Ensure the Safe, Reliable and Efficient Pipeline Transport of Gases

Why transmission and distribution natural gas pipeline companies need the visibility, control and intelligence advanced software provides

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A Transformative Era

The energy sector is undergoing a significant transformation, driven by the global call for more sustainable energy production and the imperative to reduce greenhouse gas emissions in conjunction with maintaining worker safety, driving operational efficiencies and reducing costs, mitigating cybersecurity threats and improving profitability. As a result, gas pipeline companies around the world are looking into how they can modernize their operations through advanced technologies.

Traditionally, gas pipeline companies have been divided into three different segments: gathering, transmission and distribution. Although technically different, the lines between segments are starting to overlap, which complicates pipeline operation due to different overall objectives and regulations.

To complicate matters even further, natural gas is not natural gas anymore! Historically, the natural gas that has been transported in gathering, transmission and distribution pipelines has been extracted as part of the oil and gas production. This has meant that the natural gas in the pipelines has had a relatively steady heating value, which ensures consistent energy output during combustion. However, today and in the future, the content within these pipelines will contain a higher amount of biogas or renewable natural gas (RNG), and achieving an acceptable heating value becomes more complicated. This becomes even more complex with the injection of hydrogen into the gas pipeline system.

Within this changing environment, gas pipeline operators in the control room are expected to operate their pipeline systems safely, reliably and efficiently using field devices, control systems and advanced pipeline software applications that are not easy to maintain or update with personnel that are quickly approaching retirement age. In this white paper, we will dive into the solutions available to gas pipeline companies to ensure they can continue to provide safe, reliable and efficient pipeline operations well into the future.

Challenges and Trends for Gas Pipeline Companies

Keep My Pipeline out of the News

Any pipeline executive will tell you that the last thing they want is to see their pipeline on the front page of the daily news, since that typically indicates that their pipeline has had a serious safety incident.

The gas pipeline infrastructure is showing its age, leading to increased risk of leaks, explosions and fires that gas pipeline companies are eager to prevent. A continued reliance on antiquated pipeline management systems does not enable gas pipeline companies to take full advantage of technological advances that can quickly detect and respond to leaks and other safety vulnerabilities.

As the gas pipeline industry starts to embrace digital transformation to modernize transmission and distribution pipeline management, this also introduces new security vulnerabilities. The expansion of both operational technology (OT) and information technology (IT) systems has significantly expanded the attack surface cybercriminals can exploit.

Cyber threats are a pressing concern. U.S. gas pipeline companies experienced a 70% increase in cyberattacks in 2024 compared to 2023[1], while in 2021, a cyberattack forced Colonial Pipeline to shut down its entire network making Colonial Pipeline headline news.

Improve User Experience

SCADA systems contain vast amounts of data. However, operators and managers typically use only about 20-30% of this data daily. Legacy SCADA systems lack the capacity to filter, prioritize and present relevant

information, making it difficult for operators to make informed decisions. This is especially true during high-activity times, when it is very important to receive actionable information rather than an onslaught of data. The introduction of intelligent field devices produces even more data for SCADA to decipher and advise the operator in the control room with potential actions.

Most pipeline companies have introduced new ancillary software functionality alongside their SCADA to fill niche functionality needs, making it impossible for the operator in the control room to see all necessary information in one display. This means that the operator needs to swivel their chair around to find what they are looking for and process what is presented with a different look and feel from one display to another. On top of that, transferring data between different application vendors might be a challenge, which means that operators and engineers might be updating the same data in multiple places to accommodate different vendor applications.

Comply With Regulatory Requirements

Prioritizing the safety of employees and communities is both the right thing to do and a strategic imperative. In the U.S., both state agencies and the federal Pipeline and Hazardous Materials Safety Administration (PHMSA) can impose large fines for safety violations. Safety problems can also trigger lawsuits, require costly infrastructure upgrades and increase insurance costs. Publicly traded gas pipeline companies may experience stock price declines, and the cost of capital can rise after serious incidents. In the most serious cases, gas pipeline companies risk bankruptcy and the suspension or revocation of operating licenses.

Consequently, numerous regulations have been enacted globally to bolster pipeline cybersecurity, including the Transportation Security Administration's (TSA) pipeline security directives, the National Institute of Standards and Technology (NIST) cybersecurity framework and the ISO/IEC 27001 standard. Europe's Network and Information Systems (NIS) directive and the American Petroleum Institute's (API) Standard 1164 also address cybersecurity. Compliance with these regulations is now a critical priority for gas pipeline companies. Legacy pipeline management systems leave gas pipeline companies vulnerable to sophisticated attacks and hinder the adoption of innovative digital tools.

At the same time, regulators are auditing gas pipeline companies for compliance with control room management recommended practices as outlined in API RP 1168. This ensures that processes, procedures and training contain the safety elements associated with being a pipeline operator in gas transmission and distribution control rooms.

Total Cost of Ownership (TCO)

Distribution and transmission pipeline companies face increasing pressure to contain costs and manage technical debt. This puts pipeline company leaders in a difficult position. On one hand, pipeline companies are expected to ensure safety, advance decarbonization, modernize pipeline infrastructure, drive digital transformation and contain customer rates. Accomplishing these objectives requires a clear digital strategy to streamline operations, which likely requires replacing outdated technology at significant cost to upgrade or replace.

Over the years, the distribution or transmission gas pipeline company might have purchased various software applications from different vendors to assist the operator in the control room. However, maintaining a patchwork of technologies through upgrades is both expensive (another long project) and the lack of inter-operability between the various vendor applications continues to create data silos rather than have a common repository for all data. To complicate matters further, each vendor has their own patch management program. The IT staff of the pipeline company is given the task of attempting to coordinate the schedules, updates and patches for the entire OT environment based on feedback from vendors.

Increasingly Complex Gas Network Management

From aging infrastructure and worker retirements to regulatory and cost pressures, it has never been more complicated to safely and efficiently

manage distribution and transmission gas networks. For example, a growing convergence between transmission and distribution system operations poses both challenges and opportunities for pipeline companies. More cohesive, coordinated and unified management of distribution and transmission networks can ensure energy reliability, operational efficiency and safety.

At the same time, several countries and U.S. states are also promoting hydrogen blending into traditional natural gas supplies, to decarbonize while leveraging existing pipeline networks. The European Union, for example, currently caps blending of hydrogen into natural gas at 2% of volume at cross border interconnection points, although technically it could be increased to 20% in the future with current infrastructure. Blending hydrogen, particularly at higher volumes, requires upgrading pipeline materials and modifying compressors to accommodate hydrogen's lower density and unique flow characteristics.

Another pain point for gas pipeline companies is that there is no single source of truth when discussing pipeline data. Network models used by the planning team and the engineering teams might be as-built models that are updated infrequently compared to the as-operated model operators are using in the control room. Additionally, the lack of consistency in the models used in the various functions from planning, operations and maintenance create inefficiencies and inaccuracies that affect pipeline performance.

A Changing Workforce

A significant portion of the industry's most experienced workers are retiring or nearing retirement. Knowledge transfer and training are crucial as new workers replace retirees. Many new operators must work with complex pipeline management tools and require significant training time before they become proficient.

Traditionally, operators in the control room had field experience—typically on the same pipeline asset they were operating later in life. This meant that they would have an intimate knowledge of their physical pipeline system before starting to control and operate it. Today, new trainees do not have this knowledge, because they most likely have not been field engineers. As a result, the pipeline company needs to provide even more on-the-job training and easy-to-use software applications before operators can take responsibility for their pipeline.

Key Capabilities of a Modern Pipeline Management OT System

Addressing the challenges and complexity faced by transmission and distribution gas pipeline companies is impossible with outdated OT. Pipeline company leaders must embrace systems that are cost-efficient, user-friendly and sophisticated.

This section will highlight the capabilities you should expect of a modern pipeline SCADA system, gas distribution pipeline management and gas transmission pipeline management systems. Let's look at a modern pipeline SCADA first.

Pipeline SCADA Capabilities

Capability	Description
Cybersecurity	A modern pipeline SCADA needs to meet a variety of international cybersecurity standards, and the SCADA vendor should assist in making sure the SCADA system is fulfilling any certification requirements.
High Performance and Scalability	A modern pipeline SCADA needs to be able to scale according to the number of points and users with the ability to handle a large volume of both transactions and alarms.
Independence and Cloud-Enabled	A modern pipeline SCADA should be both hardware and software operating system independent and have the capability to be cloud-enabled on both private and public clouds.
High Availability	A modern pipeline SCADA should have both the capability to have local redundancy and multiple sites redundancy, while at the same time have both flexible and robust redundancy and failover schemes.
Open and Modular	Whether collecting/sending data from field or from other enterprise systems, a modern pipeline SCADA should be open and modular to allow easy integration using industry standard communication protocols and APIs (application programming interfaces).
Integrated Apps	Control room management applications for electronic logbooks and point-to-point inspection should be integrated within a modern pipeline SCADA to allow the operator to complete all their actions in the same display.
Easy to Deploy, Use and Maintain	The modular concept of a modern pipeline SCADA should allow for easier upgrades, engineering and administration. At the same time, the user interface should be both flexible and user-friendly and be available on both desktop and web.

Table 1: Capabilities of a modern pipeline SCADA system.

As Table 1 outlines, a modern pipeline SCADA has many capabilities, and those drive a number of key benefits:

1. **Comprehensive Situational Awareness:** Although SCADA systems generate vast amounts of data, control room operators often see only a fraction and spend excessive time evaluating one-line displays and other information to determine the right actions. Operational efficiency, reliability and safety are significantly improved when operators are presented with only the most relevant data, while noise and raw, unused information are filtered out. Insights are valuable; distractions are not. Modern pipeline SCADA systems deliver critical information precisely when it's needed, at the touch of a button, empowering faster, smarter decision-making and keeping the network running safely and efficiently.
2. **Flexible and Scalable to support Future Growth:** As global energy demand continues to rise, pipeline operators are increasingly incorporating renewable natural gas and hydrogen into their systems and some may eventually distribute hydrogen exclusively. No matter which fuel flows through future pipelines, companies will require SCADA systems that are not only scalable for growth but also robust and flexible enough to ensure safe and efficient operations over the long term.
3. **Easy-to-Deploy, Use and Maintain:** Today's pipeline operators often rely on management applications from multiple vendors, each with its own interface and update strategy. This disparity creates coordination challenges during patching and maintenance, turning routine upgrades into a logistical headache for the pipeline company's SCADA engineers. A modern pipeline SCADA system, streamline maintenance and updates while offering a more intuitive, flexible environment for both operators and engineers. Ultimately, modern SCADA platforms deliver improved total cost of ownership by eliminating legacy inefficiencies and simplifying system administration.

Next, let's look at the advanced capabilities needed by gas distribution and transmission companies in addition to SCADA that enable robust pipeline management.

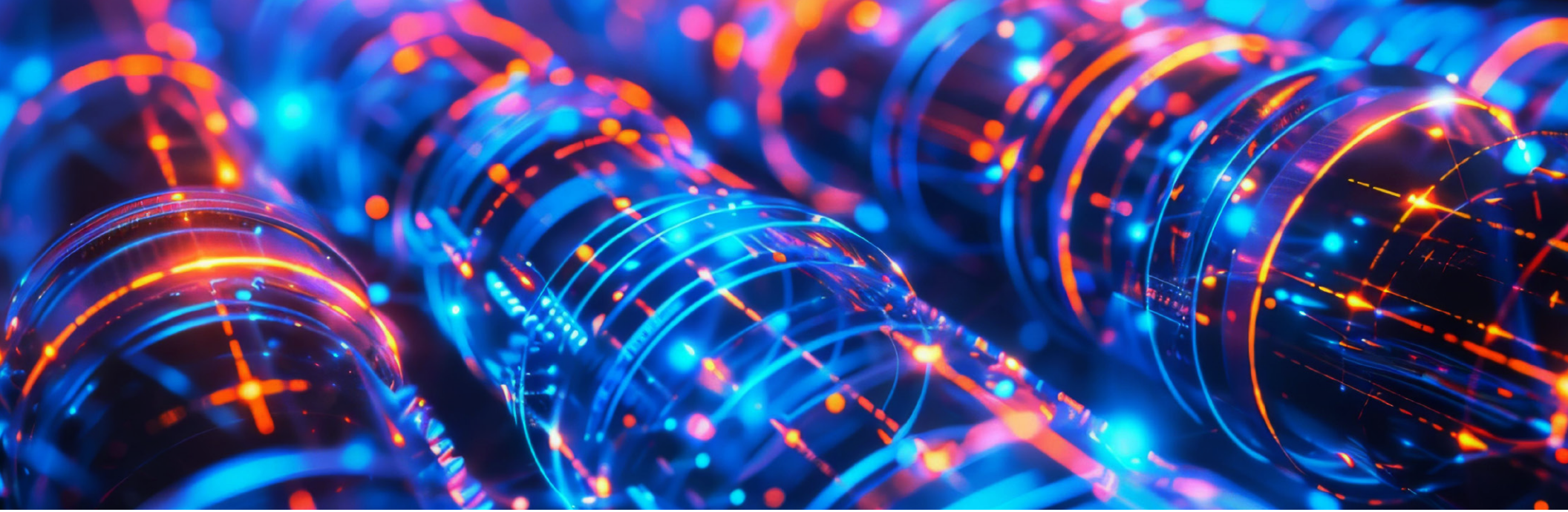
Advanced Pipeline Applications Capabilities

Capability	Description	Distribution or Transmission
Assist in Real-Time	Productized standard calculations that include calculation of corrected volume, accumulation of volumes received/delivered and calculation of linepack.	Distribution – Transmission: All Some None Some All
As-Operated Connectivity	The as-operated network topology of each pipeline system is important for real-time condition visibility with the ability to have a connectivity model that allows operators to see their pipeline on as-built maps, typically provided by an interface to the GIS database.	Distribution – Transmission: All Some None Some All
As-Operated Modeling	The connectivity model can be used for pipeline modeling in real time providing more accurate pressure, temperature and flow profiles and calculated linepacks.	Distribution – Transmission: All Some None Some All
Gas Quality Tracking	The connectivity model can be used either with the as-operated modeling results or by other AI techniques to provide metrics on the heating value of the gas delivered.	Distribution – Transmission: All Some None Some All
Prevent and Detect	Applications for preventing incidents such as verifying operator actions or detecting and alarming on high pressure. This includes detecting ruptures/leaks.	Distribution – Transmission: All Some None Some All
Short-Term Forecasting	Robust and accurate forecasting of both supply and delivery values for the next couple of gas days leveraging historical data and external inputs such as weather.	Distribution – Transmission: All Some None Some All
Tracking of Actuals	Improve accuracy by tracking the accumulation of actuals received or delivered compared with the expected or contracted supply or delivery amounts for the current gas day.	Distribution – Transmission: All Some None Some All
Short-Term Prediction	Predict whether the expected amount for the current gas day will be met or not for each supply/delivery point. The method of prediction should be selectable based around requirements for each supply/delivery point.	Distribution – Transmission: All Some None Some All
Verification of Measurements	Verify hourly electronic flow measurements (EFM) before they go to billing using configurable validation criteria.	Distribution – Transmission: All Some None Some All
Assist in Operator Training	Instruct operators with a digital twin of the as-operated pipeline model supporting both normal and abnormal pipeline conditions of their specific pipeline system.	Distribution – Transmission: All Some None Some All

Table 2: Capabilities of advanced applications typically integrated with a modern pipeline SCADA for gas distribution and transmission pipeline companies.

As Table 2 outlines, a modern set of advanced pipeline applications should have a variety of capabilities. Whether it is a distribution gas pipeline company or a transmission gas pipeline company, the following benefits can be achieved using these advanced pipeline applications together with a modern pipeline SCADA:

1. **Ensure Safe and Compliant Services:** By continuously monitoring pressure, temperature and flow rates, advanced pipeline applications can identify potential safety risks before crews are dispatched. Over time, numerous regulations and recommended practices have emerged worldwide. Safety-focused applications play a vital role in helping pipeline operators remain compliant by anticipating potential challenges during maintenance planning. These tools support proactive decisions such as system shutdowns or rerouting. These measures protect workers and ensure safe pipeline operations. With a modern suite of advanced applications, pipeline companies can more effectively align with both regulatory requirements and the pipeline industry's best practices.
2. **Increase Reliability & Resilience:** Modern SCADA systems and advanced pipeline applications equip pipeline companies with tools to enhance reliability through system redundancy and modular upgrades. This built-in resilience ensures that calculations related to measurement and volume accumulation, whether conducted in the field or at the host, remain accurate even during weather-related disruptions. These accurate calculations are critical for billing processes used by gas distribution companies. Disturbances and incidents can occasionally impact pipeline operations, implementing modern SCADA and advanced applications helps not only improve overall system reliability but also safeguard against operational disruptions.
3. **Improve Operational Excellence:** Pipeline companies are increasingly recognizing the value of data collected within SCADA and OT environments, extending its use beyond traditional operational boundaries. By leveraging modern SCADA systems and advanced pipeline applications, these companies can foster better collaboration across departments, break down legacy silos and reduce overall operational costs, therefore realizing a lower total cost of ownership. Advanced forecasting tools powered by AI and machine learning enable operators to reliably meet customer demand while minimizing the risk of over- or under-supply. These tools optimize pipeline flow, enhance compressor efficiency and confirm sufficient linepack availability to meet demand spikes. These are all critical factors for maintaining safe and efficient gas pipeline transportation.



Summary and Conclusion

Pipeline companies can no longer rely on fragmented OT approaches to address the industry's growing complexities. Without a comprehensive digital strategy, gas pipeline operators risk falling short of the technology required to meet evolving operational demands. Industry leaders must proactively assess both current systems and future needs, and craft a digitalization roadmap that aligns with business objectives ensuring resilience, efficiency, and regulatory compliance in the years ahead.

A modern pipeline SCADA system forms the backbone of safe, efficient and reliable management across both distribution and transmission natural gas pipeline systems. Operators, planners and stakeholders can unlock even greater value by incorporating integrated advanced applications tailored specifically to meet the complex demands of gas transmission and distribution operations.

Whether a pipeline company is focused on cybersecurity, operational safety or optimizing performance to better meet customer expectations, a modern SCADA system with integrated advanced pipeline applications provides essential support. By harnessing the latest digital technologies, these tools empower both control room operators and wider stakeholders with timely, relevant information that enhances decision-making and improves overall system efficiency.

[1] Cyberattacks on US utilities surged 70% this year, says Check Point | Reuters

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