

FIELD OPTIMIZATION REIMAGINED: DATA AT THE CORE EXCEPTIONS AT THE CENTER, PEOPLE IN CONTROL

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ABSTRACT

Production operations have traditionally relied on routine well checks and periodic field visits to verify performance and equipment status. While effective for coverage, this approach consumes significant labor, fuel, and operational resources on wells that are already functioning normally.

To transition from schedule-based to exception-based operations, a small-footprint digital ecosystem was deployed on a remote satellite lease in West Texas. The system integrates smart rod pump controllers, facility instrumentation, tank monitoring, and cloud-based analytics powered by artificial intelligence (AI) and machine learning (ML). The objective was to enable “pump-by-exception” operation, where wells are only acted upon when data indicates intervention is required.

Eight months after deployment, the system delivered measurable improvements: a 43% reduction in electricity consumption, 43% reduction total daily strokes, an 86% decrease in manual field interventions, a 26% reduction in hot oiling costs, and elimination of production decline relative to expected field performance. Additionally, the system prevented at least one environmental incident through visual detection monitoring and prompt operator response.

This paper demonstrates how integrated digital systems, leveraging high-frequency data acquisition and AI-driven analytics, can materially improve operational efficiency and economic performance, particularly in marginal assets.

INTRODUCTION

Artificial lift operations, particularly sucker rod pumping systems, have traditionally relied on periodic field inspections and established operating practices based on the information

and time available to field personnel. In many cases, this information is static or limited in frequency, which naturally constrains the ability to fully capture dynamic well behavior.

As a result, opportunities can exist to further enhance performance when higher-resolution, continuous data becomes available. Three key areas where additional visibility can drive improvements include:

1. Overservicing of healthy wells.
2. Delayed detection of failures.
3. Suboptimal pump operation due to static setpoints.

In mature and marginal fields, where operating costs dominate economics, the inherent nature of operations often constrained by limited and static data can directly influence asset performance and profitability.

This work presents a field implementation of a pump by exception operating model, where:

- Continuous data replaces periodic inspection.
- Automated analytics replace manual interpretation.
- Human intervention is reserved for actionable events.

The deployment targeted a remote satellite lease (Fig. 1) with minimal legacy instrumentation, providing an ideal test case for quantifying the value of digital transformation.



Fig. 1 West Texas Lease Site Map

FIELD DESCRIPTION AND BASELINE CONDITIONS

The asset consisted of five sucker rod pumping wells producing to a central tank battery equipped with two oil tanks, two water tanks, a heater treater, and a transfer pump used to move water to a satellite injection well, which was equipped with a main injection pump.

The producing wells were operated using timer-based controllers, with limited surface facility instrumentation and no remote monitoring capabilities. As a result, all operations relied on periodic field visits, and the available data was primarily static in nature.

Within this context, well operation and maintenance activities were driven by scheduled visits and the information available at the time, which can naturally limit visibility into dynamic well behavior. This creates opportunities to further optimize pumping performance, improve maintenance timing, and enhance the early detection of abnormal or critical conditions as more continuous data becomes available.

DIGITAL ECOSYSTEM ARCHITECTURE

The deployed system (Fig. 2) introduced a fully integrated, end-to-end digital infrastructure.

At the well-level, each producing well was equipped with advanced rod pump controllers that included:

- Pump-off controller with cellular connectivity.
- Wireless tubing / flowline pressure sensors.
- Wireless bridle cable clamped load cell capable of measuring:
 - Load.
 - Position.
 - Stroke Length.
 - Stroke Velocity.
- Motor current monitoring.
- System Voltage.

At the facility level:

- Tank level sensors (oil and water) capable of calculating daily produced volumes and count with integrated high, low and load taken alarms with shutdown logic across the lease.
- Heater treater and header pressure sensors.
- Water transfer pump remote control.

The injection well was upgraded with:

- Injection pressure monitoring.
- Casing pressure monitoring for tubing leak detection.
- Flow measurement.
- Remote control capability.

Producing and injector wells were also equipped with cameras, that provide visual monitoring for leaks, valve position verification and equipment condition.

All previously described sensors and controllers acquire, record, and transmit data at 10–25 samples per second per channel, continuously streaming this data to a centralized cloud platform that:

- Processes high-frequency data.
- Applies AI/ML models to:
 - Detect pump-off conditions.
 - Identify Mechanical Issues.
 - Optimize Stroke Parameters.
 - Identify critical operational conditions.
- Generates actionable insights, alerts and acts.

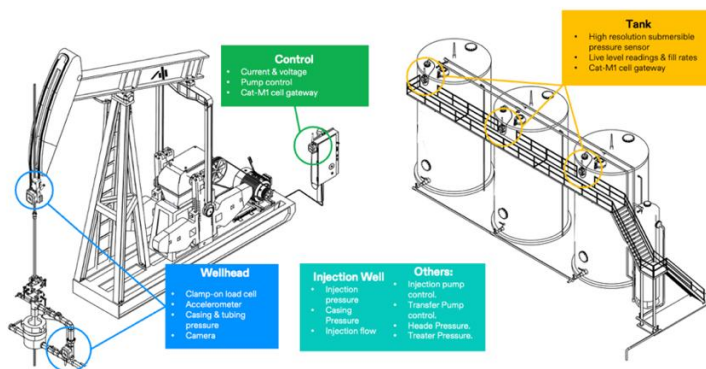


Fig. 2 Instrumentation Setup

OPERATIONAL PHILOSOPHY – PUMP BY EXCEPTION

The deployed system enables a transition from traditional schedule-based operations, where each well is routinely inspected regardless of condition, to a data-driven, exception-based approach focused on wells that require attention.

In this model, continuous monitoring and real-time analytics provide the necessary visibility to distinguish between normal and abnormal operating conditions, allowing field personnel to prioritize their efforts where they add the most value.

This “pump-by-exception” philosophy is supported by several key capabilities, including automated setpoint optimization to dynamically adjust pumping parameters based on changing well conditions (Fig. 3), event-driven alerts that highlight deviations from expected performance, and autonomous protective actions under critical scenarios. These actions include controlled shutdowns in response to conditions such as parted rods, abnormal pressure events, tank overfill situations, or equipment malfunctions. By combining continuous data acquisition. (Fig. 4) with intelligent analysis and control, the system enables a more proactive, efficient, and targeted operational strategy.

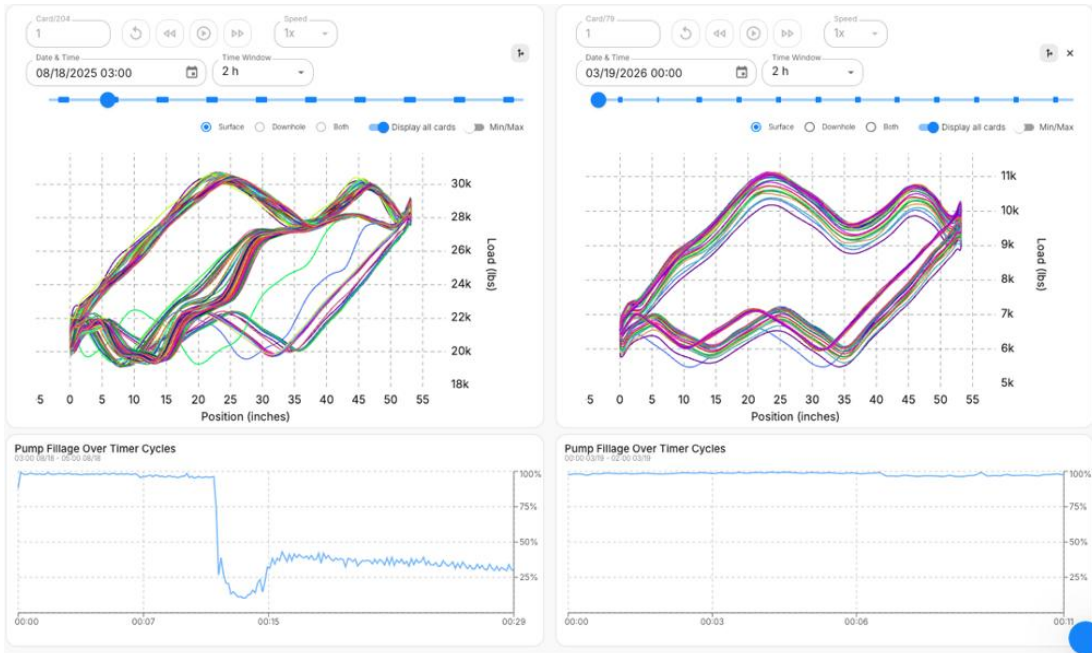


Fig. 3 AI/ML Cycle Stabilization

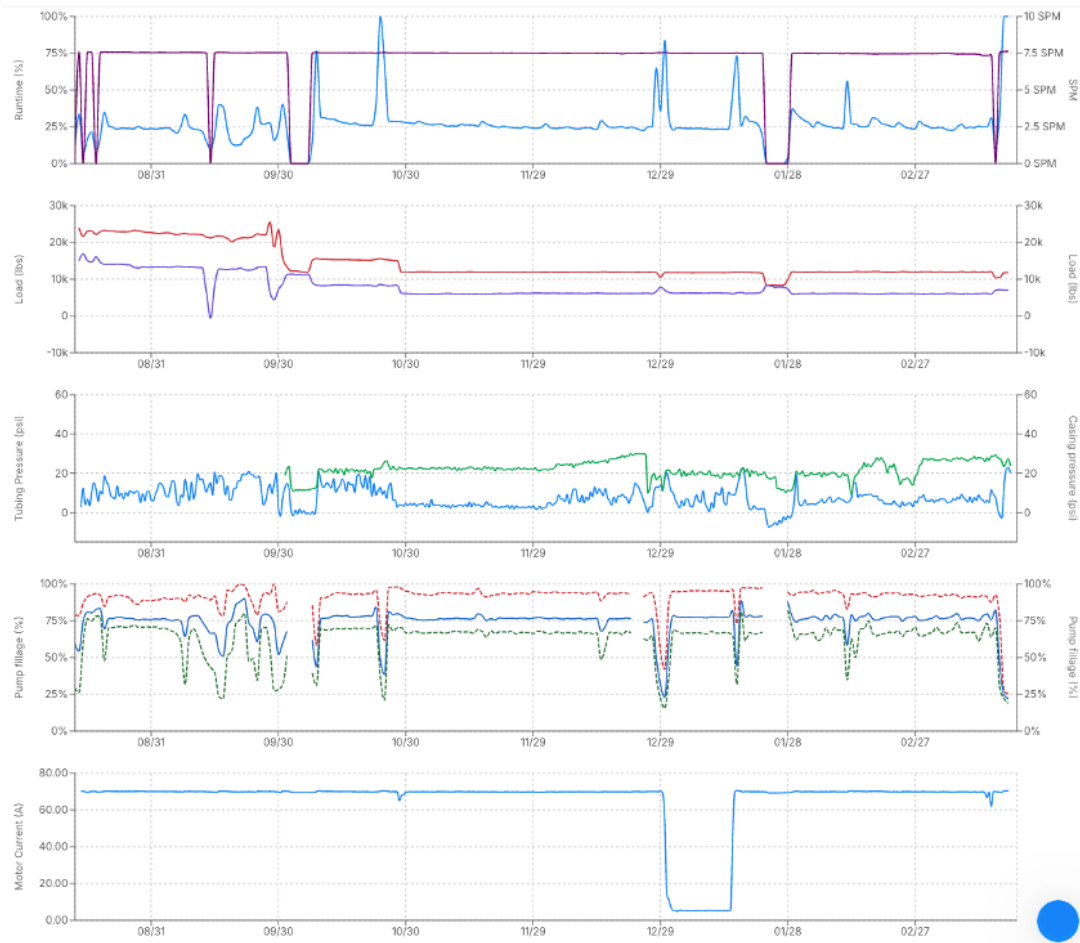


Fig. 4 Continuous Data Acquisition Example

RESULTS AND PERFORMANCE EVALUATION

Over an eight-month evaluation period, the implementation of the pump-by-exception system delivered measurable improvements across operational efficiency, production performance, and overall economics. Electricity consumption and daily stroke count were reduced by 43%, with average electricity costs decreasing from \$660 to \$376 per well per month, primarily driven by dynamic pump-off control, reduced over pumping, and optimized runtime.

Production remained stable at approximately 19 BOPD, effectively offsetting an expected annual decline of 4.25% and resulting in incremental recovered volumes. Additional efficiencies were realized through a 26% reduction in hot oiling costs, achieved by transitioning from fixed schedules to data-driven interventions based on flowline pressure

trends, and an 86% reduction in routine field time requirements, decreasing from 126 to approximately 18 hours per month, driven by a shift toward exception-based operations.

Beyond operational gains, the system also enhanced situational awareness and risk mitigation. In one instance, abnormal conditions caused by external damage to wellhead valves were detected, enabling a rapid response that prevented a potential spill and avoided an estimated \$10,000–\$15,000 in remediation costs. From an economic perspective, the solution achieved full capital recovery in slightly over one month following deployment.

Under a \$65/bbl. WTI environment, the combination of reduced operating expenses, stabilized production, and improved operational reliability generated approximately \$65,000 in incremental profits over the initial eight-month period (Fig. 5).

These gains are projected to exceed \$100,000 within the first year and surpass \$200,000 over a two-year period, demonstrating the sustained economic impact of data-driven, exception-based operations.

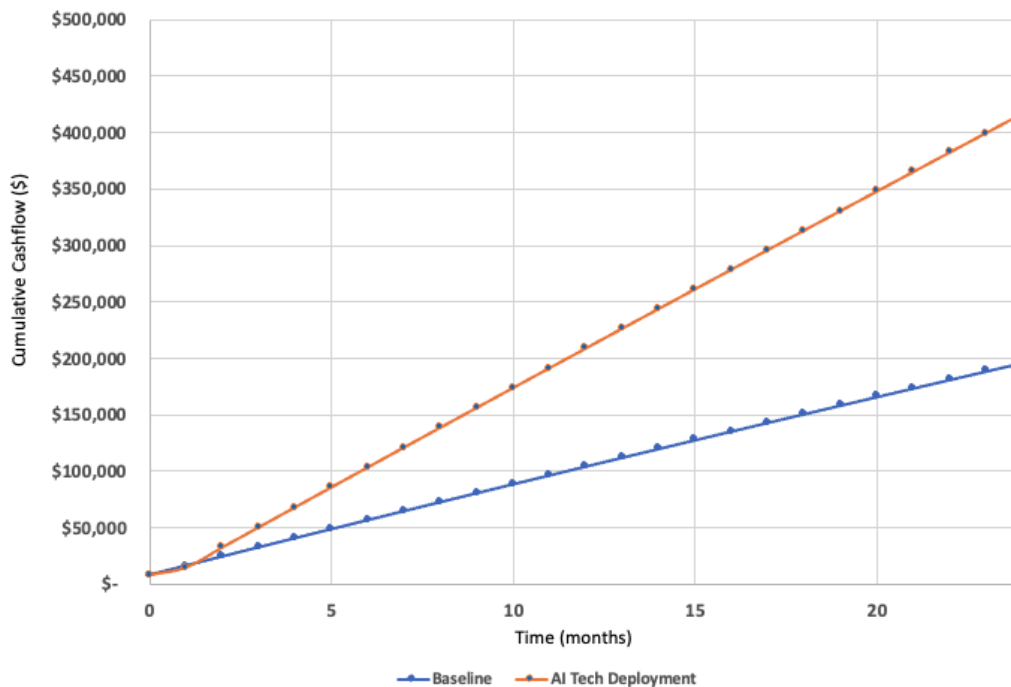


Fig. 5 Payout Time and Cumulative Cash Flow Projections

Given that this lease represents a statistically representative sample of similar assets, the observed performance can be reasonably extrapolated to larger portfolios. On a normalized basis, the implementation yields approximately \$20,000 per well per year in incremental profits, suggesting that deployment across a 400-well asset could translate into an annual economic impact on the order of \$8 million, highlighting the scalability and material value of the approach.

CONCLUSIONS

The deployment of a pump-by-exception digital ecosystem on a remote satellite lease demonstrates the tangible value of combining high-frequency data acquisition, advanced analytics, and next generation micro controllers integrated across wells and facilities. The results show that this approach can significantly reduce operating expenses while maintaining or improving production performance, particularly in mature and marginal assets where cost efficiency is critical.

A key enabler of these outcomes is the availability of high-resolution, continuous data, which provides the visibility required to capture transient well behaviors that are not observable through traditional, lower-frequency workflows. This increased data density supports more informed and timely decision-making, as well as the application of AI/ML-driven models to dynamically optimize well operation.

Importantly, this approach is designed to complement field personnel by enabling a shift toward exception-based operations, where time and expertise are focused on wells that require attention. By reducing routine field visits and enhancing situational awareness, the system allows personnel to prioritize higher-value activities and respond more effectively to changing conditions.

The results also indicate that the benefits of this approach are particularly impactful in lower-rate, marginal wells, where incremental improvements in efficiency and cost reduction can materially influence asset economics. Additionally, the integration of wells, surface facilities, tank systems, and injection infrastructure into a unified digital environment was found to be critical in maximizing overall system performance, improving reliability, and enhancing operational safety.

From an economic perspective, the observed performance demonstrates strong and scalable value, with meaningful reductions in operating costs, stabilization of production, and mitigation of operational risks. These results support the broader application of pump-

by-exception strategies as a practical and effective pathway for modernizing artificial lift operations across mature fields.