actual vs predicted plots dataset 3

The results of the three different datasets show that Model A is more accurate compared to Model B, it predicts an output closer to the reference crane model used in this research. From the correlation plots we can see that Model A's results are closer to the linear line which are the actual values compared to model B's output for all datasets. Moreover the sum squared error (SSE) of all datasets is smaller for model A compared to model B. The error between model A and the reference crane can be explained when looked at the different datasets of the reference crane, jobs where the performance prediction model ought to be smaller are in fact larger. This can be explained for the reason that the Human factor of the operator and external factors(e.g. wind) were not considered during modeling.

V. Sensitivity analysis

The output of the performance prediction model is studied by conducting a sensitivity analysis. One-at-a-time (OAT) approach was used., with the trolley velocity and spreader hoisting velocity as parameters increments for the analysis.

In Table 11 Model A showed an increase of the performance of the model when the spreader hoisting velocity is increased. Also the error rate decreases when the velocity is increased. In Table 12 we can see that Model B showed an increase of performance till the last two parameters. The SSE started to increase from there on, meaning that model B is more sensitive to parameter change.

Table 11 Sensitivity analysis trolley velocity

Trolley velocity increments (s)	*0.5*	*1*	*1.5*	*2*	*2.5*	*3*	*3.5*	*4*
Model A $t_{A,cyc}$ SSE (-)	1.85e+06	3.86e+05	1.43e+05	6.70e+04	3.73e+04	2.42e+04	1.87e+04	1.67e+04
Model B $t_{B,cyc}$ SSE (-)	1.4056e+06	2.1110e+05	5.5273e+04	2.3024e+04	1.8177e+04	2.1029e+04	2.5998e+04	3.1372e+04

Table 12 Sensitivity analysis spreader velocity

Spreader velocity increments (s)	*0.25*	*0.50*	*0.75*	*1*	*1.25*	*1.50*	*1.75*	*2.00*	*2.25*	*2.50*
Model A SSE (-)	2.50e+07	4.80e+06	1.60e+06	6.50e+05	2.91e+05	1.36e+05	6.49e+04	3.29e+04	2.015e+04	1.67e+04
Model B SSE (-)	1.98e+07	3.66e+06	1.14e+06	4.24e+05	1.64e+05	6.24e+04	2.50e+04	1.61e+04	2.06e+04	3.1403e+04

VI. Discussion

Model A predicts the performance more accurate compared to Model B. the reason here for is that model A takes, the accelerations/decelerations, the parallel movements and the automation systems into account. Moreover the model A takes the mass of the containers into consideration, the spreader hoisting velocity depends on the mass of the container. Ha and Choi(2005) which model B is based on, differentiate only if there is a load or no

load and for each situation they use an operating velocity for the spreader hoist. However for comparing model A and model B the same inputs ought to be used, which means also the container mass. So for model B the spreader hoist velocity is also load dependent.

The error between model A and the reference crane can be explained based on the different datasets of the reference crane, jobs where the performance prediction model ought to be smaller are in fact larger. This can be explained since the crane is partially operated manually during the lifting and lowering of the load but also during on deck operations where the twistlocks are attached/removed on the platforms. Other factors that play a role are external factors like weather disturbances for example the wind. The external and the operators human factors were not taking in account in model A.

V. Conclusion

The results show that for deriving a new STS crane model for an automated STS crane, automation systems, parallel movements of the cycle path and accelerations/decelerations should be included when deriving a model.

The productivity of the STS crane is a key indicator and a critical component of the overall productivity of container terminals. A more complete and accurate model is now generated compared to current models in literature. This makes it now possible to predict a more accurate performance for automated container terminals, which can have positive effect on financial and logistical processes Furthermore the model can be used for different STS cranes by changing the crane specifications or adding/removing process blocks and automation systems.

VI. References

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Appendix B: Data analysis reference jobs

Jobnr.	Job Time	TOS Message
122	01.05.2019 04:50:24	SPR Twistlocks unlocked, Position HO: 4366 [mm], TR: 30200 [mm], GA: 805848 [mm]
	01.05.2019 04:50:24	AUT Automatic Trolley target position reached TR: 30200 [mm]
	01.05.2019 04:50:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3019 Ys:0 Zp:4555 Zs:-247 Sp_L:2 Tl_St:2 W:6689
	01.05.2019 04:50:24	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:50:23	AUT Stop Automatic, Position HO: 4673 [mm], TR: 30160 [mm], GA: 805849 [mm]
	01.05.2019 04:50:23	AUT Automatic Trolley stops moving, Position HO: 4683 [mm], TR: 30159 [mm], GA: 805849 [mm]
	01.05.2019 04:50:23	TR_ Manual Drive command Forward
	01.05.2019 04:50:23	SPR Spreader landed
	01.05.2019 04:50:20	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:50:19	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 04:50:19	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:50:19	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 04:50:19	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:50:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2994 Ys:0 Zp:4265 Zs:-1506 Sp_L:2 Tl_St:2 W:-28311
	01.05.2019 04:50:15	REP Speed report HO: -59.75 [%], TR: -8.30 [%], GA: 0.00 [%]
	01.05.2019 04:50:15	AUT Container gantry deviation outside funnel range Max dev: 498.23 Act dev: 887.02 HO: 10623 [mm]
	01.05.2019 04:50:15	AUT Container in funnel area on landside HO: 10623 [mm]
	01.05.2019 04:50:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3111 Ys:-720 Zp:3617 Zs:-2101 Sp_L:2 Tl_St:2 W:-31793
	01.05.2019 04:50:13	REP WMS Actual windspeed 1.06 [m/s], direction 320 [deg]
	01.05.2019 04:50:07	AUT Hoist takeover, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
	01.05.2019 04:50:07	AUT Automatic Hoist stops moving, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
	01.05.2019 04:50:07	HO_ Manual Drive command Lowering
	01.05.2019 04:50:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5556 Ys:-3990 Zp:1861 Zs:-629 Sp_L:2 Tl_St:2 W:31160
	01.05.2019 04:50:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5911 Ys:-4010 Zp:1829 Zs:-88 Sp_L:2 Tl_St:2 W:-32135
	01.05.2019 04:50:02	AUT Automatic Hoist starts moving, Position HO: 31760 [mm], TR: 63264 [mm], GA: 805849 [mm]
	01.05.2019	HO_ Zero and Stand still

	04:49:57	
	01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8915 Ys:-2176 Zp:1829 Zs:0 Sp_L:2 Tl_St:2 W:31273
	01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9083 Ys:-2098 Zp:1848 Zs:478 Sp_L:2 Tl_St:2 W:30922
	01.05.2019 04:49:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9606 Ys:-145 Zp:2669 Zs:2099 Sp_L:2 Tl_St:2 W:32316
	01.05.2019 04:49:48	AUT Automatic Trolley starts moving, Position HO: 21513 [mm], TR: 96068 [mm], GA: 805849 [mm]
	01.05.2019 04:49:47	REP Position report HO: 19375 [mm], TR: 96067 [mm], GA: 805848 [mm]
	01.05.2019 04:49:47	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:49:47	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 04:49:47	AUT Automatic Hoist starts moving, Position HO: 19291 [mm], TR: 96067 [mm], GA: 805849 [mm]
	01.05.2019 04:49:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9607 Ys:0 Zp:3732 Zs:2099 Sp_L:2 Tl_St:2 W:-32373
	01.05.2019 04:49:40	LMS Load hangs free, Load Left: 18.4 [T], Right: 16.4 [T], Total: 34.9 [T]
	01.05.2019 04:49:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:38	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:1 C_Lenght:2
	01.05.2019 04:49:37	job started(0). new JobID: 122
	01.05.2019 04:49:37	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:37	AUT AGV leave
	01.05.2019 04:49:34	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4352 Zs:-51 Sp_L:2 Tl_St:2 W:5930
	01.05.2019 04:49:34	SPR Twistlocks locked, Position HO: 6526 [mm], TR: 96084 [mm], GA: 805849 [mm]
	01.05.2019 04:49:34	LMS Underload detected
	01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4332 Zs:-502 Sp_L:2 Tl_St:1 W:66
	01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:33	SPR Spreader landed
	01.05.2019 04:49:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4031 Zs:-98 Sp_L:2 Tl_St:1 W:16179
	01.05.2019 04:49:28	TR_ Zero and Stand still
	01.05.2019 04:49:28	AUT Automatic Cruise On
	01.05.2019	AUT Sway control On

	04:49:28	
	01.05.2019 04:49:27	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:27	HO_ Manual Drive command Lowering
	01.05.2019 04:49:27	AUT Automatic Hoist target position reached HO: 9748 [mm]
	01.05.2019 04:49:27	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4030 Zs:0 Sp_L:2 Tl_St:1 W:15455
	01.05.2019 04:49:26	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:26	AUT Automatic Trolley target position reached TR: 96092 [mm]
	01.05.2019 04:49:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9609 Ys:0 Zp:3985 Zs:-431 Sp_L:2 Tl_St:1 W:15426
	01.05.2019 04:49:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9638 Ys:-142 Zp:3942 Zs:-421 Sp_L:2 Tl_St:1 W:16588
	01.05.2019 04:49:23	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 04:49:23	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96455 [mm]
	01.05.2019 04:49:22	TR_ Manual Drive command Forward
	01.05.2019 04:49:22	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	TR_ Manual Drive command Forward
	01.05.2019 04:49:22	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96450 [mm]
	01.05.2019 04:49:21	TR_ Manual Drive command Forward
	01.05.2019 04:49:21	AUT Automatic Trolley target position reached TR: 96464 [mm]
	01.05.2019 04:49:21	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:49:21	AUT Stop Automatic, Position HO: 12102 [mm], TR: 96490 [mm], GA: 805848 [mm]
	01.05.2019 04:49:21	AUT Automatic Trolley stops moving, Position HO: 12127 [mm], TR: 96492 [mm], GA: 805848 [mm]
	01.05.2019 04:49:21	TR_ Manual Drive command Backward
	01.05.2019 04:49:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
	01.05.2019 04:49:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 04:49:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9645 Ys:0 Zp:3661 Zs:-939 Sp_L:2 Tl_St:1 W:17540
	01.05.2019 04:49:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9448 Ys:1119 Zp:3005 Zs:-1672 Sp_L:2 Tl_St:1 W:15728
	01.05.2019 04:49:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7921 Ys:3521 Zp:2118 Zs:-85 Sp_L:2 Tl_St:1 W:15735
	01.05.2019	HO_ Manual Drive command Hoisting

	04:49:06	
	01.05.2019 04:49:06	AUT Hoist takeover, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]
	01.05.2019 04:49:06	AUT Automatic Hoist stops moving, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]
	01.05.2019 04:49:06	HO_ Manual Drive command Lowering
	01.05.2019 04:49:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6603 Ys:4001 Zp:2118 Zs:0 Sp_L:2 Tl_St:1 W:15749
	01.05.2019 04:49:01	HO_ Zero and Stand still
	01.05.2019 04:48:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4607 Ys:3566 Zp:2117 Zs:0 Sp_L:2 Tl_St:1 W:14464
	01.05.2019 04:48:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3371 Ys:1482 Zp:2807 Zs:2380 Sp_L:2 Tl_St:1 W:15488
	01.05.2019 04:48:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:145 Zp:3732 Zs:2411 Sp_L:2 Tl_St:1 W:16110
	01.05.2019 04:48:49	AUT Automatic Trolley starts moving, Position HO: 10062 [mm], TR: 30153 [mm], GA: 805848 [mm]
	01.05.2019 04:48:49	REP Position report HO: 9870 [mm], TR: 30153 [mm], GA: 805849 [mm]
	01.05.2019 04:48:49	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:48:49	AUT Start Automatic to Targets HO: 19972 [mm] TR: 96373 [mm]
	01.05.2019 04:48:49	AUT Automatic Hoist starts moving, Position HO: 9777 [mm], TR: 30153 [mm], GA: 805848 [mm]
	01.05.2019 04:48:46	TOS Message:0240 SND Job_Reply JobSeq:-213 QCSeq:10 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:3 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:48:46	job finished(1). JobID: 121
	01.05.2019 04:48:46	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:10 C-Lenght:2 C-Height:0
	01.05.2019 04:48:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4510 Zs:251 Sp_L:2 Tl_St:1 W:15264
	01.05.2019 04:48:40	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4586 Zs:0 Sp_L:2 Tl_St:1 W:2513
	01.05.2019 04:48:40	HO_ Manual Drive command Hoisting
	01.05.2019 04:48:40	LMS Underload detected
	01.05.2019 04:48:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4570 Zs:-251 Sp_L:2 Tl_St:1 W:3794
	01.05.2019 04:48:39	SPR Twistlocks unlocked, Position HO: 4354 [mm], TR: 30156 [mm], GA: 805848 [mm]

01.05.2019 04:50:24	SPR Twistlocks unlocked, Position HO: 4366 [mm], TR: 30200 [mm], GA: 805848 [mm]
01.05.2019 04:50:24	AUT Automatic Trolley target position reached TR: 30200 [mm]
01.05.2019 04:50:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3019 Ys:0 Zp:4555 Zs:-247 Sp_L:2 Tl_St:2 W:6689
01.05.2019 04:50:23	TOS Message:0229 SND Status_Reset Level:0 Code:10350
01.05.2019 04:50:23	AUT Stop Automatic, Position HO: 4673 [mm], TR: 30160 [mm], GA: 805849 [mm]
01.05.2019 04:50:23	AUT Automatic Trolley stops moving, Position HO: 4683 [mm], TR: 30159 [mm], GA: 805849 [mm]
01.05.2019 04:50:23	TR_ Manual Drive command Forward
01.05.2019 04:50:23	SPR Spreader landed
01.05.2019 04:50:20	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
01.05.2019 04:50:19	TOS Message:0225 SND Loader_Not_Used
01.05.2019 04:50:19	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
01.05.2019 04:50:19	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
01.05.2019 04:50:19	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:50:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2994 Ys:0 Zp:4265 Zs:-1506 Sp_L:2 Tl_St:2 W:-28311
01.05.2019 04:50:15	REP Speed report HO: -59.75 [%], TR: -8.30 [%], GA: 0.00 [%]
01.05.2019 04:50:15	AUT Container gantry deviation outside funnel range Max dev: 498.23 Act dev: 887.02 HO: 10623 [mm]
01.05.2019 04:50:15	AUT Container in funnel area on landside HO: 10623 [mm]
01.05.2019 04:50:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3111 Ys:-720 Zp:3617 Zs:-2101 Sp_L:2 Tl_St:2 W:-31793
01.05.2019 04:50:13	REP WMS Actual windspeed 1.06 [m/s], direction 320 [deg]
01.05.2019 04:50:07	AUT Hoist takeover, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
01.05.2019 04:50:07	AUT Automatic Hoist stops moving, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
01.05.2019 04:50:07	HO_ Manual Drive command Lowering
01.05.2019 04:50:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5556 Ys:-3990 Zp:1861 Zs:-629 Sp_L:2 Tl_St:2 W:31160
01.05.2019 04:50:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5911 Ys:-4010 Zp:1829 Zs:-88 Sp_L:2 Tl_St:2 W:-32135
01.05.2019 04:50:02	AUT Automatic Hoist starts moving, Position HO: 31760 [mm], TR: 63264 [mm], GA: 805849 [mm]
01.05.2019 04:49:57	HO_ Zero and Stand still
01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8915 Ys:-2176 Zp:1829 Zs:0 Sp_L:2 Tl_St:2 W:31273
01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9083 Ys:-2098 Zp:1848 Zs:478 Sp_L:2 Tl_St:2 W:30922

01.05.2019 04:49:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9606 Ys:-145 Zp:2669 Zs:2099 Sp_L:2 Tl_St:2 W:32316
01.05.2019 04:49:48	AUT Automatic Trolley starts moving, Position HO: 21513 [mm], TR: 96068 [mm], GA: 805849 [mm]
01.05.2019 04:49:47	REP Position report HO: 19375 [mm], TR: 96067 [mm], GA: 805848 [mm]
01.05.2019 04:49:47	TOS Message:0228 SND Status_Set Level:0 Code:10350
01.05.2019 04:49:47	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
01.05.2019 04:49:47	AUT Automatic Hoist starts moving, Position HO: 19291 [mm], TR: 96067 [mm], GA: 805849 [mm]
01.05.2019 04:49:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9607 Ys:0 Zp:3732 Zs:2099 Sp_L:2 Tl_St:2 W:-32373
01.05.2019 04:49:40	LMS Load hangs free, Load Left: 18.4 [T], Right: 16.4 [T], Total: 34.9 [T]
01.05.2019 04:49:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:49:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:49:38	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:1 C_Lenght:2
01.05.2019 04:49:37	job started(0). new JobID: 122
01.05.2019 04:49:37	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:49:37	AUT AGV leave
01.05.2019 04:49:34	TOS Message:0229 SND Status_Reset Level:0 Code:8333
01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4352 Zs:-51 Sp_L:2 Tl_St:2 W:5930
01.05.2019 04:49:34	SPR Twistlocks locked, Position HO: 6526 [mm], TR: 96084 [mm], GA: 805849 [mm]
01.05.2019 04:49:34	LMS Underload detected
01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4332 Zs:-502 Sp_L:2 Tl_St:1 W:66
01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
01.05.2019 04:49:33	SPR Spreader landed
01.05.2019 04:49:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4031 Zs:-98 Sp_L:2 Tl_St:1 W:16179
01.05.2019 04:49:28	TR_ Zero and Stand still
01.05.2019 04:49:28	AUT Automatic Cruise On
01.05.2019 04:49:28	AUT Sway control On
01.05.2019 04:49:27	HO_ Manual Drive command Hoisting
01.05.2019 04:49:27	HO_ Manual Drive command Lowering

01.05.2019 04:49:27	AUT Automatic Hoist target position reached HO: 9748 [mm]
01.05.2019 04:49:27	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4030 Zs:0 Sp_L:2 Tl_St:1 W:15455
01.05.2019 04:49:26	HO_ Manual Drive command Hoisting
01.05.2019 04:49:26	AUT Automatic Trolley target position reached TR: 96092 [mm]
01.05.2019 04:49:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9609 Ys:0 Zp:3985 Zs:-431 Sp_L:2 Tl_St:1 W:15426
01.05.2019 04:49:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9638 Ys:-142 Zp:3942 Zs:-421 Sp_L:2 Tl_St:1 W:16588
01.05.2019 04:49:23	TOS Message:0228 SND Status_Set Level:0 Code:8333
01.05.2019 04:49:23	TR_ Manual Drive command Backward
01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96455 [mm]
01.05.2019 04:49:22	TR_ Manual Drive command Forward
01.05.2019 04:49:22	TR_ Manual Drive command Backward
01.05.2019 04:49:22	TR_ Manual Drive command Forward
01.05.2019 04:49:22	TR_ Manual Drive command Backward
01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96450 [mm]
01.05.2019 04:49:21	TR_ Manual Drive command Forward
01.05.2019 04:49:21	AUT Automatic Trolley target position reached TR: 96464 [mm]
01.05.2019 04:49:21	TOS Message:0229 SND Status_Reset Level:0 Code:10350
01.05.2019 04:49:21	AUT Stop Automatic, Position HO: 12102 [mm], TR: 96490 [mm], GA: 805848 [mm]
01.05.2019 04:49:21	AUT Automatic Trolley stops moving, Position HO: 12127 [mm], TR: 96492 [mm], GA: 805848 [mm]
01.05.2019 04:49:21	TR_ Manual Drive command Backward
01.05.2019 04:49:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
01.05.2019 04:49:19	TOS Message:0198 RCV Overview_Request
01.05.2019 04:49:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9645 Ys:0 Zp:3661 Zs:-939 Sp_L:2 Tl_St:1 W:17540
01.05.2019 04:49:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9448 Ys:1119 Zp:3005 Zs:-1672 Sp_L:2 Tl_St:1 W:15728
01.05.2019 04:49:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7921 Ys:3521 Zp:2118 Zs:-85 Sp_L:2 Tl_St:1 W:15735
01.05.2019 04:49:06	HO_ Manual Drive command Hoisting
01.05.2019 04:49:06	AUT Hoist takeover, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]
01.05.2019 04:49:06	AUT Automatic Hoist stops moving, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]

01.05.2019 04:49:06	HO_ Manual Drive command Lowering
01.05.2019 04:49:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6603 Ys:4001 Zp:2118 Zs:0 Sp_L:2 Tl_St:1 W:15749
01.05.2019 04:49:01	HO_ Zero and Stand still
01.05.2019 04:48:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4607 Ys:3566 Zp:2117 Zs:0 Sp_L:2 Tl_St:1 W:14464
01.05.2019 04:48:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3371 Ys:1482 Zp:2807 Zs:2380 Sp_L:2 Tl_St:1 W:15488
01.05.2019 04:48:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:145 Zp:3732 Zs:2411 Sp_L:2 Tl_St:1 W:16110
01.05.2019 04:48:49	AUT Automatic Trolley starts moving, Position HO: 10062 [mm], TR: 30153 [mm], GA: 805848 [mm]
01.05.2019 04:48:49	REP Position report HO: 9870 [mm], TR: 30153 [mm], GA: 805849 [mm]
01.05.2019 04:48:49	TOS Message:0228 SND Status_Set Level:0 Code:10350
01.05.2019 04:48:49	AUT Start Automatic to Targets HO: 19972 [mm] TR: 96373 [mm]
01.05.2019 04:48:49	AUT Automatic Hoist starts moving, Position HO: 9777 [mm], TR: 30153 [mm], GA: 805848 [mm]
01.05.2019 04:48:46	TOS Message:0240 SND Job_Reply JobSeq:-213 QCSeq:10 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:3 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
01.05.2019 04:48:46	job finished(1). JobID: 121
01.05.2019 04:48:46	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:10 C-Lenght:2 C-Height:0
01.05.2019 04:48:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4510 Zs:251 Sp_L:2 Tl_St:1 W:15264
01.05.2019 04:48:40	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4586 Zs:0 Sp_L:2 Tl_St:1 W:2513
01.05.2019 04:48:40	HO_ Manual Drive command Hoisting
01.05.2019 04:48:40	LMS Underload detected
01.05.2019 04:48:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4570 Zs:-251 Sp_L:2 Tl_St:1 W:3794
01.05.2019 04:48:39	SPR Twistlocks unlocked, Position HO: 4354 [mm], TR: 30156 [mm], GA: 805848 [mm]

Jobnr.	Job Time	TOS Message
123	01.05.2019 04:50:24	SPR Twistlocks unlocked, Position HO: 4366 [mm], TR: 30200 [mm], GA: 805848 [mm]
	01.05.2019 04:50:24	AUT Automatic Trolley target position reached TR: 30200 [mm]
	01.05.2019 04:50:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3019 Ys:0 Zp:4555 Zs:-247 Sp_L:2 Tl_St:2 W:6689
	01.05.2019 04:50:23	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:50:23	AUT Stop Automatic, Position HO: 4673 [mm], TR: 30160 [mm], GA: 805849 [mm]

	01.05.2019 04:50:23	AUT Automatic Trolley stops moving, Position HO: 4683 [mm], TR: 30159 [mm], GA: 805849 [mm]
	01.05.2019 04:50:23	TR_ Manual Drive command Forward
	01.05.2019 04:50:23	SPR Spreader landed
	01.05.2019 04:50:20	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:50:19	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 04:50:19	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:50:19	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 04:50:19	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:50:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2994 Ys:0 Zp:4265 Zs:-1506 Sp_L:2 Tl_St:2 W:-28311
	01.05.2019 04:50:15	REP Speed report HO: -59.75 [%], TR: -8.30 [%], GA: 0.00 [%]
	01.05.2019 04:50:15	AUT Container gantry deviation outside funnel range Max dev: 498.23 Act dev: 887.02 HO: 10623 [mm]
	01.05.2019 04:50:15	AUT Container in funnel area on landside HO: 10623 [mm]
	01.05.2019 04:50:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3111 Ys:-720 Zp:3617 Zs:-2101 Sp_L:2 Tl_St:2 W:-31793
	01.05.2019 04:50:13	REP WMS Actual windspeed 1.06 [m/s], direction 320 [deg]
	01.05.2019 04:50:07	AUT Hoist takeover, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
	01.05.2019 04:50:07	AUT Automatic Hoist stops moving, Position HO: 27089 [mm], TR: 44900 [mm], GA: 805848 [mm]
	01.05.2019 04:50:07	HO_ Manual Drive command Lowering
	01.05.2019 04:50:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5556 Ys:-3990 Zp:1861 Zs:-629 Sp_L:2 Tl_St:2 W:31160
	01.05.2019 04:50:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5911 Ys:-4010 Zp:1829 Zs:-88 Sp_L:2 Tl_St:2 W:-32135
	01.05.2019 04:50:02	AUT Automatic Hoist starts moving, Position HO: 31760 [mm], TR: 63264 [mm], GA: 805849 [mm]
	01.05.2019 04:49:57	HO_ Zero and Stand still
	01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8915 Ys:-2176 Zp:1829 Zs:0 Sp_L:2 Tl_St:2 W:31273
	01.05.2019 04:49:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9083 Ys:-2098 Zp:1848 Zs:478 Sp_L:2 Tl_St:2 W:30922
	01.05.2019 04:49:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9606 Ys:-145 Zp:2669 Zs:2099 Sp_L:2 Tl_St:2 W:32316
	01.05.2019 04:49:48	AUT Automatic Trolley starts moving, Position HO: 21513 [mm], TR: 96068 [mm], GA: 805849 [mm]
	01.05.2019 04:49:47	REP Position report HO: 19375 [mm], TR: 96067 [mm], GA: 805848 [mm]
	01.05.2019 04:49:47	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:49:47	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]

	01.05.2019 04:49:47	AUT Automatic Hoist starts moving, Position HO: 19291 [mm], TR: 96067 [mm], GA: 805849 [mm]
	01.05.2019 04:49:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9607 Ys:0 Zp:3732 Zs:2099 Sp_L:2 Tl_St:2 W:-32373
	01.05.2019 04:49:40	LMS Load hangs free, Load Left: 18.4 [T], Right: 16.4 [T], Total: 34.9 [T]
	01.05.2019 04:49:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:38	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:1 C_Lenght:2
	01.05.2019 04:49:37	job started(0). new JobID: 122
	01.05.2019 04:49:37	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:49:37	AUT AGV leave
	01.05.2019 04:49:34	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4352 Zs:-51 Sp_L:2 Tl_St:2 W:5930
	01.05.2019 04:49:34	SPR Twistlocks locked, Position HO: 6526 [mm], TR: 96084 [mm], GA: 805849 [mm]
	01.05.2019 04:49:34	LMS Underload detected
	01.05.2019 04:49:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4332 Zs:-502 Sp_L:2 Tl_St:1 W:66
	01.05.2019 04:49:34	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:33	SPR Spreader landed
	01.05.2019 04:49:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4031 Zs:-98 Sp_L:2 Tl_St:1 W:16179
	01.05.2019 04:49:28	TR_ Zero and Stand still
	01.05.2019 04:49:28	AUT Automatic Cruise On
	01.05.2019 04:49:28	AUT Sway control On
	01.05.2019 04:49:27	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:27	HO_ Manual Drive command Lowering
	01.05.2019 04:49:27	AUT Automatic Hoist target position reached HO: 9748 [mm]
	01.05.2019 04:49:27	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9608 Ys:0 Zp:4030 Zs:0 Sp_L:2 Tl_St:1 W:15455
	01.05.2019 04:49:26	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:26	AUT Automatic Trolley target position reached TR: 96092 [mm]
	01.05.2019 04:49:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9609 Ys:0 Zp:3985 Zs:-431 Sp_L:2 Tl_St:1 W:15426

	01.05.2019 04:49:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9638 Ys:-142 Zp:3942 Zs:-421 Sp_L:2 Tl_St:1 W:16588
	01.05.2019 04:49:23	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 04:49:23	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96455 [mm]
	01.05.2019 04:49:22	TR_ Manual Drive command Forward
	01.05.2019 04:49:22	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	TR_ Manual Drive command Forward
	01.05.2019 04:49:22	TR_ Manual Drive command Backward
	01.05.2019 04:49:22	AUT Automatic Trolley target position reached TR: 96450 [mm]
	01.05.2019 04:49:21	TR_ Manual Drive command Forward
	01.05.2019 04:49:21	AUT Automatic Trolley target position reached TR: 96464 [mm]
	01.05.2019 04:49:21	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:49:21	AUT Stop Automatic, Position HO: 12102 [mm], TR: 96490 [mm], GA: 805848 [mm]
	01.05.2019 04:49:21	AUT Automatic Trolley stops moving, Position HO: 12127 [mm], TR: 96492 [mm], GA: 805848 [mm]
	01.05.2019 04:49:21	TR_ Manual Drive command Backward
	01.05.2019 04:49:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
	01.05.2019 04:49:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 04:49:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9645 Ys:0 Zp:3661 Zs:-939 Sp_L:2 Tl_St:1 W:17540
	01.05.2019 04:49:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9448 Ys:1119 Zp:3005 Zs:-1672 Sp_L:2 Tl_St:1 W:15728
	01.05.2019 04:49:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7921 Ys:3521 Zp:2118 Zs:-85 Sp_L:2 Tl_St:1 W:15735
	01.05.2019 04:49:06	HO_ Manual Drive command Hoisting
	01.05.2019 04:49:06	AUT Hoist takeover, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]
	01.05.2019 04:49:06	AUT Automatic Hoist stops moving, Position HO: 28870 [mm], TR: 75362 [mm], GA: 805848 [mm]
	01.05.2019 04:49:06	HO_ Manual Drive command Lowering
	01.05.2019 04:49:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6603 Ys:4001 Zp:2118 Zs:0 Sp_L:2 Tl_St:1 W:15749
	01.05.2019 04:49:01	HO_ Zero and Stand still
	01.05.2019 04:48:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4607 Ys:3566 Zp:2117 Zs:0 Sp_L:2 Tl_St:1 W:14464
	01.05.2019 04:48:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3371 Ys:1482 Zp:2807 Zs:2380 Sp_L:2 Tl_St:1 W:15488

	01.05.2019 04:48:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:145 Zp:3732 Zs:2411 Sp_L:2 Tl_St:1 W:16110
	01.05.2019 04:48:49	AUT Automatic Trolley starts moving, Position HO: 10062 [mm], TR: 30153 [mm], GA: 805848 [mm]
	01.05.2019 04:48:49	REP Position report HO: 9870 [mm], TR: 30153 [mm], GA: 805849 [mm]
	01.05.2019 04:48:49	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:48:49	AUT Start Automatic to Targets HO: 19972 [mm] TR: 96373 [mm]
	01.05.2019 04:48:49	AUT Automatic Hoist starts moving, Position HO: 9777 [mm], TR: 30153 [mm], GA: 805848 [mm]
	01.05.2019 04:48:46	TOS Message:0240 SND Job_Reply JobSeq:-213 QCSeq:10 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:3 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:48:46	job finished(1). JobID: 121
	01.05.2019 04:48:46	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:10 C-Lenght:2 C-Height:0
	01.05.2019 04:48:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4510 Zs:251 Sp_L:2 Tl_St:1 W:15264
	01.05.2019 04:48:40	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4586 Zs:0 Sp_L:2 Tl_St:1 W:2513
	01.05.2019 04:48:40	HO_ Manual Drive command Hoisting
	01.05.2019 04:48:40	LMS Underload detected
	01.05.2019 04:48:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4570 Zs:-251 Sp_L:2 Tl_St:1 W:3794
	01.05.2019 04:48:39	SPR Twistlocks unlocked, Position HO: 4354 [mm], TR: 30156 [mm], GA: 805848 [mm]

Jobnr.	Job Time	TOS Message
124	01.05.2019 04:52:09	SPR Twistlocks unlocked, Position HO: 4374 [mm], TR: 30153 [mm], GA: 805849 [mm]
	01.05.2019 04:52:08	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:52:08	AUT Stop Automatic, Position HO: 4666 [mm], TR: 30151 [mm], GA: 805848 [mm]
	01.05.2019 04:52:08	AUT Automatic Trolley stops moving, Position HO: 4675 [mm], TR: 30151 [mm], GA: 805848 [mm]
	01.05.2019 04:52:08	TR_ Manual Drive command Forward
	01.05.2019	SPR Spreader landed

	04:52:08	
	01.05.2019 04:52:08	AUT Automatic Trolley target position reached TR: 30150 [mm]
	01.05.2019 04:52:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2996 Ys:0 Zp:4391 Zs:-858 Sp_L:2 Tl_St:2 W:-30071
	01.05.2019 04:52:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2998 Ys:0 Zp:4319 Zs:-1268 Sp_L:2 Tl_St:2 W:-28256
	01.05.2019 04:52:00	REP Speed report HO: -75.07 [%], TR: -10.68 [%], GA: 0.00 [%]
	01.05.2019 04:52:00	AUT Container gantry deviation outside funnel range Max dev: 495.58 Act dev: 890.13 HO: 10584 [mm]
	01.05.2019 04:52:00	AUT Container in funnel area on landside HO: 10584 [mm]
	01.05.2019 04:51:58	Message 25: Sent Data Type: Binary Number of traces in range: 283. Range Start Time: 19050104 46587354 Total number of traces: 18338. Total count Start Time: 19043018 41561833 End Time: 19050104 51587404
	01.05.2019 04:51:58	REP WMS Actual windspeed 1.14 [m/s], direction 327 [deg]
	01.05.2019 04:51:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4044 Ys:-2743 Zp:2525 Zs:-2099 Sp_L:2 Tl_St:2 W:32634
	01.05.2019 04:51:51	AUT Hoist takeover, Position HO: 29883 [mm], TR: 49810 [mm], GA: 805849 [mm]
	01.05.2019 04:51:51	AUT Automatic Hoist stops moving, Position HO: 29883 [mm], TR: 49810 [mm], GA: 805849 [mm]
	01.05.2019 04:51:51	HO_ Manual Drive command Lowering
	01.05.2019 04:51:48	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5899 Ys:-4010 Zp:1829 Zs:-81 Sp_L:2 Tl_St:2 W:-32223
	01.05.2019 04:51:47	AUT Automatic Hoist starts moving, Position HO: 31766 [mm], TR: 63134 [mm], GA: 805848 [mm]
	01.05.2019 04:51:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7793 Ys:-3915 Zp:1828 Zs:0 Sp_L:2 Tl_St:2 W:-32554
	01.05.2019 04:51:41	HO_ Zero and Stand still
	01.05.2019 04:51:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9170 Ys:-2154 Zp:1828 Zs:0 Sp_L:2 Tl_St:2 W:30475
	01.05.2019 04:51:34	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:51:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9851 Ys:0 Zp:2673 Zs:2101 Sp_L:2 Tl_St:2 W:32314
	01.05.2019 04:51:33	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 04:51:33	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:51:33	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 04:51:33	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:51:33	AUT Automatic Trolley starts moving, Position HO: 21497 [mm], TR: 98511 [mm], GA: 805849 [mm]
	01.05.2019 04:51:32	REP Position report HO: 20756 [mm], TR: 98512 [mm], GA: 805848 [mm]
	01.05.2019 04:51:32	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:51:32	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019	AUT Automatic Hoist starts moving, Position HO: 20672 [mm], TR: 98512 [mm], GA: 805848 [mm]

	04:51:32	
	01.05.2019 04:51:25	LMS Load hangs free, Load Left: 15.1 [T], Right: 17.6 [T], Total: 32.7 [T]
	01.05.2019 04:51:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9852 Ys:0 Zp:4261 Zs:247 Sp_L:2 Tl_St:2 W:-30435
	01.05.2019 04:51:23	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:2 C_Lenght:2
	01.05.2019 04:51:22	SPR Spreader landed
	01.05.2019 04:51:21	HO_ Manual Drive command Hoisting
	01.05.2019 04:51:21	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9852 Ys:0 Zp:4318 Zs:81 Sp_L:2 Tl_St:2 W:8255
	01.05.2019 04:51:21	SPR Twistlocks locked, Position HO: 6866 [mm], TR: 98524 [mm], GA: 805848 [mm]
	01.05.2019 04:51:21	LMS Underload detected
	01.05.2019 04:51:20	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 04:51:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9852 Ys:0 Zp:4321 Zs:0 Sp_L:2 Tl_St:1 W:5264
	01.05.2019 04:51:20	HO_ Manual Drive command Hoisting
	01.05.2019 04:51:19	SPR Spreader landed
	01.05.2019 04:51:19	TR_ Zero and Stand still
	01.05.2019 04:51:19	AUT Automatic Cruise On
	01.05.2019 04:51:19	AUT Sway control On
	01.05.2019 04:51:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9845 Ys:0 Zp:4221 Zs:-532 Sp_L:2 Tl_St:1 W:16300
	01.05.2019 04:51:18	AUT Automatic Trolley target position reached TR: 98452 [mm]
	01.05.2019 04:51:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9879 Ys:-151 Zp:4165 Zs:-507 Sp_L:2 Tl_St:1 W:15981
	01.05.2019 04:51:16	TR_ Manual Drive command Backward
	01.05.2019 04:51:15	TR_ Manual Drive command Forward
	01.05.2019 04:51:15	TR_ Manual Drive command Backward
	01.05.2019 04:51:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9880 Ys:0 Zp:3979 Zs:-81 Sp_L:2 Tl_St:1 W:17277
	01.05.2019 04:51:14	AUT Automatic Trolley target position reached TR: 98795 [mm]
	01.05.2019 04:51:13	HO_ Manual Drive command Lowering
	01.05.2019 04:51:13	TR_ Manual Drive command Forward
	01.05.2019 04:51:13	AUT Automatic Hoist target position reached HO: 10266 [mm]
	01.05.2019 04:51:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9879 Ys:0 Zp:3978 Zs:0 Sp_L:2 Tl_St:1 W:16327
	01.05.2019	AUT Automatic Trolley target position reached TR: 98779 [mm]

	04:51:13	
	01.05.2019 04:51:12	TR_ Manual Drive command Forward
	01.05.2019 04:51:11	AUT Automatic Trolley target position reached TR: 98745 [mm]
	01.05.2019 04:51:11	AUT Automatic Trolley target position reached TR: 98745 [mm]
	01.05.2019 04:51:10	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 04:51:09	TR_ Manual Drive command Forward
	01.05.2019 04:51:09	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:51:09	AUT Stop Automatic, Position HO: 11614 [mm], TR: 98651 [mm], GA: 805849 [mm]
	01.05.2019 04:51:09	AUT Automatic Trolley stops moving, Position HO: 11633 [mm], TR: 98654 [mm], GA: 805848 [mm]
	01.05.2019 04:51:09	TR_ Manual Drive command Backward
	01.05.2019 04:51:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9869 Ys:0 Zp:3602 Zs:-849 Sp_L:2 Tl_St:1 W:16986
	01.05.2019 04:51:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9862 Ys:167 Zp:3547 Zs:-990 Sp_L:2 Tl_St:1 W:16534
	01.05.2019 04:50:57	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:50:56	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:50:56	job started(0). new JobID: 123
	01.05.2019 04:50:56	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:50:56	AUT AGV leave
	01.05.2019 04:50:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8294 Ys:3189 Zp:2168 Zs:-773 Sp_L:2 Tl_St:1 W:14790
	01.05.2019 04:50:52	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7896 Ys:3920 Zp:2119 Zs:-85 Sp_L:2 Tl_St:1 W:15957
	01.05.2019 04:50:52	HO_ Manual Drive command Hoisting
	01.05.2019 04:50:51	AUT Hoist takeover, Position HO: 28861 [mm], TR: 74943 [mm], GA: 805849 [mm]
	01.05.2019 04:50:51	AUT Automatic Hoist stops moving, Position HO: 28861 [mm], TR: 74943 [mm], GA: 805849 [mm]
	01.05.2019 04:50:51	HO_ Manual Drive command Lowering
	01.05.2019 04:50:46	HO_ Zero and Stand still
	01.05.2019 04:50:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4387 Ys:3337 Zp:2118 Zs:0 Sp_L:2 Tl_St:1 W:15045
	01.05.2019 04:50:35	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3021 Ys:151 Zp:3623 Zs:2438 Sp_L:2 Tl_St:1 W:17083
	01.05.2019 04:50:34	AUT Automatic Trolley starts moving, Position HO: 11484 [mm], TR: 30196 [mm], GA: 805848 [mm]
	01.05.2019 04:50:34	REP Position report HO: 11308 [mm], TR: 30196 [mm], GA: 805849 [mm]
	01.05.2019	TOS Message:0228 SND Status_Set Level:0 Code:10350

	04:50:34	
	01.05.2019 04:50:34	AUT Start Automatic to Targets HO: 19972 [mm] TR: 98602 [mm]
	01.05.2019 04:50:34	AUT Automatic Hoist starts moving, Position HO: 11207 [mm], TR: 30196 [mm], GA: 805848 [mm]
	01.05.2019 04:50:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3020 Ys:0 Zp:4018 Zs:2331 Sp_L:2 Tl_St:1 W:17632
	01.05.2019 04:50:31	TOS Message:0240 SND Job_Reply JobSeq:-214 QCSeq:1 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:5 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:50:31	job finished(1). JobID: 122
	01.05.2019 04:50:31	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:1 C-Lenght:2 C-Height:0
	01.05.2019 04:50:26	TR_ Zero and Stand still
	01.05.2019 04:50:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3020 Ys:0 Zp:4587 Zs:97 Sp_L:2 Tl_St:1 W:1869
	01.05.2019 04:50:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3020 Ys:0 Zp:4588 Zs:0 Sp_L:2 Tl_St:1 W:1774
	01.05.2019 04:50:25	GA_ Zero and Stand still
	01.05.2019 04:50:25	HO_ Manual Drive command Hoisting
	01.05.2019 04:50:24	LMS Underload detected
	01.05.2019 04:50:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3020 Ys:0 Zp:4568 Zs:-251 Sp_L:2 Tl_St:1 W:4297
	01.05.2019 04:50:24	SPR Twistlocks unlocked, Position HO: 4366 [mm], TR: 30200 [mm], GA: 805848 [mm]

01.05.2019 04:54:28	SPR Twistlocks unlocked, Position HO: 4347 [mm], TR: 30285 [mm], GA: 805849 [mm]
01.05.2019 04:54:27	SPR Spreader landed
01.05.2019 04:54:24	TR_ Zero and Stand still
01.05.2019 04:54:24	AUT Automatic Cruise On
01.05.2019 04:54:24	AUT Sway control On

01.05.2019 04:54:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3029 Ys:0 Zp:4465 Zs:-134 Sp_L:2 Tl_St:2 W:-29361
01.05.2019 04:54:23	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3028 Ys:0 Zp:4460 Zs:-88 Sp_L:2 Tl_St:2 W:-25803
01.05.2019 04:54:23	HO_ Manual Drive command Lowering
01.05.2019 04:54:23	AUT Automatic Hoist target position reached HO: 5455 [mm]
01.05.2019 04:54:22	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:4458 Zs:-151 Sp_L:2 Tl_St:2 W:-25006
01.05.2019 04:54:22	AUT Automatic Trolley target position reached TR: 30242 [mm]
01.05.2019 04:54:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3117 Ys:-148 Zp:4239 Zs:-1599 Sp_L:2 Tl_St:2 W:-21547
01.05.2019 04:54:19	TR_ Manual Drive command Backward
01.05.2019 04:54:19	TR_ Manual Drive command Forward
01.05.2019 04:54:19	TR_ Manual Drive command Backward
01.05.2019 04:54:18	REP Speed report HO: -69.92 [%], TR: 0.00 [%], GA: 0.00 [%]
01.05.2019 04:54:18	AUT Container gantry deviation outside funnel range Max dev: 496.68 Act dev: 854.72 HO: 10600 [mm]
01.05.2019 04:54:18	AUT Container in funnel area on landside HO: 10600 [mm]
01.05.2019 04:54:16	AUT Automatic Trolley target position reached TR: 31169 [mm]
01.05.2019 04:54:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3116 Ys:0 Zp:3708 Zs:-1202 Sp_L:2 Tl_St:2 W:-25096
01.05.2019 04:54:15	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3164 Ys:-151 Zp:3490 Zs:-1582 Sp_L:2 Tl_St:2 W:-30561
01.05.2019 04:54:14	TR_ Manual Drive command Backward
01.05.2019 04:54:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3167 Ys:0 Zp:3335 Zs:-1421 Sp_L:2 Tl_St:2 W:-24870
01.05.2019 04:54:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3162 Ys:0 Zp:3209 Zs:-1867 Sp_L:2 Tl_St:2 W:-26743
01.05.2019 04:54:13	AUT Automatic Trolley target position reached TR: 31625 [mm]
01.05.2019 04:54:11	REP WMS Actual windspeed 1.25 [m/s], direction 306 [deg]
01.05.2019 04:54:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4261 Ys:-3108 Zp:1447 Zs:-1899 Sp_L:2 Tl_St:2 W:-27440
01.05.2019 04:53:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6250 Ys:-3948 Zp:747 Zs:-97 Sp_L:2 Tl_St:2 W:-26865
01.05.2019 04:53:57	HO_ Manual Drive command Hoisting
01.05.2019 04:53:57	HO_ Manual Drive command Lowering
01.05.2019 04:53:56	HO_ Zero and Stand still
01.05.2019 04:53:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7751 Ys:-1786 Zp:746 Zs:0 Sp_L:2 Tl_St:2 W:-28653
01.05.2019 04:53:54	AUT Automatic Hoist target position reached HO: 42592 [mm]

01.05.2019 04:53:53	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7793 Ys:-1635 Zp:746 Zs:0 Sp_L:2 Tl_St:2 W:-29887
01.05.2019 04:53:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8116 Ys:-145 Zp:1123 Zs:1665 Sp_L:2 Tl_St:2 W:-29869
01.05.2019 04:53:49	TR_ Manual Drive command Backward
01.05.2019 04:53:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:1853 Zs:81 Sp_L:2 Tl_St:2 W:-26860
01.05.2019 04:53:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:1854 Zs:0 Sp_L:2 Tl_St:2 W:-27570
01.05.2019 04:53:43	HO_ Manual Drive command Hoisting
01.05.2019 04:53:43	HO_ Zero and Stand still
01.05.2019 04:53:42	AUT Automatic Cruise On
01.05.2019 04:53:42	AUT Operation mode: 3 [2 = Loading, 3 = Unloading, 4 = Dual Cycling]
01.05.2019 04:53:41	AUT Automatic Hoist target position reached HO: 31514 [mm]
01.05.2019 04:53:41	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:1854 Zs:0 Sp_L:2 Tl_St:2 W:-29312
01.05.2019 04:53:37	HO_ Manual Drive command Lowering
01.05.2019 04:53:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:2922 Zs:1901 Sp_L:2 Tl_St:2 W:-26622
01.05.2019 04:53:24	LMS Load hangs free, Load Left: 22.4 [T], Right: 18.1 [T], Total: 40.5 [T]
01.05.2019 04:53:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:4500 Zs:246 Sp_L:2 Tl_St:2 W:-24464
01.05.2019 04:53:22	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:3 C_Lenght:2
01.05.2019 04:53:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8119 Ys:0 Zp:4573 Zs:0 Sp_L:2 Tl_St:2 W:5785
01.05.2019 04:53:20	HO_ Manual Drive command Hoisting
01.05.2019 04:53:20	LMS Underload detected
01.05.2019 04:53:20	SPR Twistlocks locked, Position HO: 4305 [mm], TR: 81183 [mm], GA: 805849 [mm]
01.05.2019 04:53:20	TOS Message:0229 SND Status_Reset Level:0 Code:8333
01.05.2019 04:53:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8118 Ys:0 Zp:4575 Zs:0 Sp_L:2 Tl_St:1 W:5667
01.05.2019 04:53:19	HO_ Manual Drive command Hoisting
01.05.2019 04:53:19	SPR Spreader landed
01.05.2019 04:53:15	TR_ Zero and Stand still
01.05.2019 04:53:15	AUT Sway control On
01.05.2019 04:53:13	AUT Automatic Trolley target position reached TR: 81241 [mm]
01.05.2019 04:53:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8124 Ys:0 Zp:4259 Zs:-958 Sp_L:2 Tl_St:1 W:16297

01.05.2019 04:53:12	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8088 Ys:145 Zp:4151 Zs:-914 Sp_L:2 Tl_St:1 W:15517
01.05.2019 04:53:11	TR_ Manual Drive command Forward
01.05.2019 04:53:10	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2020 Ann:1
01.05.2019 04:53:10	TOS Message:0225 SND Loader_Not_Used
01.05.2019 04:53:10	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2020 Ann:0
01.05.2019 04:53:10	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
01.05.2019 04:53:09	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:53:09	AUT Sway control On
01.05.2019 04:53:09	TR_ Zero and Stand still
01.05.2019 04:53:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8085 Ys:0 Zp:4011 Zs:-90 Sp_L:2 Tl_St:1 W:16794
01.05.2019 04:53:08	HO_ Manual Drive command Lowering
01.05.2019 04:53:07	AUT Automatic Trolley target position reached TR: 80820 [mm]
01.05.2019 04:53:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8082 Ys:0 Zp:4010 Zs:0 Sp_L:2 Tl_St:1 W:17239
01.05.2019 04:53:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8093 Ys:-145 Zp:4010 Zs:0 Sp_L:2 Tl_St:1 W:17715
01.05.2019 04:53:06	AUT Automatic Hoist target position reached HO: 9952 [mm]
01.05.2019 04:53:06	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8095 Ys:0 Zp:4010 Zs:0 Sp_L:2 Tl_St:1 W:17618
01.05.2019 04:53:06	TR_ Manual Drive command Backward
01.05.2019 04:53:06	AUT Automatic Trolley target position reached TR: 80949 [mm]
01.05.2019 04:53:06	TR_ Manual Drive command Backward
01.05.2019 04:53:06	TR_ Manual Drive command Forward
01.05.2019 04:53:05	TR_ Manual Drive command Backward
01.05.2019 04:53:05	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8095 Ys:0 Zp:3992 Zs:-90 Sp_L:2 Tl_St:1 W:16356
01.05.2019 04:53:04	AUT Automatic Trolley target position reached TR: 80947 [mm]
01.05.2019 04:53:04	HO_ Manual Drive command Lowering
01.05.2019 04:53:04	TR_ Manual Drive command Forward
01.05.2019 04:53:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8095 Ys:0 Zp:3992 Zs:0 Sp_L:2 Tl_St:1 W:16600
01.05.2019 04:53:03	TR_ Manual Drive command Backward
01.05.2019 04:53:03	AUT Automatic Hoist target position reached HO: 10133 [mm]

01.05.2019 04:53:02	AUT Operation mode: 0 [2 = Loading, 3 = Unloading, 4 = Dual Cycling]
01.05.2019 04:53:02	HO_ Manual Drive command Hoisting
01.05.2019 04:53:02	AUT Automatic Trolley target position reached TR: 80946 [mm]
01.05.2019 04:53:02	TR_ Manual Drive command Forward
01.05.2019 04:53:01	TR_ Manual Drive command Backward
01.05.2019 04:53:01	TR_ Manual Drive command Forward
01.05.2019 04:53:01	AUT Automatic Hoist target position reached HO: 10133 [mm]
01.05.2019 04:53:00	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8097 Ys:0 Zp:3992 Zs:0 Sp_L:2 Tl_St:1 W:15059
01.05.2019 04:53:00	TR_ Manual Drive command Backward
01.05.2019 04:53:00	TR_ Manual Drive command Forward
01.05.2019 04:53:00	TR_ Manual Drive command Backward
01.05.2019 04:53:00	TR_ Zero and Stand still
01.05.2019 04:53:00	AUT Automatic Cruise On
01.05.2019 04:53:00	AUT Sway control On
01.05.2019 04:52:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8097 Ys:0 Zp:4012 Zs:0 Sp_L:2 Tl_St:1 W:14667
01.05.2019 04:52:59	HO_ Manual Drive command Hoisting
01.05.2019 04:52:58	AUT Automatic Trolley target position reached TR: 80975 [mm]
01.05.2019 04:52:58	TR_ Manual Drive command Forward
01.05.2019 04:52:58	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8097 Ys:0 Zp:3990 Zs:-90 Sp_L:2 Tl_St:1 W:16739
01.05.2019 04:52:57	TR_ Manual Drive command Backward
01.05.2019 04:52:57	AUT Automatic Trolley target position reached TR: 80997 [mm]
01.05.2019 04:52:57	HO_ Manual Drive command Lowering
01.05.2019 04:52:57	AUT Automatic Hoist target position reached HO: 10157 [mm]
01.05.2019 04:52:57	TOS Message:0228 SND Status_Set Level:0 Code:8333
01.05.2019 04:52:57	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8101 Ys:-86 Zp:3989 Zs:0 Sp_L:2 Tl_St:1 W:18045
01.05.2019 04:52:55	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8125 Ys:-142 Zp:3949 Zs:-570 Sp_L:2 Tl_St:1 W:17184
01.05.2019 04:52:55	TR_ Manual Drive command Backward
01.05.2019 04:52:54	AUT Automatic Trolley target position reached TR: 81247 [mm]

01.05.2019 04:52:54	TR_ Manual Drive command Forward
01.05.2019 04:52:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8130 Ys:0 Zp:3850 Zs:-592 Sp_L:2 Tl_St:1 W:16565
01.05.2019 04:52:52	TR_ Manual Drive command Backward
01.05.2019 04:52:52	TR_ Manual Drive command Forward
01.05.2019 04:52:52	TR_ Manual Drive command Backward
01.05.2019 04:52:50	AUT Automatic Cruise On
01.05.2019 04:52:50	AUT Sway control On
01.05.2019 04:52:50	TR_ Zero and Stand still
01.05.2019 04:52:49	AUT Automatic Trolley target position reached TR: 81332 [mm]
01.05.2019 04:52:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8133 Ys:0 Zp:3420 Zs:-1185 Sp_L:2 Tl_St:1 W:16364
01.05.2019 04:52:45	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8258 Ys:-148 Zp:2904 Zs:-1414 Sp_L:2 Tl_St:1 W:16080
01.05.2019 04:52:44	TR_ Manual Drive command Backward
01.05.2019 04:52:44	TR_ Manual Drive command Forward
01.05.2019 04:52:44	TR_ Manual Drive command Backward
01.05.2019 04:52:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8258 Ys:0 Zp:2724 Zs:-1475 Sp_L:2 Tl_St:1 W:16239
01.05.2019 04:52:43	AUT Automatic Trolley target position reached TR: 82608 [mm]
01.05.2019 04:52:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8267 Ys:-142 Zp:2652 Zs:-1475 Sp_L:2 Tl_St:1 W:16494
01.05.2019 04:52:43	TR_ Manual Drive command Backward
01.05.2019 04:52:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8269 Ys:0 Zp:2566 Zs:-1475 Sp_L:2 Tl_St:1 W:15276
01.05.2019 04:52:33	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6771 Ys:3583 Zp:1259 Zs:-103 Sp_L:2 Tl_St:1 W:15202
01.05.2019 04:52:33	HO_ Manual Drive command Hoisting
01.05.2019 04:52:33	HO_ Manual Drive command Lowering
01.05.2019 04:52:32	AUT Automatic Hoist target position reached HO: 37465 [mm]
01.05.2019 04:52:32	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6116 Ys:3421 Zp:1259 Zs:0 Sp_L:2 Tl_St:1 W:14392
01.05.2019 04:52:29	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:52:29	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
01.05.2019 04:52:28	job started(0). new JobID: 124
01.05.2019 04:52:28	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1

01.05.2019 04:52:28	AUT AGV leave
01.05.2019 04:52:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3853 Ys:1900 Zp:2724 Zs:2502 Sp_L:2 Tl_St:1 W:16129
01.05.2019 04:52:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
01.05.2019 04:52:19	TOS Message:0198 RCV Overview_Request
01.05.2019 04:52:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:154 Zp:4283 Zs:1528 Sp_L:2 Tl_St:1 W:17827
01.05.2019 04:52:16	TOS Message:0240 SND Job_Reply JobSeq:-215 QCSeq:2 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:7 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
01.05.2019 04:52:16	TR_ Manual Drive command Forward
01.05.2019 04:52:16	job finished(1). JobID: 123
01.05.2019 04:52:16	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:2 C-Lenght:2 C-Height:0
01.05.2019 04:52:15	TR_ Zero and Stand still
01.05.2019 04:52:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4507 Zs:249 Sp_L:2 Tl_St:1 W:16391
01.05.2019 04:52:10	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4583 Zs:97 Sp_L:2 Tl_St:1 W:2555
01.05.2019 04:52:10	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4584 Zs:0 Sp_L:2 Tl_St:1 W:2464
01.05.2019 04:52:10	TR_ Zero and Stand still
01.05.2019 04:52:10	HO_ Manual Drive command Hoisting
01.05.2019 04:52:10	LMS Underload detected
01.05.2019 04:52:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4568 Zs:-249 Sp_L:2 Tl_St:1 W:3713
01.05.2019 04:52:09	SPR Twistlocks unlocked, Position HO: 4374 [mm], TR: 30153 [mm], GA: 805849 [mm]

Jobnr.	Job time	TOS Message
125	01.05.2019 04:56:27	SPR Twistlocks unlocked, Position HO: 4357 [mm], TR: 30148 [mm], GA: 805848 [mm]
	01.05.2019 04:56:26	AUT Automatic Trolley target position reached TR: 30133 [mm]
	01.05.2019 04:56:26	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:56:26	AUT Stop Automatic, Position HO: 4679 [mm], TR: 30122 [mm], GA: 805849 [mm]
	01.05.2019 04:56:26	AUT Automatic Trolley stops moving, Position HO: 4684 [mm], TR: 30122 [mm], GA: 805849 [mm]
	01.05.2019 04:56:26	TR_ Manual Drive command Forward
	01.05.2019 04:56:26	SPR Spreader landed
	01.05.2019 04:56:17	REP Speed report HO: -71.28 [%], TR: -19.60 [%], GA: 0.00 [%]
	01.05.2019 04:56:17	AUT Container gantry deviation outside funnel range Max dev: 497.82 Act dev: 836.65 HO: 10617 [mm]
	01.05.2019 04:56:17	AUT Container in funnel area on landside HO: 10617 [mm]
	01.05.2019 04:56:16	REP WMS Actual windspeed 1.64 [m/s], direction 327 [deg]
	01.05.2019 04:56:10	AUT Hoist takeover, Position HO: 27291 [mm], TR: 45828 [mm], GA: 805848 [mm]
	01.05.2019 04:56:10	AUT Automatic Hoist stops moving, Position HO: 27291 [mm], TR: 45828 [mm], GA: 805848 [mm]
	01.05.2019 04:56:10	HO_ Manual Drive command Lowering
	01.05.2019 04:56:04	AUT Automatic Hoist starts moving, Position HO: 35246 [mm], TR: 69260 [mm], GA: 805849 [mm]
	01.05.2019 04:56:01	HO_ Zero and Stand still
	01.05.2019 04:55:55	AUT Automatic Trolley starts moving, Position HO: 29492 [mm], TR: 83192 [mm], GA: 805849 [mm]
	01.05.2019 04:55:55	REP Position report HO: 29300 [mm], TR: 83192 [mm], GA: 805848 [mm]
	01.05.2019 04:55:55	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:55:55	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 04:55:55	AUT Automatic Hoist starts moving, Position HO: 29205 [mm], TR: 83192 [mm], GA: 805848 [mm]
	01.05.2019 04:55:43	LMS Load hangs free, Load Left: 11.8 [T], Right: 13.2 [T], Total: 25.0 [T]
	01.05.2019 04:55:41	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:4 C_Lenght:2
	01.05.2019 04:55:39	HO_ Manual Drive command Hoisting
	01.05.2019 04:55:32	HO_ Zero and Stand still
	01.05.2019 04:55:30	AUT Automatic Hoist target position reached HO: 4503 [mm]
	01.05.2019 04:55:28	HO_ Manual Drive command Hoisting
	01.05.2019	LMS Underload detected

	04:55:27	
	01.05.2019 04:55:27	AUT Automatic Hoist target position reached HO: 4272 [mm]
	01.05.2019 04:55:27	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 04:55:27	SPR Twistlocks locked, Position HO: 4273 [mm], TR: 83197 [mm], GA: 805848 [mm]
	01.05.2019 04:55:27	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8320 Ys:0 Zp:4578 Zs:0 Sp_L:2 Tl_St:1 W:5405
	01.05.2019 04:55:26	SPR Spreader landed
	01.05.2019 04:55:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8320 Ys:0 Zp:4464 Zs:-631 Sp_L:2 Tl_St:1 W:15700
	01.05.2019 04:55:23	TR_ Zero and Stand still
	01.05.2019 04:55:23	AUT Automatic Cruise On
	01.05.2019 04:55:23	AUT Sway control On
	01.05.2019 04:55:21	AUT Automatic Trolley target position reached TR: 83199 [mm]
	01.05.2019 04:55:21	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8320 Ys:0 Zp:4255 Zs:-593 Sp_L:2 Tl_St:1 W:17153
	01.05.2019 04:55:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8334 Ys:-142 Zp:4190 Zs:-924 Sp_L:2 Tl_St:1 W:14209
	01.05.2019 04:55:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
	01.05.2019 04:55:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 04:55:19	TR_ Manual Drive command Backward
	01.05.2019 04:55:18	TR_ Zero and Stand still
	01.05.2019 04:55:18	AUT Automatic Cruise On
	01.05.2019 04:55:18	AUT Sway control On
	01.05.2019 04:55:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8335 Ys:0 Zp:4053 Zs:-93 Sp_L:2 Tl_St:1 W:17335
	01.05.2019 04:55:17	HO_ Manual Drive command Hoisting
	01.05.2019 04:55:17	HO_ Manual Drive command Lowering
	01.05.2019 04:55:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8337 Ys:0 Zp:4053 Zs:0 Sp_L:2 Tl_St:1 W:18839
	01.05.2019 04:55:17	HO_ Manual Drive command Hoisting
	01.05.2019 04:55:17	HO_ Manual Drive command Hoisting
	01.05.2019 04:55:16	AUT Automatic Trolley target position reached TR: 83354 [mm]
	01.05.2019 04:55:16	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:55:16	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019	TOS Message:0225 SND Loader_Not_Used

	04:55:15	
	01.05.2019 04:55:15	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:55:15	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 04:55:15	TR_ Manual Drive command Forward
	01.05.2019 04:55:15	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:55:14	TR_ Zero and Stand still
	01.05.2019 04:55:14	AUT Automatic Cruise On
	01.05.2019 04:55:14	AUT Sway control On
	01.05.2019 04:55:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8332 Ys:0 Zp:3910 Zs:-368 Sp_L:2 Tl_St:1 W:16891
	01.05.2019 04:55:12	AUT Automatic Trolley target position reached TR: 83307 [mm]
	01.05.2019 04:55:12	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8329 Ys:0 Zp:3847 Zs:-226 Sp_L:2 Tl_St:1 W:16994
	01.05.2019 04:55:11	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8309 Ys:151 Zp:3804 Zs:-509 Sp_L:2 Tl_St:1 W:17218
	01.05.2019 04:55:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8304 Ys:0 Zp:3745 Zs:-565 Sp_L:2 Tl_St:1 W:17667
	01.05.2019 04:55:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8292 Ys:151 Zp:3697 Zs:-938 Sp_L:2 Tl_St:1 W:16537
	01.05.2019 04:55:08	TR_ Manual Drive command Forward
	01.05.2019 04:55:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8284 Ys:0 Zp:3547 Zs:-1134 Sp_L:2 Tl_St:1 W:16807
	01.05.2019 04:55:07	AUT Automatic Trolley target position reached TR: 82856 [mm]
	01.05.2019 04:55:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8294 Ys:-151 Zp:3485 Zs:-1144 Sp_L:2 Tl_St:1 W:17147
	01.05.2019 04:55:06	TR_ Manual Drive command Backward
	01.05.2019 04:55:06	TR_ Manual Drive command Forward
	01.05.2019 04:55:06	TR_ Manual Drive command Backward
	01.05.2019 04:55:06	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8290 Ys:0 Zp:3351 Zs:-1314 Sp_L:2 Tl_St:1 W:16721
	01.05.2019 04:55:06	AUT Automatic Trolley target position reached TR: 82902 [mm]
	01.05.2019 04:55:05	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8315 Ys:-162 Zp:3229 Zs:-1404 Sp_L:2 Tl_St:1 W:15877
	01.05.2019 04:55:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8316 Ys:0 Zp:3075 Zs:-1356 Sp_L:2 Tl_St:1 W:15383
	01.05.2019 04:55:04	TR_ Manual Drive command Backward
	01.05.2019 04:55:04	TR_ Manual Drive command Forward
	01.05.2019 04:55:03	TR_ Manual Drive command Backward
	01.05.2019	AUT Automatic Cruise On

	04:55:03	
	01.05.2019 04:55:03	AUT Sway control On
	01.05.2019 04:55:03	TR_ Zero and Stand still
	01.05.2019 04:55:01	AUT Automatic Trolley target position reached TR: 83184 [mm]
	01.05.2019 04:55:01	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8319 Ys:0 Zp:2725 Zs:-1665 Sp_L:2 Tl_St:1 W:17163
	01.05.2019 04:54:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7149 Ys:3605 Zp:1262 Zs:-1436 Sp_L:2 Tl_St:1 W:13964
	01.05.2019 04:54:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6272 Ys:3577 Zp:1089 Zs:0 Sp_L:2 Tl_St:1 W:14862
	01.05.2019 04:54:49	HO_ Manual Drive command Lowering
	01.05.2019 04:54:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4006 Ys:2271 Zp:2463 Zs:2499 Sp_L:2 Tl_St:1 W:15900
	01.05.2019 04:54:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:54:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:54:38	job started(0). new JobID: 125
	01.05.2019 04:54:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:54:38	AUT AGV leave
	01.05.2019 04:54:36	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3030 Ys:159 Zp:4324 Zs:1361 Sp_L:2 Tl_St:1 W:17449
	01.05.2019 04:54:35	TOS Message:0240 SND Job_Reply JobSeq:-216 QCSeq:3 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:100 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:54:35	job finished(1). JobID: 124
	01.05.2019 04:54:35	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:3 C-Lenght:2 C-Height:3
	01.05.2019 04:54:35	TR_ Manual Drive command Forward
	01.05.2019 04:54:34	TR_ Zero and Stand still
	01.05.2019 04:54:34	AUT Automatic Cruise On
	01.05.2019 04:54:34	AUT Sway control On
	01.05.2019 04:54:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3029 Ys:0 Zp:4483 Zs:249 Sp_L:2 Tl_St:1 W:16756
	01.05.2019 04:54:29	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3028 Ys:0 Zp:4588 Zs:0 Sp_L:2 Tl_St:1 W:1871
	01.05.2019 04:54:29	HO_ Manual Drive command Hoisting
	01.05.2019 04:54:28	LMS Underload detected
	01.05.2019 04:54:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3029 Ys:0 Zp:4570 Zs:-251 Sp_L:2 Tl_St:1 W:4461
	01.05.2019 04:54:28	SPR Twistlocks unlocked, Position HO: 4347 [mm], TR: 30285 [mm], GA: 805849 [mm]

Jobnr.	Job Time	TOS Message
126	01.05.2019 04:58:16	SPR Twistlocks unlocked, Position HO: 4378 [mm], TR: 30165 [mm], GA: 805849 [mm]
	01.05.2019 04:58:15	TR_ Zero and Stand still
	01.05.2019 04:58:14	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:58:14	AUT Stop Automatic, Position HO: 4690 [mm], TR: 30167 [mm], GA: 805848 [mm]
	01.05.2019 04:58:14	AUT Automatic Trolley stops moving, Position HO: 4695 [mm], TR: 30167 [mm], GA: 805848 [mm]
	01.05.2019 04:58:14	SPR Spreader landed
	01.05.2019 04:58:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:0 Zp:4522 Zs:-249 Sp_L:2 Tl_St:2 W:26672
	01.05.2019 04:58:13	AUT Automatic Trolley target position reached TR: 30160 [mm]
	01.05.2019 04:58:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2995 Ys:0 Zp:4390 Zs:-83 Sp_L:2 Tl_St:2 W:26555
	01.05.2019 04:58:08	HO_ Manual Drive command Hoisting
	01.05.2019 04:58:08	HO_ Manual Drive command Lowering
	01.05.2019 04:58:07	AUT Automatic Hoist target position reached HO: 6152 [mm]
	01.05.2019 04:58:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2993 Ys:-73 Zp:4390 Zs:0 Sp_L:2 Tl_St:2 W:28241
	01.05.2019 04:58:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3100 Ys:-698 Zp:4032 Zs:-2074 Sp_L:2 Tl_St:2 W:28246
	01.05.2019 04:58:03	REP Speed report HO: -92.91 [%], TR: -20.09 [%], GA: 0.00 [%]
	01.05.2019 04:58:03	AUT Container gantry deviation outside funnel range Max dev: 497.68 Act dev: 832.99 HO: 10615 [mm]
	01.05.2019 04:58:03	AUT Container in funnel area on landside HO: 10615 [mm]
	01.05.2019 04:58:02	REP WMS Actual windspeed 1.84 [m/s], direction 356 [deg]
	01.05.2019 04:57:58	AUT Hoist takeover, Position HO: 24026 [mm], TR: 41003 [mm], GA: 805848 [mm]
	01.05.2019 04:57:58	AUT Automatic Hoist stops moving, Position HO: 24026 [mm], TR: 41003 [mm], GA: 805848 [mm]
	01.05.2019 04:57:58	HO_ Manual Drive command Lowering
	01.05.2019 04:57:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5488 Ys:-3970 Zp:1873 Zs:-717 Sp_L:2 Tl_St:2 W:25662
	01.05.2019 04:57:53	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5894 Ys:-3973 Zp:1831 Zs:-81 Sp_L:2 Tl_St:2 W:26123
	01.05.2019 04:57:52	AUT Automatic Hoist starts moving, Position HO: 31737 [mm], TR: 63189 [mm], GA: 805848 [mm]
	01.05.2019 04:57:47	HO_ Zero and Stand still
	01.05.2019 04:57:45	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8275 Ys:-1470 Zp:1831 Zs:0 Sp_L:2 Tl_St:2 W:24779
	01.05.2019 04:57:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8431 Ys:-868 Zp:1882 Zs:773 Sp_L:2 Tl_St:2 W:23997

	01.05.2019 04:57:41	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8594 Ys:-148 Zp:2282 Zs:2382 Sp_L:2 Tl_St:2 W:25900
	01.05.2019 04:57:40	AUT Automatic Trolley starts moving, Position HO: 25029 [mm], TR: 85950 [mm], GA: 805848 [mm]
	01.05.2019 04:57:40	REP Position report HO: 24787 [mm], TR: 85950 [mm], GA: 805849 [mm]
	01.05.2019 04:57:40	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:57:40	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 04:57:40	AUT Automatic Hoist starts moving, Position HO: 24690 [mm], TR: 85950 [mm], GA: 805849 [mm]
	01.05.2019 04:57:40	TOS Message:0235 SND Auto_Position_Reply QC_Id:94 Accept:1
	01.05.2019 04:57:40	TOS Message:0201 RCV Auto_Pos_Req QC_Id:94 Xtr:1 Ytr:1 Ztr:1 Sptr:1 Twtr:1 T_X:10 T_Y:10 T_Z:10
	01.05.2019 04:57:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8595 Ys:0 Zp:4064 Zs:2274 Sp_L:2 Tl_St:2 W:28043
	01.05.2019 04:57:30	LMS Load hangs free, Load Left: 12.2 [T], Right: 13.8 [T], Total: 26.0 [T]
	01.05.2019 04:57:28	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:5 C_Lenght:2
	01.05.2019 04:57:27	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8595 Ys:0 Zp:4569 Zs:95 Sp_L:2 Tl_St:2 W:5211
	01.05.2019 04:57:27	LMS Underload detected
	01.05.2019 04:57:27	AUT Automatic Hoist target position reached HO: 4354 [mm]
	01.05.2019 04:57:27	HO_ Manual Drive command Hoisting
	01.05.2019 04:57:26	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8595 Ys:0 Zp:4570 Zs:54 Sp_L:2 Tl_St:2 W:7899
	01.05.2019 04:57:26	SPR Twistlocks locked, Position HO: 4352 [mm], TR: 85952 [mm], GA: 805849 [mm]
	01.05.2019 04:57:26	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 04:57:26	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8595 Ys:0 Zp:4572 Zs:0 Sp_L:2 Tl_St:1 W:6155
	01.05.2019 04:57:26	HO_ Manual Drive command Hoisting
	01.05.2019 04:57:25	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:57:25	SPR Spreader landed
	01.05.2019 04:57:25	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 04:57:25	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:57:25	AUT AGV in Position Lane: 2 GA-Pos: 805848 [mm] Offset: 0 [mm]
	01.05.2019 04:57:24	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:57:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8596 Ys:0 Zp:4517 Zs:-247 Sp_L:2 Tl_St:1 W:17347
	01.05.2019 04:57:22	TR_ Zero and Stand still

	01.05.2019 04:57:22	AUT Automatic Cruise On
	01.05.2019 04:57:22	AUT Sway control On
	01.05.2019 04:57:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8601 Ys:0 Zp:4301 Zs:-749 Sp_L:2 Tl_St:1 W:17697
	01.05.2019 04:57:20	AUT Automatic Trolley target position reached TR: 85985 [mm]
	01.05.2019 04:57:19	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8587 Ys:148 Zp:4240 Zs:-1144 Sp_L:2 Tl_St:1 W:18031
	01.05.2019 04:57:18	TR_ Manual Drive command Forward
	01.05.2019 04:57:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8584 Ys:0 Zp:4017 Zs:-290 Sp_L:2 Tl_St:1 W:16021
	01.05.2019 04:57:17	AUT Automatic Trolley target position reached TR: 85847 [mm]
	01.05.2019 04:57:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8591 Ys:-142 Zp:4006 Zs:-212 Sp_L:2 Tl_St:1 W:16816
	01.05.2019 04:57:16	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 04:57:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8595 Ys:0 Zp:3986 Zs:-203 Sp_L:2 Tl_St:1 W:16248
	01.05.2019 04:57:15	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8606 Ys:-151 Zp:3975 Zs:-212 Sp_L:2 Tl_St:1 W:17356
	01.05.2019 04:57:14	TR_ Manual Drive command Backward
	01.05.2019 04:57:14	AUT Automatic Trolley target position reached TR: 86090 [mm]
	01.05.2019 04:57:14	TR_ Manual Drive command Forward
	01.05.2019 04:57:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8608 Ys:0 Zp:3930 Zs:-385 Sp_L:2 Tl_St:1 W:16815
	01.05.2019 04:57:13	TR_ Manual Drive command Backward
	01.05.2019 04:57:13	AUT Automatic Trolley target position reached TR: 86085 [mm]
	01.05.2019 04:57:12	AUT Automatic Trolley target position reached TR: 86122 [mm]
	01.05.2019 04:57:12	TR_ Manual Drive command Forward
	01.05.2019 04:57:12	TR_ Manual Drive command Backward
	01.05.2019 04:57:12	TR_ Manual Drive command Backward
	01.05.2019 04:57:12	AUT Automatic Trolley target position reached TR: 86099 [mm]
	01.05.2019 04:57:08	AUT Automatic Trolley target position reached TR: 85901 [mm]
	01.05.2019 04:57:07	TR_ Manual Drive command Forward
	01.05.2019 04:57:06	AUT Automatic Trolley target position reached TR: 85905 [mm]
	01.05.2019 04:57:05	TR_ Manual Drive command Forward
	01.05.2019 04:57:04	AUT Automatic Trolley target position reached TR: 85876 [mm]

	01.05.2019 04:57:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8588 Ys:78 Zp:3437 Zs:-751 Sp_L:2 Tl_St:1 W:17762
	01.05.2019 04:57:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8567 Ys:148 Zp:3340 Zs:-1256 Sp_L:2 Tl_St:1 W:16196
	01.05.2019 04:57:02	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8567 Ys:0 Zp:3258 Zs:-1221 Sp_L:2 Tl_St:1 W:15883
	01.05.2019 04:57:02	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:57:02	AUT Stop Automatic, Position HO: 17623 [mm], TR: 85654 [mm], GA: 805848 [mm]
	01.05.2019 04:57:02	AUT Automatic Trolley stops moving, Position HO: 17647 [mm], TR: 85647 [mm], GA: 805848 [mm]
	01.05.2019 04:57:02	TR_ Manual Drive command Forward
	01.05.2019 04:56:58	Message 25: Sent Data Type: Binary Number of traces in range: 314. Range Start Time: 19050104 51587404 Total number of traces: 18652. Total count Start Time: 19043018 41561833 End Time: 19050104 56587614
	01.05.2019 04:56:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7531 Ys:2927 Zp:2121 Zs:-92 Sp_L:2 Tl_St:1 W:15540
	01.05.2019 04:56:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7367 Ys:3078 Zp:2120 Zs:0 Sp_L:2 Tl_St:1 W:15522
	01.05.2019 04:56:53	HO_ Manual Drive command Hoisting
	01.05.2019 04:56:53	AUT Hoist takeover, Position HO: 28847 [mm], TR: 72150 [mm], GA: 805848 [mm]
	01.05.2019 04:56:53	AUT Automatic Hoist stops moving, Position HO: 28847 [mm], TR: 72150 [mm], GA: 805848 [mm]
	01.05.2019 04:56:53	HO_ Manual Drive command Lowering
	01.05.2019 04:56:49	HO_ Zero and Stand still
	01.05.2019 04:56:46	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4633 Ys:3588 Zp:2120 Zs:0 Sp_L:2 Tl_St:1 W:14424
	01.05.2019 04:56:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3793 Ys:2188 Zp:2346 Zs:1653 Sp_L:2 Tl_St:1 W:14770
	01.05.2019 04:56:40	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:56:40	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:56:39	job started(0). new JobID: 126
	01.05.2019 04:56:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:56:39	AUT AGV leave
	01.05.2019 04:56:37	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:142 Zp:3804 Zs:2445 Sp_L:2 Tl_St:1 W:16369
	01.05.2019 04:56:36	AUT Automatic Trolley starts moving, Position HO: 9649 [mm], TR: 30140 [mm], GA: 805848 [mm]
	01.05.2019 04:56:36	REP Position report HO: 8592 [mm], TR: 30140 [mm], GA: 805849 [mm]
	01.05.2019 04:56:36	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:56:36	AUT Start Automatic to Targets HO: 19972 [mm] TR: 85715 [mm]
	01.05.2019 04:56:36	AUT Automatic Hoist starts moving, Position HO: 8513 [mm], TR: 30140 [mm], GA: 805849 [mm]

	01.05.2019 04:56:34	TOS Message:0240 SND Job_Reply JobSeq:-217 QCSeq:4 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:6 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:56:34	job finished(1). JobID: 125
	01.05.2019 04:56:34	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:4 C-Lenght:2 C-Height:0
	01.05.2019 04:56:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3014 Ys:0 Zp:4446 Zs:607 Sp_L:2 Tl_St:1 W:18193
	01.05.2019 04:56:28	TR_ Zero and Stand still
	01.05.2019 04:56:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3014 Ys:0 Zp:4587 Zs:0 Sp_L:2 Tl_St:1 W:1817
	01.05.2019 04:56:28	GA_ Zero and Stand still
	01.05.2019 04:56:28	HO_ Manual Drive command Hoisting
	01.05.2019 04:56:27	LMS Underload detected
	01.05.2019 04:56:27	SPR Twistlocks unlocked, Position HO: 4357 [mm], TR: 30148 [mm], GA: 805848 [mm]

Jobnr.	Job Time	TOS Message
127	01.05.2019 04:59:57	SPR Twistlocks unlocked, Position HO: 4355 [mm], TR: 30162 [mm], GA: 805849 [mm]
	01.05.2019 04:59:56	TR_ Zero and Stand still
	01.05.2019 04:59:56	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:59:56	AUT Stop Automatic, Position HO: 4665 [mm], TR: 30163 [mm], GA: 805849 [mm]
	01.05.2019 04:59:56	AUT Automatic Trolley stops moving, Position HO: 4672 [mm], TR: 30163 [mm], GA: 805848 [mm]
	01.05.2019 04:59:56	SPR Spreader landed
	01.05.2019 04:59:55	AUT Automatic Trolley target position reached TR: 30159 [mm]
	01.05.2019 04:59:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3012 Ys:0 Zp:4481 Zs:-251 Sp_L:2 Tl_St:2 W:27915
	01.05.2019 04:59:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2997 Ys:0 Zp:4204 Zs:-185 Sp_L:2 Tl_St:2 W:28699
	01.05.2019 04:59:46	REP Speed report HO: -68.49 [%], TR: -16.67 [%], GA: 0.00 [%]
	01.05.2019	AUT Container gantry deviation outside funnel range Max dev: 497.78 Act dev: 828.31 HO: 10617 [mm]

	04:59:46	
	01.05.2019 04:59:46	AUT Container in funnel area on landside HO: 10617 [mm]
	01.05.2019 04:59:45	REP WMS Actual windspeed 1.76 [m/s], direction 339 [deg]
	01.05.2019 04:59:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3308 Ys:-1476 Zp:3482 Zs:-2352 Sp_L:2 Tl_St:2 W:27622
	01.05.2019 04:59:37	AUT Hoist takeover, Position HO: 30535 [mm], TR: 51683 [mm], GA: 805849 [mm]
	01.05.2019 04:59:37	AUT Automatic Hoist stops moving, Position HO: 30535 [mm], TR: 51683 [mm], GA: 805849 [mm]
	01.05.2019 04:59:37	HO_ Manual Drive command Lowering
	01.05.2019 04:59:35	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5881 Ys:-4018 Zp:1833 Zs:-105 Sp_L:2 Tl_St:2 W:27137
	01.05.2019 04:59:34	AUT Automatic Hoist starts moving, Position HO: 31721 [mm], TR: 63188 [mm], GA: 805849 [mm]
	01.05.2019 04:59:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6335 Ys:-3998 Zp:1833 Zs:0 Sp_L:2 Tl_St:2 W:26810
	01.05.2019 04:59:30	HO_ Zero and Stand still
	01.05.2019 04:59:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8257 Ys:-2160 Zp:1833 Zs:0 Sp_L:2 Tl_St:2 W:24811
	01.05.2019 04:59:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8804 Ys:-647 Zp:2369 Zs:2350 Sp_L:2 Tl_St:2 W:27437
	01.05.2019 04:59:23	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8859 Ys:-156 Zp:2637 Zs:2350 Sp_L:2 Tl_St:2 W:27131
	01.05.2019 04:59:22	AUT Automatic Trolley starts moving, Position HO: 21548 [mm], TR: 88592 [mm], GA: 805849 [mm]
	01.05.2019 04:59:20	REP Position report HO: 17876 [mm], TR: 88594 [mm], GA: 805848 [mm]
	01.05.2019 04:59:20	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:59:20	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 04:59:20	AUT Automatic Hoist starts moving, Position HO: 17782 [mm], TR: 88594 [mm], GA: 805848 [mm]
	01.05.2019 04:59:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8859 Ys:0 Zp:4465 Zs:609 Sp_L:2 Tl_St:2 W:26957
	01.05.2019 04:59:13	LMS Load hangs free, Load Left: 12.5 [T], Right: 14.4 [T], Total: 26.9 [T]
	01.05.2019 04:59:11	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:6 C_Lenght:2
	01.05.2019 04:59:10	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8860 Ys:0 Zp:4568 Zs:90 Sp_L:2 Tl_St:2 W:5472
	01.05.2019 04:59:09	AUT Automatic Hoist target position reached HO: 4364 [mm]
	01.05.2019 04:59:09	LMS Underload detected
	01.05.2019 04:59:09	HO_ Manual Drive command Hoisting
	01.05.2019 04:59:09	SPR Twistlocks locked, Position HO: 4364 [mm], TR: 88597 [mm], GA: 805849 [mm]
	01.05.2019 04:59:09	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8860 Ys:0 Zp:4571 Zs:0 Sp_L:2 Tl_St:1 W:7179

	04:59:09	
	01.05.2019 04:59:08	HO_ Manual Drive command Hoisting
	01.05.2019 04:59:08	SPR Spreader landed
	01.05.2019 04:59:06	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 04:59:06	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 04:59:06	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 04:59:06	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 04:59:05	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:59:05	TR_ Zero and Stand still
	01.05.2019 04:59:05	AUT Automatic Cruise On
	01.05.2019 04:59:05	AUT Sway control On
	01.05.2019 04:59:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8856 Ys:0 Zp:4269 Zs:-1467 Sp_L:2 Tl_St:1 W:15600
	01.05.2019 04:59:04	AUT Automatic Trolley target position reached TR: 88558 [mm]
	01.05.2019 04:59:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8886 Ys:-154 Zp:4137 Zs:-1029 Sp_L:2 Tl_St:1 W:15182
	01.05.2019 04:59:02	TR_ Manual Drive command Backward
	01.05.2019 04:59:02	AUT Automatic Trolley target position reached TR: 88866 [mm]
	01.05.2019 04:59:01	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 04:58:56	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 04:58:56	AUT Stop Automatic, Position HO: 11553 [mm], TR: 88502 [mm], GA: 805849 [mm]
	01.05.2019 04:58:56	AUT Automatic Trolley stops moving, Position HO: 11582 [mm], TR: 88502 [mm], GA: 805849 [mm]
	01.05.2019 04:58:56	TR_ Manual Drive command Forward
	01.05.2019 04:58:54	AUT Automatic Trolley target position reached TR: 88503 [mm]
	01.05.2019 04:58:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8851 Ys:0 Zp:3663 Zs:-827 Sp_L:2 Tl_St:1 W:16323
	01.05.2019 04:58:52	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8850 Ys:0 Zp:3467 Zs:-1219 Sp_L:2 Tl_St:1 W:16254
	01.05.2019 04:58:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8067 Ys:2380 Zp:2223 Zs:-1104 Sp_L:2 Tl_St:1 W:14936
	01.05.2019 04:58:42	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7603 Ys:3036 Zp:2123 Zs:-90 Sp_L:2 Tl_St:1 W:15896
	01.05.2019 04:58:41	AUT Hoist takeover, Position HO: 28826 [mm], TR: 72903 [mm], GA: 805848 [mm]
	01.05.2019 04:58:41	AUT Automatic Hoist stops moving, Position HO: 28826 [mm], TR: 72903 [mm], GA: 805848 [mm]
	01.05.2019	HO_ Manual Drive command Lowering

	04:58:41	
	01.05.2019 04:58:36	HO_ Zero and Stand still
	01.05.2019 04:58:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4638 Ys:3588 Zp:2121 Zs:0 Sp_L:2 Tl_St:1 W:14485
	01.05.2019 04:58:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4444 Ys:3426 Zp:2132 Zs:354 Sp_L:2 Tl_St:1 W:15311
	01.05.2019 04:58:31	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:58:31	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:58:30	job started(0). new JobID: 127
	01.05.2019 04:58:30	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 04:58:30	AUT AGV leave
	01.05.2019 04:58:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:142 Zp:3783 Zs:2416 Sp_L:2 Tl_St:1 W:16346
	01.05.2019 04:58:24	AUT Automatic Trolley starts moving, Position HO: 9661 [mm], TR: 30162 [mm], GA: 805849 [mm]
	01.05.2019 04:58:24	REP Position report HO: 9255 [mm], TR: 30162 [mm], GA: 805848 [mm]
	01.05.2019 04:58:24	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 04:58:24	AUT Start Automatic to Targets HO: 19972 [mm] TR: 88470 [mm]
	01.05.2019 04:58:24	AUT Automatic Hoist starts moving, Position HO: 9167 [mm], TR: 30162 [mm], GA: 805848 [mm]
	01.05.2019 04:58:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4167 Zs:1929 Sp_L:2 Tl_St:1 W:16987
	01.05.2019 04:58:22	TOS Message:0240 SND Job_Reply JobSeq:-218 QCSeq:5 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:4 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 04:58:22	job finished(1). JobID: 126
	01.05.2019 04:58:22	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:5 C-Lenght:2 C-Height:0
	01.05.2019 04:58:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:5 :0 :0 Ld:0
	01.05.2019 04:58:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 04:58:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4581 Zs:0 Sp_L:2 Tl_St:1 W:2649
	01.05.2019 04:58:16	LMS Underload detected
	01.05.2019 04:58:16	HO_ Manual Drive command Hoisting
	01.05.2019 04:58:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:0 Zp:4567 Zs:-251 Sp_L:2 Tl_St:1 W:4122
	01.05.2019 04:58:16	SPR Twistlocks unlocked, Position HO: 4378 [mm], TR: 30165 [mm], GA: 805849 [mm]

Jobnr.	Job Time	TOS Message
128	01.05.2019 05:01:53	SPR Twistlocks unlocked, Position HO: 4371 [mm], TR: 30167 [mm], GA: 805849 [mm]
	01.05.2019 05:01:52	TR_ Zero and Stand still
	01.05.2019 05:01:52	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:01:52	AUT Stop Automatic, Position HO: 4683 [mm], TR: 30165 [mm], GA: 805848 [mm]
	01.05.2019 05:01:52	AUT Automatic Trolley stops moving, Position HO: 4692 [mm], TR: 30165 [mm], GA: 805848 [mm]
	01.05.2019 05:01:52	SPR Spreader landed
	01.05.2019 05:01:51	AUT Automatic Trolley target position reached TR: 30158 [mm]
	01.05.2019 05:01:46	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2994 Ys:0 Zp:4321 Zs:-95 Sp_L:2 Tl_St:2 W:29799
	01.05.2019 05:01:46	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2994 Ys:0 Zp:4320 Zs:0 Sp_L:2 Tl_St:2 W:30710
	01.05.2019 05:01:45	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2996 Ys:0 Zp:4292 Zs:-576 Sp_L:2 Tl_St:2 W:31026
	01.05.2019 05:01:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:-232 Zp:4160 Zs:-1389 Sp_L:2 Tl_St:2 W:30838
	01.05.2019 05:01:42	REP Speed report HO: -85.04 [%], TR: -11.93 [%], GA: 0.00 [%]
	01.05.2019 05:01:42	AUT Container gantry deviation outside funnel range Max dev: 495.79 Act dev: 874.62 HO: 10587 [mm]
	01.05.2019 05:01:42	AUT Container in funnel area on landside HO: 10587 [mm]
	01.05.2019 05:01:40	REP WMS Actual windspeed 2.33 [m/s], direction 318 [deg]
	01.05.2019 05:01:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4734 Ys:-3440 Zp:2125 Zs:-1753 Sp_L:2 Tl_St:2 W:25814
	01.05.2019 05:01:33	AUT Hoist takeover, Position HO: 30249 [mm], TR: 50873 [mm], GA: 805849 [mm]
	01.05.2019 05:01:33	AUT Automatic Hoist stops moving, Position HO: 30249 [mm], TR: 50873 [mm], GA: 805849 [mm]
	01.05.2019 05:01:33	HO_ Manual Drive command Lowering
	01.05.2019 05:01:31	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5892 Ys:-4012 Zp:1832 Zs:-97 Sp_L:2 Tl_St:2 W:28232
	01.05.2019 05:01:30	AUT Automatic Hoist starts moving, Position HO: 31731 [mm], TR: 63235 [mm], GA: 805849 [mm]
	01.05.2019 05:01:24	HO_ Zero and Stand still
	01.05.2019 05:01:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8385 Ys:-2215 Zp:1832 Zs:0 Sp_L:2 Tl_St:2 W:28411
	01.05.2019	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8729 Ys:-1643 Zp:1832 Zs:0 Sp_L:2 Tl_St:2 W:27786

	05:01:22	
	01.05.2019 05:01:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:7 :0 :0 Ld:0
	01.05.2019 05:01:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 05:01:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9099 Ys:-162 Zp:2352 Zs:2274 Sp_L:2 Tl_St:2 W:27621
	01.05.2019 05:01:17	AUT Automatic Trolley starts moving, Position HO: 24447 [mm], TR: 90994 [mm], GA: 805849 [mm]
	01.05.2019 05:01:17	REP Position report HO: 24309 [mm], TR: 90994 [mm], GA: 805849 [mm]
	01.05.2019 05:01:17	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:01:17	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 05:01:17	AUT Automatic Hoist starts moving, Position HO: 24217 [mm], TR: 90994 [mm], GA: 805848 [mm]
	01.05.2019 05:01:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9100 Ys:0 Zp:3308 Zs:2277 Sp_L:2 Tl_St:2 W:27826
	01.05.2019 05:01:07	LMS Load hangs free, Load Left: 14.3 [T], Right: 15.5 [T], Total: 29.9 [T]
	01.05.2019 05:01:05	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:7 C_Lenght:2
	01.05.2019 05:01:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9101 Ys:0 Zp:4579 Zs:0 Sp_L:2 Tl_St:2 W:9576
	01.05.2019 05:01:03	LMS Underload detected
	01.05.2019 05:01:03	HO_ Manual Drive command Hoisting
	01.05.2019 05:01:03	SPR Twistlocks locked, Position HO: 4242 [mm], TR: 91002 [mm], GA: 805849 [mm]
	01.05.2019 05:01:03	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 05:01:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9100 Ys:0 Zp:4581 Zs:0 Sp_L:2 Tl_St:1 W:4859
	01.05.2019 05:01:02	HO_ Manual Drive command Hoisting
	01.05.2019 05:01:02	SPR Spreader landed
	01.05.2019 05:00:59	AUT Automatic Cruise On
	01.05.2019 05:00:59	AUT Sway control On
	01.05.2019 05:00:59	TR_ Zero and Stand still
	01.05.2019 05:00:58	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 05:00:58	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 05:00:58	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 05:00:58	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 05:00:57	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9106 Ys:0 Zp:4260 Zs:-1397 Sp_L:2 Tl_St:1 W:16253

	05:00:57	
	01.05.2019 05:00:57	AUT Automatic Trolley target position reached TR: 91047 [mm]
	01.05.2019 05:00:56	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9091 Ys:142 Zp:4165 Zs:-1031 Sp_L:2 Tl_St:1 W:15384
	01.05.2019 05:00:55	TR_ Manual Drive command Forward
	01.05.2019 05:00:54	TR_ Zero and Stand still
	01.05.2019 05:00:54	AUT Automatic Cruise On
	01.05.2019 05:00:54	AUT Sway control On
	01.05.2019 05:00:54	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 05:00:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9089 Ys:0 Zp:3994 Zs:-648 Sp_L:2 Tl_St:1 W:15845
	01.05.2019 05:00:52	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9089 Ys:0 Zp:3959 Zs:0 Sp_L:2 Tl_St:1 W:15362
	01.05.2019 05:00:52	AUT Automatic Trolley target position reached TR: 90887 [mm]
	01.05.2019 05:00:52	TR_ Manual Drive command Forward
	01.05.2019 05:00:52	HO_ Manual Drive command Lowering
	01.05.2019 05:00:51	TR_ Manual Drive command Backward
	01.05.2019 05:00:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9089 Ys:0 Zp:3987 Zs:90 Sp_L:2 Tl_St:1 W:17291
	01.05.2019 05:00:51	AUT Automatic Cruise On
	01.05.2019 05:00:51	AUT Sway control On
	01.05.2019 05:00:51	TR_ Zero and Stand still
	01.05.2019 05:00:51	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:51	AUT Automatic Hoist target position reached HO: 10173 [mm]
	01.05.2019 05:00:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9088 Ys:0 Zp:3988 Zs:0 Sp_L:2 Tl_St:1 W:15167
	01.05.2019 05:00:50	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 05:00:49	AUT Automatic Trolley target position reached TR: 90879 [mm]
	01.05.2019 05:00:49	TR_ Manual Drive command Forward
	01.05.2019 05:00:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9086 Ys:0 Zp:4009 Zs:139 Sp_L:2 Tl_St:1 W:15193
	01.05.2019 05:00:49	AUT Automatic Trolley target position reached TR: 90865 [mm]
	01.05.2019 05:00:48	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9092 Ys:-148 Zp:4017 Zs:232 Sp_L:2 Tl_St:1 W:16670
	01.05.2019 05:00:47	TR_ Manual Drive command Backward
	01.05.2019	TR_ Manual Drive command Forward

	05:00:47	
	01.05.2019 05:00:47	TR_ Manual Drive command Backward
	01.05.2019 05:00:47	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9097 Ys:0 Zp:4033 Zs:90 Sp_L:2 Tl_St:1 W:14503
	01.05.2019 05:00:47	AUT Automatic Trolley target position reached TR: 90975 [mm]
	01.05.2019 05:00:47	TR_ Manual Drive command Forward
	01.05.2019 05:00:47	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:47	AUT Automatic Hoist target position reached HO: 9710 [mm]
	01.05.2019 05:00:47	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:47	HO_ Manual Drive command Lowering
	01.05.2019 05:00:47	TR_ Manual Drive command Backward
	01.05.2019 05:00:46	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:46	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9097 Ys:0 Zp:4034 Zs:0 Sp_L:2 Tl_St:1 W:14632
	01.05.2019 05:00:46	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:45	AUT Automatic Trolley target position reached TR: 90985 [mm]
	01.05.2019 05:00:45	TR_ Manual Drive command Forward
	01.05.2019 05:00:45	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 05:00:45	AUT Automatic Trolley target position reached TR: 90977 [mm]
	01.05.2019 05:00:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9103 Ys:0 Zp:3984 Zs:-80 Sp_L:2 Tl_St:1 W:17605
	01.05.2019 05:00:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9103 Ys:-103 Zp:3977 Zs:-278 Sp_L:2 Tl_St:1 W:16931
	01.05.2019 05:00:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9115 Ys:-145 Zp:3956 Zs:-437 Sp_L:2 Tl_St:1 W:16554
	01.05.2019 05:00:41	TR_ Manual Drive command Backward
	01.05.2019 05:00:41	TR_ Manual Drive command Forward
	01.05.2019 05:00:41	TR_ Manual Drive command Backward
	01.05.2019 05:00:41	AUT Automatic Cruise On
	01.05.2019 05:00:41	AUT Sway control On
	01.05.2019 05:00:41	TR_ Zero and Stand still
	01.05.2019 05:00:39	AUT Automatic Trolley target position reached TR: 91208 [mm]
	01.05.2019 05:00:38	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019	AUT Stop Automatic, Position HO: 13187 [mm], TR: 91142 [mm], GA: 805849 [mm]

	05:00:38	
	01.05.2019 05:00:38	AUT Automatic Trolley stops moving, Position HO: 13224 [mm], TR: 91142 [mm], GA: 805849 [mm]
	01.05.2019 05:00:38	TR_ Manual Drive command Forward
	01.05.2019 05:00:37	TR_ Zero and Stand still
	01.05.2019 05:00:35	AUT Automatic Trolley target position reached TR: 91146 [mm]
	01.05.2019 05:00:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9113 Ys:0 Zp:3387 Zs:-968 Sp_L:2 Tl_St:1 W:17343
	01.05.2019 05:00:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9106 Ys:115 Zp:3299 Zs:-1250 Sp_L:2 Tl_St:1 W:16564
	01.05.2019 05:00:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7956 Ys:2977 Zp:2124 Zs:-83 Sp_L:2 Tl_St:1 W:15705
	01.05.2019 05:00:24	HO_ Manual Drive command Hoisting
	01.05.2019 05:00:24	AUT Hoist takeover, Position HO: 28819 [mm], TR: 76445 [mm], GA: 805848 [mm]
	01.05.2019 05:00:24	AUT Automatic Hoist stops moving, Position HO: 28819 [mm], TR: 76445 [mm], GA: 805848 [mm]
	01.05.2019 05:00:24	HO_ Manual Drive command Lowering
	01.05.2019 05:00:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7540 Ys:3376 Zp:2123 Zs:0 Sp_L:2 Tl_St:1 W:16438
	01.05.2019 05:00:18	HO_ Zero and Stand still
	01.05.2019 05:00:17	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:00:16	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:00:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4539 Ys:3490 Zp:2122 Zs:0 Sp_L:2 Tl_St:1 W:14519
	01.05.2019 05:00:15	job started(0). new JobID: 128
	01.05.2019 05:00:15	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:00:15	AUT AGV leave
	01.05.2019 05:00:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3835 Ys:2372 Zp:2285 Zs:1390 Sp_L:2 Tl_St:1 W:14848
	01.05.2019 05:00:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:142 Zp:3716 Zs:2423 Sp_L:2 Tl_St:1 W:16587
	01.05.2019 05:00:06	AUT Automatic Trolley starts moving, Position HO: 10397 [mm], TR: 30159 [mm], GA: 805848 [mm]
	01.05.2019 05:00:06	REP Position report HO: 10151 [mm], TR: 30159 [mm], GA: 805849 [mm]
	01.05.2019 05:00:06	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:00:06	AUT Start Automatic to Targets HO: 19972 [mm] TR: 91115 [mm]
	01.05.2019 05:00:06	AUT Automatic Hoist starts moving, Position HO: 10054 [mm], TR: 30159 [mm], GA: 805849 [mm]
	01.05.2019 05:00:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4414 Zs:887 Sp_L:2 Tl_St:1 W:18028
	01.05.2019	TOS Message:0240 SND Job_Reply JobSeq:-219 QCSeq:6 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:2 TarLoc:7 AGV:1 Sp:0 Bay:0

	05:00:04	Row:0 Tier:0
	01.05.2019 05:00:03	job finished(1). JobID: 127
	01.05.2019 05:00:03	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:6 C-Lenght:2 C-Height:3
	01.05.2019 04:59:58	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4583 Zs:0 Sp_L:2 Tl_St:1 W:2533
	01.05.2019 04:59:57	LMS Underload detected
	01.05.2019 04:59:57	HO_ Manual Drive command Hoisting
	01.05.2019 04:59:57	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4569 Zs:-249 Sp_L:2 Tl_St:1 W:3998
	01.05.2019 04:59:57	SPR Twistlocks unlocked, Position HO: 4355 [mm], TR: 30162 [mm], GA: 805849 [mm]

Jobnr.	Job time	TOS Message
129	01.05.2019 05:03:58	SPR Twistlocks unlocked, Position HO: 4324 [mm], TR: 30127 [mm], GA: 805848 [mm]
	01.05.2019 05:03:56	SPR Spreader landed
	01.05.2019 05:03:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4468 Zs:-251 Sp_L:2 Tl_St:2 W:-30068
	01.05.2019 05:03:52	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4439 Zs:0 Sp_L:2 Tl_St:2 W:32352
	01.05.2019 05:03:52	HO_ Manual Drive command Lowering
	01.05.2019 05:03:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4470 Zs:85 Sp_L:2 Tl_St:2 W:-31111
	01.05.2019 05:03:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4471 Zs:0 Sp_L:2 Tl_St:2 W:-25327
	01.05.2019 05:03:51	HO_ Manual Drive command Hoisting
	01.05.2019 05:03:50	TR_ Zero and Stand still
	01.05.2019 05:03:50	AUT Automatic Cruise On
	01.05.2019 05:03:50	AUT Sway control On
	01.05.2019	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4461 Zs:-90 Sp_L:2 Tl_St:2 W:-30747

	05:03:50	
	01.05.2019 05:03:49	HO_ Manual Drive command Lowering
	01.05.2019 05:03:49	AUT Automatic Hoist target position reached HO: 5454 [mm]
	01.05.2019 05:03:49	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3012 Ys:0 Zp:4459 Zs:0 Sp_L:2 Tl_St:2 W:-28025
	01.05.2019 05:03:48	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3015 Ys:0 Zp:4439 Zs:-475 Sp_L:2 Tl_St:2 W:-27852
	01.05.2019 05:03:48	AUT Automatic Trolley target position reached TR: 30141 [mm]
	01.05.2019 05:03:48	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3005 Ys:148 Zp:4402 Zs:-824 Sp_L:2 Tl_St:2 W:-28634
	01.05.2019 05:03:47	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:03:47	AUT Stop Automatic, Position HO: 6577 [mm], TR: 30006 [mm], GA: 805849 [mm]
	01.05.2019 05:03:47	AUT Automatic Trolley stops moving, Position HO: 6601 [mm], TR: 30005 [mm], GA: 805848 [mm]
	01.05.2019 05:03:47	TR_ Manual Drive command Forward
	01.05.2019 05:03:45	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2999 Ys:0 Zp:4160 Zs:-946 Sp_L:2 Tl_St:2 W:-26106
	01.05.2019 05:03:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3014 Ys:-237 Zp:3994 Zs:-1704 Sp_L:2 Tl_St:2 W:-26806
	01.05.2019 05:03:43	REP Speed report HO: -74.66 [%], TR: -6.84 [%], GA: 0.00 [%]
	01.05.2019 05:03:43	AUT Container gantry deviation outside funnel range Max dev: 495.20 Act dev: 868.76 HO: 10578 [mm]
	01.05.2019 05:03:43	AUT Container in funnel area on landside HO: 10578 [mm]
	01.05.2019 05:03:40	REP WMS Actual windspeed 1.64 [m/s], direction 308 [deg]
	01.05.2019 05:03:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4723 Ys:-3390 Zp:2099 Zs:-1787 Sp_L:2 Tl_St:2 W:-32246
	01.05.2019 05:03:31	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5804 Ys:-3993 Zp:1833 Zs:-97 Sp_L:2 Tl_St:2 W:-30308
	01.05.2019 05:03:30	AUT Hoist takeover, Position HO: 31726 [mm], TR: 62203 [mm], GA: 805848 [mm]
	01.05.2019 05:03:30	AUT Automatic Hoist stops moving, Position HO: 31726 [mm], TR: 62203 [mm], GA: 805848 [mm]
	01.05.2019 05:03:30	HO_ Manual Drive command Lowering
	01.05.2019 05:03:30	AUT Automatic Hoist starts moving, Position HO: 31726 [mm], TR: 63119 [mm], GA: 805848 [mm]
	01.05.2019 05:03:25	HO_ Zero and Stand still
	01.05.2019 05:03:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8491 Ys:-2634 Zp:1832 Zs:0 Sp_L:2 Tl_St:2 W:-31724
	01.05.2019 05:03:23	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8675 Ys:-2218 Zp:1832 Zs:0 Sp_L:2 Tl_St:2 W:31689
	01.05.2019 05:03:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9377 Ys:-145 Zp:2672 Zs:2026 Sp_L:2 Tl_St:2 W:-30331
	01.05.2019 05:03:16	AUT Automatic Trolley starts moving, Position HO: 21534 [mm], TR: 93773 [mm], GA: 805849 [mm]
	01.05.2019	REP Position report HO: 18940 [mm], TR: 93775 [mm], GA: 805849 [mm]

	05:03:15	
	01.05.2019 05:03:15	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:03:15	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 05:03:15	AUT Automatic Hoist starts moving, Position HO: 18859 [mm], TR: 93775 [mm], GA: 805849 [mm]
	01.05.2019 05:03:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9378 Ys:0 Zp:3374 Zs:2024 Sp_L:2 Tl_St:2 W:-32233
	01.05.2019 05:03:06	LMS Load hangs free, Load Left: 16.8 [T], Right: 18.7 [T], Total: 35.5 [T]
	01.05.2019 05:03:05	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:8 C_Lenght:2
	01.05.2019 05:03:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9378 Ys:0 Zp:4573 Zs:251 Sp_L:2 Tl_St:2 W:11313
	01.05.2019 05:03:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9379 Ys:0 Zp:4584 Zs:85 Sp_L:2 Tl_St:2 W:4100
	01.05.2019 05:03:03	HO_ Manual Drive command Hoisting
	01.05.2019 05:03:02	LMS Underload detected
	01.05.2019 05:03:02	SPR Twistlocks locked, Position HO: 4188 [mm], TR: 93784 [mm], GA: 805848 [mm]
	01.05.2019 05:03:02	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 05:03:02	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9378 Ys:0 Zp:4587 Zs:0 Sp_L:2 Tl_St:1 W:6587
	01.05.2019 05:03:02	HO_ Manual Drive command Hoisting
	01.05.2019 05:03:01	SPR Spreader landed
	01.05.2019 05:02:56	TR_ Zero and Stand still
	01.05.2019 05:02:56	AUT Automatic Cruise On
	01.05.2019 05:02:56	AUT Sway control On
	01.05.2019 05:02:55	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9374 Ys:0 Zp:4197 Zs:-610 Sp_L:2 Tl_St:1 W:16974
	01.05.2019 05:02:55	AUT Automatic Trolley target position reached TR: 93739 [mm]
	01.05.2019 05:02:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9396 Ys:0 Zp:4130 Zs:-812 Sp_L:2 Tl_St:1 W:15356
	01.05.2019 05:02:53	TR_ Manual Drive command Backward
	01.05.2019 05:02:53	TR_ Manual Drive command Forward
	01.05.2019 05:02:53	TR_ Manual Drive command Backward
	01.05.2019 05:02:52	AUT Automatic Trolley target position reached TR: 93987 [mm]
	01.05.2019 05:02:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9396 Ys:134 Zp:4018 Zs:-90 Sp_L:2 Tl_St:1 W:16164
	01.05.2019 05:02:51	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9388 Ys:0 Zp:4017 Zs:0 Sp_L:2 Tl_St:1 W:17371
	01.05.2019	TOS Message:0228 SND Status_Set Level:0 Code:8333

	05:02:51	
	01.05.2019 05:02:48	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 05:02:48	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 05:02:48	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 05:02:48	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 05:02:47	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:02:47	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9367 Ys:0 Zp:3912 Zs:-90 Sp_L:2 Tl_St:1 W:16676
	01.05.2019 05:02:46	HO_ Manual Drive command Lowering
	01.05.2019 05:02:46	HO_ Manual Drive command Hoisting
	01.05.2019 05:02:46	AUT Automatic Trolley target position reached TR: 93665 [mm]
	01.05.2019 05:02:46	HO_ Manual Drive command Lowering
	01.05.2019 05:02:45	AUT Automatic Trolley target position reached TR: 93647 [mm]
	01.05.2019 05:02:44	TR_ Manual Drive command Forward
	01.05.2019 05:02:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9361 Ys:0 Zp:3911 Zs:0 Sp_L:2 Tl_St:1 W:16202
	01.05.2019 05:02:43	AUT Automatic Hoist target position reached HO: 10941 [mm]
	01.05.2019 05:02:43	AUT Automatic Trolley target position reached TR: 93631 [mm]
	01.05.2019 05:02:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9364 Ys:0 Zp:3911 Zs:0 Sp_L:2 Tl_St:1 W:16361
	01.05.2019 05:02:42	TR_ Manual Drive command Backward
	01.05.2019 05:02:42	AUT Automatic Trolley target position reached TR: 93736 [mm]
	01.05.2019 05:02:42	TR_ Manual Drive command Forward
	01.05.2019 05:02:41	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9374 Ys:0 Zp:3969 Zs:92 Sp_L:2 Tl_St:1 W:15186
	01.05.2019 05:02:41	TR_ Manual Drive command Forward
	01.05.2019 05:02:41	TR_ Manual Drive command Backward
	01.05.2019 05:02:41	HO_ Manual Drive command Hoisting
	01.05.2019 05:02:41	AUT Automatic Hoist target position reached HO: 10352 [mm]
	01.05.2019 05:02:41	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9373 Ys:0 Zp:3970 Zs:0 Sp_L:2 Tl_St:1 W:15724
	01.05.2019 05:02:39	AUT Automatic Trolley target position reached TR: 93742 [mm]
	01.05.2019 05:02:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9374 Ys:0 Zp:3932 Zs:-97 Sp_L:2 Tl_St:1 W:16618
	01.05.2019	HO_ Manual Drive command Lowering

	05:02:39	
	01.05.2019 05:02:38	AUT Automatic Hoist target position reached HO: 10743 [mm]
	01.05.2019 05:02:38	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9372 Ys:0 Zp:3930 Zs:0 Sp_L:2 Tl_St:1 W:16120
	01.05.2019 05:02:37	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9367 Ys:0 Zp:3915 Zs:-81 Sp_L:2 Tl_St:1 W:16027
	01.05.2019 05:02:37	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9366 Ys:0 Zp:3914 Zs:0 Sp_L:2 Tl_St:1 W:17113
	01.05.2019 05:02:36	AUT Automatic Trolley target position reached TR: 93638 [mm]
	01.05.2019 05:02:36	AUT Automatic Trolley target position reached TR: 93659 [mm]
	01.05.2019 05:02:35	TR_ Manual Drive command Forward
	01.05.2019 05:02:34	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:02:34	AUT Stop Automatic, Position HO: 11863 [mm], TR: 93564 [mm], GA: 805848 [mm]
	01.05.2019 05:02:34	AUT Automatic Trolley stops moving, Position HO: 11890 [mm], TR: 93563 [mm], GA: 805849 [mm]
	01.05.2019 05:02:34	TR_ Manual Drive command Backward
	01.05.2019 05:02:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9358 Ys:0 Zp:3779 Zs:-722 Sp_L:2 Tl_St:1 W:16367
	01.05.2019 05:02:31	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9359 Ys:0 Zp:3540 Zs:-970 Sp_L:2 Tl_St:1 W:16466
	01.05.2019 05:02:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8747 Ys:1975 Zp:2468 Zs:-2031 Sp_L:2 Tl_St:1 W:15152
	01.05.2019 05:02:20	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7910 Ys:3061 Zp:2123 Zs:-105 Sp_L:2 Tl_St:1 W:15028
	01.05.2019 05:02:19	AUT Hoist takeover, Position HO: 28826 [mm], TR: 75566 [mm], GA: 805848 [mm]
	01.05.2019 05:02:19	AUT Automatic Hoist stops moving, Position HO: 28826 [mm], TR: 75566 [mm], GA: 805848 [mm]
	01.05.2019 05:02:19	HO_ Manual Drive command Lowering
	01.05.2019 05:02:14	HO_ Zero and Stand still
	01.05.2019 05:02:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5267 Ys:3959 Zp:2122 Zs:0 Sp_L:2 Tl_St:1 W:16388
	01.05.2019 05:02:13	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:02:12	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:02:12	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4641 Ys:3596 Zp:2121 Zs:0 Sp_L:2 Tl_St:1 W:14563
	01.05.2019 05:02:12	job started(0). new JobID: 129
	01.05.2019 05:02:12	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:02:12	AUT AGV leave
	01.05.2019 05:02:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3042 Ys:513 Zp:3650 Zs:2414 Sp_L:2 Tl_St:1 W:16326
	01.05.2019	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:148 Zp:3803 Zs:2430 Sp_L:2 Tl_St:1 W:16443

	05:02:03	
	01.05.2019 05:02:02	AUT Automatic Trolley starts moving, Position HO: 9667 [mm], TR: 30162 [mm], GA: 805848 [mm]
	01.05.2019 05:02:02	REP Position report HO: 9439 [mm], TR: 30162 [mm], GA: 805849 [mm]
	01.05.2019 05:02:02	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:02:02	AUT Start Automatic to Targets HO: 19972 [mm] TR: 93520 [mm]
	01.05.2019 05:02:02	AUT Automatic Hoist starts moving, Position HO: 9350 [mm], TR: 30162 [mm], GA: 805849 [mm]
	01.05.2019 05:02:00	TOS Message:0240 SND Job_Reply JobSeq:-220 QCSeq:7 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:1 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 05:01:59	job finished(1). JobID: 128
	01.05.2019 05:01:59	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:7 C-Lenght:2 C-Height:0
	01.05.2019 05:01:58	Message 25: Sent Data Type: Binary Number of traces in range: 329. Range Start Time: 19050104 56587614 Total number of traces: 18981. Total count Start Time: 19043018 41561833 End Time: 19050105 1587634
	01.05.2019 05:01:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3016 Ys:0 Zp:4580 Zs:0 Sp_L:2 Tl_St:1 W:2626
	01.05.2019 05:01:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:0 Zp:4575 Zs:-231 Sp_L:2 Tl_St:1 W:3599
	01.05.2019 05:01:54	HO_ Manual Drive command Hoisting
	01.05.2019 05:01:53	LMS Underload detected
	01.05.2019 05:01:53	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3017 Ys:0 Zp:4568 Zs:-249 Sp_L:2 Tl_St:1 W:3770
	01.05.2019 05:01:53	SPR Twistlocks unlocked, Position HO: 4371 [mm], TR: 30167 [mm], GA: 805849 [mm]

Jobnr.	Job Time	TOS Message
130	01.05.2019 05:06:21	SPR Twistlocks unlocked, Position HO: 4345 [mm], TR: 30247 [mm], GA: 805849 [mm]
	01.05.2019 05:06:19	SPR Spreader landed
	01.05.2019 05:06:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:4453 Zs:-90 Sp_L:2 Tl_St:2 W:31340
	01.05.2019 05:06:15	HO_ Manual Drive command Lowering
	01.05.2019 05:06:15	AUT Automatic Hoist target position reached HO: 5530 [mm]
	01.05.2019 05:06:15	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3025 Ys:0 Zp:4452 Zs:0 Sp_L:2 Tl_St:2 W:28668
	01.05.2019 05:06:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:4472 Zs:88 Sp_L:2 Tl_St:2 W:32072
	01.05.2019 05:06:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3025 Ys:0 Zp:4473 Zs:0 Sp_L:2 Tl_St:2 W:30262
	01.05.2019 05:06:13	HO_ Manual Drive command Hoisting
	01.05.2019 05:06:13	AUT Automatic Hoist target position reached HO: 5321 [mm]
	01.05.2019 05:06:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:4473 Zs:0 Sp_L:2 Tl_St:2 W:31420
	01.05.2019 05:06:12	AUT Automatic Cruise On
	01.05.2019 05:06:12	AUT Sway control On
	01.05.2019 05:06:12	TR_ Zero and Stand still
	01.05.2019 05:06:10	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3021 Ys:0 Zp:4347 Zs:-1151 Sp_L:2 Tl_St:2 W:28900
	01.05.2019 05:06:10	AUT Automatic Trolley target position reached TR: 30212 [mm]
	01.05.2019 05:06:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3042 Ys:-165 Zp:4231 Zs:-978 Sp_L:2 Tl_St:2 W:31123
	01.05.2019 05:06:08	TR_ Manual Drive command Backward
	01.05.2019 05:06:08	TR_ Manual Drive command Forward
	01.05.2019 05:06:08	TR_ Manual Drive command Backward
	01.05.2019 05:06:08	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3045 Ys:0 Zp:4148 Zs:-98 Sp_L:2 Tl_St:2 W:32391
	01.05.2019 05:06:07	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3045 Ys:0 Zp:4145 Zs:0 Sp_L:2 Tl_St:2 W:32441
	01.05.2019 05:06:06	TR_ Zero and Stand still
	01.05.2019 05:06:06	AUT Automatic Cruise On
	01.05.2019 05:06:06	AUT Sway control On
	01.05.2019 05:06:04	AUT Automatic Trolley target position reached TR: 30460 [mm]
	01.05.2019 05:06:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3045 Ys:0 Zp:3948 Zs:-1265 Sp_L:2 Tl_St:2 W:-32416
	01.05.2019	REP Speed report HO: -51.81 [%], TR: 1.81 [%], GA: 0.00 [%]

	05:06:04	
	01.05.2019 05:06:04	AUT Container gantry deviation outside funnel range Max dev: 497.89 Act dev: 936.78 HO: 10618 [mm]
	01.05.2019 05:06:04	AUT Container in funnel area on landside HO: 10618 [mm]
	01.05.2019 05:06:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3038 Ys:176 Zp:3856 Zs:-1641 Sp_L:2 Tl_St:2 W:31582
	01.05.2019 05:06:02	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2995 Ys:162 Zp:3554 Zs:-1272 Sp_L:2 Tl_St:2 W:28201
	01.05.2019 05:06:01	TR_ Manual Drive command Forward
	01.05.2019 05:06:01	AUT Automatic Trolley target position reached TR: 29909 [mm]
	01.05.2019 05:06:00	TR_ Manual Drive command Forward
	01.05.2019 05:06:00	AUT Automatic Trolley target position reached TR: 29910 [mm]
	01.05.2019 05:06:00	TR_ Manual Drive command Forward
	01.05.2019 05:05:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2988 Ys:0 Zp:3282 Zs:-1506 Sp_L:2 Tl_St:2 W:31554
	01.05.2019 05:05:58	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3025 Ys:-142 Zp:3079 Zs:-1882 Sp_L:2 Tl_St:2 W:28556
	01.05.2019 05:05:57	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:2990 Zs:-1565 Sp_L:2 Tl_St:2 W:29270
	01.05.2019 05:05:57	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3038 Ys:-154 Zp:2896 Zs:-1161 Sp_L:2 Tl_St:2 W:28447
	01.05.2019 05:05:56	TR_ Manual Drive command Backward
	01.05.2019 05:05:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3044 Ys:0 Zp:2740 Zs:-744 Sp_L:2 Tl_St:2 W:32290
	01.05.2019 05:05:54	AUT Automatic Trolley target position reached TR: 30437 [mm]
	01.05.2019 05:05:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3038 Ys:173 Zp:2704 Zs:-982 Sp_L:2 Tl_St:2 W:32748
	01.05.2019 05:05:52	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2991 Ys:165 Zp:2492 Zs:-1219 Sp_L:2 Tl_St:2 W:28003
	01.05.2019 05:05:51	TR_ Manual Drive command Forward
	01.05.2019 05:05:50	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2987 Ys:0 Zp:2369 Zs:-97 Sp_L:2 Tl_St:2 W:30894
	01.05.2019 05:05:49	TR_ Zero and Stand still
	01.05.2019 05:05:49	AUT Automatic Cruise On
	01.05.2019 05:05:49	AUT Sway control On
	01.05.2019 05:05:49	HO_ Manual Drive command Hoisting
	01.05.2019 05:05:49	HO_ Manual Drive command Lowering
	01.05.2019 05:05:47	AUT Automatic Trolley target position reached TR: 29833 [mm]
	01.05.2019 05:05:47	TR_ Manual Drive command Forward
	01.05.2019	TR_ Manual Drive command Backward

	05:05:46	
	01.05.2019 05:05:46	TR_ Manual Drive command Forward
	01.05.2019 05:05:46	TR_ Manual Drive command Backward
	01.05.2019 05:05:46	TR_ Zero and Stand still
	01.05.2019 05:05:46	AUT Automatic Cruise On
	01.05.2019 05:05:46	AUT Sway control On
	01.05.2019 05:05:45	HO_ Zero and Stand still
	01.05.2019 05:05:44	AUT Automatic Trolley target position reached TR: 29892 [mm]
	01.05.2019 05:05:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2989 Ys:125 Zp:2367 Zs:0 Sp_L:2 Tl_St:2 W:28071
	01.05.2019 05:05:43	AUT Automatic Hoist target position reached HO: 26374 [mm]
	01.05.2019 05:05:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2974 Ys:592 Zp:2368 Zs:0 Sp_L:2 Tl_St:2 W:-31814
	01.05.2019 05:05:42	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2927 Ys:979 Zp:2361 Zs:-95 Sp_L:2 Tl_St:2 W:28698
	01.05.2019 05:05:41	REP WMS Actual windspeed 0.65 [m/s], direction 293 [deg]
	01.05.2019 05:05:41	HO_ Manual Drive command Lowering
	01.05.2019 05:05:40	AUT Automatic Hoist target position reached HO: 26452 [mm]
	01.05.2019 05:05:40	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2661 Ys:480 Zp:2360 Zs:0 Sp_L:2 Tl_St:2 W:27290
	01.05.2019 05:05:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2642 Ys:165 Zp:2367 Zs:288 Sp_L:2 Tl_St:2 W:28336
	01.05.2019 05:05:39	TR_ Manual Drive command Forward
	01.05.2019 05:05:39	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2637 Ys:0 Zp:2382 Zs:519 Sp_L:2 Tl_St:2 W:28509
	01.05.2019 05:05:39	GA_ Zero and Stand still
	01.05.2019 05:05:39	GA_ Zero and Stand still
	01.05.2019 05:05:37	AUT Gantry stops moving at position GA: 805851 [mm]
	01.05.2019 05:05:37	TR_ Manual Drive command Backward
	01.05.2019 05:05:37	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2726 Ys:0 Zp:2655 Zs:1884 Sp_L:2 Tl_St:2 W:26616
	01.05.2019 05:05:37	TOS Message:0219 SND Position_Report QC_moving:0 QC_X:80585
	01.05.2019 05:05:36	TOS Message:0229 SND Status_Reset Level:0 Code:10609
	01.05.2019 05:05:35	TOS Message:0228 SND Status_Set Level:0 Code:10609
	01.05.2019 05:05:35	AUT Gantry starts moving at position GA: 805848 [mm]
	01.05.2019	GA_ Manual Drive command Right

	05:05:35	
	01.05.2019 05:05:35	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2620 Ys:159 Zp:3088 Zs:1611 Sp_L:2 Tl_St:2 W:-32205
	01.05.2019 05:05:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2617 Ys:0 Zp:3139 Zs:1402 Sp_L:2 Tl_St:2 W:-32481
	01.05.2019 05:05:34	TR_ Manual Drive command Forward
	01.05.2019 05:05:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2633 Ys:-547 Zp:3219 Zs:1007 Sp_L:2 Tl_St:2 W:-32696
	01.05.2019 05:05:32	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2819 Ys:-1747 Zp:3303 Zs:0 Sp_L:2 Tl_St:2 W:31831
	01.05.2019 05:05:30	REP WMS Actual windspeed 0.65 [m/s], direction 293 [deg]
	01.05.2019 05:05:29	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:05:29	AUT Stop Automatic, Position HO: 19448 [mm], TR: 35667 [mm], GA: 805848 [mm]
	01.05.2019 05:05:29	AUT Automatic Trolley stops moving, Position HO: 19518 [mm], TR: 35807 [mm], GA: 805848 [mm]
	01.05.2019 05:05:29	TR_ Manual Drive command Backward
	01.05.2019 05:05:29	HO_ Manual Drive command Hoisting
	01.05.2019 05:05:25	AUT Hoist takeover, Position HO: 27200 [mm], TR: 45297 [mm], GA: 805848 [mm]
	01.05.2019 05:05:25	AUT Automatic Hoist stops moving, Position HO: 27200 [mm], TR: 45297 [mm], GA: 805848 [mm]
	01.05.2019 05:05:25	HO_ Manual Drive command Lowering
	01.05.2019 05:05:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5182 Ys:-3915 Zp:1957 Zs:-1231 Sp_L:2 Tl_St:2 W:29273
	01.05.2019 05:05:22	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5917 Ys:-4007 Zp:1832 Zs:-105 Sp_L:2 Tl_St:2 W:30657
	01.05.2019 05:05:21	AUT Automatic Hoist starts moving, Position HO: 31733 [mm], TR: 63462 [mm], GA: 805848 [mm]
	01.05.2019 05:05:15	HO_ Zero and Stand still
	01.05.2019 05:05:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:8876 Ys:-2280 Zp:1832 Zs:0 Sp_L:2 Tl_St:2 W:30004
	01.05.2019 05:05:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9081 Ys:-2104 Zp:1831 Zs:0 Sp_L:2 Tl_St:2 W:28849
	01.05.2019 05:05:08	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9613 Ys:-145 Zp:2525 Zs:2175 Sp_L:2 Tl_St:2 W:29745
	01.05.2019 05:05:07	AUT Automatic Trolley starts moving, Position HO: 22845 [mm], TR: 96132 [mm], GA: 805848 [mm]
	01.05.2019 05:05:07	REP Position report HO: 22670 [mm], TR: 96132 [mm], GA: 805849 [mm]
	01.05.2019 05:05:07	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:05:07	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 05:05:07	AUT Automatic Hoist starts moving, Position HO: 22626 [mm], TR: 96132 [mm], GA: 805849 [mm]
	01.05.2019 05:05:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9613 Ys:0 Zp:3418 Zs:2175 Sp_L:2 Tl_St:2 W:30598
	01.05.2019	GA_ Zero and Stand still

	05:05:01	
	01.05.2019 05:04:57	LMS Load hangs free, Load Left: 14.3 [T], Right: 15.4 [T], Total: 29.7 [T]
	01.05.2019 05:04:55	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:9 C_Lenght:2
	01.05.2019 05:04:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9614 Ys:0 Zp:4589 Zs:256 Sp_L:2 Tl_St:2 W:4074
	01.05.2019 05:04:53	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 05:04:53	HO_ Manual Drive command Hoisting
	01.05.2019 05:04:53	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9614 Ys:0 Zp:4597 Zs:-102 Sp_L:2 Tl_St:2 W:5234
	01.05.2019 05:04:53	LMS Underload detected
	01.05.2019 05:04:53	SPR Twistlocks locked, Position HO: 4080 [mm], TR: 96138 [mm], GA: 805848 [mm]
	01.05.2019 05:04:51	SPR Spreader landed
	01.05.2019 05:04:46	AUT Automatic Cruise On
	01.05.2019 05:04:46	AUT Sway control On
	01.05.2019 05:04:46	TR_ Zero and Stand still
	01.05.2019 05:04:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9613 Ys:0 Zp:4030 Zs:0 Sp_L:2 Tl_St:1 W:17558
	01.05.2019 05:04:44	AUT Automatic Trolley target position reached TR: 96130 [mm]
	01.05.2019 05:04:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9614 Ys:0 Zp:4025 Zs:0 Sp_L:2 Tl_St:1 W:16302
	01.05.2019 05:04:43	HO_ Manual Drive command Lowering
	01.05.2019 05:04:43	AUT Automatic Hoist target position reached HO: 9797 [mm]
	01.05.2019 05:04:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9622 Ys:0 Zp:4025 Zs:0 Sp_L:2 Tl_St:1 W:17665
	01.05.2019 05:04:42	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 05:04:41	TR_ Manual Drive command Backward
	01.05.2019 05:04:41	TR_ Manual Drive command Forward
	01.05.2019 05:04:41	TR_ Manual Drive command Backward
	01.05.2019 05:04:40	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 05:04:39	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 05:04:39	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 05:04:39	AUT AGV in Position Lane: 2 GA-Pos: 805848 [mm] Offset: 0 [mm]
	01.05.2019 05:04:39	AUT Automatic Trolley target position reached TR: 96356 [mm]
	01.05.2019	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1

	05:04:39	
	01.05.2019 05:04:39	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:04:39	AUT Stop Automatic, Position HO: 11098 [mm], TR: 96361 [mm], GA: 805849 [mm]
	01.05.2019 05:04:39	AUT Automatic Trolley stops moving, Position HO: 11126 [mm], TR: 96363 [mm], GA: 805848 [mm]
	01.05.2019 05:04:39	TR_ Manual Drive command Backward
	01.05.2019 05:04:36	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9637 Ys:0 Zp:3668 Zs:-792 Sp_L:2 Tl_St:1 W:16169
	01.05.2019 05:04:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9589 Ys:458 Zp:3453 Zs:-1389 Sp_L:2 Tl_St:1 W:15928
	01.05.2019 05:04:25	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7989 Ys:3348 Zp:2120 Zs:-85 Sp_L:2 Tl_St:1 W:15689
	01.05.2019 05:04:24	AUT Hoist takeover, Position HO: 28856 [mm], TR: 76023 [mm], GA: 805849 [mm]
	01.05.2019 05:04:24	AUT Automatic Hoist stops moving, Position HO: 28856 [mm], TR: 76023 [mm], GA: 805849 [mm]
	01.05.2019 05:04:24	HO_ Manual Drive command Lowering
	01.05.2019 05:04:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7409 Ys:3993 Zp:2119 Zs:0 Sp_L:2 Tl_St:1 W:15683
	01.05.2019 05:04:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
	01.05.2019 05:04:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 05:04:19	HO_ Zero and Stand still
	01.05.2019 05:04:17	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4641 Ys:3588 Zp:2118 Zs:0 Sp_L:2 Tl_St:1 W:14800
	01.05.2019 05:04:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3747 Ys:2059 Zp:2382 Zs:1777 Sp_L:2 Tl_St:1 W:14244
	01.05.2019 05:04:09	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:04:08	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:04:08	job started(0). new JobID: 130
	01.05.2019 05:04:08	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:04:08	AUT AGV leave
	01.05.2019 05:04:08	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:156 Zp:3744 Zs:2411 Sp_L:2 Tl_St:1 W:16338
	01.05.2019 05:04:07	AUT Automatic Trolley starts moving, Position HO: 9706 [mm], TR: 30123 [mm], GA: 805848 [mm]
	01.05.2019 05:04:06	REP Position report HO: 8020 [mm], TR: 30123 [mm], GA: 805848 [mm]
	01.05.2019 05:04:06	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:04:06	AUT Start Automatic to Targets HO: 19972 [mm] TR: 96302 [mm]
	01.05.2019 05:04:06	AUT Automatic Hoist starts moving, Position HO: 7947 [mm], TR: 30123 [mm], GA: 805848 [mm]
	01.05.2019	TOS Message:0240 SND Job_Reply JobSeq:-221 QCSeq:8 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:3 TarLoc:7 AGV:1 Sp:0 Bay:0

	05:04:04	Row:0 Tier:0
	01.05.2019 05:04:04	job finished(1). JobID: 129
	01.05.2019 05:04:04	TOS Message:0218 SND Container_Down C_X:80584.796875 C-Loc:7 Seq:8 C-Lenght:2 C-Height:3
	01.05.2019 05:04:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3012 Ys:0 Zp:4458 Zs:510 Sp_L:2 Tl_St:1 W:18102
	01.05.2019 05:03:59	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4585 Zs:0 Sp_L:2 Tl_St:1 W:2345
	01.05.2019 05:03:58	HO_ Manual Drive command Hoisting
	01.05.2019 05:03:58	LMS Underload detected
	01.05.2019 05:03:58	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3013 Ys:0 Zp:4573 Zs:-249 Sp_L:2 Tl_St:1 W:4438
	01.05.2019 05:03:58	SPR Twistlocks unlocked, Position HO: 4324 [mm], TR: 30127 [mm], GA: 805848 [mm]

Jobnr.	Job Time	TOS Message
131	01.05.2019 05:08:20	SPR Twistlocks unlocked, Position HO: 4377 [mm], TR: 30177 [mm], GA: 805849 [mm]
	01.05.2019 05:08:19	AUT Automatic Trolley target position reached TR: 30169 [mm]
	01.05.2019 05:08:19	TOS Message:0229 SND Status_Reset Level:0 Code:10350
	01.05.2019 05:08:19	AUT Stop Automatic, Position HO: 4679 [mm], TR: 30155 [mm], GA: 805849 [mm]
	01.05.2019 05:08:19	AUT Automatic Trolley stops moving, Position HO: 4689 [mm], TR: 30152 [mm], GA: 805849 [mm]
	01.05.2019 05:08:19	TR_ Manual Drive command Forward
	01.05.2019 05:08:19	SPR Spreader landed
	01.05.2019 05:08:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2998 Ys:0 Zp:4279 Zs:-1214 Sp_L:2 Tl_St:2 W:23014
	01.05.2019 05:08:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:2999 Ys:0 Zp:4237 Zs:-975 Sp_L:2 Tl_St:2 W:21824
	01.05.2019 05:08:11	REP Speed report HO: -47.34 [%], TR: -12.55 [%], GA: 0.00 [%]
	01.05.2019 05:08:11	AUT Container gantry deviation outside funnel range Max dev: 499.26 Act dev: 845.22 HO: 10639 [mm]
	01.05.2019 05:08:11	AUT Container in funnel area on landside HO: 10639 [mm]
	01.05.2019 05:08:09	REP WMS Actual windspeed 0.75 [m/s], direction 0 [deg]
	01.05.2019 05:08:06	AUT Hoist takeover, Position HO: 20083 [mm], TR: 36474 [mm], GA: 805849 [mm]
	01.05.2019 05:08:06	AUT Automatic Hoist stops moving, Position HO: 20083 [mm], TR: 36474 [mm], GA: 805849 [mm]
	01.05.2019 05:08:06	HO_ Manual Drive command Lowering
	01.05.2019 05:08:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:4133 Ys:-2838 Zp:2508 Zs:-2382 Sp_L:2 Tl_St:2 W:23567
	01.05.2019 05:07:57	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6516 Ys:-3990 Zp:1381 Zs:-81 Sp_L:2 Tl_St:2 W:23412
	01.05.2019 05:07:56	AUT Automatic Hoist starts moving, Position HO: 36242 [mm], TR: 69253 [mm], GA: 805849 [mm]
	01.05.2019 05:07:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:7890 Ys:-3898 Zp:1381 Zs:0 Sp_L:2 Tl_St:2 W:22854
	01.05.2019 05:07:50	HO_ Zero and Stand still
	01.05.2019 05:07:48	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9579 Ys:-1549 Zp:1380 Zs:0 Sp_L:2 Tl_St:2 W:21774
	01.05.2019 05:07:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9880 Ys:-154 Zp:1781 Zs:2219 Sp_L:2 Tl_St:2 W:24089
	01.05.2019 05:07:44	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9881 Ys:0 Zp:1944 Zs:2431 Sp_L:2 Tl_St:2 W:22495
	01.05.2019 05:07:43	AUT Automatic Trolley starts moving, Position HO: 29812 [mm], TR: 98806 [mm], GA: 805849 [mm]

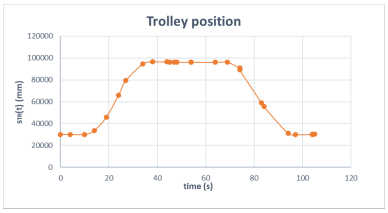
	01.05.2019 05:07:43	REP Position report HO: 29661 [mm], TR: 98806 [mm], GA: 805849 [mm]
	01.05.2019 05:07:43	TOS Message:0228 SND Status_Set Level:0 Code:10350
	01.05.2019 05:07:43	AUT Start Automatic to Targets HO: 9000 [mm] TR: 30200 [mm]
	01.05.2019 05:07:43	AUT Automatic Hoist starts moving, Position HO: 29560 [mm], TR: 98806 [mm], GA: 805849 [mm]
	01.05.2019 05:07:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9880 Ys:0 Zp:4346 Zs:1407 Sp_L:2 Tl_St:2 W:27371
	01.05.2019 05:07:31	LMS Load hangs free, Load Left: 11.1 [T], Right: 13.4 [T], Total: 24.5 [T]
	01.05.2019 05:07:30	TOS Message:0237 SND Container_Up C_X:80585 C_Loc:1 Seq:10 C_Lenght:2
	01.05.2019 05:07:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9881 Ys:0 Zp:4589 Zs:0 Sp_L:2 Tl_St:2 W:7669
	01.05.2019 05:07:28	LMS Underload detected
	01.05.2019 05:07:28	HO_ Manual Drive command Hoisting
	01.05.2019 05:07:28	SPR Twistlocks locked, Position HO: 4148 [mm], TR: 98808 [mm], GA: 805849 [mm]
	01.05.2019 05:07:28	TOS Message:0229 SND Status_Reset Level:0 Code:8333
	01.05.2019 05:07:28	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9881 Ys:0 Zp:4591 Zs:0 Sp_L:2 Tl_St:1 W:6040
	01.05.2019 05:07:27	HO_ Manual Drive command Hoisting
	01.05.2019 05:07:26	SPR Spreader landed
	01.05.2019 05:07:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9881 Ys:0 Zp:4489 Zs:-432 Sp_L:2 Tl_St:1 W:18105
	01.05.2019 05:07:23	TR_ Zero and Stand still
	01.05.2019 05:07:23	AUT Automatic Cruise On
	01.05.2019 05:07:23	AUT Sway control On
	01.05.2019 05:07:22	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9876 Ys:0 Zp:4313 Zs:-1472 Sp_L:2 Tl_St:1 W:16715
	01.05.2019 05:07:22	AUT Automatic Trolley target position reached TR: 98768 [mm]
	01.05.2019 05:07:21	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9893 Ys:-148 Zp:4199 Zs:-1307 Sp_L:2 Tl_St:1 W:15851
	01.05.2019 05:07:20	TR_ Manual Drive command Backward
	01.05.2019 05:07:20	TR_ Manual Drive command Forward
	01.05.2019 05:07:20	TR_ Manual Drive command Backward
	01.05.2019 05:07:19	TOS Message:0212 SND Status_Overview Pw:0 Cd:0 X:80585 AMin:69660 AMax:90860 Seq:0 :0 :0 Ld:0
	01.05.2019 05:07:19	TOS Message:0198 RCV Overview_Request
	01.05.2019 05:07:19	AUT Automatic Trolley target position reached TR: 98953 [mm]

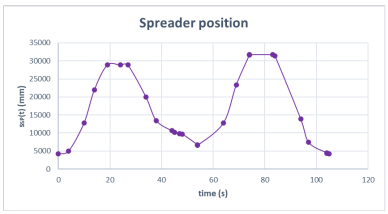
	01.05.2019 05:07:18	TOS Message:0228 SND Status_Set Level:0 Code:8333
	01.05.2019 05:07:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9893 Ys:0 Zp:4004 Zs:-103 Sp_L:2 Tl_St:1 W:16992
	01.05.2019 05:07:18	AUT Automatic Trolley target position reached TR: 98941 [mm]
	01.05.2019 05:07:18	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9894 Ys:0 Zp:4002 Zs:0 Sp_L:2 Tl_St:1 W:16381
	01.05.2019 05:07:18	AUT Automatic Trolley target position reached TR: 98936 [mm]
	01.05.2019 05:07:17	HO_ Manual Drive command Hoisting
	01.05.2019 05:07:17	HO_ Manual Drive command Lowering
	01.05.2019 05:07:16	AUT Automatic Hoist target position reached HO: 10024 [mm]
	01.05.2019 05:07:16	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9874 Ys:178 Zp:4002 Zs:0 Sp_L:2 Tl_St:1 W:17326
	01.05.2019 05:07:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9830 Ys:151 Zp:3949 Zs:-504 Sp_L:2 Tl_St:1 W:15500
	01.05.2019 05:07:14	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9826 Ys:0 Zp:3930 Zs:-426 Sp_L:2 Tl_St:1 W:17680
	01.05.2019 05:07:13	TR_ Manual Drive command Forward
	01.05.2019 05:07:13	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9831 Ys:0 Zp:3893 Zs:-244 Sp_L:2 Tl_St:1 W:16868
	01.05.2019 05:07:13	AUT Automatic Trolley target position reached TR: 98304 [mm]
	01.05.2019 05:07:11	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9808 Ys:103 Zp:3857 Zs:-87 Sp_L:2 Tl_St:1 W:16314
	01.05.2019 05:07:11	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9805 Ys:134 Zp:3855 Zs:0 Sp_L:2 Tl_St:1 W:17960
	01.05.2019 05:07:10	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:1
	01.05.2019 05:07:10	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9786 Ys:154 Zp:3839 Zs:-270 Sp_L:2 Tl_St:1 W:16333
	01.05.2019 05:07:10	TOS Message:0225 SND Loader_Not_Used
	01.05.2019 05:07:10	TOS Message:0202 RCV Load_AGV_Req AGV_X:80585 NoChs:1 AGV_Loc:7 Flr_Hght:2260 Ann:0
	01.05.2019 05:07:10	AUT AGV in Position Lane: 2 GA-Pos: 805849 [mm] Offset: 0 [mm]
	01.05.2019 05:07:09	TOS Message:0204 RCV Light_Req2 Pres:0 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:07:09	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9786 Ys:0 Zp:3801 Zs:-397 Sp_L:2 Tl_St:1 W:16970
	01.05.2019 05:07:09	AUT Automatic Trolley target position reached TR: 97858 [mm]
	01.05.2019 05:07:06	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9727 Ys:148 Zp:3715 Zs:-524 Sp_L:2 Tl_St:1 W:15681
	01.05.2019 05:07:06	TR_ Manual Drive command Forward
	01.05.2019 05:07:05	AUT Automatic Trolley target position reached TR: 97244 [mm]
	01.05.2019 05:07:04	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9721 Ys:0 Zp:3592 Zs:-595 Sp_L:2 Tl_St:1 W:17723

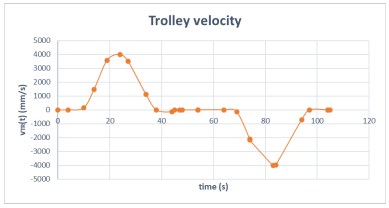
	01.05.2019 05:07:03	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9708 Ys:151 Zp:3526 Zs:-917 Sp_L:2 Tl_St:1 W:16679
	01.05.2019 05:07:03	TR_ Manual Drive command Forward
	01.05.2019 05:07:02	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9710 Ys:0 Zp:3410 Zs:-919 Sp_L:2 Tl_St:1 W:15781
	01.05.2019 05:07:02	AUT Automatic Trolley target position reached TR: 97104 [mm]
	01.05.2019 05:06:58	Message 25: Sent Data Type: Binary Number of traces in range: 330. Range Start Time: 19050105 1587634 Total number of traces: 19311. Total count Start Time: 19043018 41561833 End Time: 19050105 6587974
	01.05.2019 05:06:54	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:9046 Ys:1903 Zp:2388 Zs:-1629 Sp_L:2 Tl_St:1 W:16654
	01.05.2019 05:06:45	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:6550 Ys:3658 Zp:1191 Zs:-90 Sp_L:2 Tl_St:1 W:15263
	01.05.2019 05:06:44	HO_ Manual Drive command Hoisting
	01.05.2019 05:06:44	HO_ Manual Drive command Lowering
	01.05.2019 05:06:44	AUT Automatic Hoist target position reached HO: 38148 [mm]
	01.05.2019 05:06:43	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:5941 Ys:3147 Zp:1190 Zs:0 Sp_L:2 Tl_St:1 W:13863
	01.05.2019 05:06:39	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:0 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:06:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:1 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:06:38	job started(0). new JobID: 131
	01.05.2019 05:06:38	TOS Message:0204 RCV Light_Req2 Pres:1 Cur:1 Next:1 OCS:1 Leav:0 PresP:1 PresN:1 Tw_Car:1
	01.05.2019 05:06:38	AUT AGV leave
	01.05.2019 05:06:34	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3449 Ys:1205 Zp:3123 Zs:2501 Sp_L:2 Tl_St:1 W:15952
	01.05.2019 05:06:30	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3026 Ys:156 Zp:4004 Zs:2380 Sp_L:2 Tl_St:1 W:17850
	01.05.2019 05:06:29	TR_ Manual Drive command Forward
	01.05.2019 05:06:28	TOS Message:0240 SND Job_Reply JobSeq:-222 QCSeq:9 OrgLoc:0 AGV:2 Sp:0 Bay:0 Row:0 Tier:5 TarLoc:7 AGV:1 Sp:0 Bay:0 Row:0 Tier:0
	01.05.2019 05:06:27	job finished(1). JobID: 130
	01.05.2019 05:06:27	TOS Message:0218 SND Container_Down C_X:80584.898438 C-Loc:7 Seq:9 C-Lenght:2 C-Height:0
	01.05.2019 05:06:24	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3024 Ys:0 Zp:4547 Zs:247 Sp_L:2 Tl_St:1 W:10372
	01.05.2019 05:06:22	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3025 Ys:0 Zp:4591 Zs:0 Sp_L:2 Tl_St:1 W:1699
	01.05.2019 05:06:21	HO_ Manual Drive command Hoisting
	01.05.2019 05:06:21	LMS Underload detected
	01.05.2019 05:06:21	TOS Message:0236 SND Pos_Inf QC_Id:94 Xp:80585 Xs:0 Yp:3025 Ys:0 Zp:4570 Zs:-251 Sp_L:2 Tl_St:1 W:3959
	01.05.2019 05:06:21	SPR Twistlocks unlocked, Position HO: 4345 [mm], TR: 30247 [mm], GA: 805849 [mm]

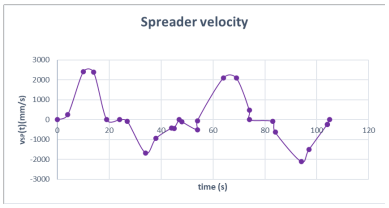
B1. Cycle path determination with TOS

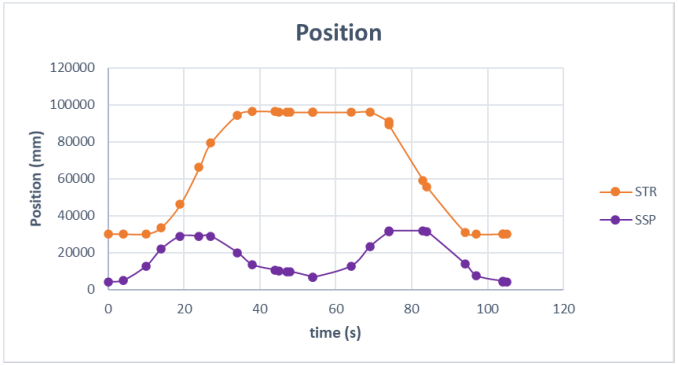
job	W(MT)	S_{TR}(mm)		S_{SP}(mm)		S_{GA}(mm)
122	34,9	96084		6526		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30150	0	50056	45860	4196	0
4	30150	0	50056	45100	4956	251
10	30160	145	50056	37320	12736	2411
14	33710	1482	50056	28070	21986	2380
19	46070	3566	50056	21170	28886	0
24	66030	4001	50056	21180	28876	0
27	79210	3521	50056	21180	28876	-85
34	94480	1119	50056	30050	20006	-1672
38	96450	0	50056	36610	13446	-939
44	96380	-142	50056	39420	10636	-421
45	96090	0	50056	39850	10206	-431
47	96080	0	50056	40300	9756	0
48	96080	0	50056	40310	9746	-98
54	96080	0	50056	43320	6736	-502
54	96080	0	50056	43520	6536	-51
64	96070	0	50056	37320	12736	2099
69	96060	-145	50056	26690	23366	2099
74	90830	-2098	50056	18480	31576	478
74	89150	-2176	50056	18290	31766	0
83	59110	-4010	50056	18290	31766	-88
84	55560	-3990	50056	18610	31446	-629
94	31110	-720	50056	36170	13886	-2101
97	29940	0	50056	42650	7406	-1506
104	30190	0	50056	45550	4506	-247
104	30200	0	50056	45680	4376	-251
105	30200	0	50056	45880	4176	0

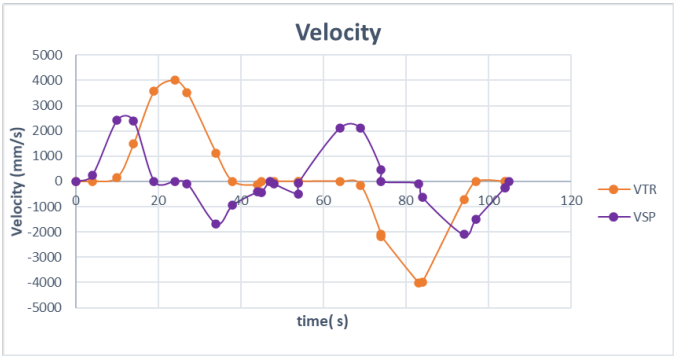






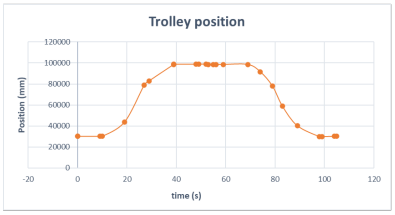


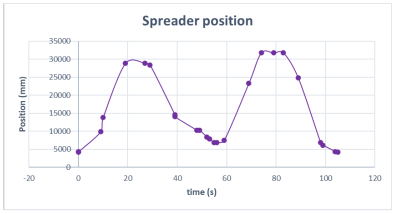


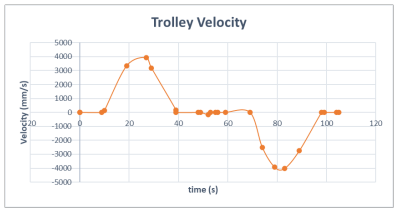


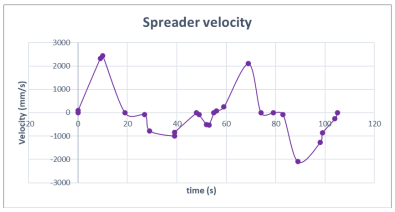
job	W (MT)	S_{TR} (mm)	S_{SP} (mm)	S_{GA} (mm)
123	32.7	98524	6866	80585

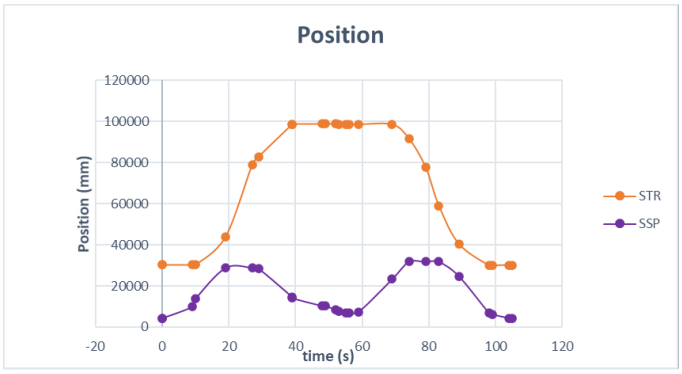
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30200	0	50056	45880	4176	0
0	30200	0	50056	45780	4276	97
9	30200	0	50056	40180	9876	2331
10	30210	151	50056	36230	13826	2438
19	43870	3337	50056	21180	28876	0
27	78960	3920	50056	21190	28866	-85
29	82940	3189	50056	21680	28376	-773
39	98620	167	50056	35470	14586	-990
39	98690	0	50056	36020	14036	-849
48	98790	0	50056	39780	10276	0
49	98800	0	50056	39790	10266	-81
52	98790	-151	50056	41650	8406	-507
53	98450	0	50056	42210	7846	-532
55	98520	0	50056	43210	6846	0
56	98520	0	50056	43180	6876	81
59	98520	0	50056	42610	7446	247
69	98510	0	50056	26730	23326	2101
74	91700	-2514	50056	18280	31776	0
79	77930	-3915	50056	18280	31776	0
83	58990	-4010	50056	18290	31766	-81
89	40440	-2743	50056	25250	24806	-2099
98	29980	0	50056	43190	6866	-1268
99	29960	0	50056	43910	6146	-858
104	30150	0	50056	45680	4376	-249
105	30150	0	50056	45840	4216	0

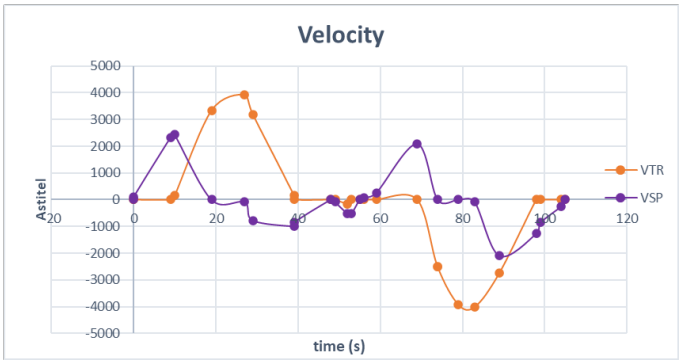




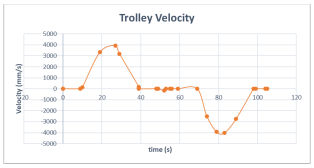


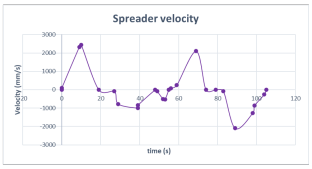


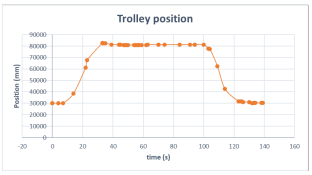


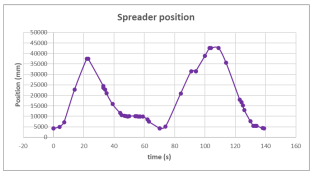


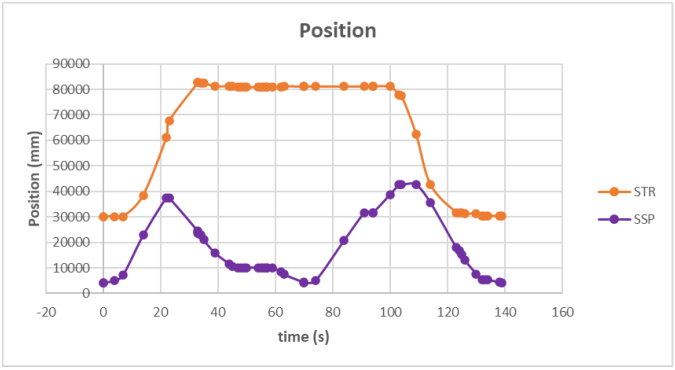
job	w(MT)	s_{TR}(mm)		s_{SP} (mm)		s_{GA} (mm)
124	40.5	81183		4305		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30150	0	50056	45840	4216	0
0	30150	0	50056	45830	4226	97
4	30150	0	50056	45070	4986	249
7	30170	154	50056	42830	7226	1528
14	38530	1900	50056	27240	22816	2502
22	61160	3421	50056	12590	37466	0
23	67710	3583	50056	12590	37466	-103
33	82690	0	50056	25660	24396	-1475
33	82670	-142	50056	26520	23536	-1475
34	82580	0	50056	27240	22816	-1475
35	82580	-148	50056	29040	21016	-1414
39	81330	0	50056	34200	15856	-1185
44	81300	0	50056	38500	11556	-592
45	81250	-142	50056	39490	10566	-570
47	81010	-86	50056	39890	10166	0
48	80970	0	50056	39900	10156	-90
49	80970	0	50056	40120	9936	0
50	80970	0	50056	39920	10136	0
54	80950	0	50056	39920	10136	0
55	80950	0	50056	39920	10136	-90
56	80950	0	50056	40100	9956	0
57	80930	-145	50056	40100	9956	0
57	80820	0	50056	40100	9956	0
59	80850	0	50056	40110	9946	-90
62	80880	145	50056	41510	8546	-914
63	81240	0	50056	42590	7466	-958
70	81180	0	50056	45750	4306	0
70	81190	0	50056	45730	4326	0
74	81180	0	50056	45000	5056	246
84	81180	0	50056	29220	20836	1901
91	81180	0	50056	18540	31516	0
94	81180	0	50056	18540	31516	0
94	81180	0	50056	18530	31526	81
100	81160	-145	50056	11230	38826	1665
103	77930	-1635	50056	7460	42596	0
104	77510	-1786	50056	7460	42596	0
109	62500	-3948	50056	7470	42586	-97
114	42610	-3108	50056	14470	35586	-1899
123	31620	0	50056	32090	17966	-1867
124	31670	0	50056	33350	16706	-1421
125	31640	-151	50056	34900	15156	-1582
126	31160	0	50056	37080	12976	-1202
130	31170	-148	50056	42390	7666	-1599
132	30240	0	50056	44580	5476	-151
133	30280	0	50056	44600	5456	-88
134	30290	0	50056	44650	5406	-134
138	30290	0	50056	45700	4356	-251
139	30280	0	50056	45880	4176	0

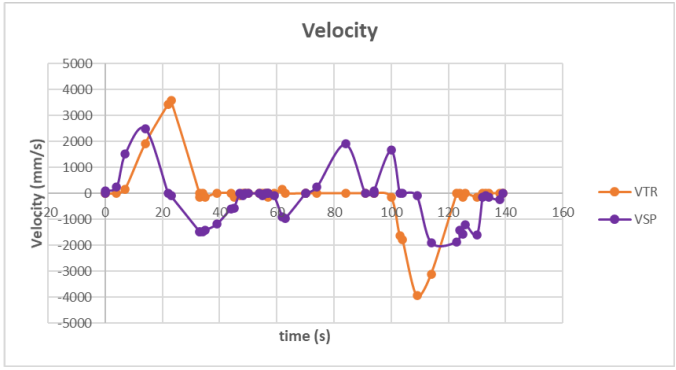






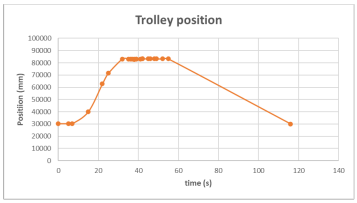


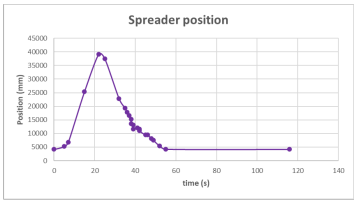


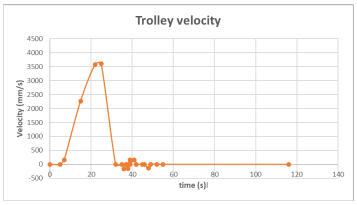


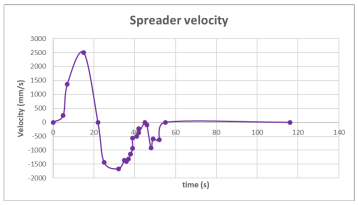
job	W (MT)	S_{TR} (mm)		S_{SP} (mm)		S_{GA} (mm)
125	25	83197		4273		80585

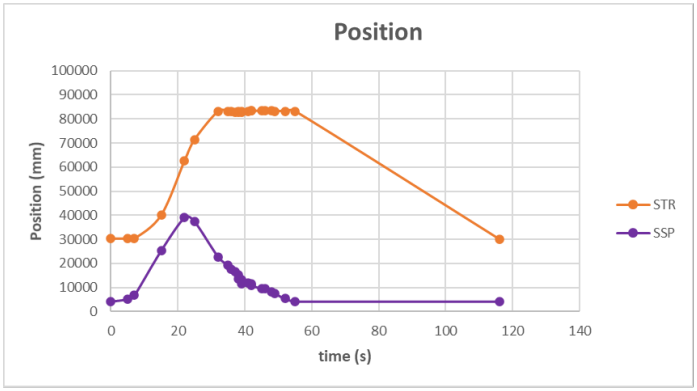
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30280	0	50056	45880	4176	0
5	30290	0	50056	44830	5226	249
7	30300	159	50056	43240	6816	1361
15	40060	2271	50056	24630	25426	2499
22	62720	3577	50056	10890	39166	0
25	71490	3605	50056	12620	37436	-1436
32	83190	0	50056	27250	22806	-1665
35	83160	0	50056	30750	19306	-1365
36	83150	-162	50056	32290	17766	-1404
37	82900	0	50056	33510	16546	-1314
38	82940	-151	50056	34850	15206	-1144
38	82840	0	50056	36470	13586	-1134
39	82920	151	50056	36970	13086	-938
39	83040	0	50056	38450	11606	-565
41	83090	151	50056	38040	12016	-509
42	83290	0	50056	38470	11586	-226
42	83320	0	50056	39100	10956	-368
45	83370	0	50056	40530	9526	0
46	83350	0	50056	40530	9526	-93
48	83340	-142	50056	41900	8156	-924
49	83200	0	50056	42550	7506	-593
52	83200	0	50056	44640	5416	-631
55	83200	0	50056	45780	4276	0
116	30140	0	50056	45870	4186	0

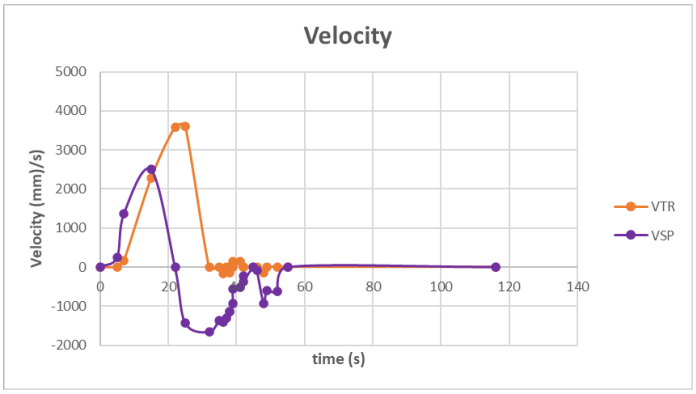




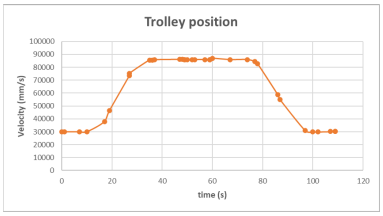


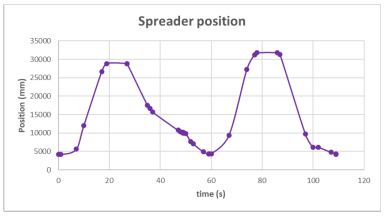


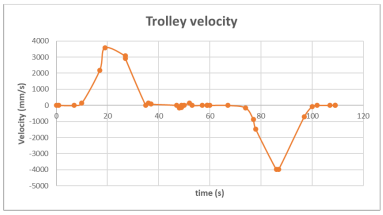


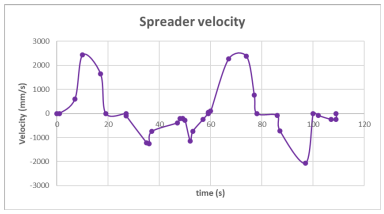


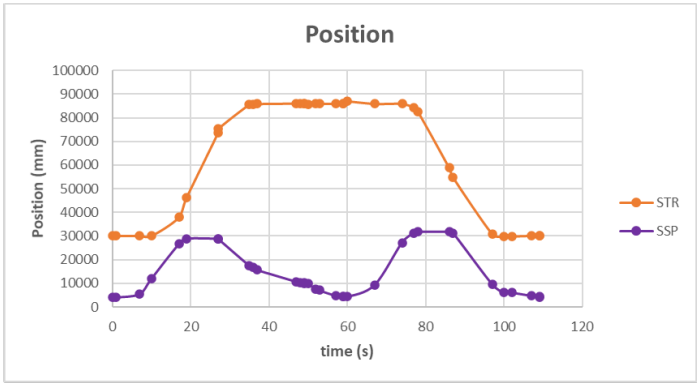
	W	S_{TR}		S_{SP}		S_{GA}
job	(MT)	(mm)		(mm)		(mm)
126	26	85952		4352		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30140	0	50056	45870	4186	0
1	30140	0	50056	45870	4186	0
7	30140	0	50056	44460	5596	607
10	30150	142	50056	38040	12016	2445
17	37930	2188	50056	23460	26596	1653
19	46330	3588	50056	21200	28856	0
27	73670	3078	50056	21200	28856	0
27	75310	2927	50056	21210	28846	-92
35	85670	0	50056	32580	17476	-1221
36	85670	148	50056	33400	16656	-1256
37	85880	78	50056	34370	15686	-751
47	86080	0	50056	39300	10756	-385
48	86060	-151	50056	39750	10306	-212
49	85950	0	50056	39860	10196	-203
49	85910	-142	50056	40060	9996	-212
50	85840	0	50056	40170	9886	-290
52	85870	148	50056	42400	7656	-1144
53	86010	0	50056	43010	7046	-749
57	85960	0	50056	45170	4886	-247
59	85950	0	50056	45720	4336	0
59	85950	0	50056	45700	4356	54
60	86950	0	50056	45690	4366	95
67	85950	0	50056	40640	9416	2274
74	85940	-148	50056	22820	27236	2382
77	84310	-868	50056	18820	31236	773
78	82750	-1470	50056	18310	31746	0
86	58940	-3973	50056	18310	31746	-81
87	54880	-3970	50056	18730	31326	-717
97	31000	-698	50056	40320	9736	-2074
100	29930	-73	50056	43900	6156	0
102	29950	0	50056	43900	6156	-83
107	30170	0	50056	45220	4836	-249
109	30170	0	50056	45670	4386	-251
109	30160	0	50056	45810	4246	0

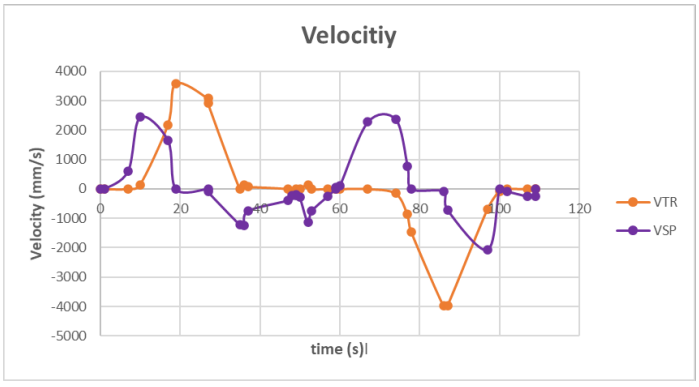






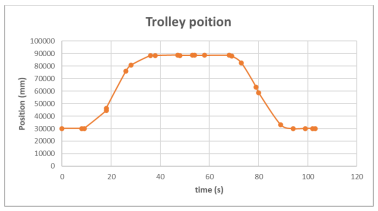


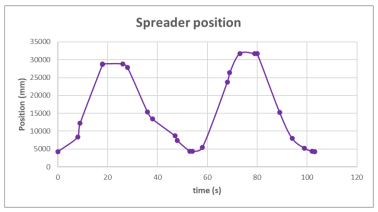


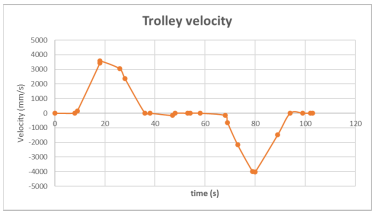


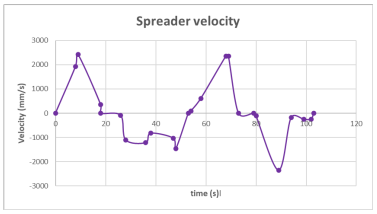
	W	S_{TR}		S_{SP}		S_{GA}
job	(MT)	(mm)		(mm)		(mm)
127	26.9	88597		4364		80585

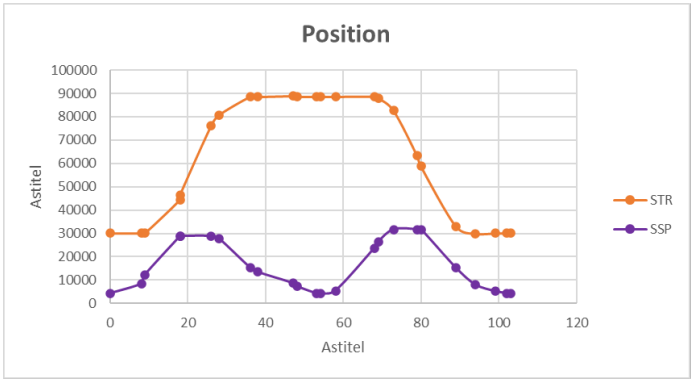
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30160	0	50056	45810	4246	0
8	30160	0	50056	41670	8386	1929
9	30170	142	50056	37830	12226	2416
18	44440	3426	50056	21320	28736	354
18	46380	3588	50056	21210	28846	0
26	76030	3036	50056	21230	28826	-90
28	80670	2380	50056	22230	27826	-1104
36	88500	0	50056	34670	15386	-1219
38	88510	0	50056	36630	13426	-827
47	88860	-154	50056	41370	8686	-1029
48	88560	0	50056	42690	7366	-1467
53	88600	0	50056	45710	4346	0
54	88600	0	50056	45680	4376	90
58	88590	0	50056	44650	5406	609
68	88590	-156	50056	26370	23686	2350
69	88040	-647	50056	23690	26366	2350
73	82570	-2160	50056	18330	31726	0
79	63350	-3998	50056	18330	31726	0
80	58810	-4018	50056	18330	31726	-105
89	33080	-1476	50056	34820	15236	-2352
94	29970	0	50056	42040	8016	-185
99	30120	0	50056	44810	5246	-251
102	30160	0	50056	45690	4366	-249
103	30160	0	50056	45830	4226	0

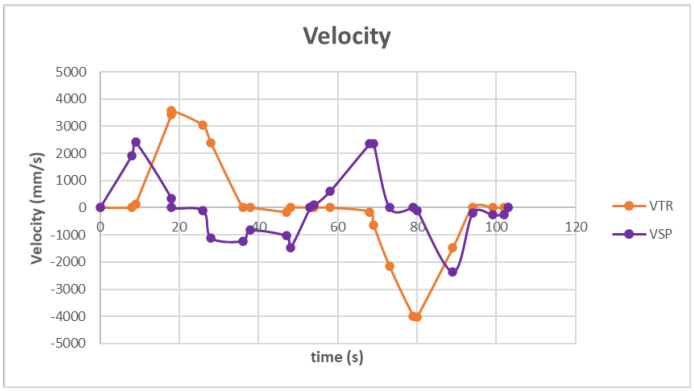




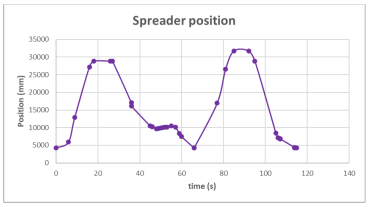


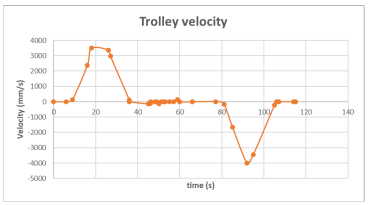


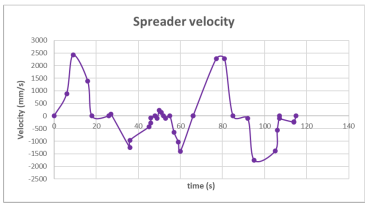


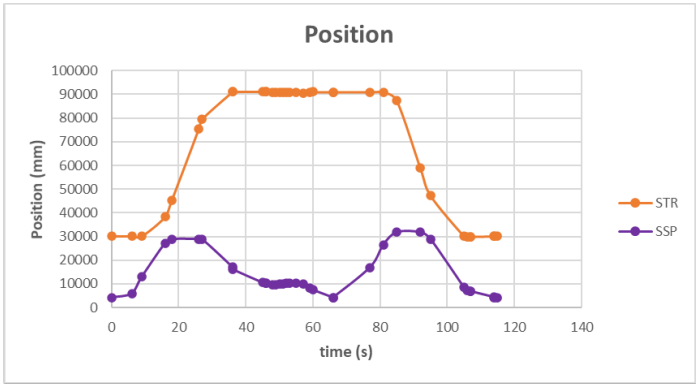


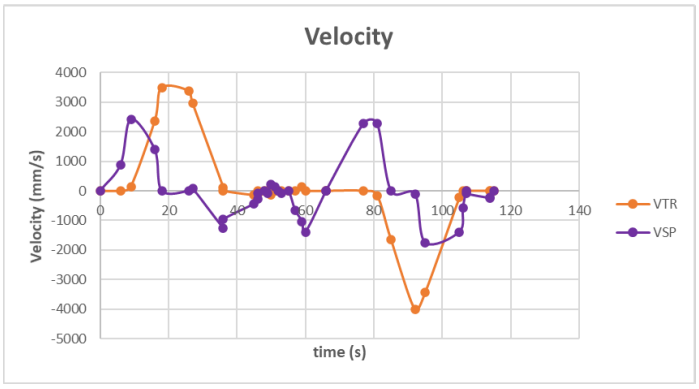
job	W (MT)	S_{TR} (mm)		S_{SP} (mm)		S_{GA} (mm)
128	29.9	91002		4242		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30160	0	50056	45830	4226	0
6	30160	0	50056	44140	5916	887
9	30170	142	50056	37160	12896	2423
16	38350	2372	50056	22850	27206	1390
18	45390	3490	50056	21220	28836	0
26	75400	3376	50056	21230	28826	0
27	79560	2977	50056	21240	28816	83
36	91060	115	50056	32990	17066	-1250
36	91130	0	50056	33870	16186	-968
45	91150	-145	50056	39560	10496	-437
46	91030	-103	50056	39770	10286	-278
46	91030	0	50056	39840	10216	-80
48	90970	0	50056	40340	9716	0
49	90970	0	50056	40330	9726	-90
50	90920	-148	50056	40170	9886	232
51	90860	0	50056	40090	9966	139
52	90880	0	50056	39880	10176	0
53	90890	0	50056	39870	10186	-90
55	90890	0	50056	39590	10466	0
57	90490	0	50056	39940	10116	-648
59	90910	142	50056	41650	8406	-1031
60	91060	0	50056	42600	7456	-1397
66	91000	0	50056	45810	4246	0
66	91010	0	50056	45790	4266	0
77	91000	0	50056	33080	16976	2277
81	90990	-162	50056	23520	26536	2274
85	87290	-1643	50056	18320	31736	0
92	58920	-4012	50056	18320	31736	-97
95	47340	-3440	50056	21250	28806	-1753
105	30130	-232	50056	41600	8456	-1389
106	29960	0	50056	42920	7136	-567
107	29940	0	50056	43200	6856	0
107	29940	0	50056	43210	6846	-95
114	30170	0	50056	45680	4376	-249
114	30170	0	50056	45750	4306	-231
115	30160	0	50056	45800	4256	0



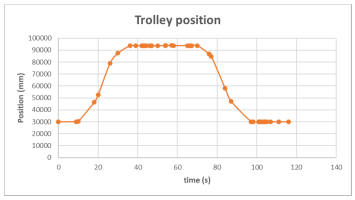


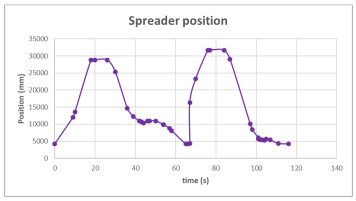


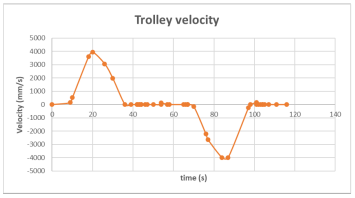


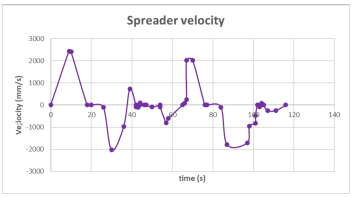


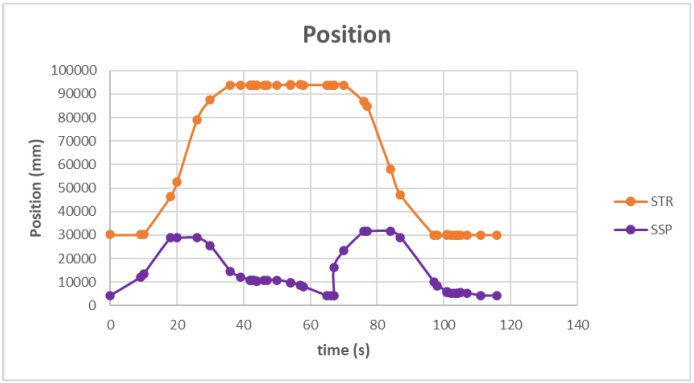
job	W (MT)	S_{TR} (mm)		S_{SP} (mm)		S_{GA} (mm)
129	35.5	93784		4188		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30160	0	50056	45800	4256	0
9	30170	148	50056	38030	12026	2430
10	30420	513	50056	3650	46406	2414
18	46410	3596	50056	21210	28846	0
20	52670	3959	50056	21220	28836	0
26	79100	3061	50056	21230	28826	-105
30	87470	1975	50056	24680	25376	-2031
36	93590	0	50056	35400	14656	-970
39	93580	0	50056	37790	12266	722
42	93660	0	50056	39140	10916	0
42	93670	0	50056	39150	10906	-81
43	93720	0	50056	39300	10756	0
43	93740	0	50056	39320	10736	-97
44	93730	0	50056	39700	10356	0
44	93740	0	50056	39690	10366	92
46	93640	0	50056	39110	10946	0
47	93610	0	50056	39110	10946	0
50	93670	0	50056	39120	10936	-90
54	93880	0	50056	40170	9886	0
54	93960	134	50056	40180	9876	-90
57	93960	0	50056	41300	8756	-812
58	93740	0	50056	41970	8086	-610
55	93780	0	50056	45870	4186	0
56	93790	0	50056	45840	4216	85
57	93780	0	50056	45730	4326	251
67	93780	0	50056	33740	16316	2024
70	93770	-145	50056	26720	23336	2026
76	86750	-2218	50056	18320	31736	0
77	84910	-2634	50056	18320	31736	0
84	58040	-3993	50056	18330	31726	-97
87	47230	-3990	50056	20990	29066	-1787
97	30140	-237	50056	39940	10116	-1704
98	29990	0	50056	41600	8456	-946
101	30050	148	50056	44020	6036	-824
101	30150	0	50056	44390	5666	-475
102	30120	0	50056	44590	5466	0
103	30130	0	50056	44610	5446	-90
104	30130	0	50056	44710	5346	0
104	30130	0	50056	44700	5356	85
105	30130	0	50056	44390	5666	0
107	30130	0	50056	44680	5376	-251
111	30130	0	50056	45730	4326	-249
116	30130	0	50056	45850	4206	0

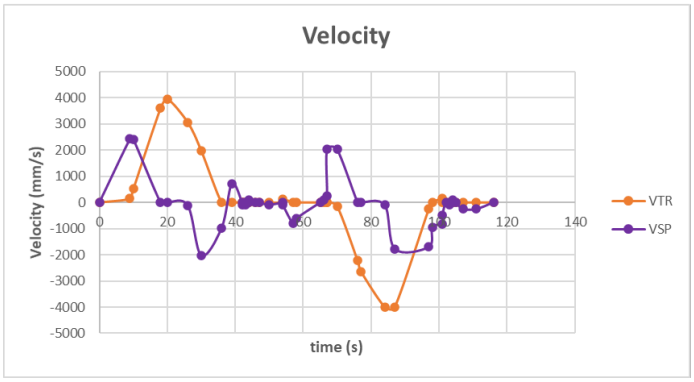




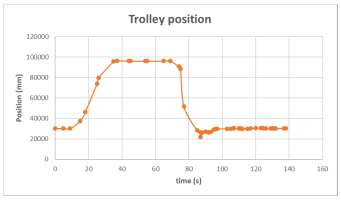


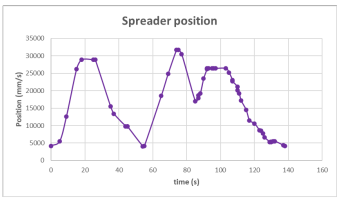


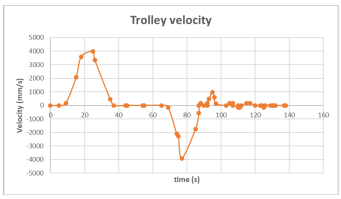


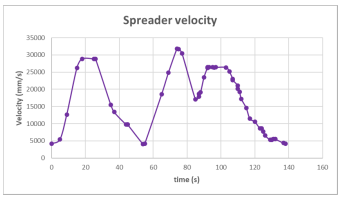


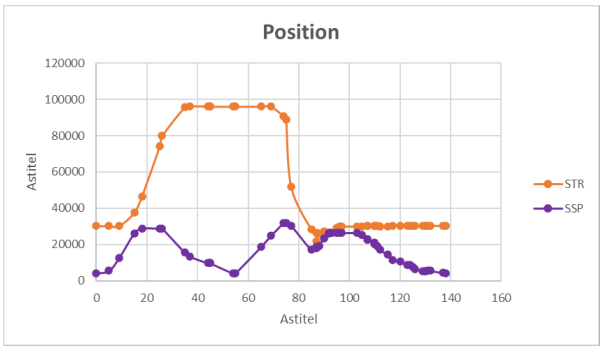
job	W (MT)	S_{TR} (mm)		S_{SP} (mm)		S_{GA} (mm)
130	29.7	96138		4080		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30130	0	50056	45850	4206	0
5	30120	0	50056	44580	5476	510
9	30130	156	50056	37440	12616	2411
15	37470	2059	50056	23820	26236	1777
18	46410	3588	50056	21180	28876	0
25	74090	3993	50056	21190	28866	0
26	79890	3348	50056	21200	28856	-85
35	95890	458	50056	34530	15526	-1389
37	96370	0	50056	36680	13376	-792
44	96220	0	50056	40250	9806	0
45	96140	0	50056	40250	9806	0
45	96130	0	50056	40300	9756	0
54	96140	0	50056	45970	4086	-102
55	96140	0	50056	45890	4166	256
65	96130	0	50056	31480	18576	2175
69	96130	-145	50056	25250	24806	2175
74	90810	-2104	50056	18310	31746	0
75	88760	-2280	50056	18320	31736	-105
77	51820	-3915	50056	19570	30486	-1231
85	28190	-1747	50056	33030	17026	0
87	26330	-547	50056	32190	17866	1007
87	21670	0	50056	31390	18666	1402
88	26200	159	50056	30880	19176	1611
90	27260	0	50056	26550	23506	1884
92	26370	0	50056	23820	26236	519
92	26420	165	50056	23670	26386	288
93	26610	480	50056	23600	26456	0
95	29270	979	50056	23610	26446	-95
96	29740	592	50056	23680	26376	0
97	29890	125	50056	23670	26386	0
103	29870	0	50056	23690	26366	-97
105	29910	165	50056	24920	25136	-1219
107	30380	173	50056	27040	23016	-982
107	30440	0	50056	27400	22656	-744
110	30380	-154	50056	28960	21096	-1161
110	30240	0	50056	29900	20156	-1565
111	30250	-142	50056	30790	19266	-1882
112	29880	0	50056	32820	17236	-1506
115	29950	162	50056	35540	14516	-1272
117	30380	176	50056	38560	11496	-1641
120	30450	0	50056	39480	10576	-1265
123	30450	0	50056	41450	8606	0
124	30450	0	50056	41480	8576	-98
125	30420	-165	50056	42310	7746	-978
126	30210	0	50056	43470	6586	-1151
129	30240	0	50056	44730	5326	0
130	30250	0	50056	44730	5326	0
130	30240	0	50056	44720	5336	88
131	30250	0	50056	44520	5536	0
132	30240	0	50056	44530	5526	-90
137	30250	0	50056	45700	4356	-251
138	30250	0	50056	45910	4146	0

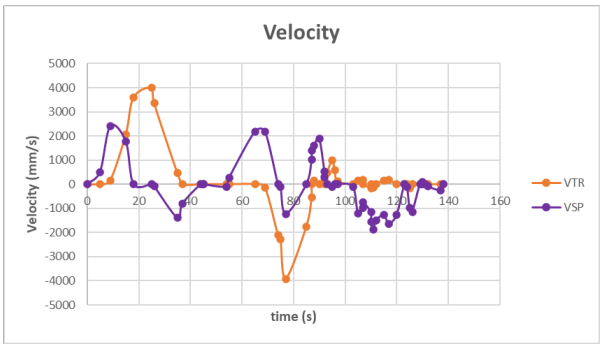




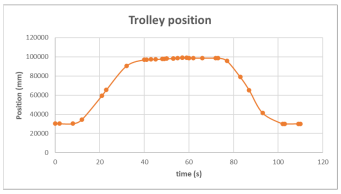


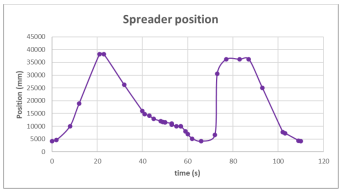


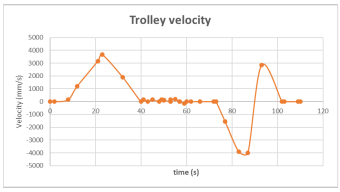


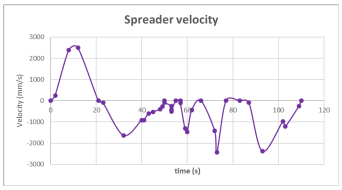


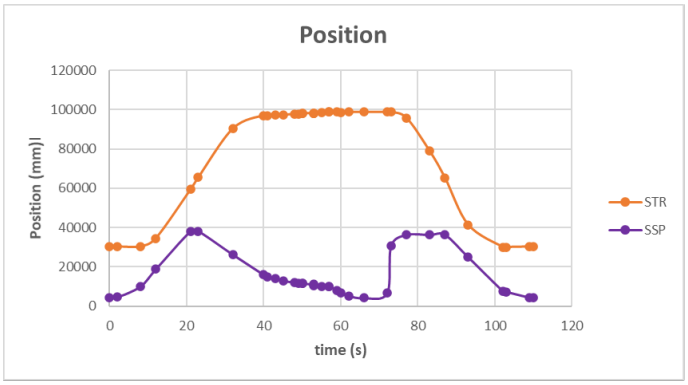
	W	S_{TR}		S_{SP}		S_{GA}
	(MT)	(mm)		(mm)		(mm)
131	24.5	98808		4148		80585
t(s)	s_{TR}(mm)	v_{TR}(mm)	$s_{TR,bh}$(mm)	z(mm)	s_{SP}(mm)	v_{SP}(mm)
0	30250	0	50056	45910	4146	0
2	30240	0	50056	45470	4586	247
8	30260	156	50056	40040	10016	2380
12	34490	1205	50056	31230	18826	2501
21	59410	3147	50056	11900	38156	0
23	65500	3658	50056	11910	38146	-90
32	90460	1903	50056	23880	26176	-1629
40	97100	0	50056	34100	15956	-919
41	97080	151	50056	35260	14796	-917
43	97210	0	50056	35920	14136	-595
45	97270	148	50056	37150	12906	-524
48	97860	0	50056	38010	12046	-397
49	97860	154	50056	38390	11666	-270
50	98050	134	50056	38550	11506	0
50	98080	103	50056	38570	11486	-87
53	98310	0	50056	38930	11126	-244
53	98260	0	50056	39300	10756	-426
53	98300	151	50056	39490	10566	-504
55	98749	178	50056	40020	10036	0
57	98940	0	50056	40020	10036	0
57	98930	0	50056	40040	10016	-103
59	98930	-148	50056	41990	8066	-1307
60	98760	0	50056	43130	6926	-1472
62	98810	0	50056	44890	5166	-432
66	98810	0	50056	45910	4146	0
72	98800	0	50056	43460	6596	-1407
73	98810	0	50056	19440	30616	-2431
77	95790	-1549	50056	13800	36256	0
83	78900	-3898	50056	13810	36246	0
87	65160	-3990	50056	1381	48675	-81
93	41330	2838	50056	25080	24976	-2382
102	29990	0	50056	42370	7686	-975
103	29980	0	50056	42790	7266	-1214
109	30180	0	50056	45670	4386	-249
110	30170	0	50056	45890	4166	0

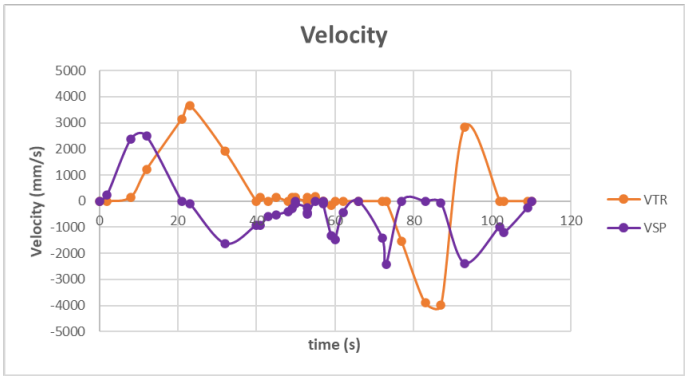












B2 .Data analysis verification cycle path with PLC-trace

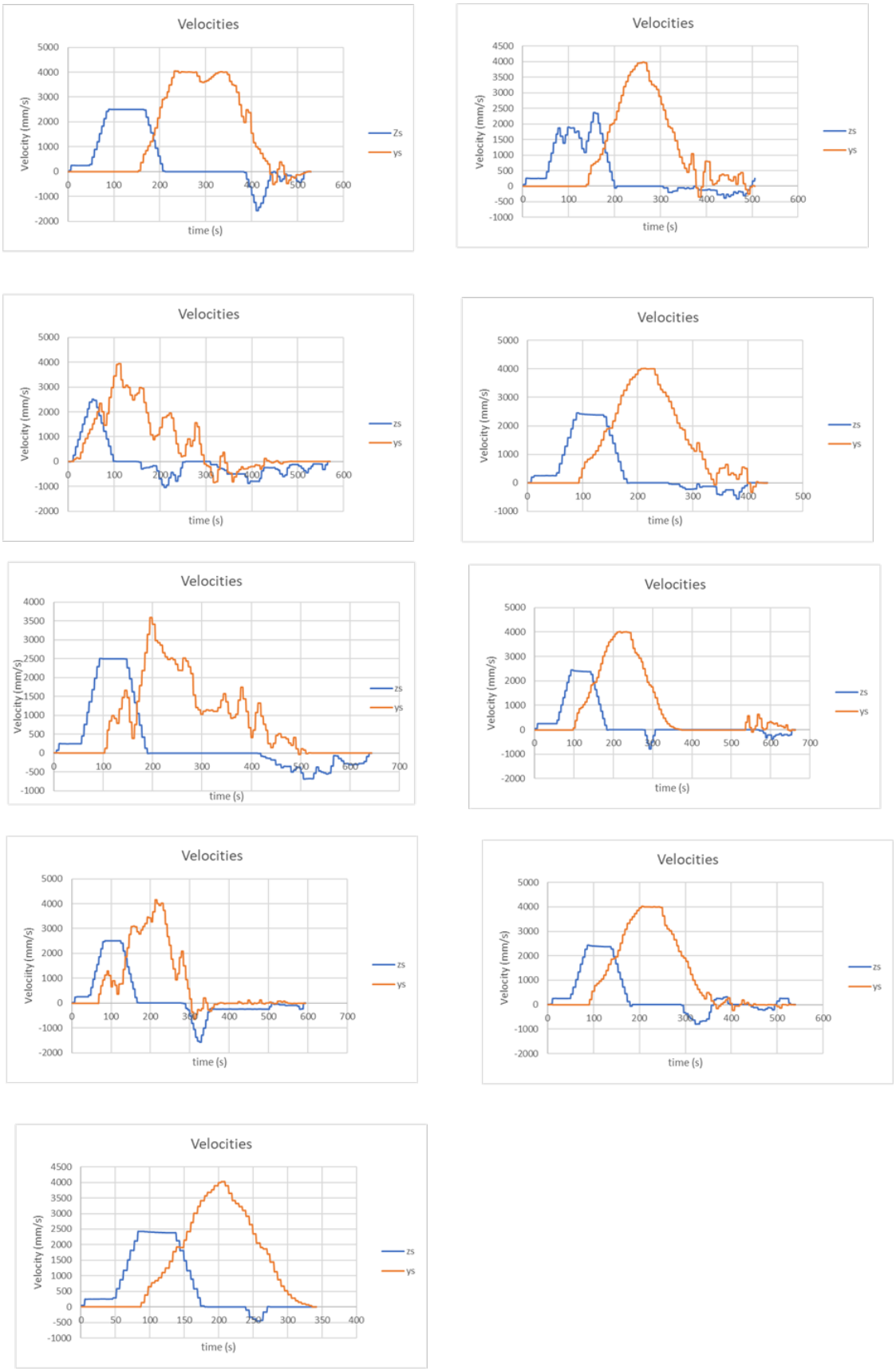


Figure 40 Verification cycle path half-cycles result using PLC-traces

C. PLC-trace comparison with model

Table 30 PLC trace Job 1

W: 17(MT)	s_{TR}: 80.919 (m)	s_{SP}: 24.967 (m)	
	Crane	Model A	Difference
process	Time (s)	Time (s)	Δt (s)
Hoist to upper	17.6	22.469	-4.869
Trolley to source+ sway control	6.0	10.279	-4.279
Lower to source	11.4	18.561	-7.161
Twist lock	1.0	2.323	-1.323
Hoist to upper +Load measurement	14.4	18.2023	-3.802
Trolley to platform+sway control	5.2	2.9771	2.223
Lower to platform	15.4	16.909	-1.509
Detach Locks	8.6	13.2350	-4.4635
Hoist to upper	6.2	5.407	0.793
Trolley to destination + sway control	4.6	4.7974	-0.197
Lower to destination	16.2	12.687	3.513
Twist lock	3.0	2.323	-0.667

Table 31 PLC trace Job 2

W: 10 (MT)	s_{TR}: 83.981 (m)	s_{SP}: 24.609 (m)	
	Crane	Model A	Difference
process	Time (s)	Time (s)	Δt (s)
Hoist to upper	21.0	22.469	-1.469
Trolley to source+ sway control	9.2	10.993	-1.793
Lower to source	18.2	19.326	-1.126
Twist lock	1.0	2.323	-1.323
Hoist to upper +Load measurement	10.4	18.346	-7.946
Trolley to platform+sway control	8.0	3.743	4.257
Lower to platform	13.8	16.909	-3.109
Detach Locks	21.0	13.235	7.765
Hoist to upper	6.0	5.407	0.593
Trolley to destination + sway control	6.2	4.797	-1.403
Lower to destination	14.8	12.687	2.113
Twist lock	1.2	2.323	-1.123

Table 32 PLC trace Job 3

W: 7 (MT)	s_{TR}: 85.594 (m)	s_{SP}: 24.558 (m)	
	Time (s)	Time (s)	Difference
process	Crane	Model A	Δt (s)
Hoist to upper	17.6	22.469	-4.869
Trolley to source+ sway control	7.2	11.396	-4.196
Lower to source	14.0	19.729	-5.729
Twist lock	1.0	2.323	-1.323
Hoist to upper +Load measurement	19.6	18.3659	-0.3473
Trolley to platform+sway control	8.2	4.146	4.054
Lower to platform	14.8	16.909	-2.109
Detach Locks	10.6	13.2350	-2.635
Hoist to upper	5.6	5.407	0.193
Trolley to destination + sway control	4.8	4.797	0.003
Lower to destination	13.2	12.687	0.513
Twist lock	3.2	2.323	0.877

Table 33 PLC trace Job 4

W: 20 (MT)	s_{TR}: 88.589 (m)	s_{SP}: 25.599 (m)	
process	Crane	Model A	Difference
	Time (s)	Time (s)	Δt (s)
Hoist to upper	18.4	22.469	-4.069
Trolley to source+ sway control	8.8	12.145	-3.345
Lower to source	11.2	20.478	-9.278
Twist lock	1.20	2.323	-1.123
Hoist to upper +Load measurement	12.6	17.950	-5.350
Trolley to platform+sway control	8.4	4.895	3.505
Lower to platform	13.6	16.909	-3.309
Detach Locks	9.0	13.235	-4.235
Hoist to upper	5.8	5.407	0.393
Trolley to destination + sway control	9.8	4.797	5.003
Lower to destination	17.4	12.687	4.713
Twist lock	1.8	2.323	-0.520

Table 34 PLC trace Job 5

W: 18 (MT)	s_{TR}: 94.132 (m)	s_{SP}: 25.421 (m)	
process	Crane	Model A	Difference
	Time (s)	Time (s)	Δt (s)
Hoist to upper	19.400	22.469	-3.069
Trolley to source+ sway control	13.8	13.530	-0.270
Lower to source	18.8	21.864	-3.064
Twist lock	2.40	2.323	-0.077
Hoist to upper +Load measurement	13.60	18.021	-4.421
Trolley to platform+sway control	10.00	6.280	3.720
Lower to platform	14.40	16.909	-2.509
Detach Locks	11.6	13.235	-1.635
Hoist to upper	7.00	5.407	1.593
Trolley to destination + sway control	6.40	4.797	1.603
Lower to destination	17.60	12.687	4.913
Twist lock	2.6	2.323	0.277

Table 35 PLC trace Job 6

W: 7 (MT)	s_{TR}: 96.263 (m)	s_{SP}: 24.735 (m)	
process	Crane	Model A	Difference
	Time (s)	Time (s)	Δt (s)
process	Crane	Model A	
Hoist to upper	19	22.469	-3.469
Trolley to source+ sway control	12	14.063	-2.063
Lower to source	21.2	22.397	-1.197
Twist lock	1	2.323	1.337
Hoist to upper +Load measurement	14.8	18.295	-3.495
Trolley to platform+sway control	7.4	6.813	0.587
Lower to platform	15.8	16.909	-1.109
Detach Locks	10.6	13.235	-2.635
Hoist to upper	6.2	5.407	0.793
Trolley to destination + sway control	7.6	4.797	2.803
Lower to destination	19.0	12.687	-6.313
Twist lock	2.80	2.323	-0.477

Table 36 PLC trace Job 7

W: 9 (MT)	s_{TR}: 98.697 (m)	s_{SP}: 25.061 (m)	
process	Crane	Model A	Difference
	Time (s)	Time (s)	Δt (s)
Hoist to upper	17.4	22.469	-5.069
Trolley to source+ sway control	12.2	14.672	-2.472
Lower to source	9.4	23.005	-13.605
Twist lock	1	2.323	-1.323
Hoist to upper +Load measurement	10.8	18.165	-7.365
Trolley to platform+sway control	11.2	7.422	3.778
Lower to platform	12.8	16.909	-4.109
Detach Locks	11.8	13.235	-1.435
Hoist to upper	5.8	5.407	0.393
Trolley to destination + sway control	6.2	4.797	1.403
Lower to destination	19.6	12.687	6.913
Twist lock	1.4	2.323	-0.923

Table 37 PLC trace Job 8

W: 9 (MT)	s_{TR}: 101.094 (m)	s_{SP}: 24.925 (m)	
process	Crane	Model A	difference
	Time (s)	Time (s)	Δt (s)
Hoist to upper	17.6	22.469	4.869
Trolley to source+ sway control	13	15.271	-2.271
Lower to source	18	23.604	-5.604
Twist lock	1	2.323	-1.323
Hoist to upper +Load measurement	11.8	18.219	-6.419
Trolley to platform+sway control	10.8	8.021	2.779
Lower to platform	14.4	16.909	-2.509
Detach Locks	7.4	13.235	-5.835
Hoist to upper	4.8	5.407	-0.607
Trolley to destination + sway control	6.0	4.797	1.203
Lower to destination	22	12.687	9.313
Twist lock	1.8	2.323	-0.537

Table 38 PLC trace Job 9

W: 8 (MT)	s_{TR}: 103.274 (m)	s_{SP}: 24.637 (m)	
process	Crane	Model A	Difference
	Time (s)	Time (s)	Δt (s)
Hoist to upper	17.4	22.469	-5.069
Trolley to source+ sway control	13.2	15.816	-2.616
Lower to source	12.8	24.149	-11.349
Twist lock	1.2	2.323	-1.123
Hoist to upper +Load measurement	12.8	18.334	-5.534
Trolley to platform+sway control	12.4	8.566	3.834
Lower to platform	13.8	16.909	-3.109
Detach Locks	23.4	13.235	10.165
Hoist to upper	5.6	5.407	0.193
Trolley to destination + sway control	7.2	4.797	2.403
Lower to destination	14.4	12.687	1.713
Twist lock	2.2	2.323	-0.123

D. Process times

Table 39 Sway control duration result using PLC-traces

Start time	End time	Delta t (s)
12:39:35,001	12:39:37,701	1.7
12:39:43,701	12:39:45,501	1.8
12:47:36,701	12:47:37,301	0.6
12:55:27,501	12:55:28,201	0.7
12:55:42,401	12:55:43,401	1
12:56:20,301	12:56:21,301	0.7
12:56:28,501	12:56:29,601	1.1
13:00:23,101	13:00:24,301	1.2
13:00:39,401	13:00:40.001	0.6
13:01:17,001	13:01:17.601	0.6
13:01:26,801	13:01:27.801	1
	Mean μ	1
	Standard deviation σ	0.4090

Table 40 Twistlock duration result using PLC-traces

Start time	End time	Delta t (s)
12:38:39.301	12:38:41.201	1.9
12:44:46.901	12:44:49.401	2.5
12:58:41.601	12:58:44.001	2.4
13:00:03.801	13:00:06.301	2.5
	Mean μ	2.325
	Standard deviation σ	0.2487

Table 41 Twistlock duration platform result using PLC-traces

Start time	End time	Delta t (s)
13:14:56.901	13:15:04.701	7.6
13:16:36.501	13:16:41.501	5.0
13:18:39.301	13:18:49.901	8.6
13:20:35.701	13:21:01.701	26.2
13:22:40.901	13:22:49.901	9
13:24:55.901	12:25:19.301	23.4
12:56:28.501	12:56:29.601	24.2
13:31:02.101	13:31:11.901	9.8
13:33:04.901	13:33:14.501	8.6
13:36:11.501	13:36:21.101	9.6
	Mean μ	13.2
	Standard deviation σ	7.597

E Performance Prediction Analysis

Table 42 Results individual jobs Dataset1

s_{TR}(m)	s_{SP}m)	w(MT)	Crane t_{cyc}(s)	Model A t_{cyc}(s)	Δ t_{cyc}(s)	Δ t_{cyc}^2(s)	Model B t_{cyc}(s)	Δ tcyc(s)	Δ t_{cyc}^2(s)
96.084	**6.526**	**34.9**	**105**	133.942	-28.942	837.631	113.283	-8.283	68.610
98.524	**6.866**	**32.7**	**105**	133.369	-28.369	804.825	113.341	-8.341	69.570
81.183	**4.305**	**40.5**	**139**	132.164	6.836	46.734	109.951	29.049	843.847
83.197	**4.273**	**25**	**119**	122.208	-3.208	10.290	104.387	14.613	213.543
85.952	**4.352**	**26**	**111**	124.301	-13.301	176.920	106.201	4.799	23.027
88.597	**4.363**	**26.9**	**101**	126.309	-25.309	640.561	107.955	-6.955	48.366
91.002	**4.242**	**29.9**	**116**	129.878	-13.878	192.598	110.659	5.341	28.522
93.784	**4.188**	**35.5**	**115**	135.302	-20.302	412.160	114.473	0.527	0.278
96.138	**4.080**	**29.7**	**133**	132.435	0.565	0.319	113.274	19.726	389.096
98.808	**4.148**	**24.5**	**119**	130.113	-11.113	123.504	112.037	6.963	48.489
81.340	**1.654**	**44.6**	**117**	137.312	-20.312	412.566	114.020	2.980	8.882
83.669	**1.705**	**40.2**	**111**	135.667	-24.667	608.460	113.535	-2.535	6.427
86.187	**1.615**	**35.7**	**114**	133.967	-19.967	398.690	113.082	0.918	0.844
88.845	**1.630**	**39.4**	**111**	137.801	-26.801	718.301	115.887	-4.887	23.880
91.115	**1.584**	**34.4**	**107**	135.537	-28.537	814.356	115.021	-8.021	64.331
93.759	**1.609**	**39.1**	**106**	140.079	-34.079	1161.394	118.247	-12.247	149.985
96.166	**1.560**	**46.3**	**111**	145.831	-34.831	1213.181	122.107	-11.107	123.372
98.664	**1.507**	**43.4**	**136**	145.383	-9.383	88.038	122.401	13.599	184.929
81.243	**-1.104**	**36.3**	**153**	134.388	18.612	346.401	113.333	39.667	1573.447
83.501	**-1.232**	**38.6**	**146**	137.257	8.743	76.448	115.561	30.439	926.508
86.287	**-1.314**	**39.5**	**155**	139.345	15.655	245.094	117.403	37.597	1413.546
88.911	**-1.209**	**37.2**	**179**	138.960	40.040	1603.203	117.653	61.347	3763.463
91.284	**-1.251**	**26.5**	**148**	131.928	16.072	258.319	113.687	34.313	1177.407
94.104	**-1.223**	**30.1**	**147**	136.239	10.761	115.789	116.963	30.037	902.223
96.176	**-1.175**	**29.5**	**164**	136.757	27.243	742.171	117.654	46.346	2147.909
98.819	**-1.188**	**24.1**	**136**	134.388	1.612	2.600	116.050	19.950	397.998
81.091	**-3.898**	**35.8**	**176**	136.482	39.518	1561.683	115.568	60.432	3652.031
83.623	**-3.915**	**39.2**	**152**	140.236	11.764	138.384	118.377	33.623	1130.534
86.118	**-3.829**	**37.6**	**152**	140.258	11.742	137.864	118.840	33.160	1099.587
89.142	**-3.959**	**54.1**	**187**	152.346	34.654	1200.891	126.765	60.235	3628.293
91.317	**-3.910**	**26.9**	**146**	134.458	11.542	133.222	116.103	29.897	893.823
94.148	**-3.949**	**44.7**	**157**	149.243	7.757	60.177	125.925	31.075	965.657
96.372	**-3.853**	**35.7**	**154**	144.007	9.993	99.864	123.121	30.879	953.504
98.805	**-3.912**	**49**	**144**	154.204	-10.204	104.114	129.815	14.185	201.228
81.250	**-6.373**	**52.1**	**157**	149.756	7.244	52.469	124.633	32.367	1047.650
83.631	**-6.363**	**45.3**	**155**	146.734	8.266	68.328	123.263	31.737	1007.230
86.078	**-6.362**	**45**	**171**	147.760	23.240	540.116	124.365	46.635	2174.798
88.755	**-6.326**	**29.5**	**114**	137.411	-23.411	548.064	118.308	-4.308	18.559
					SSE	**1.67E+04**			**3.14E+04**

Table 43 Results individual jobs Dataset2

s_{TR}(m)	s_{SP}m)	w(MT)	Crane t_{cyc}(s)	Model A t_{cyc}(s)	Δ t_{cyc}(s)	Δ t_{cyc}^2(s)	Model B t_{cyc}(s)	Δ t_{cyc}(s)	Δ t_{cyc}^2(s)
73.824	**31.468**	**25.8**	**105**	117.068	-12.068	145.648	98.073	6.927	47.988
76.274	**31.592**	**26.6**	**110**	118.500	-8.500	72.249	100.088	9.912	98.251
81.554	**31.468**	**25.3**	**117**	120.745	-3.745	14.028	101.372	15.628	244.248
83.955	**31.336**	**28.7**	**111**	123.392	-12.392	153.563	106.401	4.599	21.152
86.407	**31.381**	**27.8**	**110**	124.215	-14.215	202.067	106.633	3.367	11.334
88.993	**31.106**	**22.1**	**115**	124.644	-9.644	92.998	101.574	13.426	180.245
91.700	**30.952**	**25.2**	**137**	126.195	10.805	116.743	106.744	30.256	915.399
94.111	**30.904**	**27.5**	**114**	128.341	-14.341	205.667	110.557	3.443	11.856
96.802	**30.747**	**26.7**	**124**	129.494	-5.494	30.188	111.154	12.846	165.032
99.218	**30.645**	**27.4**	**117**	131.068	-14.068	197.910	113.215	3.785	14.324
101.661	**30.141**	**29.2**	**120**	133.459	-13.459	181.157	116.785	3.215	10.335
104.621	**31.169**	**25.9**	**132**	132.747	-0.747	0.558	113.826	18.174	330.305
106.892	**31.213**	**27.8**	**126**	134.597	-8.597	73.908	117.015	8.985	80.724
109.131	**31.169**	**30.7**	**129**	136.953	-7.953	63.254	121.186	7.814	61.055
68.918	**28.780**	**24.4**	**121**	116.467	4.533	20.549	96.149	24.851	617.558
71.255	**27.909**	**22**	**112**	118.332	-6.332	40.096	95.029	16.971	288.023
73.669	**28.221**	**23.4**	**107**	119.290	-12.290	151.033	97.752	9.248	85.526
76.34	**28.379**	**23.4**	**127**	120.499	6.501	42.267	98.964	28.036	786.023
					SSE	**1.80E+03**			**3.97E+03**

Table 44 Results individual jobs Dataset3

s_{TR}(m)	s_{SP}m)	w(MT)	Crane t_{cyc}(s)	Model A t_{cyc}(s)	Δ t_{cyc}(s)	Δ t_{cyc}^2(s)	Model B t_{cyc}(s)	Δ t_{cyc}(s)	Δ t_{cyc}^2(s)
99.391	**27.630**	**45**	**134**	142.212	-8.212	67.444	131.539	2.461	6.055
96.894	**27.620**	**49.3**	**135**	142.730	-7.730	59.751	133.462	1.538	2.365
91.523	**28.483**	**19.4**	**123**	128.736	-5.736	32.905	100.722	22.278	496.312
88.816	**28.602**	**21**	**134**	127.288	6.712	45.056	101.413	32.587	1061.934
86.603	**28.557**	**19.9**	**147**	126.217	20.783	431.929	98.884	48.116	2315.181
84.612	**28.371**	**19.7**	**145**	125.370	19.630	385.321	97.756	47.244	2232.000
119.358	**31.306**	**36**	**142**	144.919	-2.919	8.522	130.617	11.383	129.563
116.685	**30.952**	**37.1**	**172**	144.370	27.630	763.405	130.575	41.425	1716.061
112.096	**31.420**	**38.3**	**142**	142.148	-0.148	0.022	128.882	13.118	172.092
109.375	**31.335**	**38.4**	**162**	140.908	21.092	444.890	127.685	34.315	1177.545
106.612	**30.193**	**32.2**	**148**	137.909	10.091	101.821	121.683	26.317	692.599
104.369	**30.142**	**35.5**	**161**	138.265	22.735	516.898	123.726	37.274	1389.367
101.806	**30.518**	**34.7**	**158**	136.300	21.700	470.909	121.372	36.628	1341.623
96.724	**30.628**	**36.5**	**133**	134.431	-1.431	2.048	120.362	12.638	159.722
93.982	**31.612**	**19.1**	**167**	127.463	39.537	1563.206	99.259	67.741	4588.906
91.670	**31.839**	**21.1**	**119**	126.125	-7.125	50.766	100.527	18.473	341.242
89.177	**31.832**	**20.6**	**120**	124.884	-4.884	23.854	98.651	21.349	455.777
86.615	**31.993**	**20**	**125**	123.474	1.526	2.328	96.478	28.522	813.517
84.361	**31.876**	**18.6**	**120**	122.441	-2.441	5.958	93.586	26.414	697.674
81.051	**31.103**	**28.2**	**149**	122.660	26.340	693.805	104.036	44.964	2021.723
71.576	**31.533**	**35.5**	**106**	120.612	-14.612	213.512	106.073	-0.073	0.005
68.613	**31.727**	**31.8**	**139**	117.403	21.597	466.437	100.956	38.044	1447.383
124.273	**34.321**	**27.7**	**173**	141.400	31.600	998.557	122.444	50.556	2555.939
121.588	**34.003**	**26.7**	**153**	139.952	13.048	170.254	120.304	32.696	1069.059
119.256	**34.505**	**23.3**	**143**	137.785	5.215	27.194	114.938	28.062	787.495
114.636	**34.667**	**24**	**151**	135.346	15.654	245.060	113.306	37.694	1420.822
109.291	**34.696**	**27.9**	**131**	133.672	-2.672	7.139	114.850	16.150	260.834
106.599	**33.067**	**21.6**	**151**	132.607	18.393	338.299	107.684	43.316	1876.240
104.321	**33.145**	**25.3**	**148**	131.511	16.489	271.883	110.830	37.170	1381.627
101.460	**32.952**	**22.5**	**133**	130.130	2.870	8.239	106.299	26.701	712.965
99.204	**33.332**	**22.6**	**133**	128.698	4.302	18.511	104.997	28.003	784.153
96.825	**33.532**	**25.3**	**95**	127.452	-32.452	1053.148	106.771	-11.771	138.553
94.045	**34.997**	**20.7**	**146**	124.786	21.214	450.030	98.840	47.160	2224.076
91.668	**34.856**	**21.1**	**123**	123.710	-0.710	0.505	98.250	24.750	612.584
89.054	**35.055**	**21**	**113**	122.244	-9.244	85.455	96.670	16.330	266.669
86.576	**34.944**	**21.2**	**133**	121.094	11.906	141.753	95.759	37.241	1386.864
84.155	**34.952**	**21.3**	**121**	119.877	1.123	1.261	94.665	26.335	693.547
80.953	**34.189**	**28.9**	**128**	120.302	7.698	59.253	102.131	25.869	669.181
73.582	**33.661**	**27**	**128**	116.340	11.660	135.967	96.903	31.097	967.049
71.371	**34.465**	**26.6**	**116**	114.429	1.571	2.467	94.710	21.290	453.270
68.458	**34.800**	**24.4**	**114**	112.150	1.850	3.422	90.565	23.435	549.178
121.356	**37.422**	**24.8**	**171**	136.502	34.498	1190.140	115.371	55.629	3094.547
119.015	**37.933**	**23.6**	**143**	134.922	8.078	65.249	112.476	30.524	931.705
					SSE	**1.16E+04**			**4..61E+04**