



Knowledge-based services for and optimization of machines

## Deliverable D1.5c\_1

# Description of demonstrator implemented in farm logistics for food production

Deliverable type:	Document
Deliverable reference number:	ITEA 18030   D1.5c
Related Work Package:	WP1: Use Cases, Requirements & Evaluation
Due date:	M38 (30 November 2022)
Actual submission date:	7.12.2022
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Confidentiality	Public
Version	v 1.0

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### Revision History

Version	Date	Description
v 1.0	19/12/2022	Initial draft

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## 1. Abstract

This document describes the Dutch use case demonstration activities for the Machinaide project. The Dutch ecosystem contains two use-cases:

- Farm logistics for food production
- Additive manufacturing processes in a Smart Factory

This deliverable focuses on the farm logistics for food production demonstrator. Logistics is not only transporting goods from factories to the customers. It involves also important part in the food production and animal welfare. Factories of today could be extremely well specified and have been highly automated for a long time. However, farms form completely different environment that could pose many challenges for automation. One important research question is, how farms can benefit from the use of digital twins and digital twin documents?

In a traditional approach expert judgement is used to determine Juno installation. The traditional and desired approach for managing the Juno farm installation can be seen in Figure 1. Optimization of the Juno installation during operation relies heavily on expert judgement and (expensive and repetitive) on-site manual activities. A desired approach entails automatically optimize the Juno installation before operation using the Overall Equipment Effectiveness (OEE).

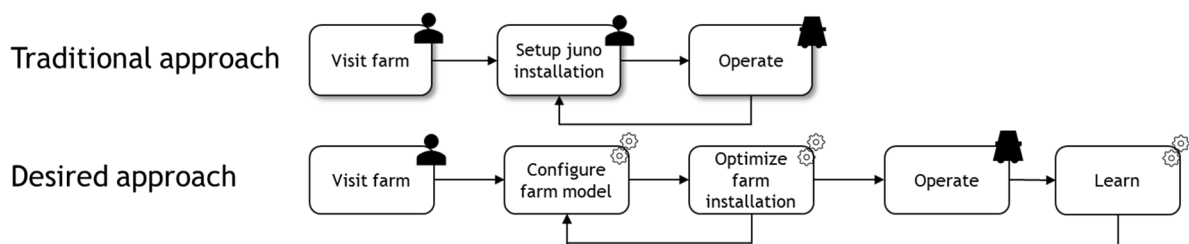


Figure 1: The current versus the desired approach for managing the Juno farm installation across the lifecycle.

The demonstrator shows an implementation of the desired approach where the farm installation is analyzed and optimized based on simulation models. The demonstrator is implemented using KE-chain, whilst the simulation models are implemented by Lely and TNO. The following chapters show first the methodology in Chapter 2 and next the resulting implementation is shown in Chapter 3, finally Chapter 4 presents the conclusions and future directives.

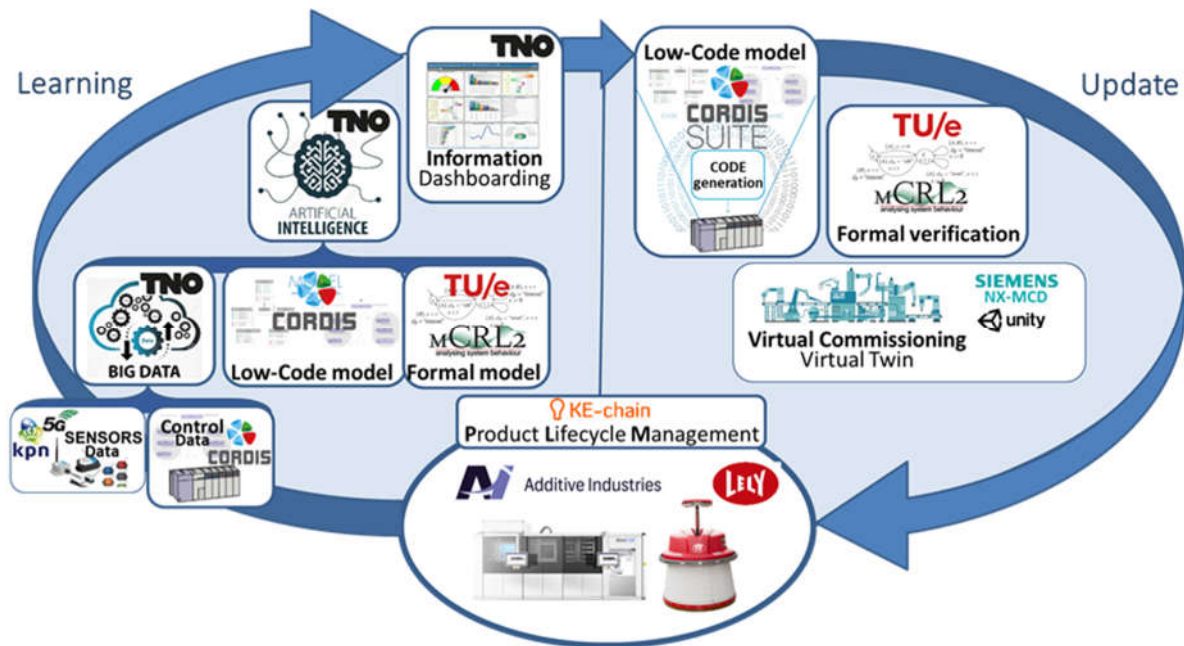


Figure 2: Overview of the Dutch ecosystem and primary components as part of the digital twin update cycle.

## 2. Methodology of the demonstrator

In this chapter the methodology underlying the demonstrator is presented.

### 2.1. Assessing OEE (Overall Equipment Effectiveness) of a Juno installation

To have a better insight of how a farm robot Lely Juno installed at a farm is performing, we've realized a pipeline to process the data from this "live installation" and output a OEE plot (Figure 3). As a result, processed data can be visualized in charts (Figure 4).

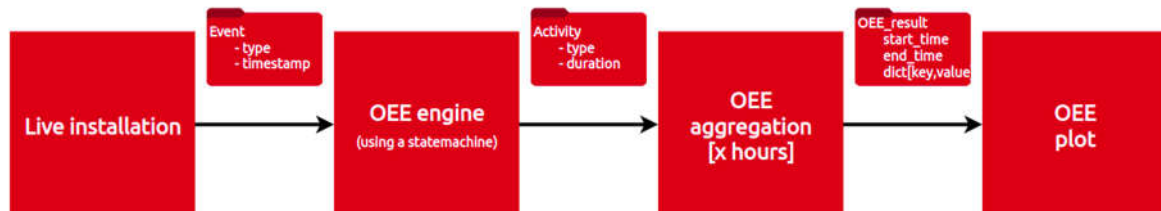


Figure 3: Flow chart of Overall Equipment Effectiveness estimation based on a data from live farm installation

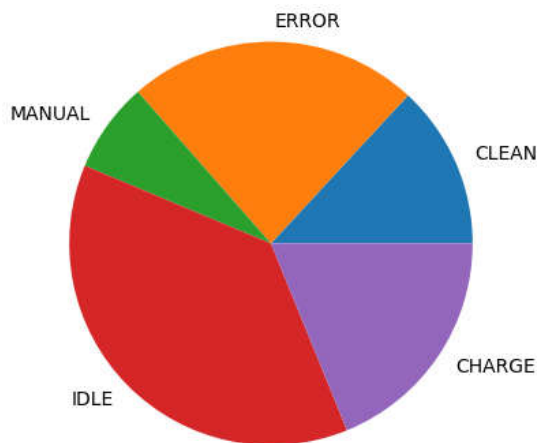


Figure 4: An example of time usage of live Juno installation at the test site.

### 2.2. Improving an installation with Juno simulation

Given the above pipeline where it is possible to assess a 'live' installation, we replaced the live installation with a simulated farm and Lely Juno running in the simulation. This can be done to find out best concept at the design phase of the project, before doing real installations. To configure the key-parameters of this simulated installation, the KE-chain platform is used in Figure 5.

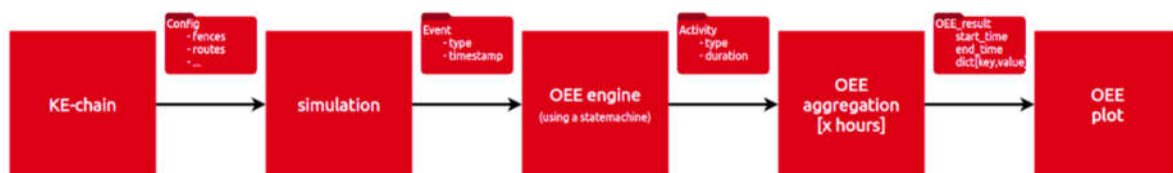


Figure 5: Flow chart of Overall Equipment Effectiveness estimation based on data from simulation.

### 2.3. Simulation of a Juno installation

The developed simulator can do a high-speed simulation of a certain period and will output events of Juno actions. This is similar to a Juno driving in a live farm. For now, this simulator is acting as in a perfect world, but imperfectness could be added to make it more realistic in future iterations. The simulation domain can be visualized in 2D (Figure 6).

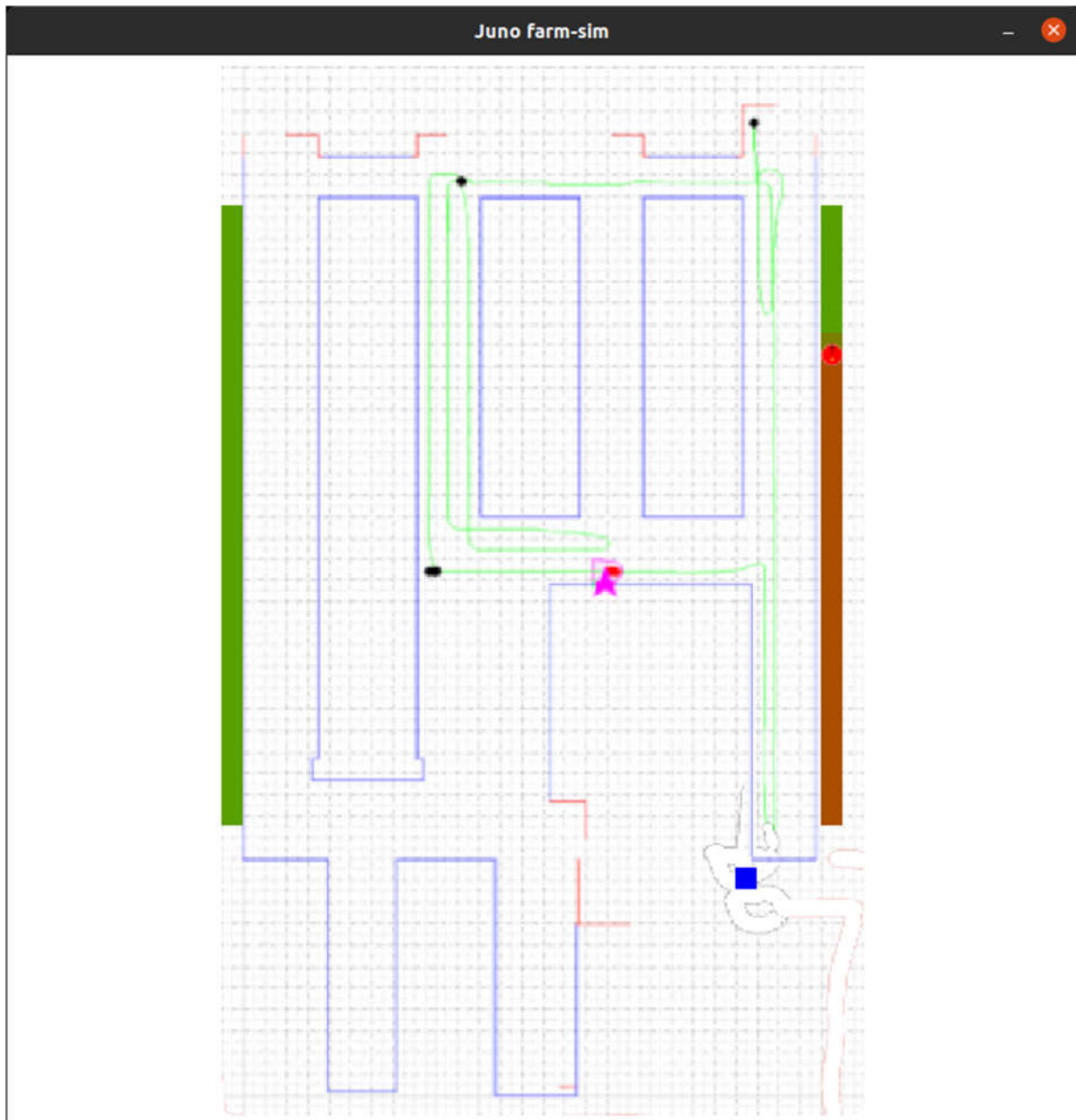


Figure 6: Example: Green is ready pushed feed at the fence, red is not pushed yet. Blue square is the charger. Blue lines are walls.

### 2.4. Configuration of the simulation

The improved simulation chain for a Juno installation will be integrated in KE-chain [1]. KE-chain is web-based collaborative environment enabling integration of both experts and tools in a single environment. KE-chain will provide the interface to specify the installation configuration. The

following information can be entered in tables (the class diagram shown in Figure 7 reflects the underlying data model):

- The Datapoint (x,y) locations describing the topology of the farm
- Location of the charge poles
- Location of driving lanes (from datapoint, to datapoint)
- Feeding fences (with settings on the frequency of refreshing)
- The frequency of pushing
- Number of Juno's and their starting locations
- Settings for each Juno such as speed and maximal pushing force

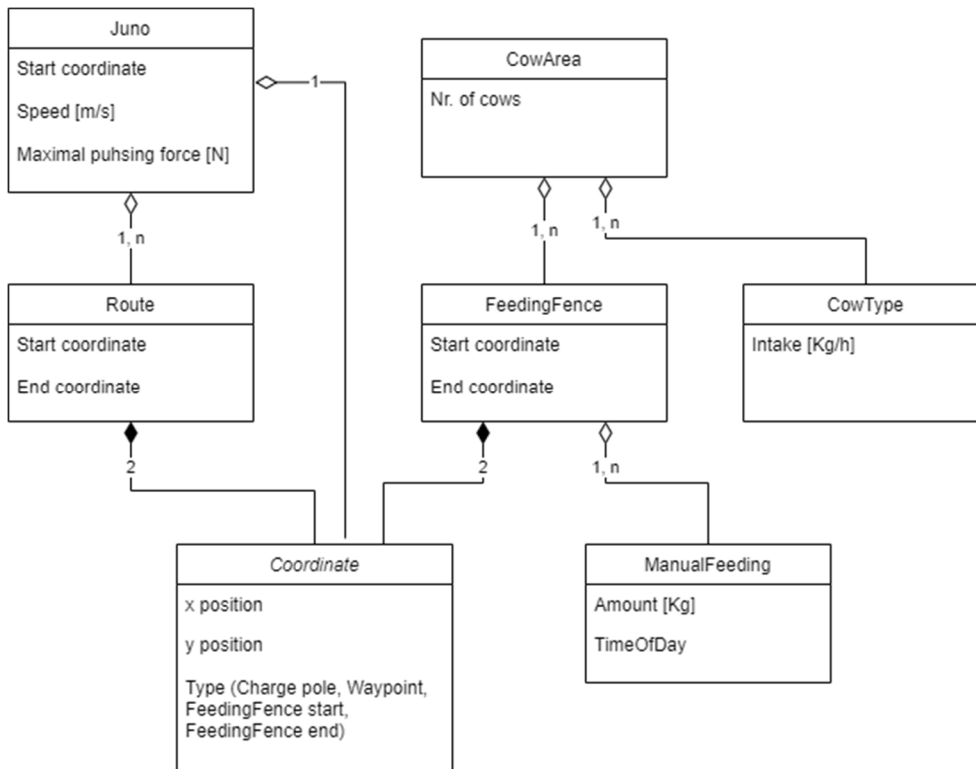


Figure 7: Class diagram of the Juno installation.

The figure below (Figure 8) describes how the Juno simulation described above is integrated as a service in KE-chain. KE-chain allows end-users to manage one or more farm installations. For each farm installation, the installation can be specified through a KE-chain form. This data is retrieved and stored in the KE-chain database using a REST API. Each form makes use of an engineering service to evaluate the performance of the installation. This engineering service is executed on the KE-chain server where an execution infrastructure will be instantiated using docker, when the service is executed. The services first retrieves inputs from KE-chain, through the Pykechain [2] interface. Next, these inputs are fed into the Juno simulation. Finally, the results are fed back to KE-chain through Pykechain. Through KE-chain, the end-users can inspect the simulation results.



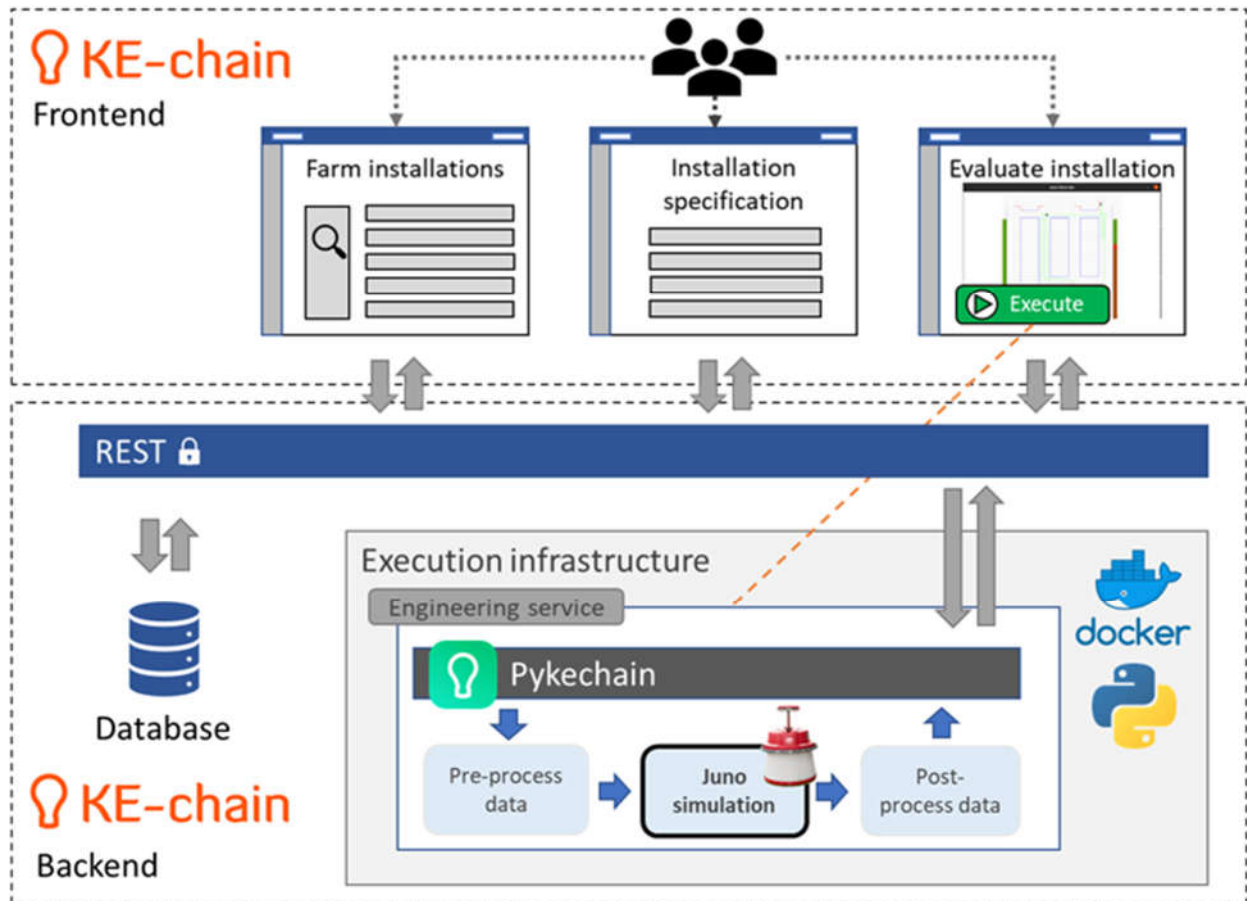


Figure 8: Integration overview of the Juno simulation with KE-chain.

### 3. Results

The desired approach is implemented in a KE-chain form. Using KE-chain multiple farms can be managed in various life-cycle stages in parallel. a map on a phone or tablet. KE-chain uses interactive web maps provided by ArcGIS online. The farm configuration is stored on the KE-chain server. Using this data, an on-platform services parses the farm layout and automatically creates the following data elements:

- Nodes: the coordinates in x, y position over which the Juno robot may travel
- Route segments: the connection between the nodes, which indicate clear pathway the Juno is allowed to use.
- Feeding fences: this indicates the interaction between a route segment and a cow area.
- Charging poles: these indicate potential starting positions of the Juno where they automatically can return for charging the battery.

Together these data elements form a graph. As indicated in Figure 9 this graph is used for a next step: simulation and OEE calculation. A high-speed simulation developed by TNO and Lely simulates the farm simulation over time using this graph data. Dijkstra algorithms are used to continuously determine the shortest path for a Juno to perform its primary task: push feed in front of feeding fences. Whilst performing the task, the battery drains, after which the battery needs to be recharged. After a full day simulation is performed in a matter of seconds, a report is generated showing the OEE.

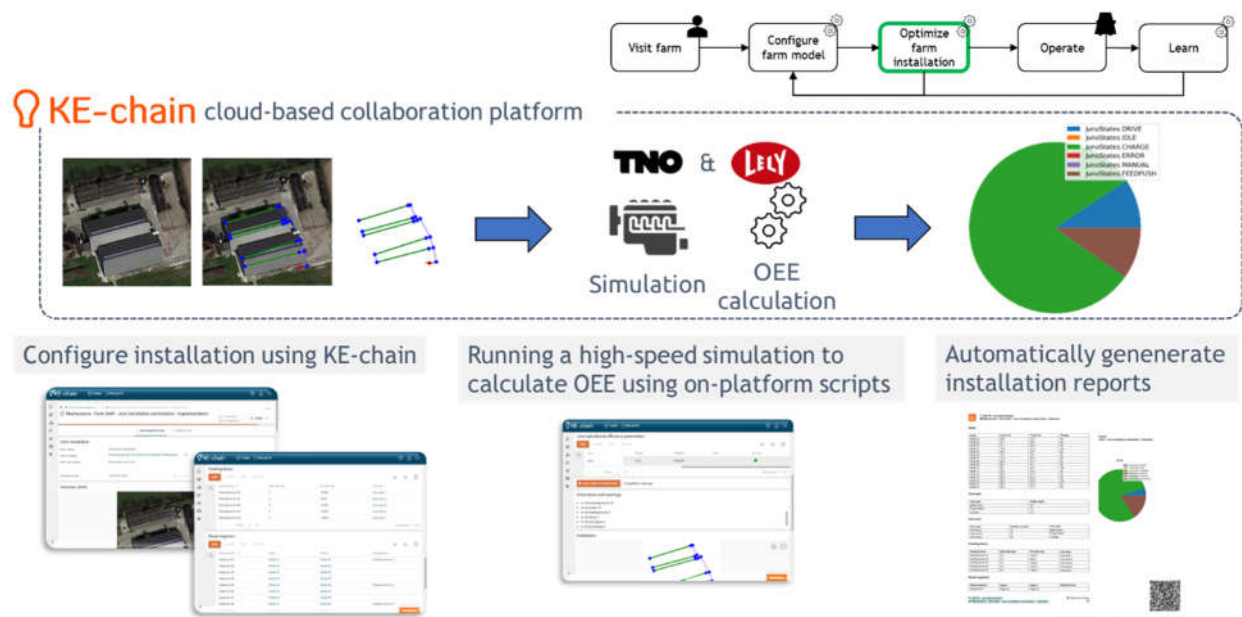


Figure 9: Overview of the components in the Lely demonstrator using KE-chain forms.

After the reports are generated the Lely expert can change various inputs of the farm, such as potential starting positions or the number of Junos for a given configuration. The impact of changing the parking position is illustrated in Figure 10. Changing the parking position from the edge of the farm to the center has the potential to increase the push efficiency of 14% versus 10%.



Figure 10: Example of different parking positions and how it influences the OEE parameters.

During the actual operation of the physical Juno robots, data related to OEE is continuously gathered. This data can be used to further improve the model of the high-speed simulation. This leads to higher quality simulation results for future analyses.

#### 4. Conclusions and future directives

In this demonstrator an implementation can be seen of a high-speed simulations of Juno robots on digitalized farm installations integrated with web-based collaborative environment KE-chain. A proof-of-concept implementation allows farm experts to draw farm installations on a map and perform on-platform simulations to give advice on optimal farm layouts. Reports are made directly on platform.

In future implementations the underlying models will be extended with more realistic models including the interaction of cows and the milk production. It is assumed that the amount of feed has a positive effect on the milk production, making the farm installation effectiveness directly translatable to productivity.

## 5. Bibliography

- [1] KE-works B.V., “KE-chain,” [Online]. Available: <https://ke-chain.com/en/>. [Accessed 19 12 2022].
- [2] KE-works B.V., “Pykechain: KE-chain Python SKD,” [Online]. Available: <https://pykechain.readthedocs.io/en/main/>. [Accessed 19 12 2022].