VIEW POINT

ENHANCING TERMINAL AUTOMATION SYSTEMS WITH AI: THE NEXT FRONTIER FOR OIL & GAS TERMINALS

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Executive Summary

Oil and gas terminals today are complex, highly automated facilities where Terminal Automation Systems (TAS) oversee the safe and compliant execution of product receipt, storage, blending, dispatch, and safety processes. These systems provide the backbone of operational control and integrity, ensuring transactions are accurate, workflows are enforced, and compliance obligations are met.

Despite these advances, operators face mounting pressures. Throughput volumes continue to rise, regulatory expectations are increasing, and margins remain under sustained pressure. TAS has been highly effective in delivering automation and control, but it was not designed to provide predictive insight, optimisation across multiple variables, or continuous learning. Artificial Intelligence (AI) offers a new layer of intelligence that can complement and extend TAS, providing predictive capabilities, dynamic optimisation, and real-time decision support. Together, TAS and AI create an operating model that is both safe and intelligent, delivering efficiency gains, cost reduction, and resilience.

The Context: Terminal Operations Under Pressure

Operators of oil and gas terminals are dealing with a combination of operational and financial challenges. Scheduling inefficiencies frequently result in demurrage costs and throughput delays across vessel, truck, and rail movements. Inventory management remains a persistent issue, with reconciliation discrepancies, shrinkage, and theft undermining accuracy and creating compliance risk. Blending and additive operations, while automated, often rely on rigid, rule-based recipes that fail to optimise for cost or changing product quality. Loading racks face congestion and long turnaround times that reduce utilisation and increase cost, while safety and environmental compliance requirements demand real-time vigilance. Compounding these challenges is the fragmentation of systems and data across TAS, SCADA, ERP, and IoT platforms, which creates reporting inefficiencies and hinders holistic decision-making.

These challenges illustrate that while TAS provides strong foundations for automation, the complexity of modern terminal operations requires a more intelligent, predictive, and adaptive approach.

TAS Today: The Backbone of Terminal Operations

Terminal Automation Systems have become indispensable in modern oil and gas operations. They enable automation of product receipt and custody transfer, provide accurate tank gauging and reconciliation, and ensure blending and additive injections are carried out within specification. TAS systems also govern truck and rail loading, driver validation, and sequencing of loading arms, while embedding safety interlocks and emergency shutdown procedures to protect people and assets.

In this role, TAS provides the core backbone for safe and compliant execution. It ensures that operational activities are performed consistently and within defined workflows, offering confidence to both operators and regulators that processes are being followed to the required standard.

The Gaps: Where TAS Needs Help

Despite its central role, TAS is inherently limited by its design. It excels at automating what is already known but struggles to anticipate or adapt to what is new. TAS data is often siloed and rule-based, lacking the capacity for pattern recognition across systems or the ability to predict future events. It cannot dynamically optimise blending recipes, forecast equipment failures before they occur, or integrate insights across the full value chain of operational and business systems. These limitations constrain the ability of operators to fully address today's challenges and future demands.

The Opportunity: AI as a Complementary Intelligence Layer

Artificial Intelligence provides a natural complement to TAS. Rather than replacing existing automation, AI enhances it by enabling prediction, optimisation, and continuous improvement. TAS continues to execute workflows and enforce compliance, while AI analyses the data flowing through TAS and other systems to anticipate demand, optimise scheduling, detect anomalies, and provide decision support.

The synergy between the two is clear: TAS delivers execution, while AI delivers insight. TAS ensures compliance and safety, while AI continuously seeks efficiency and optimisation. Together, they create a terminal operating model that is both robust and adaptive.

Use Cases: AI and TAS in Action

Across product receipt and transfer, TAS automates custody transfer and unloading workflows, yet inefficiencies in scheduling still cause delays and costs. AI can enhance this domain through predictive scheduling of vessels, trucks, and railcars, anomaly detection in metering data, and computer vision to validate connections and procedures. This allows operators to reduce demurrage, strengthen quality assurance, and minimise manual intervention.

In storage and inventory management, TAS provides reliable stock reporting and reconciliation, but is reactive in nature. AI can build predictive reconciliation models to detect shrinkage or theft in near real time, develop digital twins of tanks to simulate utilisation and maintenance requirements, and monitor sensor data for anomalies in temperature or density. This shifts inventory management from static reporting to proactive risk reduction.

For blending and additive injection, TAS reliably executes recipes, yet often at a higher additive cost than necessary. AI can introduce optimisation algorithms that minimise dosing while maintaining quality and compliance, predict blend outcomes using machine learning, and adjust recipes dynamically based on input feedstock and demand. The result is more consistent product quality and reduced additive spend.

Loading and dispatch operations, while safely controlled by TAS, are frequently hampered by congestion and downtime. AI enhances this by forecasting demand across channels, applying reinforcement learning to optimise truck and rail allocation, predicting maintenance needs for pumps and loading arms, and using vision systems to monitor compliance with PPE and safety protocols. This reduces waiting times, improves asset utilisation, and enhances safety.

In the domain of safety and compliance, TAS provides alarms, shutdowns, and interlocks, but it does so reactively. AI extends this by detecting unsafe behaviours, leaks, or spills before they escalate, predicting asset failures that could lead to incidents, and generating compliance reports automatically by integrating data across TAS, SCADA, and environmental monitoring systems.

Finally, in automation and data integration, TAS sequences and interfaces with SCADA and ERP, but its scope is limited. AI enables the creation of a digital twin of the terminal, integrating operational and business data into a single model for real-time optimisation. It orchestrates data flows across TAS, ERP, and IoT and introduces natural language assistants that generate reports and insights for decision-makers.

1. Predictive Inventory Optimization

Traditional TAS solutions rely on static reorder points and historical patterns, which often fail to respond to real-time fluctuations in terminal throughput and refinery feedstock variability. AI-driven predictive inventory optimization uses machine learning models trained on consumption trends, refinery dispatch schedules, and product demand cycles to dynamically forecast stock levels. By automating replenishment triggers and tank changeover planning, terminals can prevent both stockouts and overstocking. The result is a 40–70% reduction in stockouts, 10–25% improvement in working capital, and annual savings of 1.80M $ across reduced demurrage, emergency sourcing, and inventory carrying costs.

2. AI-Driven Real-Time ERP–TAS Synchronization

A common operational pain point is last-minute scheduling changes initiated in ERP after TAS schedules are locked, leading to manual overrides and disrupted workflows. AI bridges this gap through intelligent data synchronization, ensuring that changes in ERP automatically re-sequence the TAS schedule using dynamic optimization algorithms. This reduces manual interventions and delays by up to 25%, cutting 400–600 operational labor hours annually and saving 0.12 M $ in productivity and operational risk mitigation.

3. Load Sequencing and Prioritization Optimization

During peak demand, TAS often follows fixed sequencing logic that underutilizes loading bays. AI optimization engines apply reinforcement learning models that evaluate demand priority, product compatibility, and bay availability in real time. This dynamic load sequencing unlocks 12–18% higher throughput and 5–12% lower truck dwell times, potentially avoiding 0.34M $/year in demurrage, detention, and lost revenue opportunities.

4. Agentic AI for Dynamic Workflow Communication

Communication breakdowns between control rooms and field staff often cause missed slots, idle time, and demurrage. AI-enabled agentic systems automate notifications and workflow updates across the terminal ecosystem, synchronizing TAS, mobile operator devices, and ERP. These digital agents improve responsiveness and reduce demurrage costs by 20–30%, equivalent to 181,440 $/year savings, while boosting operator productivity 10–15%.

5. AI-Enabled Pre-Check and Digital Document Verification

Compliance lapses and delays occur when drivers arrive without complete documentation. Using computer vision and NLP, AI agents can pre-verify documents and validate driver credentials before arrival. This reduces gate congestion and strengthens compliance assurance, delivering 15–25% reduction in average loading delays, saving 103,680 $ annually in demurrage and waiting charges, while increasing throughput capacity 5–10% without adding infrastructure.

6. Emission and Energy Optimization

Energy management within terminals is often reactive, with limited visibility into vapor recovery or compressor utilization. AI introduces intelligent energy orchestration by continuously balancing equipment loads, optimizing power consumption, and monitoring vapor recovery rates. This delivers 10–15% energy savings, cutting 1–2.5 M $/year in operating cost, while reducing carbon emissions by 5–12%, aligning directly with ESG compliance and lowering carbon tax exposure by 0.6–0.8 M $/year.

7. Agentic AI for Inventory Autonomy

Manual decision-making in stock movement or replenishment creates latency in operations. Agentic AI introduces autonomous control agents capable of initiating inventory transfers, triggering orders, and managing tank switches in real time. These self-optimizing systems reduce human intervention by 40–60%, prevent stockouts worth 1.2 M $/year, and unlock 5–10% higher asset utilization, progressively transforming terminals into autonomous hubs.

8. Digital Twin and Scenario Simulation

Operational planning in terminals has traditionally been reactive, lacking foresight into maintenance schedules or demand surges. AI-powered digital twins replicate tank operations and simulate what-if scenarios across inventory, equipment performance, and demand variations. This delivers 15–25% faster decision cycles and 10–20% reduction in unplanned downtime, translating into 0.6 M $ annually in avoided disruptions and better capacity utilization.

Value Realisation: The Impact of AI and TAS Together

The combination of TAS and AI creates measurable value across terminal operations. Predictive scheduling reduces demurrage by as much as 15%. Inventory reconciliation accuracy can exceed 95%. Blending optimisation lowers additive costs by five to 10%. Truck and rail turnaround times can improve by as much as 30%, while predictive maintenance reduces unplanned downtime by up to 40%. Compliance reporting effort can be cut by a quarter through automation. Together, these improvements strengthen financial performance, operational efficiency, and regulatory compliance.

Infosys Consulting Approach

Infosys Consulting helps clients unlock this potential by building on their existing TAS investments. Our approach begins with AI opportunity mapping, identifying the areas where intelligence can add the greatest value. We then move to rapid prototyping, using real operational data to demonstrate tangible benefits. Digital twin deployment enables operators to simulate and optimise terminal performance, while our integration services connect TAS with SCADA, ERP, and IoT systems to provide unified intelligence. Finally, we support change enablement, ensuring staff are trained and confident in working alongside AI-powered insights.

Conclusion

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