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Enterprise AI to Improve Gas Turbine Compressor Reliability

A major Asian oil & gas company wanted to improve the efficiency of its upstream operations by increasing the reliability of the Gas Turbine Compressors (GTC) used across its fields.

GTCs are equipped with hundreds of sensors that constantly monitor the state of this critical equipment using predefined thresholds to maintain production. However, the system monitoring the GTCs generated thousands of alerts every month for each compressor unit and could not prioritize alerts or provide prescriptive insights. As a result, engineers manually sifted through alarms to identify anomalies, perform failure mode analyses, and recalibrate thresholds. This time-intensive process required a high level of expertise and knowledge of compressor systems.

To address these challenges and increase the reliability of its compressors, the oil & gas company developed a prototype machine learning model to detect anomalous equipment behaviors with greater accuracy. The company then selected Baker Hughes and C3 AI® to deploy the model at scale using the BHC3™ Reliability application.

In 6 weeks, the Baker Hughes and C3 AI (BHC3) team ingested over one billion rows of data from 4 disparate data sources, re-factored the existing anomaly detection model, embedded it into a scalable deployment framework, and integrated the oil & gas company's proprietary Failure Mode Library to provide prescriptive insights in the application.

The configured BHC3 Reliability application accurately detects over 88% of anomalous events, while reducing the number of generated alarms by 99%. Furthermore, the BHC3 team demonstrated how additional rotating equipment can be incorporated in a matter of days, and how the application can be scaled across the company's operations in weeks.

With BHC3 Reliability, the oil & gas company can achieve over $40M in annual savings from increased efficiency, increased production, and reduced maintenance costs, and the ability to deploy a cohesive predictive maintenance strategy across its fleet of compressors.

Project Objectives

- Create a unified, federated data model integrating disparate data sources (e.g., aset hierarchy, telemetry, anomaly events, and Failure Mode Library)
- Deliver a workflow-enabled application that uses machine learning to detect anomalies in GTCs and provides prescriptive insights to prevent unplanned outages
- Reduce the number of false alarms created by the existing rules-based system
- Reduce Non-Productive Time caused by unplanned downtime

Results After Six Weeks

99%
Reduction in false alarms

$40M
Estimated annual savings

88%
Compressor failures accurately predicted using 6 months of data

4.7%
Reduction in Non-Productive Time

Challenges

High-power GTCs are capital-intensive, critical assets for oil & gas upstream operations. GTCs are used to compress gas for injection in order to increase production or to drive gas from the fields to gas processing facilities, LNG facilities, and local markets. With several compression and expansion stages and many operating parameters (e.g., temperature, pressure, flow, rotational frequency, vibration) that need to be controlled simultaneously, GTCs are amongst the most complex equipment across onshore and offshore fields.

The oil & gas company utilized a conventional rules-based application to monitor a fleet of 60 GTCs of different types, each equipped with more than 150 sensors. Due to the high sensitivity of the rules-based alerting system, more than 1,000 alerts were triggered for each compressor unit every month, most of which were false alarms. Engineers manually sifted through alerts to identify critical anomalies and perform failure mode analyses, a time-consuming process that requires high level of expertise and knowledge of sensor systems.

Furthermore, operators and engineers found it challenging to maintain the current monitoring software. Nearly 100,000 individual thresholds form the rule base for the fleet. As assets are maintained and parts replaced, production set points adjusted, and sensors calibrated, the task of keeping these individual thresholds up to date became an additional time-consuming task.

While operators and asset engineers leveraged their field experience to investigate and resolve the failures and alarms, several challenges remained. Operators:

- Lacked the tools to accurately detect anomalous behavior of GTCs and prevent unplanned compressor shutdowns
- Analyzed over 1,000 alarms per month from each compressor unit, most of which were false alarms
- Manually inspected and identified potential failure modes in the case of an anomaly, a process that required a high level of expertise to interpret raw sensor signals and maintenance and inspection logs
- Manually updated the rule-based alerting system with changing operating set points, part replacements, and instrumentation, requiring high effort and time

To address these challenges, the company developed a prototype machine learning model, and engaged Baker Hughes and C3 AI to help build a production-ready application that could scale across all of its GTCs.

About the Oil & Gas Company

- $50B+ in 2019 annual revenue
- 40,000+ employees
- Fully integrated oil & gas company operating in 20+ countries globally

Project Highlights

- Six weeks from data availability to production-ready application
- One billion+ rows of data ingested from four disparate data sources across four+ years of operational data
- Created a unified and scalable object model to represent asset hierarchy, telemetry data, anomaly events, and integrated a proprietary Failure Mode Library
- Re-factored the company's existing anomaly detection model onto the BHC3 AI Suite and demonstrated successful scaling to a second compressor
- 150+ sensor signals used as machine learning features per asset
- 10+ machine learning model configurations trained and tested per compressor
- Six BHC3 Reliability application user interfaces configured

Approach

Over 6 weeks, a team of Baker Hughes and C3 AI experts collaborated with data scientists and subject matter experts from the oil & gas company to re-factor the prototype machine learning model onto the BHC3 AI Suite, and extend the model into a production-ready application that could detect compressor anomaly events, provide operators with early warning signals, and incorporate failure mode insights to reduce unplanned downtime.

The BHC3 team began by ingesting over 1 billion rows of data from four disparate source systems to create a unified, federated data image. This analytics-ready data image included more than 4 years of telemetry data, anomaly events, an asset hierarchy representation, and the company's proprietary Failure Mode Library.

The existing anomaly detection model was refactored to run at scale on the BHC3 AI Suite and using a dataset with labelled anomaly events created by experts from company, the BHC3 team configured asset-optimal alerting thresholds to improve the quality of alerts. A proprietary Failure Mode Library was integrated to generate prescriptive insights and enable faster alarm resolution, with specific focus on an extensible implementation of the Failure Mode Library that allows for continuous improvement and regular updates. The team demonstrated the scalability of the new application by onboarding a second GTC in only two days. This separately trained anomaly detection model was fed by its own data pipelines using a BHC3 asset deployment framework and a newly developed workflow for structured asset onboarding.

Lastly, to provide an easily customizable UI framework, the BHC3 Reliability application was configured to visualize the AI-based alerts and prescriptive insights generated by the models. User-friendly dashboards provide a managerial view of high-level KPIs, top AI-driven alerts, and overall asset health of the compressor systems and subsystems. Users can filter alerts and are provided with the most likely Failure Modes for each anomaly.

Benefits

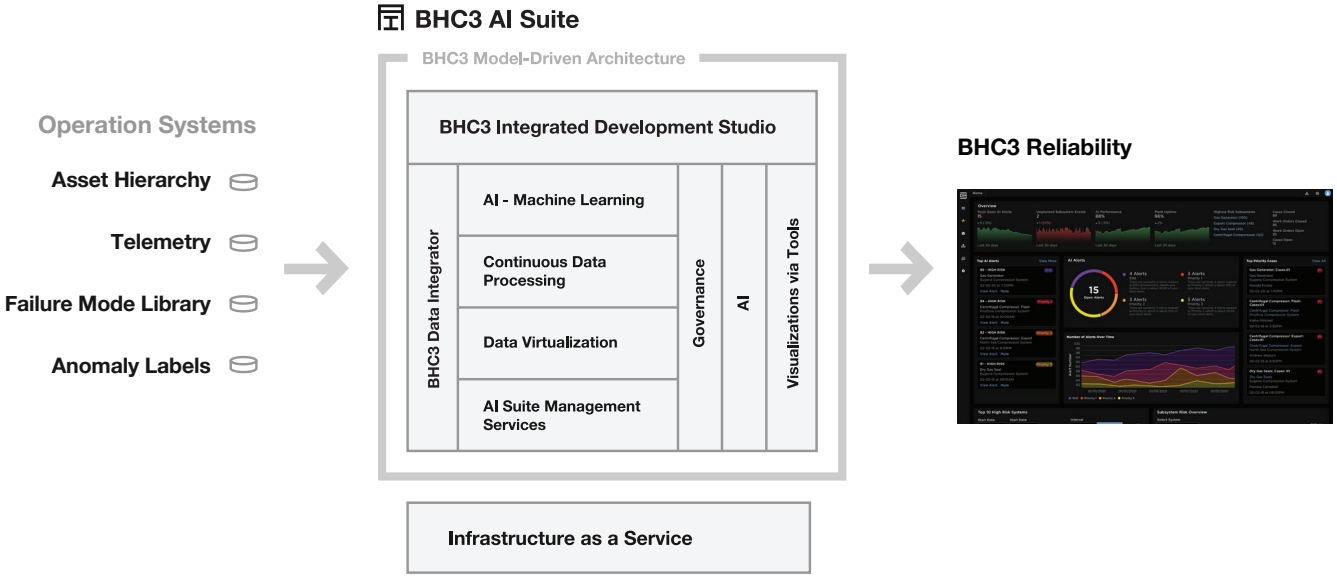
With the BHC3 Reliability application, the oil & gas company can:

- Reduce Non-Productive Time by 4.7%, equivalent to at least $40M in annual savings when scaled across upstream operations
- Reduce maintenance costs by enabling predictive, versus reactive, maintenance
- Extend compressor asset lifetime due to reduced operating hours in anomalous state
- Reduce high-risk emergency repairs and improve safety

By using the BHC3 Reliability application, the operators will be able to:

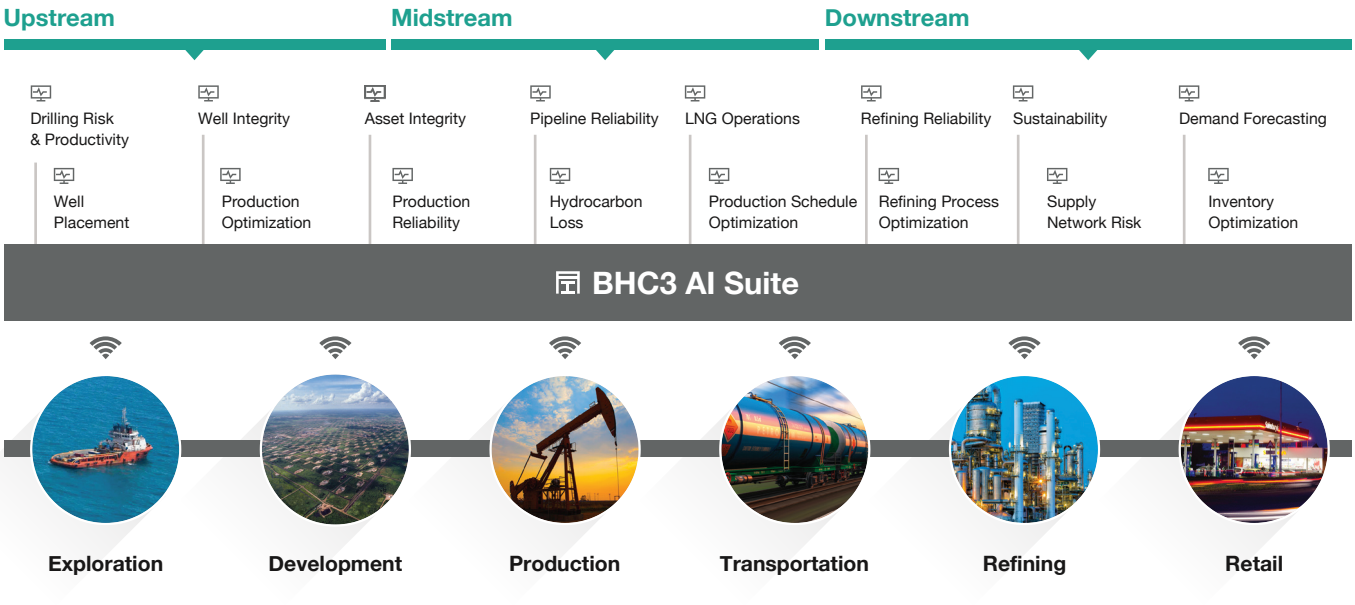
- Identify high-risk compressor units by accurately detecting over 88% of all GTC anomaly events and proactively dispatching resources to address impending outages
- Increase alert quality, with a 99% reduction in false alarms
- Resolve issues faster by leveraging precise Failure Mode insights that inform the AI alerts
- Onboard new assets into the application in a matter of days
- View top-line operating KPIs such as overall system health and all relevant data through a single application

Solution Architecture



Enterprise AI for Oil & Gas

The BHC3 AI Suite provides the necessary and comprehensive services to build enterprise-scale AI applications up to 25x faster than alternative approaches. The BHC3 AI Suite integrates all relevant data sources to rapidly generate predictive insights across the oil and gas value chain. When deployed at enterprise-scale, BHC3 applications can deliver up to $100 million and more in annual economic value to oil and gas organizations.



BHC3 provides wide-ranging Enterprise AI applications for oil and gas companies, including optimizing artificial lift systems operations, selection of drilling targets, and production operations. These pre-configured applications provide insights to automate the well lifecycle design process, allow real-time monitoring of process reliability, and lower costs of maintenance interventions.

BHC3 Reliability

Increase operations uptime by anticipating equipment risks using a system of systems approach. Unsupervised deep-learning algorithms leverage the unified data to identify anomalies and recommend prescriptive actions. Actionable insights increase production, reduce unplanned downtime, and improve safety in operations.

BHC3 Process Optimization

Improve throughput and product quality by applying advanced machine learning to complex discrete, batch, or process manufacturing data in order to pinpoint process opportunities to identify defects early and improve production yield.

BHC3 Production Optimization

Optimize upstream oil & gas production, reduce operational expenses, and improve operational visibility. BHC3 Production Optimization unifies all available data and uses AI to generate well-based virtual metering network, provide surface network visualizations, and optimize injection wells to optimize upstream production.

BHC3 Inventory Optimiztion

Minimize industrial parts and equipment inventory levels, free up working capital and reduce stock-out risks. BHC3 Inventory Optimization real-time visibility across all inventory and dynamically optimizes reorder parameters to minimize holding and shipping costs.

BHC3 Production Schedule Optimization

Optimize planning and scheduling of midstream, and downstream operations using advanced AI and machine learning. BHC3 Production Schedule Optimization generates dynamic manufacturing and distribution plans and optimal industrial schedules using a holistic view of customer demand, supply chain, manufacturing, and distribution.

BHC3 Asset Integrity

Prevent downtime, loss of containment, or safety hazards by applying advanced machine learning and computer vision to identify and address corrosion risks. Integrate physics-based models with machine learning algorithms and computer vision to predict corrosion risks and optimize intervention.

Initial Results in 8-12 Weeks | **Visit BakerHughesC3.ai/get-started**