WHITEPAPER

Maximise Oil and Gas Production with a Digital Twin Strategy

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Executive Summary:

A digital twin is the foundation of a digital transformation that optimises production, detects equipment problems before failures occur, uncovers new opportunities for process improvement, all while reducing unplanned downtime. This white paper will discuss the approach to leverage data, simulation and analytics in a Digital Twin Strategy to maximise Oil and Gas Production at lower cost:

1. Increase throughput and yield
2. Reduce unplanned downtime
3. Discover additional unattained potential uplift
4. Identify and resolve the bottlenecks preventing the extra uplift
5. Improve field workforce efficiency

Introduction

Maximise Oil and Gas Production with a Digital Twin Strategy

Oil prices have been swinging sharply in recent years, fluctuating between $30/bbl to a high of $100/bbl. The unexpected price volatility is causing stress on the CAPEX and OPEX of the oil and gas value chain. Compounding the challenges, the negative perception of fossil fuels, rising trade tensions and geopolitical upheaval are adversely affecting near-term demand and business costs.

As a result, more companies are looking towards "Digital Transformation" to drive effective capacity, not only through CAPEX, but also OPEX investments by optimising operations and improving asset availability as these are more scalable and have a shorter lead time, enabling companies to swiftly respond to market changes.

Leveraging Digital Twin Strategy in Digital Transformation

A digital twin is a complete 360-degree replica of a physical asset such as pipelines, gathering systems, heat exchangers, turbines, pumps, compressors or entire plants that enables modelling of process and control, and monitoring of equipment health. It is the foundation of a digital transformation that optimises production, detects equipment problems before failures occur, uncovers new opportunities for process improvement, all while reducing unplanned downtime.

The concept of a digital twin has been around for more than a decade. However, it is the advancement in technology in recent years – cloud platform, analytics and increased computing power – combined with greater clarity on how to use these innovations - has accelerated the adoption of digital twins in industry for more than a decade.

From unprecedented real-time insights of their operations, to elevating their operational excellence to the next level, it is no wonder oil and gas companies are starting to realise the benefits that digital twins can bring. For example, a 0.1% increase in production due to improved process and operating efficiency can easily yield several millions of dollars in additional revenue.

A Robust Asset Information Management System is Key to Achieving a Digital Twin

At a recent AVEVA World Summit, an executive from a major gas company spoke about their digital transformation journey and identified information management as the root of all challenges and opportunities of digital transformation[1].

Lacking a robust information management system to maintain up-to-date critical information and operational data around assets during operations will result in significant waste in maintenance and operations budgets, and will increase the resources needed to keep the assets running. Therefore, the key to achieving a digital twin is a comprehensive information management system that combines a centralised data repository with enterprise-wide information access and visualisation. This allows users to have complete control of their asset information throughout the entire asset lifecycle.

Building a Digital Twin

To build a digital twin for an asset, an initial 3D model is created. This model is then tagged with all the necessary attributes and engineering documentation – such as geometry, layout, connectivity of key components and process data, and other business and safety-critical engineering and design information. Through a robust information gateway, information and data around the asset are extracted from disparate data sources and validated for accuracy against known standards to create viewable renditions of documents and drawings. This acts as a data validation layer to ensure that all data meet the correct standards throughout the asset lifecycle. Next, this common set of data and information is shared across departments – from engineering, to procurement, to construction, to commission, and to operations.

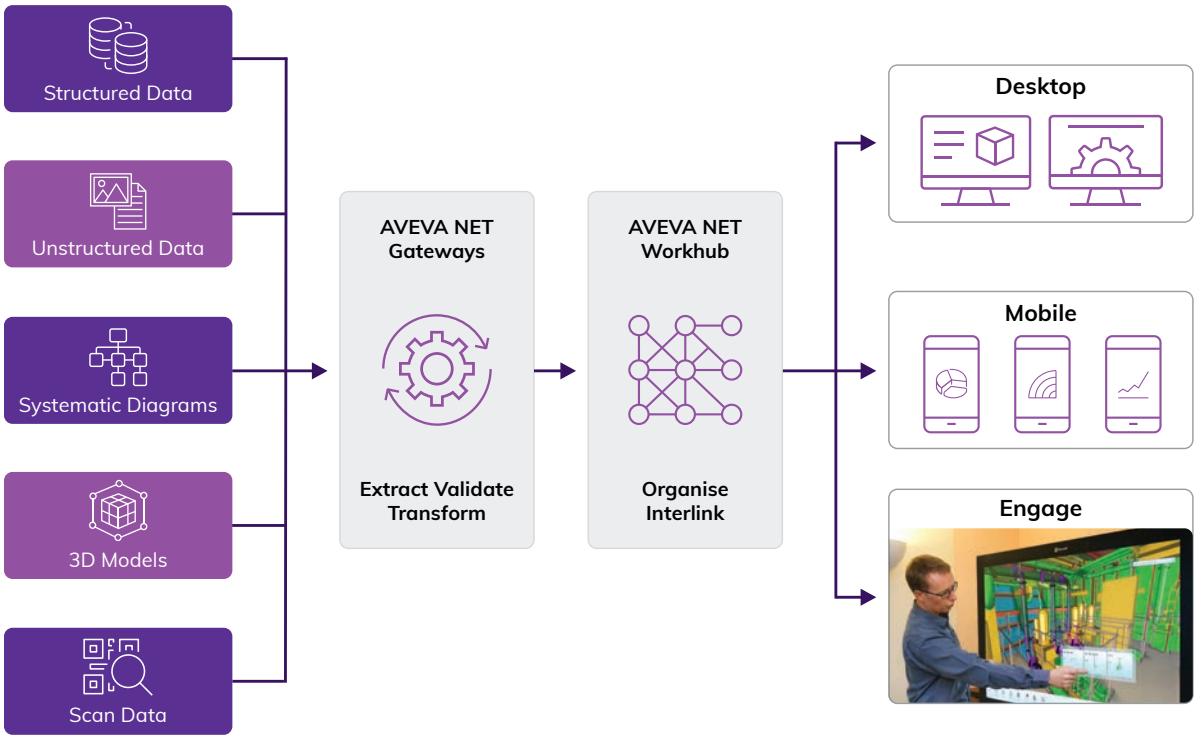

Figure 1: AVEVA NET gateways provide the interface to the source data

As the operational life continues, the digital copy is updated automatically, in real time, with current data, work records and engineering information to optimise maintenance and operational activites. Using this information, engineers and operators can easily search the asset tags to access critical up-to-date engineering and work information, and find the health of a particular asset. Previously, such tasks would take considerable time and effort, and would often lead to issues being missed, leading to failures or production outages. With the digital twin, operational and asset issues are flagged and addressed early-on, and the workflow becomes preventative, instead of reactive.

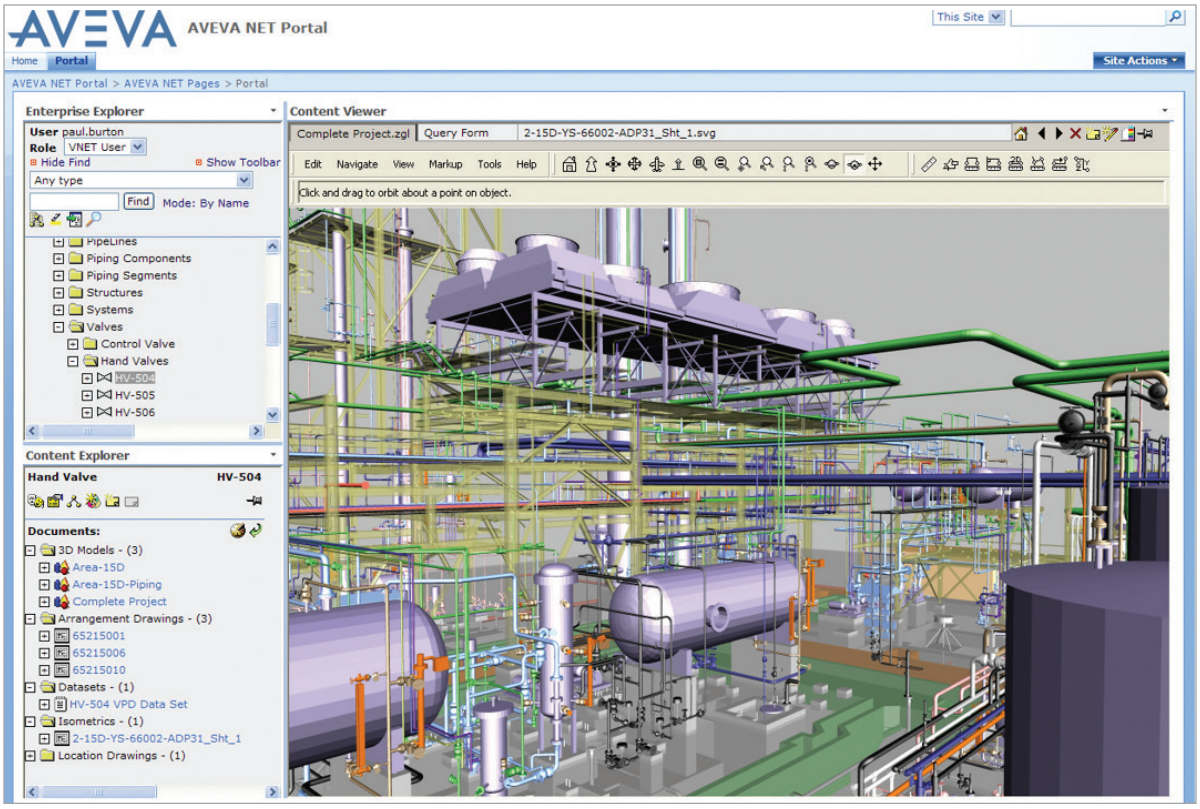

Figure 2: 3D visualisation of assets using a single, integrated source of up-to-date, trustworthy information

Figure 3: An operations management user interface

Digital Twin Enables Simulation and Analytics in Oil and Gas Fields

The reliable, real-time process data from the digital twin can be fed into simulation and analytics to optimise overall production, process conditions and even predict failures ahead of time. A digital twin, when combined with powerful analytics and process simulations, enables predictive maintenance and optimised processes.. Analytics leverage advanced pattern recognition, statistical models and machine learning technology to model an asset's operating profile and processes, and predict future performance. Appropriate, timely actions are then recommended to reduce unplanned downtime and to optimise operating conditions. With the digital twin, process simulation can also be performed to optimise the operating models based on their physical properties and thermodynamic laws.

The following four steps approach enabled by Digital Twin to maximising oil and gas production - from gathering systems to gas processing plants - is fundamental to improving performance and boosting profitability:

1. **Steady-state and dynamic simulation:** At Front End Engineering and Design (FEED) stage, steady-state simulation models of topside gas processing, such as gas dehydration, mercury removal, gas sweetening, liquification, fractionation and others, can be created to optimise the design. During operations, engineers and operators can perform engineering studies to identify design changes that will significantly increase throughput, and the reliability and safety of plant operation. Analytics can also be used to model fluid flow behaviours in pipeline multiphase or single-phase flow to predict pipeline holdup and potential slugging in the network. Understanding flow performance is key to optimising the gathering network design, reducing CAPEX, and optimising pipeline throughput. With a unified simulation platform, the evolution from a steady state to dynamic simulation can be achieved easily.

   Dynamic simulation can be performed on these models to validate process design such as relief and flare systems, changes in feedstock, production capacity adjustment, and controls, enabling engineers to optimise design and reduce CAPEX and OPEX. In addition, the dynamic simulation allows effective troubleshooting, control system checkouts and comprehensive evaluations of standard and emergency operational procedures to shorten time requirements for safe plant start-up and shutdown. This forms the backbone of an Operator Training Simulator (OTS) where operators can be trained on procedures to address real experiences in a safe and controlled classroom environment before they are deployed to offshore platforms. Major oil and gas operators have already reaped significant benefits using simulators as part of their enterprise-wide training programs, enabling them to significantly reduce training costs and time to proficiency.

2. **Analytics to reduce process variability:** Reducing process variability not only improves product quality, but also enables the process to be operated closer to its optimum points, reducing energy consumption, maximising capacity and improving product yield. Advanced Process Control (APC) has been used widely in gas processing plants to stabilise operations and reduce process variability due to varying feed gas rates, gas composition and ambient temperature. It is a multivariable model predictive control and adjusts the process conditions in real time to maximise process profits while maintaining the plant operations within the constraints.

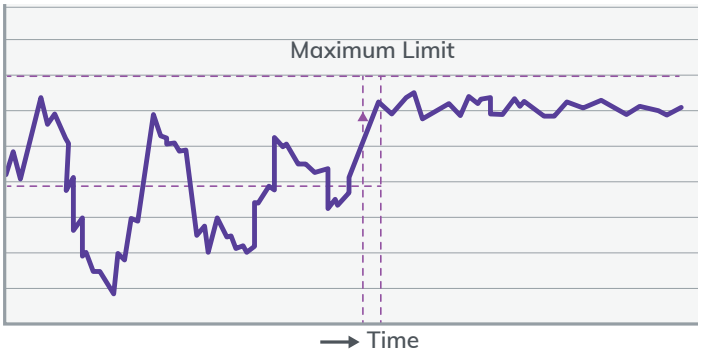

Figure 4: Reducing process variability and operating closer to the optimum points

Estimates suggest that applying APC can yield up to 2-3% increase in production and 2-5% saving in energy consumption over the asset lifecycle. Other benefits include extended equipment life, reduced operator intervention and consistent shift to shift performance. APC has been successfully implemented in liquids recovery (Cryogenic NGL recovery, Condensate stabilization, NGL fractionation) and treating/sulphur recovery.

3. **Process Performance Monitoring:** In production process, heat exchangers handle complex heat transfer and are critical to production. Equipment efficiency and instrumentation accuracy should be monitored constantly as degradation of the heat exchanger can lead to inefficiencies and production slowdowns. Having an integrated model to monitor all rotating equipment, distillation towers and heat exchangers not only allows analysis of the interactions of various plant components, but also provides additional metrics on efficiency and utilisation. Reconciliation of material, energy and equilibrium balances around a piece of equipment or entire plant can also help to identify bad instrument readings and pinpoint material and energy loss locations, effectively acting as a data validation layer. This is valuable information that cannot be measured directly, but is calculated based on first-principle, rigorous models that have been tuned to actual plant conditions.

2	Debutanizer Column	Tag Name	Actual Data	Efficiency of 1	Di
3	Ovhd LPG Rate	OVHDR.OUT	75.23	75.19	
4	BTMS Naphtha Rate	BTMSR.OUT	565.96	566.00	
5	Reboiler Duty	RDUTY.OUT	18.95	18.24	
6	Ovhd Temperature	OVHDT.OUT	171.54	171.77	
7	Feed Tray Pressure	FEEDP.OUT	177.61	177.56	
8	Bottom Pressure	BOTP.OUT	174.61	174.56	
9	Top Pressure	OVHDP.OUT	175.31	175.26	
10	Reflux Rate	REFLUXR.OU	429.54	406.67	
11	Bottom Temperature	BTMST.OUT	406.67	406.60	
12	Equilibrium Efficiency	EFF.OUT	0.9861	1.00	
13					
14					
15	Feed_BTMS Exchanger	Tag Name	Actual Data	Clean	Di
16	Overall Heat Transfer Coeff	FBHXU.OUT	81.68	103.00	
17	Overall Fouling Factor	FBHXF.OUT	0.0076	0.0050	

Figure 5: Accurately estimating efficiencies and instrument drift is possible through performance monitoring via the digital twin

4. **Predictive analytics to monitor equipment health:** Offshore platforms operate in locations exposed to extreme weather conditions, which means it often takes longer to restore back to full production rates after a planned or unplanned shutdown. Minimising plant shutdowns is therefore key to improving production. This is where predictive analysis comes in. Predictive analytics enables modelling of rotating equipment performance – such as pumps, compressors and turbines – using advanced pattern recognition and machine learning algorithms to identify and diagnose any potential operating issues, days or weeks before failures occur. Operating models including past loading, ambient and operational conditions are used to create a unique asset signature for each type of equipment. Real-time operating data is then compared against these models to detect any subtle deviations from expected equipment behaviour, allowing reliable and effective monitoring of different types of equipment with no programming required during setup. The early-warning notification allows reliability and maintenance teams to assess, identify and resolve problems, preventing major breakdowns that can cost companies millions of dollars in production slowdowns or stoppages.

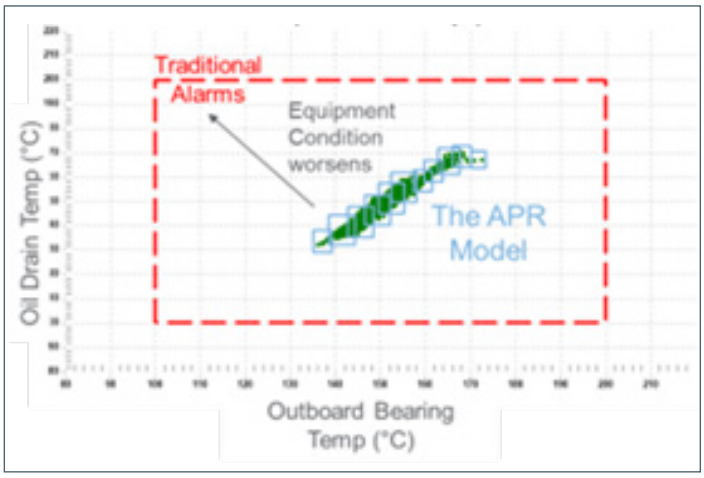

Figure 6: Using predictive analytics to monitor asset effectively

Last mile to close the performance loop

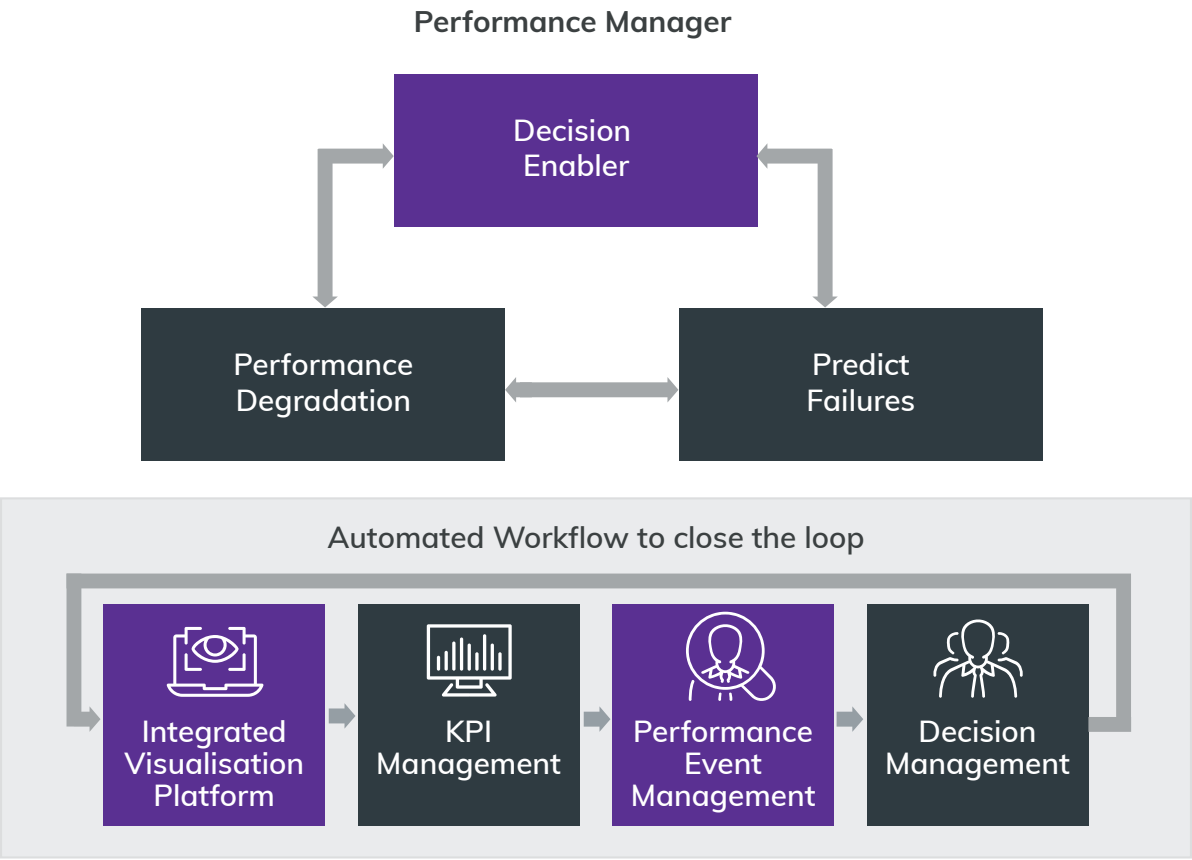

Figure 7: Closing the loop is key to extract business values from big data and analytics

Insight and process optimisation advice do not create value until action is taken to adopt and implement the new optimised set points and to address the potential equipment issues uncovered by analytics. Accurate, reliable and timely information must be channelled not only to the subject matter experts but also to executives who are empowered to make operating decisions that impact the bottom line. This is where enables like workflow management are critical to ensuring that actionable data is executed upto to seize any profit improvement opportunities. The right information is delivered to the right person at the right time.

"Technology doesn't provide value to the business. Instead, technology's value comes from doing business differently because technology makes it possible."

- George Westerman
MIT Sloan Management Review article[2].

Digital transformation allows companies to create new capabilities, new business models, and innovate ahead of their competition. It is a journey through deployment of information management systems, powerful analytics, automation of workflows and work orders, and driving behavioral change in workforce – changing when, where, which, and how work is performed and evolved.

Although digital transformation may seem like a daunting task to some, making the transition successfully can be profoundly rewarding for companies, since even slight improvements in asset utilisation can result in huge gains in revenue and cashflow.

Conclusion

The digital twin framework, enables operational excellence by helping oil and gas operators and owners take a model-focused approach that quickly turns massive amounts of data into wisdom that generates business value.

These powerful data insights mean asset failure can be predicted, hidden revenue opportunities can be uncovered and realised, and businesses can continuously improve in the ever-changing, competitive marketplace.

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About the Author

Eddy Lek, Industry Marketing Manager, AVEVA, is responsible for expanding awareness and marketing of its engineering and design, simulation, training, analytics and advanced control software in the Oil and Gas Industry. He is passionate in advocating the use of digital tools to help companies improve operational efficiency. He has more than 15 years of experience in product management, marketing, business development and application consultation in process and industrial automation including controls, sensors, instrumentations and industrial software. He holds a Bachelor of Engineering from Nanyang Technological University and a Master's in Business Administration from National University of Singapore.