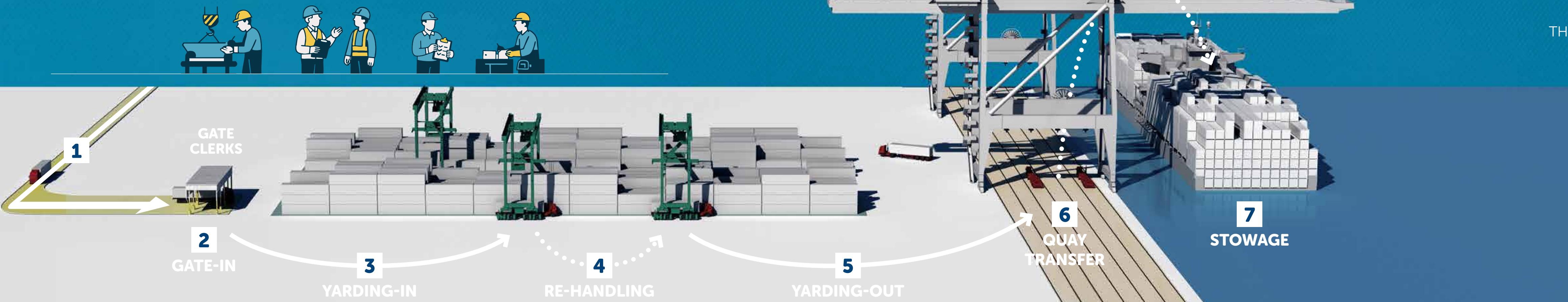# From road to vessel

ELIMINATING HUMAN ERROR THROUGH DIGITIZATION

IN CONTAINER TERMINAL OPERATIONS, PRECISION IS EVERYTHING. VESSEL TURNAROUND TIMES ARE SHRINKING, CUSTOMER EXPECTATIONS ARE RISING, AND EVEN SMALL MISTAKES CAN HAVE FAR-REACHING CONSEQUENCES. AMONG THE MOST PERSISTENT CHALLENGES FOR TERMINAL OPERATORS ARE THOSE CAUSED BY HUMAN INTERACTION— ERRORS THAT QUIETLY DISRUPT CARGO FLOW, CONSUME RESOURCES, REDUCE EFFICIENCY, AND CREATE HIDDEN COSTS.

ELIMINATING THE HUMAN FACTOR

MAKING CONTAINER FLOWS FAIL-SAFE

CAMCO TECHNOLOGIES

Many terminals have already made the shift from manual to digital—step by step, and with immediate **gains in traceability, cost control, and performance.** It's time to rethink how human dependency impacts your operations—and **move toward becoming fully traceable, digitally visible, and future-ready**—from road to vessel.

IN CONTAINER HANDLING, EVEN THE SMALLEST ERROR RATE BECOMES SIGNIFICANT.

1

2
GATE-IN

GATE CLERKS

3
YARDING-IN

4
RE-HANDLING

5
YARDING-OUT

6
QUAY TRANSFER

7
STOWAGE

MOVE BY TRUCK ●●●● MOVE BY CRANE

0.05%

A typical container journey from road to vessel involves 11 visual checks (ID and location). With a conservative 0.05% error rate per check, more than 5 out of every 1,000 moves will face a problem caused by human error alone.

1

One wrongly entered container ID or a misplaced stack doesn't just affect a single move. It can cause vessel delays, unnecessary equipment moves, congested yard space, and—most visibly—dissatisfied customers waiting for their cargo.

100%

Digitization gives the TOS "eyes." Every container move is automatically logged with pictures, GNSS-based location data, and precise timestamps.

The result is a 100% accurate reflection of the physical terminal—enabling smarter planning, real-time decisions, and immediate detection of anomalies.

CAMCO
TECHNOLOGIES

3

Manual processes for execution and communication

Despite significant investments in Terminal Operating Systems (TOS), many container terminals still rely heavily on manual processes for execution and communication. Even in the most efficient setups, it typically takes multiple process steps and at least five individual moves to transfer a container from a truck at the gate to a vessel at berth.

Each of these steps is orchestrated by the TOS, which dispatches tasks to frontline workers—gate clerks, tallymen, and crane operators. Instructions are usually sent via handheld terminals or two-way radios, with feedback returned in the same way. And that is exactly where the vulnerability lies.

As terminals strive for greater efficiency, the limitations of human-dependent operations become increasingly apparent. Addressing this blind spot is critical—not only for improving productivity, but also for reducing costly errors and enhancing traceability in terminal logistics.

CAMCO
TECHNOLOGIES

When humans disrupt the flow

The 7 stages and 6 moves	Container or truck ID check	drop/pickup location check
Arrival	–	–
Gate-in	1	1
Yarding-in	1	1
Re-handling/ reshuffling	–	2
Yarding-out	1	1
STS handover	1	1
STS vessel stowage	–	1
Total visual checks	**4**	**7**

The hidden risk of human-dependent TOS operations

The successful execution and accurate feedback of every single move in this setup rely entirely on human workers. These individuals often perform long, repetitive shifts, frequently in harsh weather conditions. Even the most experienced personnel are susceptible to fatigue, distraction, or simple human error.

The result? The TOS becomes effectively blind. It has no autonomous means of verifying whether its work orders have been executed correctly. Over time, this can lead to significant operational issues—such as containers being unaccounted for, misplaced in the yard, or even lost entirely, with no reliable data trail to recover them. As terminals strive for greater efficiency, the limitations of human-dependent operations become increasingly apparent. Addressing this blind spot is critical—not only to improve productivity, but also to reduce costly errors and enhance traceability.

The **true cost** of human error

Mistakes in container handling don't just delay a single container—they trigger a chain reaction. A wrongly entered container ID, a misplaced stack, or a miscommunication between departments can lead to vessel delays, unnecessary equipment moves, congested yard space, and dissatisfied customers waiting for missing containers. These errors are particularly frustrating because they are entirely preventable—but only by fully digitizing every step of the process, from road to vessel.

Manual checks: small errors, big impact

The two most critical sources of error in terminal operations are container identification and location accuracy. Small mistakes in these areas can escalate quickly. Errors typically occur during manual reading of container or truck numbers and visual verification of pickup and drop-off locations.

Consider a typical container journey from road to vessel. This process involves seven stages. Across these stages, the container or truck ID must be checked four times, and the pickup or drop-off location verified seven times. That's 11 manual visual checks—and this is a conservative estimate assuming only one re-handling event.

When numbers reveal **the risk**

In reality, re-handling is often more frequent, which increases both the number of checks and the risk of error. Even with highly attentive staff, every check carries a small chance of error. Assuming an extremely low 0.05% error rate per check (99.95% accuracy), the cumulative failure probability across 11 checks becomes significant.
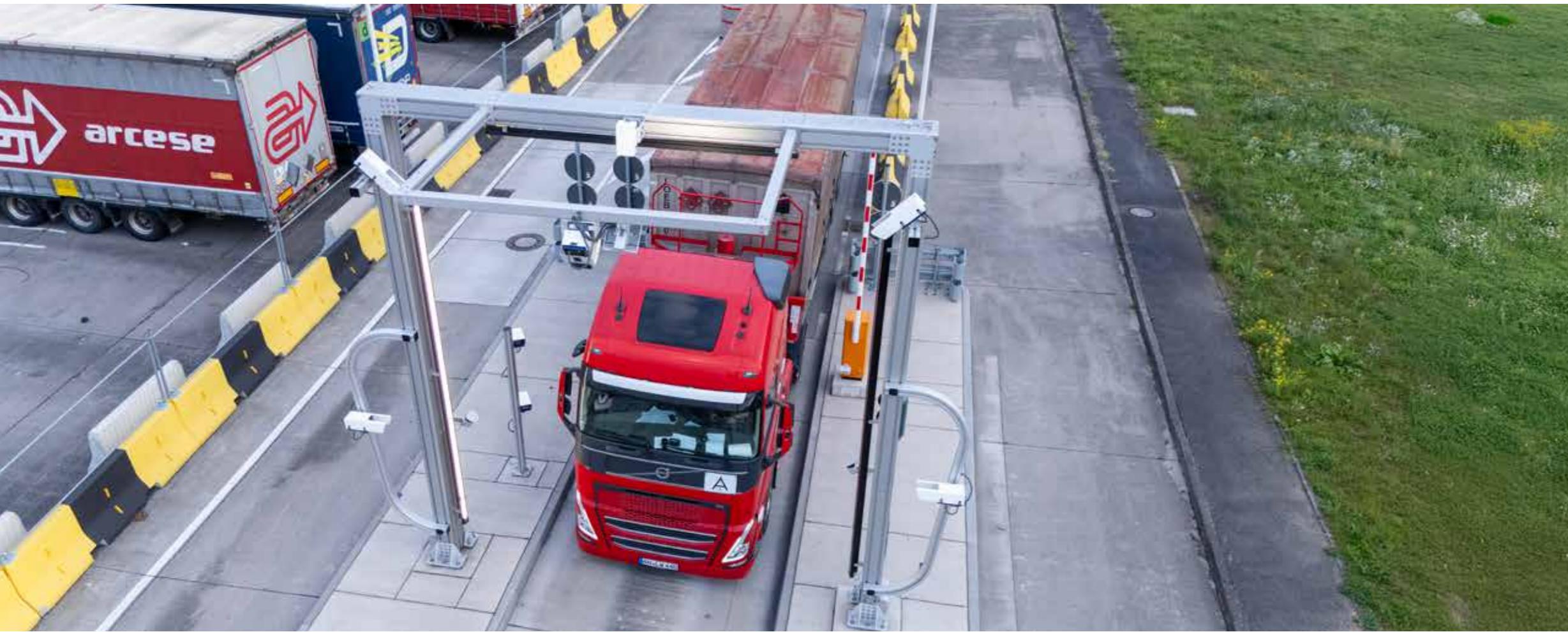
The probability that all 11 checks are correct is roughly $0.9995^{11} \approx 0.9946$. That means the probability of at least one error is $1 − 0.9946 \approx 0.0054$, or 0.54%. In other words: more than five out of every 1,000 container moves from road to vessel may encounter a problem purely due to human error during visual verification.

Even with well-trained personnel and low individual error rates, the sheer volume of manual checks across complex container flows introduces unavoidable operational risk.

As terminals seek to increase throughput and reduce errors, automation and AI-driven verification are no longer optional—they are essential. Industry reports and anecdotal data confirm these theoretical calculations.

From manual mistakes to digital precision

Type of terminal	Estimated error rates
Manual & old terminals	Up to 1 to 2%
Modern semi automated terminals	Between 0,1 to 2%

More than **5 out of every 1,000 container moves** from road to vessel may result in a problem purely due to human error during visual verification.

CAMCO TECHNOLOGIES

By removing the human factor from critical control points, terminals can deliver **digitally verified jobs directly to the TOS** – eliminating uncertainty and improving data accuracy.

KEY OPERATIONAL BENEFITS OF DIGITIZATION

Automated checking reduces truck, train and vessel turnaround time. Faster and more accurate checking means better use of the infrastructure, leading to shorter visits increasing throughput and capacity.	Providing man less access control at perimeters and validation of asset ID to eliminate the human element so common in theft, pilferage and other criminal activities.	By digitalization and automation of the operation process, one can save on operational costs. Some experts project operational cost savings up to 55% with automation.	Providing real-time visibility of an asset and its location to enable process automation and control.	Ensuring the safety of personnel and equipment, typically within a facility environment.	Offset Carbon emissions > 10% or more
ENHANCING PRODUCTIVITY AND MAXIMIZING EFFICIENCY	**REMOVING HUMAN MISTAKES AND FRAUDS**	**REDUCE COSTS**	**INCREASE OPERATIONAL CONTROL**	**INCREASING SAFETY**	**ENHANCE SUSTAINABILITY**

CAMCO
TECHNOLOGIES

Digitizing the identification and location verification processes across gates, yards, rail areas, and cranes represents **a major step forward in container terminal operations.**

With a complete digital mirror of the terminal
—covering the yard, vessel stowage, and rail cars—
the TOS becomes a 100% accurate reflection
of the physical environment.

CAMCO
TECHNOLOGIES

Digitizing identification and location verification across gates, yards, rail areas, and cranes represents a major leap in terminal operations. By removing the human factor from critical control points, terminals can deliver digitally verified jobs directly to the TOS—eliminating uncertainty and improving data accuracy.

Each container move can be **automatically logged** with pictures, GNSS-based location data, and precise timestamps, all stored in a central database. This provides full traceability, supports audits, and enables powerful operational optimizations based on real-world movement data. With a complete digital mirror of the terminal—covering the yard, vessel stowage, and rail cars—the TOS becomes a 100% accurate reflection of the physical environment. In other words: the TOS is no longer blind.
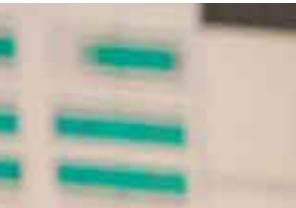
By streamlining and accelerating gate, yard, and crane processes, digitalization reduces human dependency while **boosting efficiency, consistency, and overall terminal performance.**

This new level of precision enables **smarter planning, real-time decision-making, and immediate detection of anomalies.** The benefits go beyond data accuracy. Digitization reduces the need for human clerks at gates and crane operations, lowering operational costs and improving workplace safety by minimizing exposure to high-risk areas.

In addition to automating container and vehicle ID checks, digital systems can take over other routine tasks traditionally handled by clerks, including **seal verificat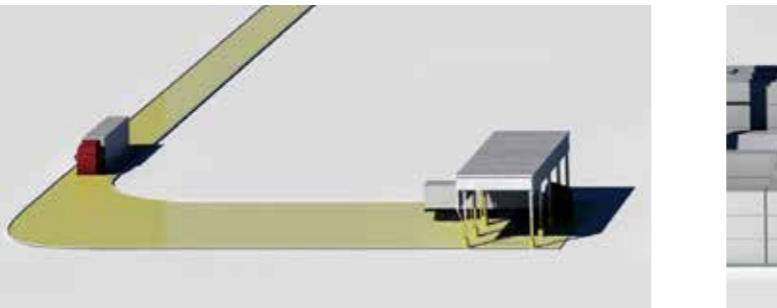ion, IMDG compliance checks, and automatic damage inspection.** By streamlining and accelerating gate, yard, and crane processes, digitization reduces human dependency while boosting efficiency, consistency, and overall terminal performance.

CAMCO
TECHNOLOGIES

CONTAINER
& TRUCK
IDENTIFCATION

LOCATION
TECHNOLOGIES

GATE AUTOMATION

Our VBS system as well as our **Truck OCR portals** capture container numbers, trailer numbers, license plates, and RFID tags at arrival. Integrated with kiosks and our proprietary **Gate Operating System** (GOS), they connect seamlessly with any TOS to deliver a fully automated gate.

Pictures are used for 20' location(s) on the truck chassis.

YARD AUTOMATION

Our yard automation solutions provide reliable truck and container identification at **RTG and RMG. Using RFID, RTLS**, and **PoleEye** technology, both internal and external trucks are identified instantly.

RTLS location technology on RTG/RMG with PLC interfacing.

CRANE AUTOMATION

BoxCatcher crane OCR ensures accurate container identification during vessel loading and unloading, providing immediate and reliable data at the quay.

Roof cameras, RTLS & UWB location technologies for lane matching and VLB for vessel loading.

THEBRIDGE

Camco's recently developed integrated platform, The Bridge, **enhances integration across all operational levels by providing a unified web-based system that connects GOS, truck OCR, rail OCR, RTLS, and Crane OCR**, enabling the management of multiple terminals and Camco installations from a single screen. The Bridge is not just a multi-terminal system; it's a comprehensive platform. It serves as an operator exception handling tool, an analytics dashboard, a single access point for container pictures and data, and, in the near future, an interface to other third-party solutions. In short, The Bridge is an all-in-one user interface empowering operators to monitor, adjust, and validate operations.

Staying close
to our customers,
on all four corners
of the world

Camco Headquarters
Researchpark Haasrode
Technologielaan 13
B-3001 Heverlee
Belgium
Phone: +32 16 38 92 72
Fax: +32 16 38 92 74

Camco Asia
Room 802, Building #18
PortMix
No. 2177 Shenkun Rd
Minhang District
Shanghai
China
Phone: +86 21 69796800

Camco US
One World Trade Center
8th Floor
Long Beach
Ca. 90831
United States
Phone: +1-833-40CAMCO
Phone: +1-532-506-0051

Camco Australia
32 Turbot Street
Level 27
Brisbane QLD 4000
Australia
Phone: +61 1300 599 640

Camco Middle East FZE
JAFZA ONE Tower
Building A
Office N° FZJOAB 1003
Jebel Ali Free Zone
Dubai
United Arab Emirates
Phone: +97 1 4 888 6009

Camco Saudi Arabia
Support office

Camco Spain
Enric Valor Av., 3,
(Algon Building)
Office 306B
Burjassot, E46100
Spain
Phone: +34 638 043 181

Camco India
Ahmedabad

Camco Israel
Support office

camcotechnologies.com