iSAM GROUP

A company of HHLA

Autonomous Operation of Pneumatic Unloaders

3D Ship Model and Autonomous Operation

- Seamless integration into machine PLC while maintaining all existing safety features and control modes
- Virtualization of the control system is possible, i.e. no need for a control PC on the machine
- 3D LiDAR-based collision prevention, hatch detection and product mapping for safe and efficient machine control
- Supervision of multiple machines by one operator in central control room

The Task

Pneumatic unloaders have been proven to be a reliable solution for unloading low density materials from grain via fertilizes to alumina. Especially in the non-food sector, the terminals are frequently located in harsh environments which creates additional challenges and limits the availability of skilled operators.

With the exception of fewer than 20 grab ship unloaders - which were exclusively automated by iSAM - all ship unloaders worldwide, whether pneumatic, grab or continuous bucket chain, still need to be manned by an operator and only basic teach-in procedures are available to support manual operation.
To allow truly autonomous operation, an automation system must not only be capable of controlling the pneumatic suction process, but also have a real-time 3D view of the vessel, the material distribution inside the hatch and all ship movements caused by tides, waves from other vessels and the unloading process itself (trim tanks, weight distribution etc.).

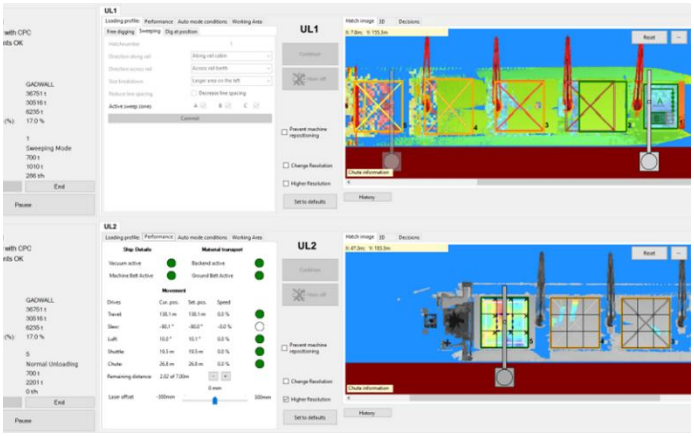
The Solution

iSAM utilized its existing and well-proven autonomous control system for GSUs and combined it with its 3D model used for ship loaders. From a geometric standpoint, a ship loader and a pneumatic unloader are very similar, which is why this approach significantly reduced development costs and time to market.

All these systems require a combination of the latest 3D LiDAR technology originating in self-driving cars, highly accurate RTK GPS systems for machine positioning and internally developed leading-edge control technology including sophisticated filtering algorithms allowing the use of LiDAR in reduced visibility conditions.

3D Ship Model

One of the key components of the systems is the 3D Ship Model, which is based on a high resolution (128 lines) real-time laser scanner and mounted on a tightly synchronized turntable. This enables a complete hemispherical view even when right above the vessel in high air draft situations.

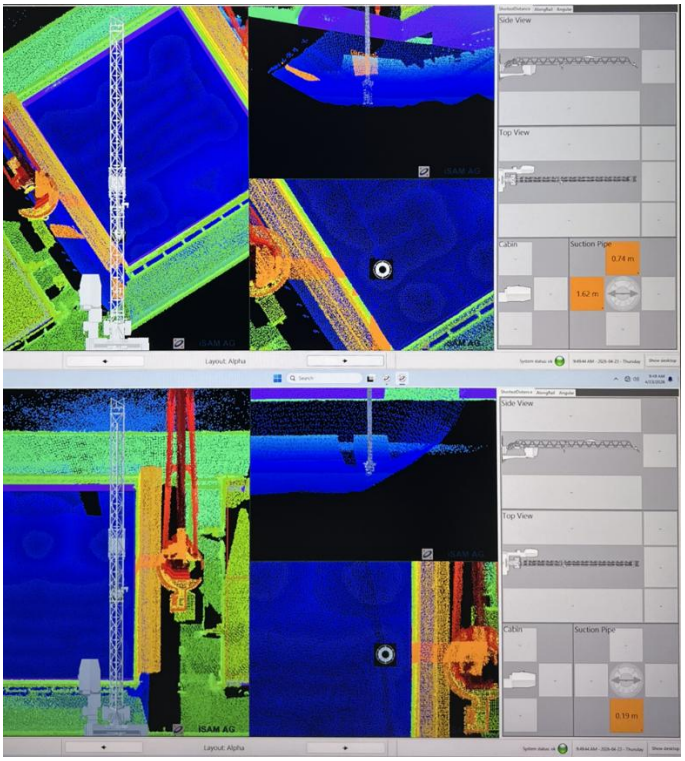


Autonomous Control HMI – supervision of multiple machines from a central control room

By combining data from multiple scanners, the Ship Model not only ensures a safe operation close to hatch covers and deck cranes, but also measures the material distribution inside the hatch, thus enabling an efficient unloading process all the way down to the bottom of the hatch.

Machine Control

Whereas the 3D scanner is the “eyes” of the automation system, iSAM’s leading-edge control technology connected with the PLC is the “brain”. The optimal unloading strategy is automatically determined on the basis of the known material properties and the current sensor data of the machine environment, thereby minimizing machine movements and optimizing continuous unloading performance.



3D Ship Model HMI for situational awareness in central control room, especially when the machine is controlled remotely for unloading tasks involving front loaders

Easy-to-Use Operator Interface

To define a job order, the operator in the central control station just needs to enter the amount of material as well as the desired strategy for unloading. After release of the operation, the unloader moves to the calculated starting position autonomously and handles the order. Different strategies are available incl. specialized operations such as “directed digging” for unloading more product from underneath the coaming, or “floor sweeping” for unloading down to the bottom of the hatch, effectively minimizing the amount of product left before front-end loaders are required for the final tons.

Highlights

- Real autonomous operation, not a remote control
- Autonomous control all the way down the bottom of the hatch including “directed digging” and “floor-sweeping”, effectively minimizing the time required for front-end loaders in the hatch.
- Very uniform and steady unloading performance, which minimizes the idle times of the equipment.
- Driverless operation even very close to the hatch coaming, under virtually any weather conditions.
- Operation of all equipment from a central control station, i.e. minimum stress for the supervisory operator thanks to a maximum degree of automation (easily up to 6 cranes by one operator).
- Possibility of manual intervention from the central control station by remote control.
- Lower wear and tear because mechanical performance limits are always respected in automated mode.

Autonomous “floor sweeping” to minimize the product left prior to start front-end loader operation

About iSAM

iSAM AG, Gesellschaft fuer angewandte Kybernetik, located in Muelheim an der Ruhr, Germany, develops and implements automation solutions that enable industry, commerce and service suppliers to increase their performance.

iSAM’s team includes specialists from the engineering, computer science and physics sectors as well as business economics, focusing on increasing customer value. The company’s customers can be found all over the world and in almost every industry, such as mining, coal handling, transport and logistics, steel and metal manufacturing and processing, tube welding and pipeline construction, mechanical engineering and plant building, electronics and aerospace.

The company is a subsidiary of HHLA AG, the main operator of the Port of Hamburg.

Facts

Customers:	■ Port-Alfred, La-Baie, Canada	Software:	■ iSAM 3D Ship Model (for collision prevention) ■ iSAM Autonomous Operation System
Industries:	■ Bulk material import terminals ■ Mining and bulk product processing facilities	Data output:	■ Fieldbus/Ethernet to machine PLC ■ Variable interface to 3rd party planning system
Hardware:	■ 3D LiDAR scanner on turntable ■ RTK GPS system for machine positioning	Visualization:	■ iSAM 3D Ship Model HMI ■ iSAM Autonomous Unloader HMI