TERMINAL AUTOMATION & SAFETY SYSTEM

Joint Submission to the 3rd TTClub Innovation in Safety Award

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Winter Haven Terminal Automation & Safety System

This paper has been jointly prepared and summarizes the project results of a joint automation project in Winter Haven, Florida. Winter Haven can be considered a medium size inland rail intermodal terminal with changes in traffic density over the year. Thus, it was chosen to deploy the technology there first. After the successful implementation in Winter Haven, CSXIT decided to equip a new build facility in Fairburn, GA with the same technology. Besides the fact that Fairburn is a larger terminal, the system was also deployed in a greenfield portion of the terminal while the Winter Haven project was a brownfield project deployed in the middle of a fully operational terminal.

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Introduction

CSX Transportation is a Class 1 freight railroad operating in the eastern United States and the Canadian Province of Quebec. CSX operates about 34.000 km of track and 3600 locomotives. CSX Intermodal Terminals (CSXIT) operates 30 Intermodal Terminals on the CSX network.

CSXIT is always looking to develop and incorporate new technologies to improve safety and operational efficiency. CSXIT operates under the principles of scheduled railroading two of which are "Optimizing Asset Utilization" and "Operating Safely." There is no doubt that safety and operation go hand in hand –no operation is efficient if it is not safe. Operating Safely necessitates that CSXIT does not take commercial or legal risks.

When CSXIT chose to automate cranes in terminal operations to improve the overall productivity and efficiency, one of the largest challenges was to ensure the safety of the personnel who are required to operate in close proximity to the automated equipment. It was mandatory that the system deployed had very high redundancy, reliability and availability. The intermodal cranes selected for the initial automation are very large with a span between the legs of 46 meters and an overall span of 85 meters. They operate over a 6 rail processing tracks each 920 meters long and a 5 wide by 4 high stacking area. The crane location precision required to lock and unlock the containers on the spreader is only a few centimeters.

A typical CSX Intermodal train can extend in length to over 4,200 meters and carry more than 250 double stacked 53' intermodal containers. In order to realize the efficiency of intermodal transportation, containers are double stacked on railcars connected by manually operated Inter Box Connectors (IBCs). During the loading and unloading cycle, personnel are needed to place, lock, unlock and remove the IBCs. Currently, there is not an automatic connectivity solution for the upper and lower containers in a double stack train. Therefore, personnel and the automated equipment must safely share the same workspace. The automation of the crane work would not have been possible without the Yardeye system technology.

In order to automate their intermodal cranes, Künz has worked out a full automation concept customized to the specific CSXIT requirements for personnel safety and productivity. This project was a joint effort by CSXIT, Künz and Yardeye.

The Yardeye technology is part of an automation ecosystem that pushes intermodal operations to the next level, securing Yardeye's position as an enabler for the most efficient container terminal handling company in terms of container lifts per man hour worked (LPMH).

The Künz/Yardeye system implemented in Winter Haven has provided a significantly safer and more productive environment for my workforce.

Jamie Watkins, Winter Haven Hub Manager


J.B. HUNT
J.B. HUNT

Safety Challenge

An intermodal terminal is a complex operation with multiple personnel performing different distinct tasks to efficiently and safely move containers in the same workspace. This is not ideal but the only way an intermodal terminal can achieve the productivity and efficiency to make rail intermodal transportation commercially attractive. It starts with the commercial truck driver that brings containers into the terminal and receives instructions to proceed to a designated spot. The crane driver picks up the container and lifts it to a railcar that has been designated by the terminal operating system. Once the container is placed, an IBC (Interbox Connector) needs to be placed on top so that a second container can be placed. Once this placement is done, the IBCs need to be locked. At the same time, inspection and possible minor repairs are performed on the railcars.

The following chart shows the personnel that may be or are near to an operational intermodal crane lifting containers. A container on the spreader is defined by Occupational Safety and Health Administration (OSHA) Regulation 29 CFR 1910.180 as a suspended load. According to this, no personnel may be in the danger area below or near the container-spreader combination.

Personnel	Jobs Performed	Risks, especially Likelihood of Proximity to suspended Load	Risk Mitigation Manual Intermodal Crane Mode	Risk Mitigation in Automatic Intermodal Crane Mode	Technology	Safety Improvement
Commercial Truck Driver	Provide containers on their chassis for pick up or drop by intermodal crane	Depending on their position	Provide containers on their chassis for pick up or drop by intermodal crane	Operator needs to see driver standing outside truck cab	Künz Camera	Yes – multiple views allow detecting second driver in cab / around chassis
Load Dispatcher / Foreman	Dispatch from office	Only if in field	To be seen by crane operator	Uses tagged vehicle – thus protected	Yardeye	Yes
Crane Driver	Driving Crane	Suspended Load: low; back-stress, trips and fall	None	Full remote control station	Yardeye, Künz	Ergonomic improvement
IBC Cone Kart/ Grunt Driver	Opening and Closing Twistlocks	High	Manual Operator observes Vehicle	Crane path is optimized to avoid vehicle, stop / interlock of Crane, active warning of driver Cone Cart Driver	Yardeye	Massive as automatic interlock if too close proximity
TTX Inspection	FRA required railcar inspections to be completed in the intermodal operating area	High	Manual operator observes people and vehicles	Crane path is optimized to avoid vehicle, stop / interlock of Crane, active warning of work vehicle driver	Yardeye	Massive as automatic interlock if too close proximity
Road & Rail Personnel	Movement of railcars in the crane processing area	Moderate	Manual operator observes people and vehicles	Crane path is optimized to avoid vehicle, stop / interlock of Crane, active warning of work vehicle driver	Yardeye	Massive as automatic interlock if too close proximity
Manager	Supervise operations in the rail processing area	Only if in the field	Manual operator observes people and vehicles	Uses tagged vehicle – thus protected	Yardeye	Massive as automatic interlock if too close proximity

In order to reduce the number of personnel exposed to the hazards associated with container handling in an intermodal rail terminal, CSXIT desired to semi-automate container handling cranes and move the crane operators into a terminal building. This resulted in the need to ensure automated container handling cranes did not move a suspended load over personnel or a manned vehicle.

In a terminal with operating personnel in the cab of the crane, responsibility for ensuring personnel are not under a suspended container load rests with the crane operator and with the people on the ground in the vicinity of container handling cranes. CSXIT desired to remove the operators from the crane cab and allow automated crane motion in portions of the operating area. This necessitated a safety system with very high accuracy, reliability, and availability closely integrated with the crane operating system to:

a) Accurately and reliably track personnel (vehicle) location in the Rail Processing Area (RPA)
b) Provide the vehicle with a "safety halo"
c) Continuously feed personnel location to the crane systems
d) Develop and implement crane slow down and stop distances
e) Provide an intermediate layer to direct work orders from the terminal operating system to the cranes

Whenever a CRMG (Cantilever Rail Mounted Gantry Crane) is automated or even remote controlled, the responsibility from the operator in the cabin goes to an algorithm or to a remote-control station. Also, remote control and automation go hand in hand in a semi-automated process flow.

Thus, it is of extreme relevance that the information of personnel and vehicles working in the intermodal area is at easy disposal at the remote control station. What has been the eyes of the operator in the crane needs to be "automated" and covered by technology.

Several technologies might be generally used for this. However, a proven track record shows that RTLS (Real Time Location Services) are the most reliable source. This is because vehicles and personnel are tacked and tracked in real time. The Yardeye system can be considered the most innovative one, as it uses three different frequencies and two different algorithmic approaches to measure the position in real time. Previous approaches with GPS only failed because of a lack of redundancy and the dependency on a WiFi communication channel. Optical system failed because of a lack of ability to distinguish objects and to track them. Several approaches with thermal cameras also failed due to shadowing of containers, etc.

KPIs and Targets for the project

Commercial project targets from CSXIT to Künz and their suppliers were:

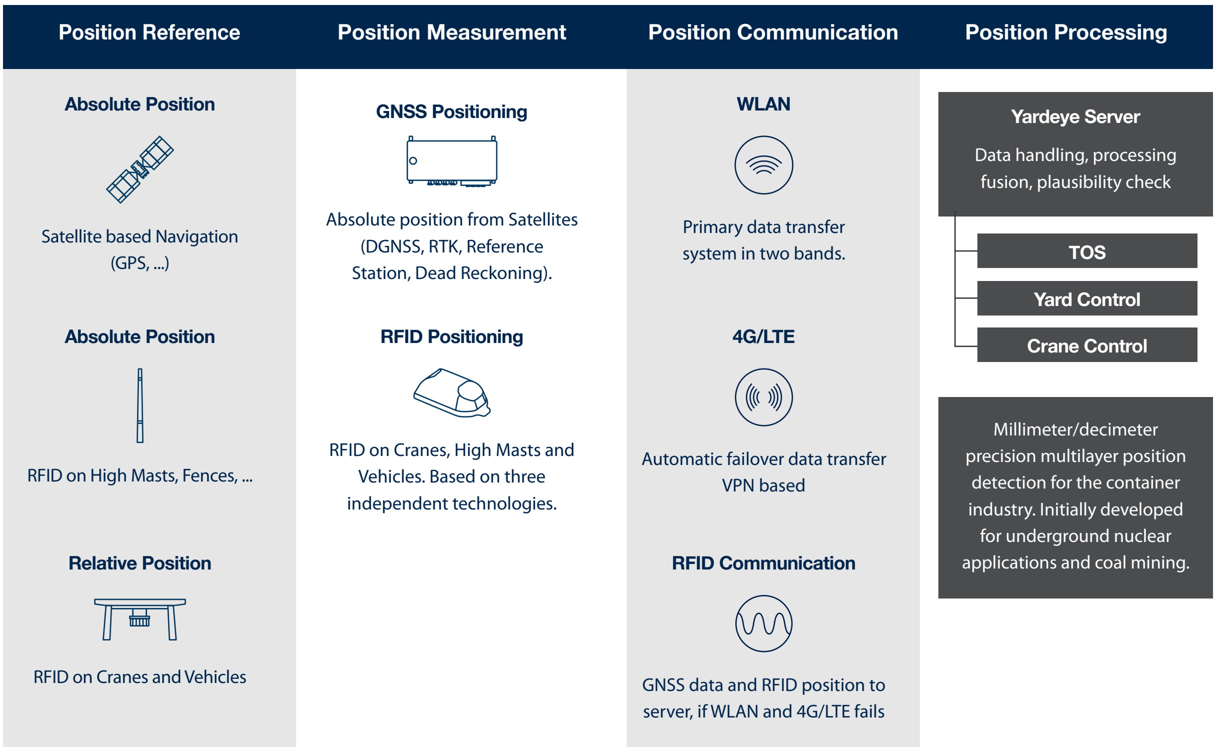
a) Comparable amount of lifts per shift – so no productivity reduction
b) Reduced process variability – so more stable lifts per hour distributed over the day, less dependency on operator concentration level / fatigue and environmental conditions (rain, night, …)
c) A 50% reduction of terminal personnel from the direct terminal operating environment into an office building
d) Improve terminal and truck driver productivity
e) Implement the automation system and the safety system while operating the terminal. The terminal was not shut down during the commissioning phase.

Safety targets from CSXIT to Künz and their suppliers were:

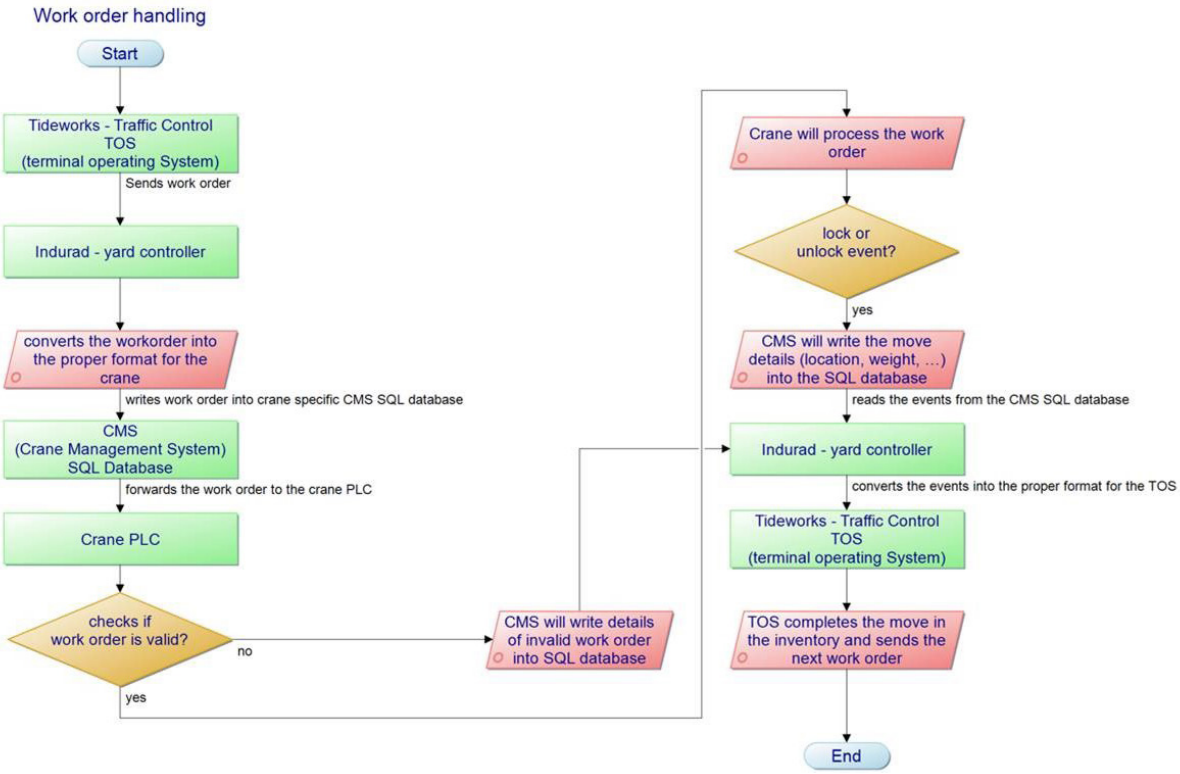
a) A quantifiable reduction in incidents of back stress by providing crane operators with a more ergonomic environment.
b) Reduce the risks associated with climbing a ladder to a crane cab in all weather conditions
c) Remove the need to evacuate personnel from crane cabs during rapidly developing severe weather (Florida summer thunderstorms)
d) Provide for enhanced truck driver safety
e) Safety for maintenance people working on the ground
f) Safety for anybody else on the ground

Yardeye technology description

The Yardeye technology consist of two major layers, a differential global navigational system with real time kinematic (D-GNSS-RTK) and a Real Time Location System (RTLS). The reason for choosing two technologies is primary redundancy with diverse technologies. Although the system is not safety certified yet, the system has been developed following certain design criteria and mechanisms on circuit base up to solution software. On all layers, the best available technology has been chosen.
Each of the two technology components has built in watchdogs and some sort of internal diversity. In the D-GNSS-RTK unit, three GNSS units are combined. Two high precision and one low precision. The two high precision units provide position and true heading, the low precision GNSS has a better noise to signal ration and thus is some sort of watchdog to validate D-GNSS-RTK position measurements for general plausibility. Besides this, an integrated dead reckoning functionality is included that also provides (to be frank not very precise information) for plausibility check.
The RTLS system itself is a triTag which uses three different frequencies for communication and position measurement. It deploys a sub-1 Gigaherz, an Ultra Wideband / Wideband and a 2.4 Ghz physical layer. On this layer, several ways are used to process position data, e.g. RSS (Received Signal Strength), TOF (Time of Flight) and TDOA (Time Differential of Arrival).
The cranes are equipped with a -D-GNSS-RTK Unit on each trolley. Thus the system know the trolley position. Besides this, the safety rated encoders from Künz provide redundant position information. Above each lane and to each side, the Crane is equipped with the RTLS-Tags.
On the ground, all moving equipment is equipped with the G-GNSS-RTK and a RTLS Unit.
The D-GNSS-RTK vehicles communicate via WLAN and as a fall back LTE, the crane Units communicate via Fibreoptics with a physical server. The RTLS technology uses their own proprietary communication interface. The following chart shows the different communication channels.



The Yardeye System however is only one part in an complex automation solution. The following process flow chart shows the data flow:



Solution Deployment

The project implementation was a challenge – as it is common for these projects between Research and Development. That was clear to the parties from the beginning. Additional challenge was the implementation while the terminal was still operated. As the human brain and even experienced project teams cannot foresee all challenges, especially in automation projects, the project execution took in total 24 months from planned 18 months.

An exceeding of the project time by factor 25% is not uncommon in these kinds of projects due to the fact that the last automation mile is usually full of challenges and time-consuming programming work to deal with the exceptions.

Results

The overall results of this project met or exceeded the requirements from CSXIT. Additionally, the safety and productivity gains of the automation project were not possible without the final integrated Künz/Yardeye solution. The results from a period of twelve months in full operation are:

1. The total number of personnel required to operate the terminal was reduced by 33% (39 to 26) while also adding an additional crane (a 4th crane was added in conjunction with the automation). Moving the crane operators inside to a remote operating station (ROS) allows pooling the crane operation of the semi-automated cranes such that 1 or 2 operators are required to operate all 4 cranes.

2. The number of personnel operating outside on the terminal grounds was reduced by 50%. By moving the crane operators inside instead of eight people outside, only four are needed outside in an average shift.

3. Terminal productivity improved 43% from 2.76 LPMH to 3.94 LPMH

4. All cranes operated from the terminal building. Operators have a comfortable and ergonomic operating station. They appreciate their new workspace and find it a massive improvement compared to the operator cab on the crane. This has led to an improved workforce satisfaction. Also the operators work together in one room, adjacent to the clerical support. Information flow is improved, and overall team-spirit has been established. This leads to better work results.

5. Truck drivers are serviced more quickly as there is no down time in operations from shift changes or lunch breaks. Estimate is an additional 2.5 hours of crane working time each day.

6. Truck drivers are outside of their cabs and visible to the remote operators. The available camera angles from the ROS are better than the view from the cab.

7. Remote operators are actively supervising or in direct control of cranes during critical portions of the container movement.

8. There have been no recorded instances of unsafe container movements since the solution was put in place.

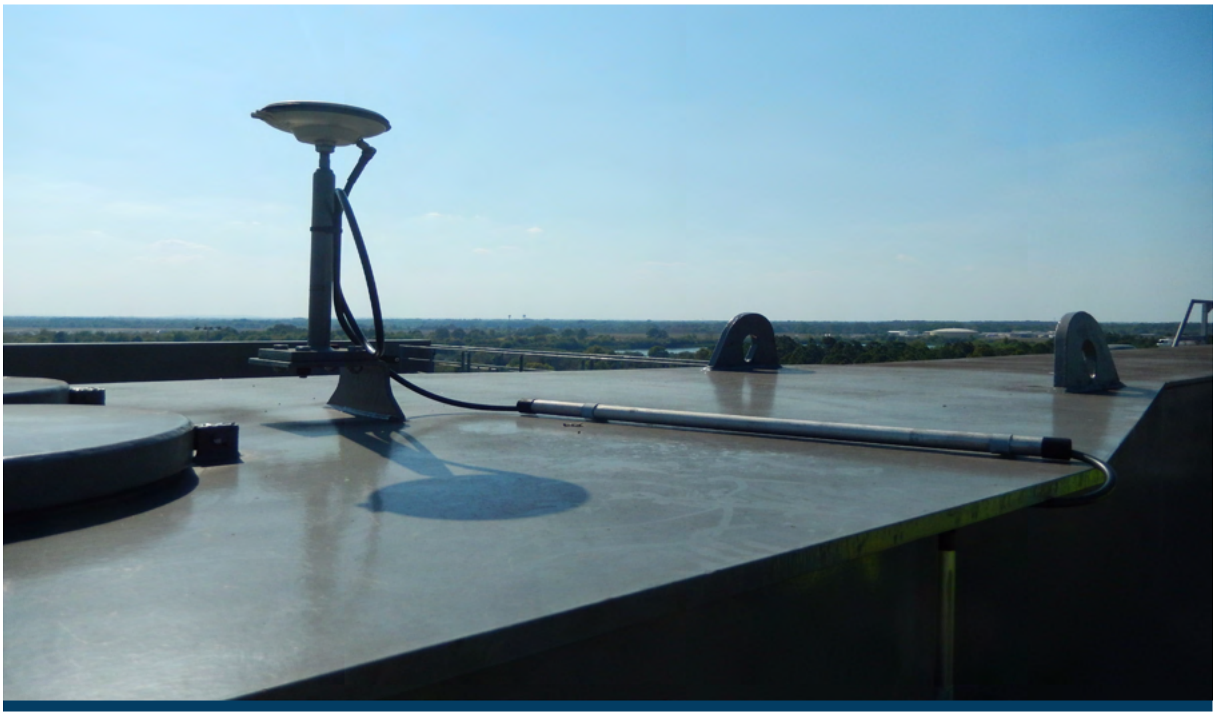
9. Overcoming the additional challenge while the terminal was operating.

10. Based on the success in Winter Haven, CSXIT implemented the same solution at a larger facility in Fairburn, GA and are considering future projects using the same solution.

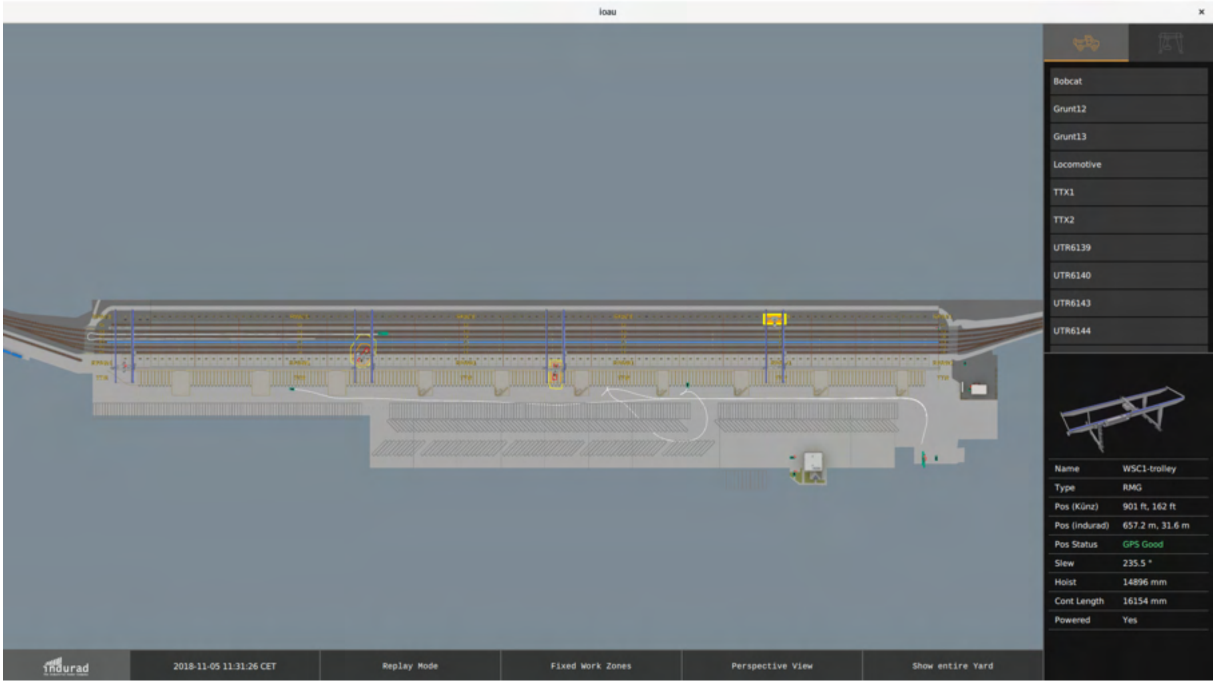
Bill Traub, Director of Lifting Equipment at CSXIT states:
“The Kuenz/Yardeye solution met or exceeded all project goals for safety and productivity”
This is true, but at the same time, only as a team we could archive these results.

ANNEX/Photos of the Solution

Top: One of four intermodal cranes in Winter Haven
Bottom Left: IBC Kart in operation at night - tracked by the Yardeye system

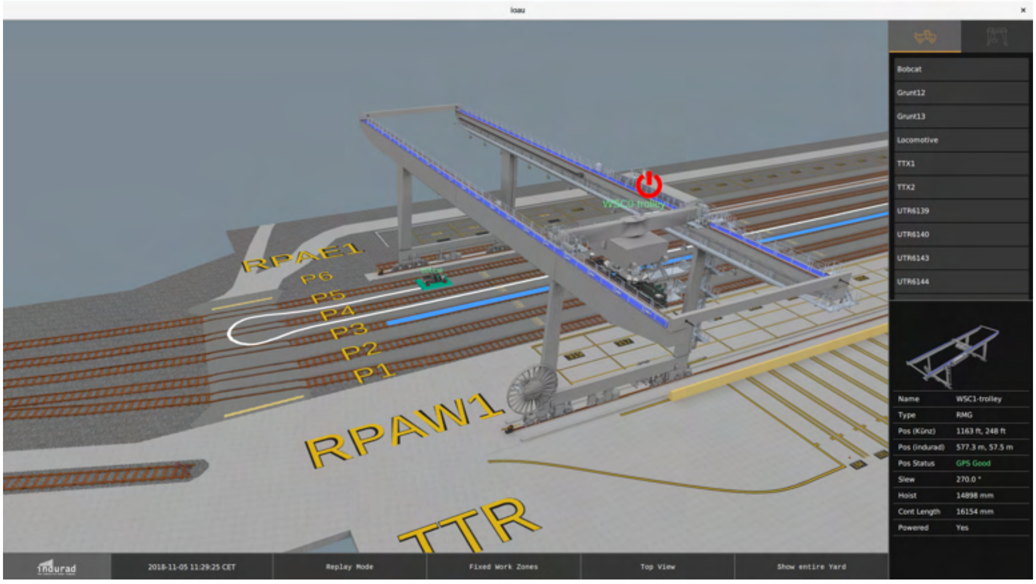


Top: Crane GNSS System.
Bottom: Crane RTLS System. All systems in a redundant manner



Left Page, Top: Orthographic map view of the entire yard
Left Page, Bottom: User Screen: CRMG with a container on a spreader

Right Page, Top: Crane turned off - Vehicle driving in the lane
Right Page, Middle: Yard orientation made easy - visualisation of infrastructure and parked vehicles
Right Page, Bottom: Geofenced area left (blue), Grunt parked (you can see it by the halo size)


Bobcat
Grunt12
Grunt13
Locomotive
TTX1
TTX2
UTR6139
UTR6140
UTR6143
UTR6144
RPAE1
P6
P5
P4
P3
P2
P1
RPAW1
TTR
Name WSC1-trolley
Type RMG
Pos (Künz) 1163 ft, 248 ft
Pos (indurad) 577.3 m, 57.5 m
Pos Status GPS Good
Slew 270.0 °
Hoist 14898 mm
Cont Length 16154 mm
Powered Yes
indurad
2018-11-05 11:29:25 CET
Replay Mode
Fixed Work Zones
Top View
Show entire Yard


Bobcat
Grunt12
Grunt13
Locomotive
TTX1
TTX2
UTR6139
UTR6140
UTR6143
UTR6144
Name UTR6139
Type UTR
Pos (Künz) 2517 ft, 601 ft
Pos (indurad) 164.8 m, 165.3 m
Pos Status Offline
WiFi WAP 1
LEDs
indurad
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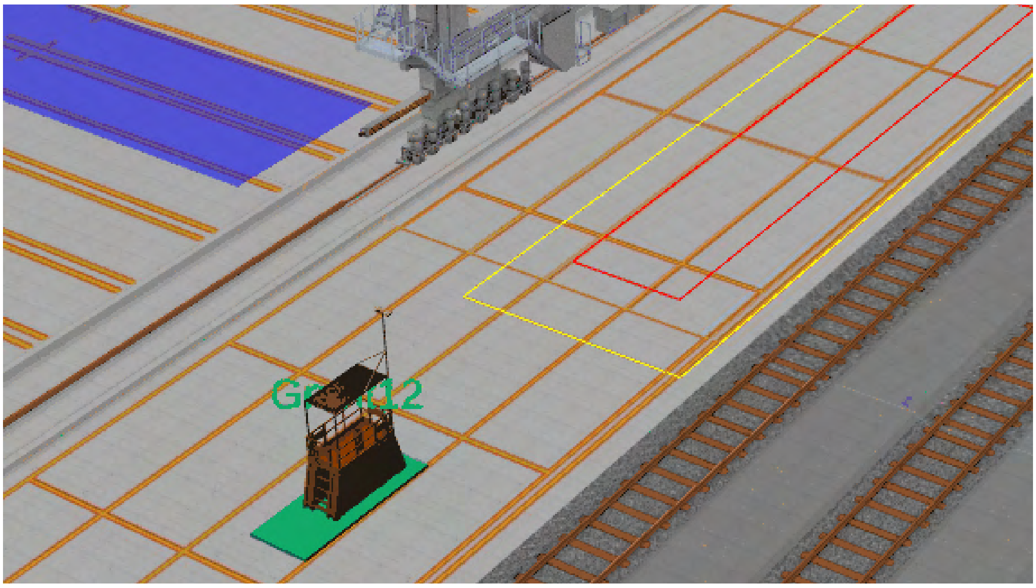
Replay Mode
Fixed Work Zones
Top View
Show entire Yard



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