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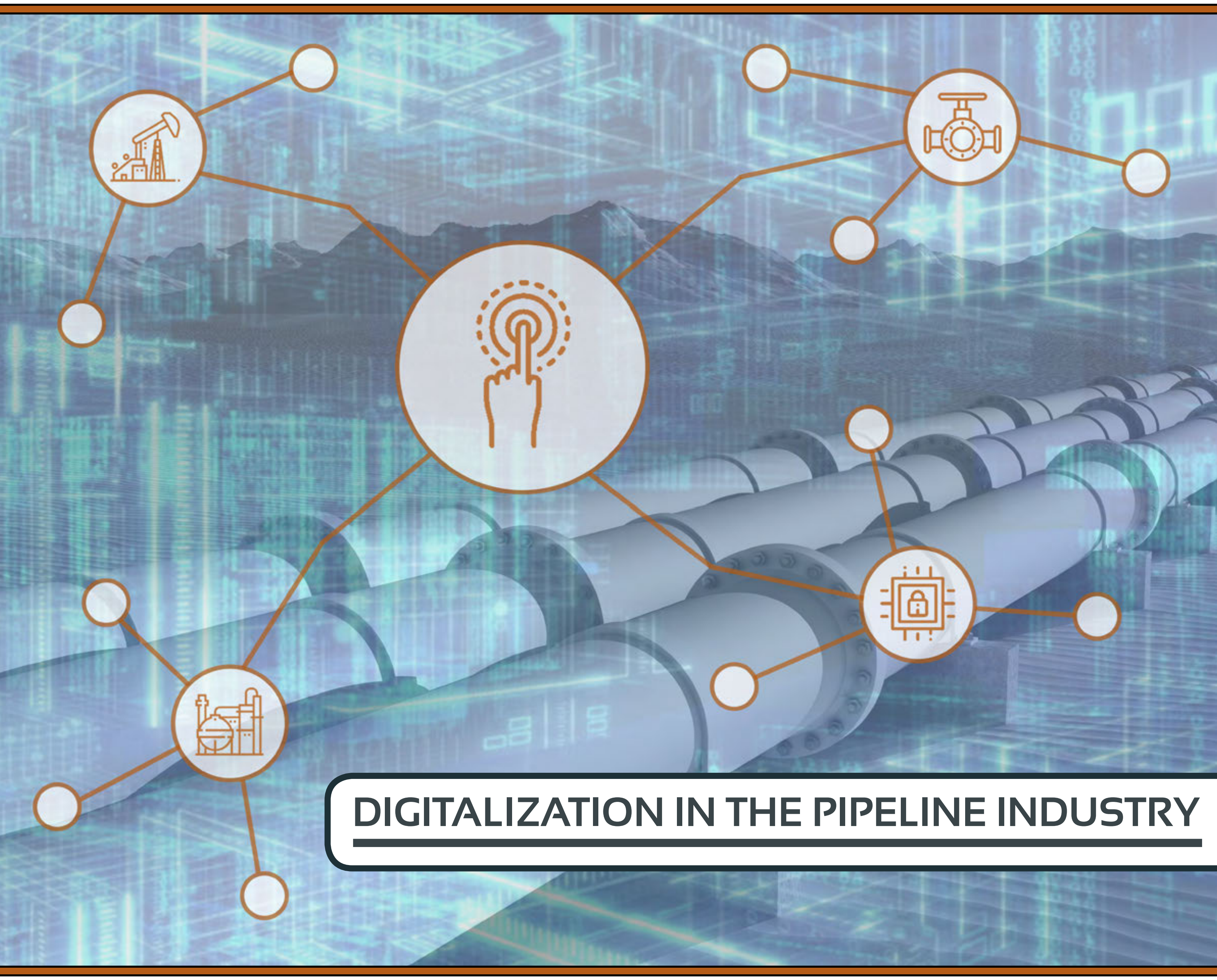

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Moving forward with digitalization and data smart technologies in the pipeline industry

Kaare Helle
Innovation Manager at
DNV GL - Oil & Gas

Each year at DNV GL we produce a report which is an industry benchmark study on the outlook for the year ahead in the oil and gas industry. The 2019 report, 'A test of resilience' is based on a global survey that incorporates the views of 791 senior industry professionals.

Our survey found that digitalization is comfortably the leading R&D priority for the oil and gas industry in 2019 with 45% of respondents putting it at number one and 15% putting R&D in the pipeline sector at number five.

A tight focus on efficiency has been the status quo across the oil and gas industry ever since the downturn in 2014. It comes as little surprise, then, that much of the industry's research and development (R&D) spend is focused on technologies to enhance the efficiency of new projects or existing operations.

Digitalization and data-smart technologies are core to the strategies of many organisations and vital to contain costs, improve safety and reduce downtime.

At DNV GL we see the following as some of key digital technologies influencing the pipeline industry:

- **Blockchain- Decentralized energy transactions, metering and billing.**
- **Artificial intelligence/Machine learning- Enhanced forecasting models, new insights into large operational asset data sets.**
- **Data platforms - Data sharing between asset owners, operators, regulators and investors, DNV GL's platform Veracity being an example.**
- **Drones and remote sensing - Enhanced safety through use of drones for pipeline inspections, monitoring using satellite data.**
- **Mobile connectivity and tablet devices - Mobile and tablet devices to standardize field-based workflow and automate data collection.**
- **Big data and data management - Benchmarking of asset performance, application of machine learning across large numbers of diverse assets.**
- **Application programming interface (API) and software as a service (SAAS) - Engineering and analytic models provided and shared between stakeholders enabling enhanced cooperation between stakeholders.**
- **Digital twins - Pipeline digital twins for remaining life calculations, failure and reliability forecasts.**

So, looking into the future we believe new pipelines, including cross-border and national transmission systems, LNG export and receiving terminals, LNG bunkering and LNG carriers of varying scale will all be required as the industry connects new sources of supply with changing demand centres. Decarbonization, digitalization and the now ingrained need for cost-efficiency, will help create the reshaped pipeline sector of the future.

This issue of ptj will highlight some of the key digital transformations we are seeing in the pipeline industry including pipeline performance, maintenance and integrity management.

Yours,

Kaare Helle

> Kaare Helle, Innovation Manager, DNV GL - Oil & Gas

THIS ISSUE'S COMPLETE CONTENT

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Operations & Integrity Management and Compliance in an age of IIOT

Steve Hill > Honeywell Process Automation Solutions

Abstract

There are approximately 4 million miles of pipelines spanning some 120 countries across the globe, carrying oil, gas and other potentially volatile liquids and gases. The pipelines cross deserts, oceans and some of the most inhospitable environments known to man.

Honeywell have provided control systems for pipelines for over 30 years, and now we see how IIOT is being used by Maintenance and Operations staff with innovations such as Intelligent Wearables to bring plant critical data back to a central location and how it can be analysed and used to make the right decisions expediently. UAV's are now being used to detect hairline fractures in pipelines, as well as providing high-resolution images to assist with security and maintenance procedures.

Remote Operations is becoming more prevalent with the shortage of skilled personnel driving this demand, we will share some of the technologies involved in this solution, along with this we will also discuss what the modern control room looks like and the drivers to replace Modbus and how this forms part of a modern Cyber Secure facility.

The move from Operation to Business Management and how technology can empower staff to combine the knowledge they have with powerful analytics to make intelligent decisions is leading to increased profitability with the knowledge the process is being managed with the highest level of safety.

INTRODUCTION

As IIOT, EU legislation, local government, HSE and cyber and physical security challenges converge to provide every more complex challenges for today's pipeline operator, we will take a look at some of the advances that have been made to help ease the burden of operation and management. We will visit in general terms how this technology is being adopted and then late look at the steps one would need to take to embark upon a programme of adoption for the technologies we will discuss. Finally, we will summarise the current situation and look at how IIOT will influence us all going forwards.

Figure 2: The evolution of control systems

NEW TECHNOLOGIES

We all know how industry lags adoption of new technology, this is both due to the conservative nature of the industry and the time taken to convert innovation to a meaningful solution that is readily understood and hence adoptable. Taking advantage of technology such as Microsoft's HoloLens, we are able to tackle one of the issues industry faces with retiring workforce leading to knowledge loss and also the shift in learning styles forced on us by the Millennial Generation. We can now train maintenance and operations staff in a safe environment using a training method they are both familiar and comfortable with to give a 'pick up and go' method which can be revisited to refresh and reinforce learning at a pace to suit the individual in a location convenient for the user and their manager.

Figure 3: IIOT and its influence on technology

Figure 1: Intelligent Wearables & Augmented Reality (AR)

As technology advances and processes which previously relied upon manual intervention become more automated, we have seen the changes and improvements in safety as a result of automation. This change is relentless and we now see a new generation dealing with the innovation shown in figure 3.

As a result of this we now see how Intelligent Wearables can be used to train new staff, supplement & refresh the knowledge of experienced operators and provide cutting edge remote diagnostic data to the right people, propitiously.

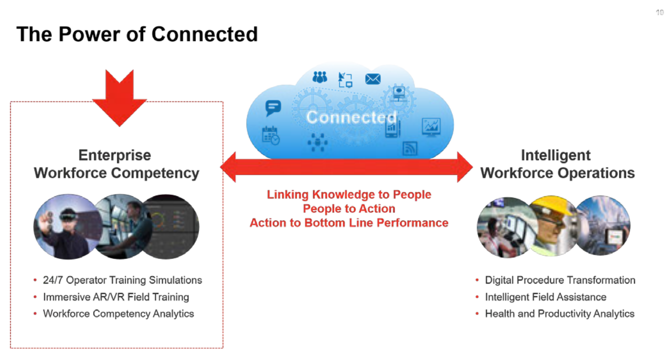

Figure 4: Connecting the right people at the right time

The modern worker can learn at their own pace, refresh their learning at a time to suit them and gain valuable insight and learning from more-experienced staff, ensuring operational safety, knowledge retention and reduced downtime.

Figure 5: Unmanned Aerial Vehicle

Another technology that has come to the fore in recent years is the UAV or 'Drone'. Originally seen as a novelty, the enhancements such as lift technology, GPS, gyroscopic stabilisation, 4k camera miniturisation and lithium battery technology and, most importantly of all, the intelligent software advances, have meant that these units are now used for a variety of industrial applications, such as :-

- Pipeline Inspection
- Crack detection
- Maintenance inspections
- GIS mapping
- Flarestack inspections
- Solar farm inspections
- Security routines
- Vegetation management

This technology, in the hands of trained pilots, along with the right analytical software is attracting new clients every week, making operations safer, proactive and more cost-effective, as well as streamlining maintenance routines and providing access to topographically and geographically challenging terrains.

Figure 6: The rise of Cyber attacks

With the introduction of legislation and regulation such as ISO 27001 and IEC 27443 and the Directive on Security of Network & Information Systems (the NIS Directive) another layer of responsibility is introduced for an increasingly pressurised work-force to manage. This is exacerbated by the retirement of the 'Baby-Boomers' and 'Generation X' taking with it a valuable amount of knowledge and experience which is very difficult to capture and transition to a modern workforce, who are extremely capable but have not benefited from the experience and learning the transition from pneumatics to electronic processes have afforded the earlier generations.

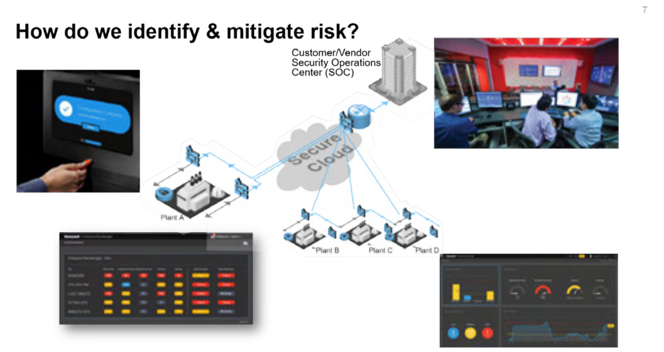

Figure 7: Mitigation of risk

We need a comprehensive solution with several touchpoints to address the various risks industries face. If we look at the physical and the logical, they each bring their own set of unique challenges. From the physical perspective, we have USB-interfaces hosting keyboards, mice, pen-drives etc, RJ-45, serial and parallel (for us older users!) amongst others. The logical entry points are innumerable but not unmanageable. Layered defence is the best approach: using advanced threat intelligence; live risk management reporting on Network & Endpoint security, Patching and Back-up status and physical checkpointing of hardware all backed up by an over-arching remote Security Operations Centre.

> *"Legislation, external forces and technology are forcing companies to look to the future, today*
> Steve Hill

REMOTE OPERATIONS

Traditionally remote operations were the preserve of clients with pipelines assets in uninhabitable or hard to reach locations. There is now a real push to locate services and applications in datacentres (either managed by third-parties like Microsoft or by the client themselves), this is driven by the lack of IT resources needed to manage the server infrastructure, including patching, upgrades, maintenance and repair or to capitalise on much reduced CAPEX costs involved in a remote installation, preferring instead to move to a predictable SaaS model.

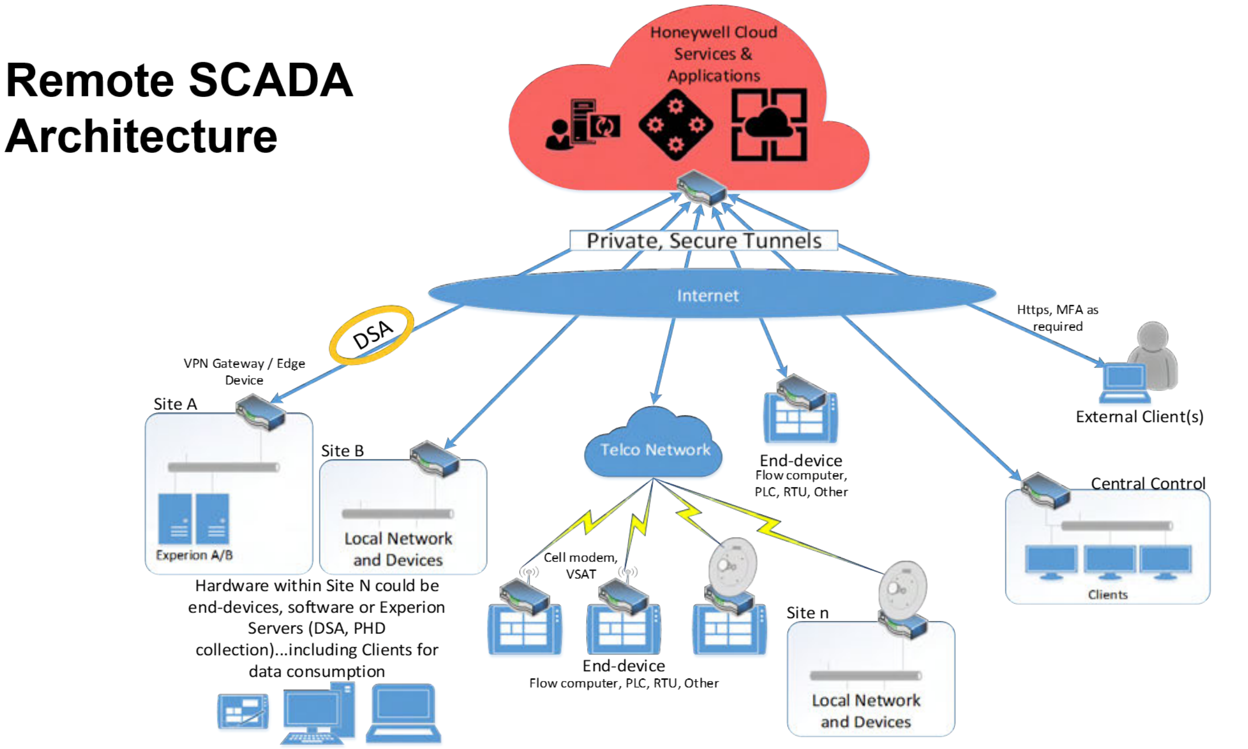

Figure 8: Typical remote SCADA architecture

We can see from model above that we have a much-reduced hardware footprint, this also means that initial start-up can be much quicker, providing meaningful data from project kick-off in less than two weeks in some cases. The engine remains the same, so technicians don't need to learn new system configuration or architectures, it's just a remote model.

SECURITY CONCERNS

Modern datacentres attract the most investment, have the best physical & logical security and have some of the best engineers operating and maintaining their systems. Users pay to access their data securely across the globe 24*7, clients from banking, pharmaceutical, security, accounting and government agencies have used these facilities for several years, so it's not new, it's just new to pipelines.

MODBUS REPLACEMENT

Modbus has served us well since its inception by Modicon at the end of the 1970's. Once you had mastered its idiosyncrasies it was easy to apply across a number of systems, regardless of manufacturer. However, in the last few years there has been a concerted drive to replace Modbus to address the security issues it exposes, such as user authentication, certification, endpoint protection issues or the ability to view the data with readily available sniffer software. Even if we do decide to secure it, it's not a low-cost solution nor is it widely adopted.

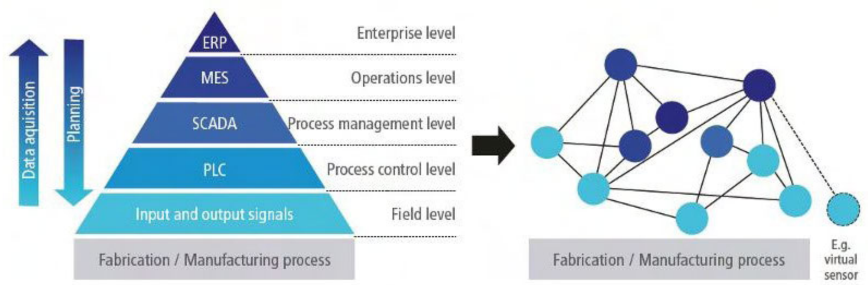

Figure 9: OPC vertical and horizontal integration

With the mass adoption of OPC-UA since its introduction several years ago, Modbus is slowly being replaced as users become more security conscious and data hungry. OPC-UA has a number advantages; it is plug-and-play, if you follow guideline implementation suggestions it has good protection out of the box, packet security can be added readily, data integration with third-parties is supported allowing secure passage of data from sensor to Enterprise level easily.

Multi-platform support is provided and the migration path from legacy OPC is straightforward.

THE MODERN CONTROL ROOM

So, what does the modern control room look like? What does it offer the operator and how does it allow them to move from Pipeline Operator to Pipeline Business Operator?

Figure 10: Operations, Engineering & Management collaboration

The figure above shows us what is happening now, we can use Collaboration Stations to share ideas, data-sheets, P&ID's and live video streams to analyse pipeline operations in real-time and make sound business decisions rapidly using the most up-to-date information. If we then couple this with intelligence we can import from Wearable Solutions in conjunction with input from experts who can also access the live data remotely and provide input via Skype or other video streaming tools, we can start to see how the Operator moves towards a Business Operator role because they have the correct information, at the right time with the best analysis, allowing them to move from a reactive to proactive/predictive operational standpoint.

Figure 11: The Orion Console

The advances we have made in recent times bringing this data together complements the solutions we have had for many years with our Console Stations shown below, incorporating, ICSS, DCS, ESD, F&G and PABX onto a single working environment capable of safe operation by one or two operations staff.

WHERE TO START?

How do we start to incorporate this thinking into our new or existing projects?

> *"Embracing technology and adapting is no longer an option... it's a must"* Steve Hill

UAV

If we look at UAV technology, the hardware costs have fallen and sophisticated units can be made available for a tenth of the cost they were even five years ago, couple that with the advanced analytical software that has been developed and the availability of certified pilots and it can seen that this offering is within reach, starting with proof of concept programme offerings to establish value, through to fully managed support contracts with training, reporting and remedial capabilities with three deployment centres in Central Europe alone.

INTELLIGENT WEARABLES

Intelligent Wearables have been adopted by a number of major Oil & Gas companies, the ability to train, maintain and inform in real-time is seen as a major benefit and, according to independent research, is welcomed by the 'Millennial Generation' who demand instant information access and have been proven to respond well to this delivery method as opposed to the traditional classroom approach (which still has a place for certain trainees). Trial programmes are again available and the range of product and solution training we offer is growing all the while.

CYBER SECURITY

As of May 2018, Governments were under obligation in Europe to identify Critical Infrastructure as part of the NIST directive. At Honeywell, we have worked closely with industry to provide consultative services as well as engineering support to analyse customer's needs, implement protection programmes and provide ongoing 24*7 support to provide piece of mind, active threat analysis and on-line patching. We can also offer 'Ethical Hacking' to pressure test systems as part of our consultative service in order to establish a base-line for new clients prior to putting together a solution. This is augmented by our hardware solutions including SMX, or Secure Media Exchange, available in both ruggedised (RT) and non-ruggedised (ST) versions to provide gatekeeper services where USB pen-drives are part of normal operations.

REMOTE OPERATIONS

Imagine being able to go from letter of intent to first information delivery in a matter of weeks, well, that is one of the benefits of Remote SCADA, smooth transitioning from a legacy system to Remote SCADA is key to a successful project, and this is what we can offer as part of a turnkey solution.

MODBUS REPLACEMENT

Documentation and comprehensive survey works help us to map a legacy system for transition to OPC, we can use Matrikon, FieldServer protocol, Matrikon or even Kepware to as an interim measure as we map the legacy system before replacing the hardware as part of a longer-term project, this is often done as part of a DCS migration or upgrade and is a common requirement for our project teams.

CONTROL ROOM MODERNISATION

With the capability to survey, supply, install and configure a comprehensive range of control room furniture, in conjunction or separately to our control system solutions, Honeywell are very experienced in offering client's consultation to ensure adherence to the latest NAMUR & EEMUA guidelines as well as HSE guidelines for Operator heating, lighting and ventilation requirements. Adopting our Collaboration Station solution has proved very popular with customers and has enriched operators role as the more mundane tasks become automated (and hence, not overlooked), allowing them to concentrate on more interesting and compelling tasks lead them to start to act as Business Managers of the systems they oversee and providing them with the necessary data in a timely manner to allow informed business decisions which are backed-up with reporting to ensure the correct decision is made at the right time.

CONCLUSION

Honeywell have a range of scaleable solutions designed for small, medium and large scale pipeline owners and operators. Our full lifetime service starts with our best-in-class auditing services followed by planning, installation & implementation. This is followed by post-installation maintenance and constantly-current hardware and software offering, providing piece of mind, cost-effective implementation and the reassurance of a world-wide support network.

Owners of oil and gas pipelines need to recognise that the most important elements of a security program (both physical and digital) are identifying business risks, being proactive, embracing a security philosophy, and developing a long-term strategy that eliminates (or reduces) potential threats.

In order to protect their systems and networks, pipeline operators require a comprehensive approach to new technology, cyber security and innovative adoption policies which involves ongoing risk assessment, well-defined security policies and an aggressive overall security posture. This will lead to safer operating and working environments, lower OPEX costs and increased margins if implemented successfully.

> *"Digital transformation affects all industry and it's becoming more important to ensure your process and operations keep pace, or risk getting left behind*
>
> *Steve Hill*

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New Technologies Drive Operational Performance by Connecting Smart Stations to Distribution Networks

Rossella Mimmi > Emerson Automation Solutions

Abstract

Natural Gas distribution companies have been historically slow to adopt new technologies, especially so-called "Smart" technologies, in their networks. Their counterparts in electric utilities, process plants, and even gas transmission have widely adopted connected components and solutions to quickly give them access to data to make decisions, improve the safety of their systems, and provide them with the functionality they need to improve their operations. Recently, the Natural Gas distribution segment has begun to catch up by adopting these types of technologies to enjoy similar results. Solution providers in the industry have developed customized systems for customers and when coupled with a digital ecosystem, they can drive substantial value for gas utility companies.

INDUSTRY CHALLENGES

There are several challenges that Natural Gas Transmission and Distribution companies are facing in these days.

Together with traditional Natural Gas sources, other sources are becoming relevant, such as LNG and fracking gas. The increased attention to the environment and the necessity to comply to European directives is incentivizing the use of Biomethane, coming from renewable sources; private and public companies are now interested in the production of Biomethane that can be injected into the Natural Gas grid. Of course, the gas supply diversification must be controlled. Gas utilities have clear objectives to meet the target quantity for each source, but they need to ensure that the gas quality is acceptable before injection. In addition, the unconventional sources must be seamlessly integrated into the grid, so operators can take advantages of them when they are available but can also count on traditional sources if necessary.

The environmental cause is driving also the need of a drastic reduction of emissions and energy consumption; the impact of GHG emissions on the atmosphere is well known, and the gas industry is evaluating different solutions to reduce emissions and optimize energy consumption.

The customer base has to be adjusted and expanded to include more users and new usages such as Natural Gas vehicles. In the meantime, it's necessary to remember that Natural Gas is potentially a dangerous fluid, so the attention to safety must be higher than ever to minimize accidents and their undesirable outcome: leakage, possible interruption in gas delivery and, in the worst cases, explosions that can cause harm to pipelines, devices and people. Among the safety concerns also noise must be included, as it can be considered as a potential issue; it's important to reduce it as much as possible, especially in the countries where pressure reducing stations are installed in areas with a high population density.

Figure 1: Axial Flow Pressure Regulators equipped with RAF system

Cost reduction is another important challenge for gas companies. In many cases budgets have been reduced, and companies have now to perform the same activities and reach the same goals with reduced resources. This brings the necessity to optimize resources and possibly reduce some of their activities on site. With reference to equipment, an improved reliability (achieved, from example, from avoiding working at stress limit) means reduced unplanned maintenance activities and, at the end, lower ownership costs.

At the distribution end, new pressure reducing and metering stations are oversized, include redundant layers of safety, and are set at higher than necessary pressure to anticipate further demand growth, or plan for failures and emergency demand picks. Several manual adjustments are required to modify the district station set point, in order to operate at the required pressure levels and fulfill variable demand requirements from users (seasonal demand variations but also different consumption values during the day). This activity is time consuming and requires dedicated personnel to be on site. This is more true and challenging if it is considered that gas grids are designed to satisfy the maximum demand in the extreme operating conditions, that typically happens once or twice a year (or sometimes never) and for a limited time frame. This means that gas grids are normally operated at the highest pressure level to ensure gas availability during high demand periods. These practices increase upfront investments, creates stress on the pressure management equipment, while higher set pressure results in downstream gas leakages.

OBJECTIVES & STRATEGIES

Several years ago, gas distribution companies launched their first foray into value-driving technology when they began to adopt smart metering to improve the accuracy and efficiency of their billing. Now in various parts of the world, these companies are more willing to experiment with technology that can give operators the ability to monitor system parameters, manage the flow of gas through their network, and control individual stations from remote locations. The complete system benefits include improvement in safety, reliability, operational efficiency and profitability, while giving operators greater visibility and control of their gas systems. This article explores the key strategies that gas distribution companies are employing today and how interconnected "Smart" systems are driving value for key stakeholders in these organizations.

During our analysis, we determined that companies in this space have four common themes which drive the basis of their strategic priorities:

1. System Risk Management
2. Improvement in Gas Delivery Efficiency
3. Emphasis on System Infrastructure and Design
4. Environmental Stewardship

All the critical strategies just described often come with execution challenges that cost operators unnecessary expenses and lost product.

However, advancements in technology available to gas distribution will effectively address all four of these common themes. Using innovative and interconnected solutions through the entire lifecycle of Natural Gas, especially in Distribution, allows companies to optimize their operations, keeping an optimal timing, utilizing resources in a more effective way and improve systems safety.

SOLUTIONS & METHODOLOGIES

What are the features and functionality of "Smart" gas systems, and how can they assist distribution companies in achieving their strategic goals?

Smart technologies are essentially scalable systems which enable local and remote control and monitoring of the pressure reducing stations. They are based on dedicated logic, and they can be customized to meet customers' specific requirements.

Figure 2: Smart Skid Demo Unit

These systems consist of a central unit which receives system parameters (temperature, pressure, flow), processes that information, controls pressure management equipment and interfaces with control loops. It could be used at an individual station or for multiple pressure reducing and metering points across the distribution grid. An interface can control various components such as solenoid valves, pressure transducers, and temperature sensors. Communication with existing networks is also vitally important for the success of any system upgrade. Local and remote communication capabilities (webserver, USB, Ethernet, GPRS, etc.) and the possibility to interface with existing SCADA system (through MODBUS, TCP/UIP Protocols) are desirable features of equipment in such networks.

Let's now analyze the more interesting functionalities.

SAFETY AND RISK MANAGEMENT:

The ability to remotely monitor and operate smart gas systems is one of the main advantages of this technology. Not only are operators able to manage the system quicker, but also fewer trips to the field are required, meaning fewer safety concerns from sending people to remote and potentially hazardous areas. Noise levels are a common concern at such stations; this technology enables maintenance personnel to distance themselves from high noise levels. The system is also able to split the total flow into more lines and control the flow through each regulator, further reducing the noise emitted from a station. In addition, the capability of precisely control the flow in each of the reducing line has a positive effect on the regulators, enabling them to work in their ideal range and avoiding unnecessary stress on these devices.

Figure 3: Axial Flow Pressure Regulators equipped with RAF system

Another application of Smart technologies is represented by odorant injection systems. Gas needs to be odorized to ensure that eventual leaks can be immediately smelled. The quantity of odorant liquid to inject into the gas must be very accurate; both under-odorization and over-odorization bring some issues. In case of under-odorization, the gas will not be correctly odorized and that brings a high safety concern in case of a leak. On the other end, over-odorization can expose all devices to a potential risk (odorant liquid is highly corrosive) and ownership costs will increase due to the high cost of the liquid. Moreover, a small discharge of gas during, for example, the opening of a relief valve, will cause an intense odor resulting in many calls to the authorities. Smart equipment can be installed in odorant injection systems to reduce complexity of the process and ensure that a very accurate mixture of gas and odorant is injected into the grid.

GAS DELIVERY EFFICIENCY:

The ability to estimate gas flow where no meter is installed and monitor other parameters (temperature and pressure) at multiple points allows accurate flow/pressure mapping across the grid. During standard operation, the user could utilize this information to properly balance the grid by adjusting pressure setpoints, thereby remotely accommodating seasonal changes in downstream demand.

It will also be possible to control each regulating line, deciding the exact flow rate that flows through it, and even to close one line by bringing the pressure regulator in closing mode. This will allow the regulators to work in the proper range, avoiding stress limits and reducing unplanned maintenance interventions and risk of interrupted delivery.

Another great application of these smart technologies is relevant to the gas pre-heating. Natural Gas, depending on the weather conditions and the reference country, can have a very low temperature that can become dangerous when the pressure is reduced, causing the water particles inside the gas to freeze and possibly obstruct the small tubing inside the pilots. To avoid this, it is necessary to pre-heat the gas using, for example, gas/water heat exchangers. If the energy consumption is not optimized, there is the risk to heat the water when it's not necessary (for example in case of no flow), wasting energy. Smart technologies can now manage the boiler room and control, with a high accuracy, the inlet and outlet temperatures of both gas and water, optimizing energy consumption and reducing unnecessary costs.

In Fiscal Measurement applications, the possibility of controlling the flow capacity in each line will help guarantee Custody Transfer accuracy and ensure compliance to regulations. The system will close the line when the flow rate will decrease under the limit guaranteed to ensure the measurement accuracy requested by the Standards.

SYSTEM INFRASTRUCTURE AND DESIGN:

Often when distribution companies build out their infrastructure, they tend to oversize the regulating station because the commercial or residential demand downstream has yet to be established. When grid upgrades are considered, smart systems can limit oversizing. And as Natural Gas supply becomes more diverse, for example the expanded use of biomethane, new technologies can seamlessly balance various gas sources at grid injection points and manage gas quality for non-traditional gas sources with no change in system operating conditions.

Taking this a step further, control loops have been programmed to balance, locally and in real time, the supply/demand ratio. Additionally, the system can collect data to use in predictive analytics and forecasting which can later be used in elaborate predictive maintenance algorithms. This enables distribution companies to better utilize their manpower for maintenance tasks and operations that must be performed locally from the time of installation.

ENVIRONMENTAL STEWARDSHIP:

Through remote monitoring and tighter control of system pressure, the average pressure in the grid can be lowered, therefore lowering stress on system joints and piping. In addition, as there is a link between the operating pressure in a network and the leakage and emissions rate, it will be possible to limit this risk by lowering the grid pressure; this will result in cost saving, avoiding discharging gas into the atmosphere, and protection for the environment.

It has already been mentioned the system capability of working with Biomethane and integrating the new stations that are being built; Biomethane is considered a renewable gas and its injection into the grid contributes to meet the European Union renewable energy targets and contrast climate change.

RESULTS

Many control systems developed by industry experts can generate continuous savings and even a return on investment in less than a year, depending on the size of the network and the complexity of the system. At the network level, the system advances critical strategies of gas utilities through smarter grid management and savings in maintenance costs, lost gas, and more efficient resource deployment.

By embracing these new technologies and tapping into vast solution expertise in the space, distribution companies can reach peak operational performance while also improving their safety and environmental metrics in the process.

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Intelligent Predictive Maintenance in the context of Maintenance 4.0 for Oil & Gas Industry

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Abstract

Scenario of oil prices fluctuations has not only forced inefficient Oil & Gas companies to improve their productivity and supply chain costs, but it will also push the efficient companies to find ways to protect their top & bottom lines. A set of new digital technologies such as Internet of Things (IoT), Industry 4.0 promises to aid Oil & Gas companies tackle the challenges arising out in this new oil price regime. IoT basically integrates sensing, communications, and analytics capabilities of equipment, infrastructure like pipelines, etc. using digital technology and to manage their existing assets in an efficient manner. Thus, purpose of this paper is to investigate the impact of these new digital technologies on predictive maintenance practices.

A detailed literature survey has been carried out in order to identify and describe the conceptual constructs contributing to predictive maintenance within a Maintenance 4.0 setting such as value creation through Internet of Services (IoS), Internet of Things (IoT), Smart Solutions (SS), Smart Factory (SF), Cloud Computing (CC). Further, a survey through Focus Group Discussions/ Semi-structured Interviews was conducted in Indian Oil & Gas companies with reference to identified conceptual constructs.

A conceptual Intelligent Predictive Maintenance (IPM) framework and CSSI (Create-Share-Synthesize-Implement) model have been developed in this study for the aspects related to IPM such as value creation through smart services, remote-service delivery, smart solutions & digital innovation, digital analytics, data-driven operational excellence, machine-to-machine communication, and mobile & cloud computing and merits of this framework. This study shows that it is possible to perform & provide a remote technical assistance and asset maintenance support using intelligent sensors, real time condition monitoring, predicate analytics, and distributive system technologies with need of least manual intervention.

IPM framework and CSSI model is beneficial to practitioners such as asset maintenance engineers and managers in the midstream Oil & Gas companies in the industry in order to decide on the development of IPM infrastructure and its implementation in their organizations. Key challenges with recommended actions based on IPM framework are also proposed.

1.0 INTRODUCTION

The industrial revolutions were always led by new technology developments happened in the industry. Industry 1.0 was the result of invention of water and steam mechanical equipment and its manufacturing at the end of the 18th Century. The second major industrial revolution Industry 2.0 was the use of conveyor belts for assembly lines during the starting of the year 1900. The new technology development of microelectronics used Personal Computers (PC) & Programmable Logic Controllers (PLC) for automation purposes in manufacturing industry in the 1970's led to third major industrial revolution Industry 3.0. Now, the development of connectivity of PCs and equipment throughout large networks named as Internet could enable the Cyber Physical Systems (CPS) which leads to fourth industrial revolution- Industry 4.0 (Indsutrie4.0_Report, 2013).

This connectivity technology is playing crucial role in the industry where internet enables growing number of devices become web-enabled and these concepts would be applied to improve manufacturing efficiencies. This kind of application is referred as Internet of Things (IoT). The industry experts estimate that worldwide 80% of organizations will implement IoT applications into their businesses in some or other way in next five years' time. Further, Internet of Things is a crucial driver to deliver 2% to 3% additional revenue in the business (Koch, Geissbauer, & Schrauf, 2014).

There are four basic elements in IoT such as Device, Connectivity with the device, Data and Analytics of the data. The device could be from one sensor to a large-scale control system. The data generated by the sensor or control system are collected through the network connectivity. And, the analysis of these data to prepare actionable information would help industry managers to make informed decisions in business problems (Zorzi, Gluhak, Lange, & Bassi, 2010). Application of IoT to drive new insights and optimizations of manufacturing process and overall supply chain in industry is referred as Industrial Internet of Things (IIoT).

The major challenges in maintenance are the technology left unused completely even after implementation of systems like Computerized Maintenance Management Systems (CMMS) because it failed to address the specific industry needs, reactive approach to maintenance, design mistakes & failures of sensors due its complexity and maintainability, and the skilled manpower to handle such sophisticated and automated systems. One of the solutions to these issues is implementation of Intelligent Predictive Maintenance (IPM) using IIoT technology which expands conventional condition monitoring approaches by offering an insight into the "equipment's future". It is therefore providing new alternatives for increasing efficiency and reducing the Total Cost of Ownership (Schaeffler Technologies AG & Co., 2015).

Oil & Gas organizations in the industry have also started using the basic principles of IoT and Industry 4.0 to implement the interconnected equipment and systems in order to form an intelligent network spanning its entire value chain. This type of selfcontrolled network systems helps to identify the unexpected changes in the production process, predict equipment failures and also to prompt timely maintenance actions using Intelligent Predictive Maintenance (IPM) framework (World Economic Forum, 2015)

The Maintenance 4.0 technology enabled just-in time IPM helps Oil & Gas organizations to achieve near-zero downtime in operations. In an industry as diverse as Oil & Gas, there is no one IPM framework fits to all. But, there are three business objectives relevant to IPM framework in O & G Industry: improving reliability, optimizing operations and creating new value across value chain. However, O & G organizations in mid-stream business can understand the impediments to value creation across hydrocarbon supply chain such higher pipeline network integrity, new commercial activities etc. and position themselves to capture maximum out of Maintenance 4.0 IPM framework (Michael & Mark, 2015).

The conceptual constructs contributing to predictive maintenance within a Maintenance 4.0 setting such as value creation through Internet of Services (IoS), Internet of Things (IoT), Smart Solutions (SS), Smart Factory (SF), Cloud Computing (CC) with reference to maintenance management are reviewed and discussed in detail in this paper. Further, it is also discussed the influence of these factors in maintenance at Oil & Gas organizations. The structure of this paper is as given under:

In Section 2, the concepts and background of the above conceptual constructs with respect to predictive maintenance in the context of Maintenance 4.0 are provided. In Section 3, IoT deployments in mid-stream O & G organizations to create flow information around the value loop which are most relevant to a given business opportunity are discussed in detail. This section also presents the key bottlenecks and addresses the solutions to them. In Section 4, a conceptual framework for implementing intelligent predictive maintenance system within Maintenance 4.0 environment in mid-stream O & G organizations in the industry is proposed and discussed. In Section 5, the merits of the proposed IPM conceptual framework are deliberated and also highlighted the key challenges with recommended actions to overcome present maintenance challenges in the industry. Section 6 concludes with contributions, future scope and limitations of this study.

2.0 INTELLIGENT PREDICTIVE MAINTENANCE – MAINTENANCE 4.0 CONCEPTUAL CONSTRUCTS

2.1 INTERNET OF SERVICES

The data emerged in the age of Internet of information is named as Internet of Services (IoS). The two key contributors for technological or business purposes are Web Service Interface (WSI) and Service Oriented Architecture (SOA) (schroth & Janner, 2007). The purpose of these services available in these platforms is interconnection of people, process, objects and systems. It can also facilitate features such as adaptability, collaborative use application support, and process deployment of diverse mobile end devices along the lines of the system software applications with safety, security and reliability guarantee (Industrie4.0_Final_Report, 2013).

This can be explained with an industrial application such as that one cross country pipeline network located in south part of the country can be connected to another cross-country pipeline network located in north part of the country through system application software in order to access the process parameters such pressure, temperature, flow, etc. so that the information can be used to optimize the operations & maintenance of pipelines. The benefits of IoS/Smart Services should be utilization of resources based on online data. One of the examples to such kind of application is the oil company (Total) can able to get maintenance decision support for its new Martin Linge Field in Norway based on maintenance data from their older Ofon Field in River Niger's delta area of Nigeria through cloud-based data service.

2.2 CLOUD COMPUTING

The definition of Cloud computing: it is a model for enabling ubiquitous, expedient, on-demand network access to a shared poll of configurable computing resources such as networks, servers, storage, applications and services. Cloud computing can be rapidly stipulated and released with least management effort or service provider interaction (Mell & Grance, 2011). Therefore, Cloud computing is a cluster of service that can be leveraged using Industry 4.0 concepts (Bai, Ma, & Zhu, 2012). This theory defined the three major components of Cloud computing model with the following compositions: Five essential characteristics such as On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, and measured services; Three service models like Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Four deployment models such as Private cloud, Community cloud, Public cloud, and Hybrid cloud. Cloud computing helps to share the huge amount data emerged out of Intelligent Predictive Maintenance infrastructure.

2.3 SMART SOLUTIONS

Maintenance 4.0 concepts are the key to a thriving Oil & Gas Sector in the future. Smart Solutions can be factored in to both Smart Products and Smart Services. Smart Products are also called as Cyber Physical Systems (CPS). These smart products are offering new features and functions based on network connectivity. Smart services open up ways for new business models & markets through innovative delivery models and service assistance. These smart solutions integrate selfmanagement and communication capabilities. Then, this can trigger new business models in the age of decentralized decision making and independent operations (Lee & Wang, New technologies for maintenance in complex system maintenance handbook, 2008). The smart products are equipped with Cyber Physical System with the ability to do equipment-to-equipment communication, embedded interfaces and enables interaction with human users. The concept can be extended to Cyber Physical Production Systems (CPPS) in an industrial maintenance scenario. The smart solutions have the advantages such as indicates early warnings, mitigate surprises, etc. Therefore, any smart solution is well suited to predictive maintenance applications within the ambit of the industrial internet. One such example can be Gas Turbines interacting with social & equipment networks to decide on its service needs. This means operator requires attention only when Gas Turbine triggers for maintenance support. Further, smart products could also able to self-maintain its configuration & function during its lifecycle based on interconnectivity with OEM who can able to provide wealth of information for product optimization and innovation.

2.4 INTERNET OF THINGS

Today the internet connectivity provides connection over one billion of people through social network platforms. The invention of advanced and cheaper sensing devices connected through internet protocol IPv6 networking helps to manage such kind of wide connectivity throughout world. Basically, the wide network is managed by assigning Internet Protocol (IP) addresses to every sensing device such as sensor, actuator or any other object. All these devices are networked directly with the Internet using IP addresses (Indsutrie4.0_Report, 2013). Therefore, The Internet of Things refers to such kind of insidious network society in which a lot of objects are connected to have common connectivity in order to share information (Yan, Zhang, Yang, & Ning, 2008). IoT can be views as a subset of the Cyber Physical Systems which is discussed above. Authors interchangeably use these terms IoT & CPS with the influence of their area (or) region in which they carry out their research.

2.5 SMART FACTORY

The Smart Factory constitutes one of the components of Maintenance 4.0 in line with the vision for Industry 4.0. Smart Factory consists of a set of networked arrays of equipment, a new plane of self-organization and process optimization is enabled in the form of Decentralized Production Control. Secondly, the wealth of operations related information which also provides the basis for Data-driven Operational Excellence (Lucke, Constantinescu, & Westkamper, 2008). The major components of the Smart Factory are Calm-System (Hardware) and the context-aware applications (Software). These components use network logic and advanced computing process to create virtual duplicate physical systems. The systems built on smart factory concepts should be robust, resistant to disturbances to enable the physical sensor data update through real-time virtual representations. Further, these systems should also accommodate the faster recovery from failures using self-healing processes. In order to measure, calculate and collate the information about the machine performance, predictive health conditions on real time basis from physical data (sensors), smart algorithms are performed and processed in the cyberspace (Lee, Kao, & Yang, Service innovation and smart analytics for Industry 4.0 and big data environment, 2014).

Smart Factory concept is a vision for the manufacturing plant where operations form part of an intelligent system and all the equipment are integrated by means of Machine-to-Machine (M2M) communication or other intelligent algorithms.

Factories of the Future (FoF) concept with in an environment of Smart Factory will be an environment occupied with large amounts of small intelligent devices interfaced and communicating in a collaborative way to create an overall smart system. This approach is shared network of loosely coupled and decentralized intelligent devices and this network is capable for a system to easily adapt and reconfigure in order to meet the demands of the business (Colombo & Karnouskos, 2009). FoF feature is based on customer centric approach in the business processes and increasing the product quality and specifications (Souza, Sacco, & Porto, 2015). It also envisioned the sustainability into the manufacturing environment for aiming higher productions and zero-defect tolerances with the energy efficiency.

3.0 MIDSTREAM OIL & GAS COMPANIES: TRANSFORMING STRATEGIES WITH MAINTENANCE 4.0

In the midstream sector of Oil & Gas Industry, there are raising concerns of business complexity due to more dynamic model of transporting variable volumes and grades of products from multiple locations to new end markets and users. The concern of business complexity includes the following challenges: Ageing of pipeline networks, legacy & manual monitoring, and old control devices. Even in the developed country like USA, the estimated annual loss is $10 billion due to fuel leaks and thefts (Penn Energy, 2014). The immediate shift in the sector is required towards investment in data-enabled infrastructure instead of conventional hardware and software physical devices of pressure, temperature, vibration, level, etc. Therefore, the sensors should be smart enabled product which can create new data for predictive maintenance analysis. The fact is midstream Oil & Gas companies are lagging behind than other companies in the industry (Lars Larsson, 2014).

Few oil & gas companies (e.g. TransCanada, Enbridge, and PG & E) in this sector are working towards mitigating the above bottleneck of creating new data by installing advanced smart sensors inside and outside of oil & gas transporting pipelines. The four new technologies being test by these oil companies (TransCanada, 2014) are as follows: Vapor-sensing tubes to see bitumen spilled by shooting air down a tube; Fiber optic cable to feel the temperature variations caused by bitumen leaking into ambient soil; Hydrocarbon sensing cables that send electric signals to smell hydrocarbons; Fiber optic distributed acoustic sensing system to hear sound variations and can indicate pipeline leak (Jesse, 2014).

As shown in above example the pipeline safety is the core interest of all the Oil & Gas companies in the mid-stream sector since a spillage from pipelines can lead to higher costs and tighter regulations for the entire industry. Therefore, the companies are preparing themselves for developing a data-enabled monitoring infrastructure. Midstream companies would accumulate a competitive and commercial advantage if they perform network wide product and flow data reconciliation. The estimate shows that 150, 000 miles of pipeline generates 10 terabytes of data which an amount of data equal to the complete printed collection of the Library of Congress (General Electric, 2014).

The midstream Oil & Gas companies can put forward insights of new created data across its pipelines, helping the transporters to find better ways to market and charging the consumers differently for having route options in contracts. Pricing incentives that encourages producers and end users to smooth volumes can be forecasted using historic volumes transported through the pipeline networks (Gautreaux, 2014).

The newly created pipeline data along with the data from an export facility, markets, shipping terminals and product grades acquired in a timely manner help the Oil & Gas companies to take advantage in predictive maintenance analysis and improving operational efficiency. Further, emerging types of data like equipment data, geo location data, weather data, log data are become useful at high volumes especially when correlated against other data sets according to Horton works (Kohlleffel, 2015).

The above literature survey concludes that the midstream Oil & Gas companies are targeting for higher network integrity and new commercial opportunities. For creating such huge data across the pipeline networks, sensors play the crucial role. The key solution to the midstream sector is investing in sensors so as to capture every aspect of the facilities in order to implement the predictive maintenance frameworks. Therefore, the above discussion suggested that the key enablers for implementation of intelligent predictive maintenance framework are Reliability, Scale of Operations, Pipeline/Asset Integrity, and Creation of data using Sensors.

4.0 CONCEPTUAL FRAMEWORK OF INTELLIGENT PREDICTIVE MAINTENANCE FOR OIL & GAS COMPANIES IN MIDSTREAM SECTOR

In Section 2, Conceptual constructs related to Intelligent Predictive Maintenance (IPM) in the context of Maintenance 4.0 are discussed in detail. In this section, Conceptual constructs emerged out from this study are summarized in the context of Intelligent Predictive Maintenance Framework with the specific reference to Oil & Gas companies. The conceptual constructs identified through literature survey and the key enablers developed from the major reports from Oil & Gas Industry are compared together. Accordingly, a conceptual frame work of Intelligent Predictive Maintenance based on the concepts of Maintenance 4.0 has been developed and presented in Figure 1.

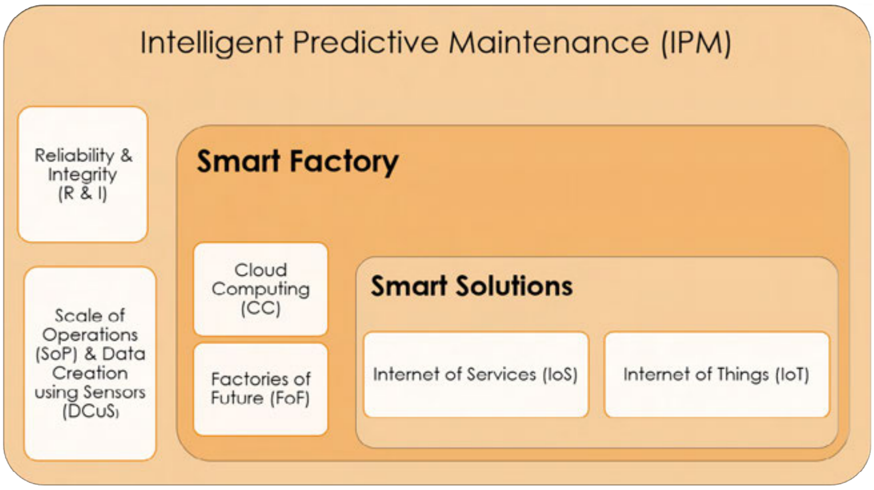

Figure 1: Intelligent Predictive Maintenance Framework based on Maintenance 4.0 for Midstream Oil & Gas Companies

The following prepositions are emerged out from the detailed study of the proposed conceptual IPM framework.

P1: Smart Services such as Internet of Services & Smart Products such as Internet of Things are the technology enablers to Smart Solutions

P2: Smart Solutions, Cloud Computing and Factories of Future are the key enablers for Smart Factory

P3: Smart Factory & Smart Solutions are Growth Drivers for effective implementation of Intelligent Predictive Maintenance in the context of Maintenance 4.0

P4: Reliability, Integrity, Scale of Operations, and Creation of new data using sensors are the major enablers for Intelligent Predictive Maintenance.

P5: The major enablers such as Reliability, Integrity, Scale of Operations, and Creation of new data using sensors and the growth drivers such as Smart Factory and Smart Solutions together contributes for effective implementation of IPM.

Focus Groups were set up to deliberate on the new developments of Maintenance 4.0 within the environment of Industry 4.0 and the effective implementation of Intelligent Predictive Maintenance based on Maintenance 4.0 concepts for midstream Oil & Gas companies in the industry. Focus Group participants were from the senior executives from the midstream Indian Oil & Gas companies. Focus Group discussions were conducted for an hour and the discussions were audio taped and recorded. The Focus Group discussions were conducted by an experienced moderator. The questionnaire was developed based on the above prepositions (P1- P5) and questions were asked in a semi-structured manner (Kruger, 1994).

Transcribed interview recordings were analyzed using constant comparison method. This method is undertaken by constant comparison of data and contrasting data to assess the range of possibilities that emerge from the Data (Glaser & Strauss, 1967). The empirical data emerged out from the data analysis could prove the above prepositions P1 to P5 are valid in the context of Maintenance 4.0. The detailed discussions and results are presented in Section V.

5.0 DISCUSSIONS & RESULTS

Maintenance 4.0 could able to provide crucial support in the present business scenario to operations & maintenance in order to sustain operational efficiency and increased productivity. It suggests the creation of new business models and also forms the basis for new and novel services. One such example of novel service emerging out in the Oil & Gas industry is distributed cloud-based systems for implementation of Asset

Maintenance. The current paper assesses the Maintenance 4.0 and IoT concepts in terms of Predictive Maintenance application in the context of midstream Oil & Gas companies and emerged out with a conceptual framework with the key growth drivers and major enablers for developing IPM infrastructure. The major theoretical contributions of this paper are the proposed IPM conceptual framework and the CSSI model (Fig. 2) for Predictive Maintenance Implementation developed from the empirical study done through Focus Group Discussions (FGD).

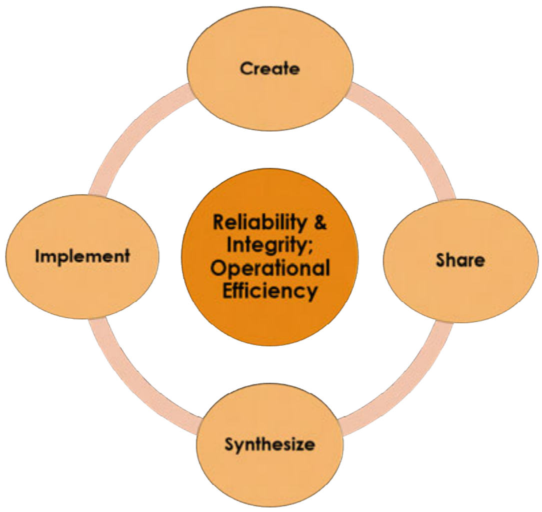

Figure 2: CSSI model for Intelligent Predictive Maintenance

The CSSI model supports the effective implementation of Intelligent Predictive Maintenance model for midstream Oil & Gas companies. A new data is created using the sensors in the shared and controlled network. Then the information collected from sensors is communicated among the Predictive Maintenance infrastructure such as machine to machine, control systems etc. through distributed networks. The standards (legal, technical, regulatory or social) allow that information/data to be aggregated across time and space. The captured information is collectively used to analyze and synthesize then passed on implementation. Further, analytical support systems via technologies that either enables automated predictive maintenance actions or human interventions in a manner leading to improved implementation of Predictive maintenance.

The CSSI model developed can be merited with the important results as summarized below:

- An increased automation in asset maintenance in the context of Maintenance 4.0 will be beneficial to asset maintenance managers in order to maximize the availability of equipment and quick retrieval of equipment after shutdown. The closed loop model ensures the availability of equipment historical data, predictive information of particular equipment, and shared information since similar equipment are linked through as distributed cloud network globally and also in company's intranet, depending upon its functional configuration. This model integrates well into Maintenance 4.0 Factories of the Future framework discussed in Section 2.

- IPM framework and CSSA model reduces the human intervention in maintenance, increases the availability of equipment, improves safety performance since most of the predictive maintenance decisions are based on huge new data generated in consultation with Original Equipment Manufacturers (OEMs).

- The systems developed through IPM framework are using technologies such as Smart Solutions, Cyber Physical Systems, IoT, IoS, Cloud Computing etc. which not only ensures effective and efficient implementation of IPM and it also provides huge cost benefits. The example is Maintenance 4.0 cloud-based asset maintenance systems are implemented across the value chain of the organization.

- The systems installed in the IPM network for remote access will become highly susceptible to attacks with the aim of sabotaging industrial facilities. Organisations need to protect themselves against such attacks from cyber crime sponsored entities, politically motivated hackers, and organized crime. CSSI model suggests that base line information about cyber risk level of production assets is to be assessed based on the following parameters such as potential damage to facility, technology/firmware suppliers' capability, policies on audit trails of application software, quick isolation procedure of compromised component within the distributed system, and system-wide security abstractions. According to the risk level identified, the protection of assets needs to be prioritized in the IPM model.

- Humans interacting with Cyber Physical Systems (CPS) are mentioned by researchers as Cyber Physical Human Systems (CPHS). The humans may not be controlling directly CPS. However, they may be associated with the systems as maintenance supervisors, engineers, customers, collaborators etc. The CPS autonomous components in the network perceive about the real world are not always effective at representing uncertainties and interpreting ambiguous or conflicting information. Therefore, applications must rely on effective humanautonomy interaction. This arise the need for coordinated human system interaction on developing principled approaches to leverage complementary strengths of humans and computers. Further, to develop new modes of communication between humans to ensure synergistic plant operations using intelligent predicative maintenance model.

The above proposed intelligent predictive maintenance framework is not only contributing to theory in the area asset maintenance management, it is also helpful to practitioners such as asset maintenance engineers and managers in the midstream oil & gas companies in the industry to decide on the development of IPM infrastructure and its implementation in their organizations.

6.0 CONCLUSION

The findings in this paper demonstrated that the relatioships among Smart Solutions & Smart Factory concepts of Maintanance 4.0 within the environment of Industry 4.0 and Intelligent Predictive Maintenance. Literature survey and industrial Focus Group Discussions aimed at finding conceptual constructs related predictive maintenance in the context of Maintenance 4.0 and developing the conceptual framework for Intelligent Predictive Maintenance. Further, suggesting a working model for implementation of Intelligent Predictive Maintenance in midstream Oil & Gas companies. The prepositions developed in theory are validated through industrial experts and their valued opinions/ experiences are also aggregated in to the theoretical study. Industry experts recommended for support in research on the unique challenges and opportunities in the areas of CPS security & cyber-human systems development. Few suggestions are minimal operating systems to create CPS with smaller attack planes, newer ways to detect and prevent strange network traffic, and high-level policy languages for specifying permisible communication patterns.

The developed CSSI model along with the IPM framework contributes significantly to the practitioners in midstream Oil & Gas company asset managers. Limitation of this study is the generalization of the results to the industry. Further research is therefore required to do large empirical survey involving major Oil & Gas companies worldwide. The research outcomes should be deliberated through an active dialog between key constituents of the community, including government, industry, and academia. This will ensure that the challenges are met in a timely manner and that the Intellgent Predictive Maintenance model based on Maintenance 4.0 concepts has the greatest impact possible in the plant operations.

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Digital disruption will occur in Midstream as it is underway in other asset intensive industries

Sam Hemeda > Arundo Analytics

Abstract

The massive growth in Permian production further underscores the role Midstream companies play in the Hydrocarbon value chain. A lack of processing facilities and pipeline capacity adversely impacts the value of E&P onshore pure plays. The access to markets is curtailed for these E&P companies by lack of capacity to process and transport production to refining facilities and/or export markets.

Midstream operators must adopt a technology-based approach to guarantee the readiness of aging asset, maximize utilization and guarantee the safety of resources. Additionally, tap into a treasure of operational data for a precise understanding of equipment behavior, deploy "proven value" analytics to optimize operation, maximize the yield without compromising safety or environmental regulation. The article highlights key functions areas within Midstream Value Chain that can benefits from embedding analytics in workflow, additionally a quick recipe for digital transformation and key success factors.

The current business model for companies in the Midstream Oil & Gas industry is unsustainable. Additional regulations, aging infrastructure, limited resources and labor shortages are forcing these firms to adapt and change. The massive growth in Permian production further underscores the role Midstream companies play in the Hydrocarbon value chain. A lack of processing facilities and pipeline capacity adversely impacts the value of E&P onshore pure plays. The access to markets is curtailed for these E&P companies by lack of capacity to process and transport production to refining facilities and/or export markets.

The advent of digital enablement such as cloud storage, open source Artificial Intelligence (AI), Deep Learning applications and low-cost super-computing can be of a great benefit to Midstream operators. Embracing a technology-oriented mind-set allows operating companies to explore innovation and deploy non-traditional processes to mitigate capacity constraints and key operational challenges. Adopting a digital transformation theme points the way to operational performance gains, minimized downtime, utilize any identified capacity and further enhances shareholder value.

While the benefits of digitalization are proven and documented in other Oil & Gas segments, Midstream must avoid a "follow the herd" approach. The adaptability and scaling of technology can only be considered when needed and with precise business goals. Embarking on the digital transformation mission requires that companies perform a thorough assessment of organizational digital readiness and available technologies to attain business value. Many existing applications such as ERP, Computerized Maintenance Management Systems (CMMS) , Historian (OSI PI) and others offer a head-start, and only then if operational data are accessible with an acceptable level of veracity.

WHAT ARE THE BENEFITS?

The digital path may be structured for each business function, where each has its own set of significant value building blocks. The table below illustrates potential areas of gain per activity or function and many of these functions are in practice. Midstream companies can explore areas to extract more value, such as asset condition monitoring to increase uptime and prediction of failures, spills and emissions to avoid hefty penalties.

Midstream facilities operate varieties of industrial control systems and digital sensors. Secure and reliable streaming of sensor data is a key step in implementing a holistic digital vision that yields considerable gains. After connectivity and visibility are addressed, virtual sensors, combined with physical sensor data, provide real-time monitoring of critical equipment such as compressors and pumps. Selection of specific analytic tools depends on specific use cases. Critical operational decisions are based on intelligent data and less reliant on management intuition or "gut feel".

Once data is available and labeled, machine learning models are then deployed to improve critical asset uptime, anticipation of unplanned shutdowns, alerts of potential bottlenecks, predicting failures that would otherwise have triggered major stoppages, incidents and in some cases fatalities.

The procurement team will be equipped with intelligent supply chain tools with the capability to explore potential risk scenarios based on analytics. Procurement will also be alerted to supplier issues in order to take proactive action to minimize supply route disruptions. As data quality improves, equipment performance is optimized. Utility expenditure can be reduced by using alternative pipeline networks with lower tariffs. Assessing the condition and availability of operating assets can also identify potential capacity in the pipeline and enables the operator to respond to spot orders, thereby increasing operating margins.

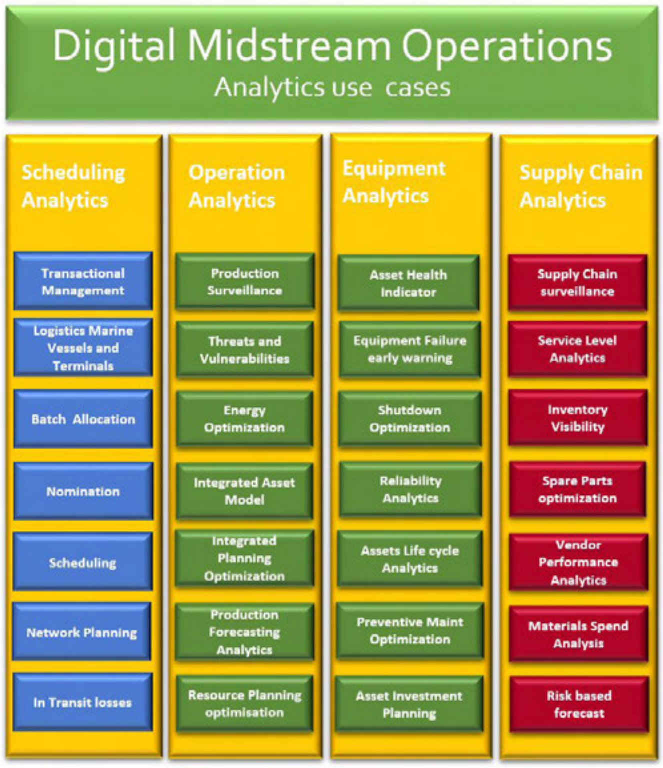

Figure 1: Deployment of Artificial Intelligence in Midstream operation is limitless

A typical midstream asset encompasses multiple facilities, each with critical equipment and devices. However, for the purpose of this article, we will only explore Pipeline and Terminals as they play significant roles in Midstream value chain.

PIPELINES

The installation of sensors and use of SCADA is widespread among many Midstream operators. However, aging assets with obsolete SCADA and legacy technology can stifle digital transformations. Aging infrastructure is a prime candidate for a technology upgrade, installing Edge Devices, replacing analog sensors with digital, mounting strain sensors, vibration monitoring coupled with terrain and topography information enables Midstream operators to visualize and pinpoint weak spots in the pipeline. Commercial drones are being deployed to canvas pipelines network using thermal, infrared sensors to identify weak points within the network and stream data to operation team for critical operational decision.

Many Midstream operators have adopted a 1st principal equations for computational monitoring such as leak detection, spills and theft. Running smart PIGS for In Line inspection (ILI) data is a key input in Integrity management programs and a leading indicator of internal corrosion. Using advanced analytics and incorporating data from ILI and, metallurgy and previous historical data provide a self-learning models for the optimum corrosion prediction. Advanced analytics tools offer engineers acceptable means to predict the outcomes of future operational decisions and monitoring the integrity of the pipelines with/out the absence of PVT simulation models.

Virtualizing the pipeline and boosting stations by creating a digital-twin that mimics the behavior of the assets will prove valuable in exploring optimal operational scenarios and determining remedies for bottleneck and unplanned events. Compressor and pump performance is monitored and machine learning tools offer a "look-ahead" early warning of failures.

TERMINALS

Terminals operation is a complex system of processes, executing a significant number of orders, as well as delivery and storage of various products. The focus on quality, safety and efficiency is paramount. Terminal operation has benefited from installing ERP systems for handling massive amounts of data with remarkable success in streamlining operations. The U.S. onshore production and demand fluctuation, increased U.S. export and LNG spot buying adds another level of complexity to terminal operations. Running Terminals analytics can trim few percentages in operation expenditure while increasing capacity.

THE RECIPE

As we indicated earlier, many Midstream applications -currently in use- offer a digital transformation head-start. However, that fact does not guarantee successful outcomes. Data quality, availability and veracity is essential, digital readiness, vision and business value among other should be ascertain before rushing into "low hanging fruit" initiative. The following Spider Web diagram touches upon some of the key variables. Midstream companies can adjust the diagram appropriate to their operations and objectives. Additionally, determining "Business Value" has always been the subject of many budget discussions and Go/No Go decisions. Companies can tap into the possibilities of creating a mock-up or a proof of concept (PoC) use cases to explore the value and feasibility of scaling. However, once deployed on larger scale, the expected value might be diminished due to other variable such as Change Management, implementation risk and management appetite to re-create the business model. Therefore, while the PoC results might be very attractive, what are the expected benefits of ramping up.

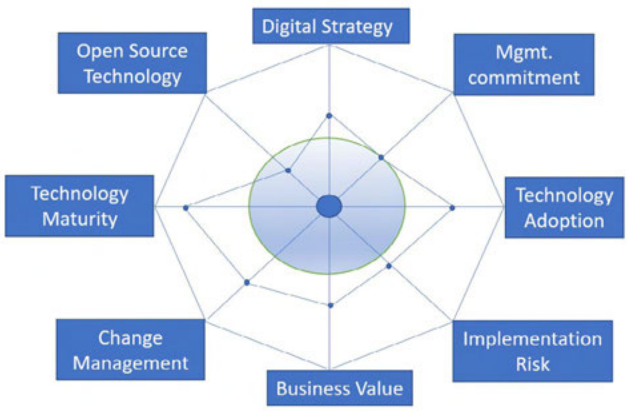

Figure 2: Key factors to consider in drafting a Digital Transformation Initiative

MANAGEMENT COMMITMENT

There is often too much hype around new technologies for the C-suite to ascertain what will work and what won't. A large set of the C-suite find challenges in making the digital opportunity real. They hesitate because it is complex and outside the realm of other tech/management initiatives of the past like ERP, or quality practice like Lean Six Sigma. There are many different components, many moving parts and many are unproven technologies. Creating mock-ups and PoC's , getting the C-suite to experience first-hand new technologies proved beneficial in generating a deeper understanding of digital transformation and its contribution to business value.

DIGITAL STRATEGY

The objective of Digital strategy is business performance improvement, exploring new products, re-inventing current methodology and restructure business models. New technology makes it possible for innovative companies to provide new and add-on services. Digital Strategy proposes how technology enables organizations to create new competitive advantages, as well as the tactics to achieve realize gains. However, organizations should not be lured into the "low hanging fruit" and "quick gains" if it hampers the pursuit of holistic digital vision with less desired impact on competitiveness or performance.

IMPLEMENTATION RISK

IT Project Management and execution developed a reputation of cost overruns, missed deadlines, scope creep, and failure to meet business requirements. Companies must adopt agile methods and a transformative approach to keep pace with constantly evolving technologies. Use of analytics to predict and manage risks and steering a course correction becomes inevitable.

CHANGE MANAGEMENT

Change management is a catalyst for digital transformation success. Yet, it is often undervalued by organizations when embarking on major IT initiatives which is a key contribution to project success. Organizations must cultivate a philosophy of supporting workers to adopt to the changes that drive project success.

TECHNOLOGY MATURITY

Digital Maturity is an evolving process and is achieved thru different development phases. Technology matured organizations easily deploy innovations and conduct business in a new and different ways. Additionally, monitoring and adopting to how your partners, clients and competitors use such technology is a sign of a technologically mature organization.

BUSINESS VALUE

When mapping your path of digital transformation, it is essential to know what market segment you will be in and what your customers objectives will be in 3-5 years, not just meeting their current expectations. Mirroring their vision will help in laying foundations of a transformation, delivery of a milestones with defined and measured KPI's that will address near and long term business objective of your customer.

TECHNOLOGY ADOPTION

Digital transformation requires more than just the IT and business sides working together. Human resources and development teams have a big role to play in accomplishing a true enterprise-wide results from digital transformation. Alignment between different business functions is a none trivial undertaking, yet essential. HR & IT teams need to partner together more closely to synchronize their goals and get the most out the employees as jobs and functions evolve.

OPEN SOURCE TECHNOLOGY

One of the key benefits of open source technology is its minimalist cost. While IT cost is a factor, true value of open source applications arrives by aligning the operation and developer teams and accelerating the collaboration towards business objectives. Participating in technology focused industry forums, data sharing and pursuing open source cognitive analytics is a desirable approach. Containerization has been gaining momentum, it enables developers to interact with business operation and create predictable outcomes from their newly developed applications..

CONCLUSION

Current Midstream business models and practices are being challenged by endless changes in Oil & Gas exploration and production landscape. Embracing digital transformation can equip Midstream operators with tools to cope with ebbs and flows in both upstream & downstream. Additionally, Midstream companies can tap into a treasure trove of operational data to evaluate the integrity of their assets, understand equipment behavior and abandon "run to failure" operating philosophy. Deploying advanced analytics to explore optimum operational scenarios for yield increase without compromising quality or safety. Start small and evaluate the result of specific use cases. Finally, Digital Transformation requires bold actions, develop serious initiatives in pioneering new Midstream business models.

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The Big Data Revolution: Detecting Pipeline Leaks, Encroachments, and more Using Satellites

John Zhou & Caroline Beck > Satelytics

Abstract

Benefiting from the vast capacity and speed provided by cloud computing, remote sensing technology is quickly expanding from infrequent projects to becoming an integral part of on-going operations.

We have seen many innovative applications in this arena, particularly at oil & gas, pipeline, and power companies, where their large spatial footprint is challenging for conventional approaches. In this article, we make the case for applying Remote Sensing Technology (RST) and Geospatial Analytics (GA) for on-going operations and give two examples to demonstrate RST in operation could significantly reduce risks and liabilities for pipeline operators.

This technology can also be used to monitor pipelines and the rights-of-way for hydrocarbon leaks, change detection, land slips and slides, vegetation growth, water temperature, illegal (hot) tapping, and many more biological and chemical constituents of both land and water. We are confident that with the rapid commoditization of remote sensing data collection, RST/GA will be widely adopted in pipeline, oil & gas, and power companies.

INTRODUCTION

"Satellite remote sensing and big data derived from spectral imagery are transforming the way pipeline companies do business." John Zhou, Chief Technology Officer, Satelytics

The pipeline industry has witnessed massive acceleration in the acquisition of big data. A technological race is underway to create opportunities out of the digital disruption that are changing the status quo. Many in the industry acknowledge technology improvements directly enhance safety and increase profitability. Assets in high risk areas require careful observation to cope with the effects of time, man-made threats and severe weather. Analyzing infrastructure in remote and difficult-to-access areas is very challenging with traditional monitoring techniques, but much easier and safer with remote sensing technologies. The ability to solve critical business problems by utilizing spectral data processed through satelytics.io can be accomplished within hours of capturing data.

REMOTE SENSING TECHNOLOGIES AND GEOSPATIAL ANALYTICS

Big-data-based digitalization like Remote Sensing Technologies (RST) and Geospatial Analytics (GA) apply algorithmic analysis to data obtained from electromagnetic energy. This is energy reflected off the earth's surface or atmosphere which is then collected by remote sensors. Data collection occurs passively (using an external energy source, such as radiation from sunlight) or actively (by generating the energy source internally, e.g., a laser beam).

Sensors may be mounted on satellites, nano-satellites, fixed wing aircrafts, drones or UAVs, stratospheric balloons, fixed stations or a combination of platforms. Each sensor platform has its own advantages and disadvantages in terms of cost, spatial resolution, temporal resolution, and geographical coverage. Raw data are collected and transferred from spectral sensors to computing assemblies where analytical and algorithmic applications convert that raw data into actionable information.

The series of steps involved in RST-GA are illustrated in Figure 1.

RST-GAs are widely available commercial technologies that identify, alert, and quantify specific measurements. These technologies address key challenges facing the oil and gas pipeline industry. Satelytics' RST-GA technologies are not limited to the oil and gas sector; other industries that share similar operating conditions and challenges can benefit as well. For example, rail and pipeline markets both share a common set of operating environments, predicated on large and often inaccessible infrastructure. They are also subject to extensive government agency regulations and have similar issues to pipeline operators as it relates to securing the social license to operate in the court of public opinion.

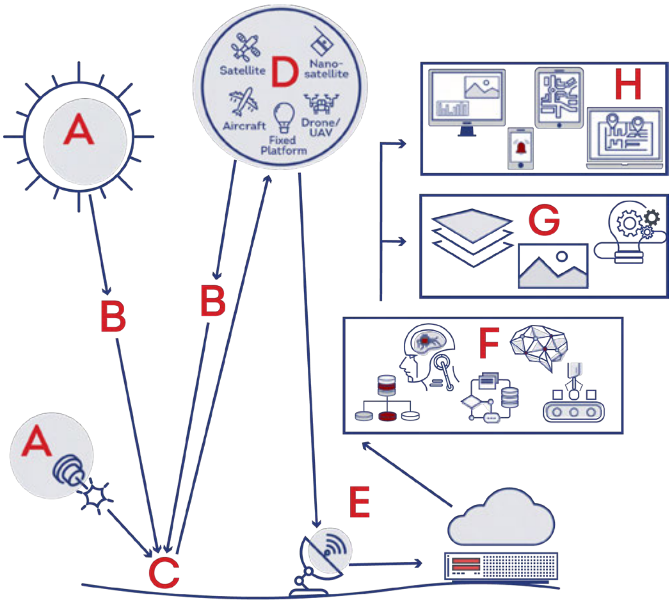

Figure 1: Remote Sensing Technologies and Geospatial Analytics

- A. Energy Source (Active/Passive)
- B. Radiation and the Atmosphere
- C. Interaction with the Target
- D. Sensor Platforms to Record Energy
- E. Transmission, Reception and Processing
- F. Automated Processes: Machine Learning and Artificial Intelligence
- G. Presentation of Analytics
- H. Display Platforms

RST-GAS MAKE IT EASIER TO DETECT THREATS

> *"The big leaks anyone can spot. SCADA alarms indicate pressure drops with a high degree of efficiency and immediacy. No, it's the small leaks that go undetected for months that are of concern to our customers* Sean Donegan

There are many targets of interest including hydrocarbon leak detection, land movement and other geohazard identification, right-of-way change detection and encroachment monitoring, vegetation management and general maintenance, as well as a new, high-profile use to identify fugitive methane emissions. The science behind RST-GA is well developed and understood and has broad applications that align with or support other pipeline infrastructure tasks, such as the following:

- Mapping and analysis of right-of-way conditions, encroachments, and third-party interference;
- Liquid leak detection;
- Gas/methane leak and emissions detection;
- Asset integrity;
- Permitting and siting; and
- Triggering emergency response.

Early detection of oil spills and leaks can improve protection of critical habitats and identify sources of pollution. Detecting threats to pipeline infrastructure using a spectroscopic approach with digital analytics enables pipeline operators to quickly react to a multitude of conditions.

Changes in the vicinity of pipeline infrastructure can arise from many sources. Third-party interference and liquid hydrocarbon leaks are the major cause of pipeline failure and cause a significant risk for health, safety and the environment. Geohazards and land movements can be precursors to events that lead to unwelcome operational disruptions and regulatory consequences. Easily preventable, but unmitigated natural changes like landslides or riverbank erosion can lead to damaged infrastructure that interrupt operations, contaminate local ecologies, and pose health and safety risks to workers, residents and the environment.

To detect hydrocarbon presence, certain bands of spectral data are analyzed to detect subtle changes in reflectance of the target. These changes, when present, illustrate the hydrocarbon chemical effect in surface materials. Affected areas shown by increased or decreased energy absorption are interpreted by Satelytics' analytical software and the spectral data showing evidence of leakage is displayed visually.

The spectral indices of vegetation growing near oil and gas pipelines are other excellent indicators of hydrocarbon leakage. Remotely sensed hyperspectral data has long been used to monitor phenology and to measure the relative density and health of vegetation. Established indices, in particular the Normalized Difference Vegetation Index (NDVI), allow scientists to classify typical growing conditions. Once those normal growth parameters are established, any changes due to hydrocarbon pollution (leaks, spills) can be identified. Oil spills directly cause biophysical and biochemical alteration of vegetation and surface soil which is detected in the spectral signature. Hydrocarbon leaks alter the soil and interfere with nutrient and oxygen uptake, thus weakening the photosynthetic cycle. Chlorophyll concentration and water absorption are affected, and in turn the plant foliage characteristics change. Since vegetation health indices register the norm, even minute changes can be detected by Satelytics software.

In short, the concept is similar to early mining days where a canary was the most important companion for the miners, e.g. using a sensitive surrogate (vegetation) to indicate existence of dangerous material (oil/gas leak).

EXAMPLES

ANALYTICS IN ACTION: EAGLE FORD

The Eagle Ford Shale Play in Texas, the most capital intense oil and gas development in the world, has had a huge impact on the oil and gas industry. Nearly $30 billion (USD) went into the development of the Eagle Ford Play since it began in 2013. The Eagle Ford, Texas area is potentially expected to recover 10 billion barrels of oil. This hydrocarbon-rich area lies directly beneath the Austin Chalk, an historically well-known onshore oil and gas play that extends across south-central Texas into southern Louisiana.

This huge oil producing region relies heavily on pipelines to transport the shale oil to refineries. The area has shallow soil with concentrated sodium and chloride ions (salts), and the shale oils themselves contain hydrogen sulfide (H2S), all of which set the stage for aggressive corrosion.
The operator in our case study discovered the original four

Figure 2: February 9, 2015 (left) and August 10, 2015 (right). The yellow ovals indicate areas of leakage confirmed by the operator

areas of leaks while surveying the line (on another issue) in late 2015 where visible hydrocarbons were bubbling on the surface. We were asked to look back in time to establish (if possible) when this leak started and when Satelytics would have raised the alert. In the example illustrated, there were two sets of available data: February and August 2015 (see Figure 2). We applied RST-GA techniques to both sets of data and established that there were no leaks in February. Six leaks were detected by Satelytics in August of the same year. In October 2015, the operator was aware of only four leaks. This area represented in Figure 3 shows the eight-inch buried transmission line, with leaks identified in yellow. The blue rectangle represents the multi-million-dollar clean up and remediation. It would have been possible to assess, identify and alert the operator shortly after the image capture in February as the next series of image captures would have shown the infrared signature of vegetation health to have altered. This would NOT have been visible to the naked eye. The financial impact from remediation could have been reduced by over 93%.

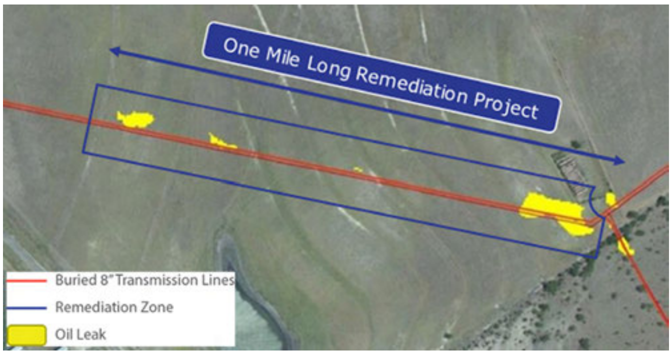

Figure 3: Satelytics processed imagery illustrating the original four leaks, as well as two additional areas of leaks (circled in yellow) originally undiscovered by the operator

ANALYTICS IN ACTION: NORTH DAKOTA

"iPIPE is seeking emerging technologies that can assist pipeline operators in preventing and detecting pipeline leaks. No one wishes for zero leaks more than the pipeline operators themselves. These leaks, when they occur, often take months to clean up and sometimes cost the companies millions of dollars, or even tens of millions of dollars, in restoring the surrounding soils to original condition. This is precisely why industry is willing to invest in the development of new tools to prevent these events." – Jay Almlie, Principal Engineer and Mid/Downstream Oil & Gas Group Lead at the EERC

Satelytics was invited to participate in the Intelligent Pipeline Integrity Program (iPIPE) in the Summer of 2018 to provide RST-GA analysis of gathering pipelines in North Dakota. IPIPE (The Intelligent Pipeline Integrity Program - www.ipipepartnership.com) is a research and development project focused on advancing new technologies to prevent and detect pipeline leaks. Funding was provided by the North Dakota Industrial Commission and companies within the oil and gas industry. The program is an industry-led consortium whose mission is to accelerate the application of emerging technologies to prevent and detect pipeline leaks. Current iPIPE partners include: Andeavor, ONEOK, Equinor, Hess, DCP Midstream, Goodnight Midstream, Whiting and Oasis.

This comprehensive project utilized weekly collection of several different types of spectral data. This project illustrates the effectiveness of RST-GAs to aid pipeline companies in preventing problems and to deliver a safe, consistent, and unfaltering product while realizing operational efficiencies.

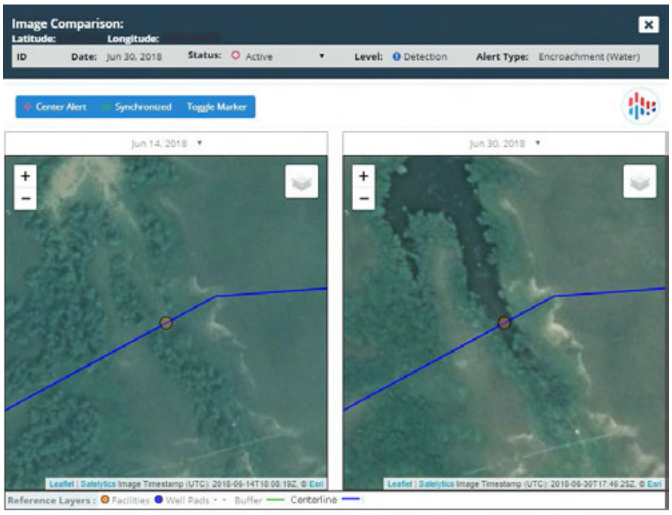

Figure 4: Significant increase in water level detected on a participating company's line

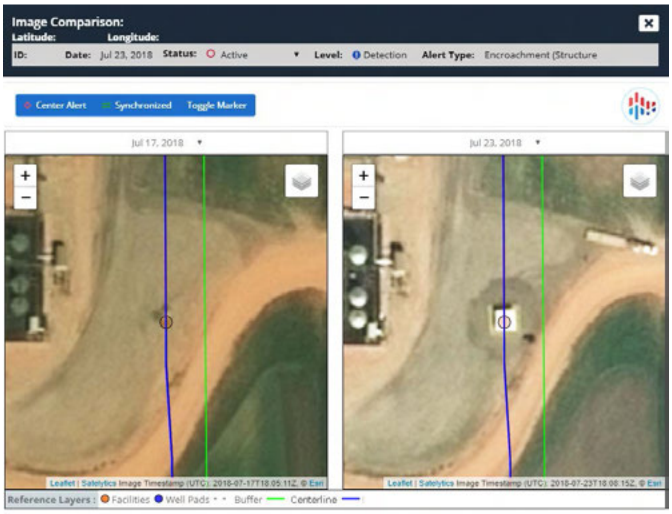

Figure 5: New structure or object detected within the right of way

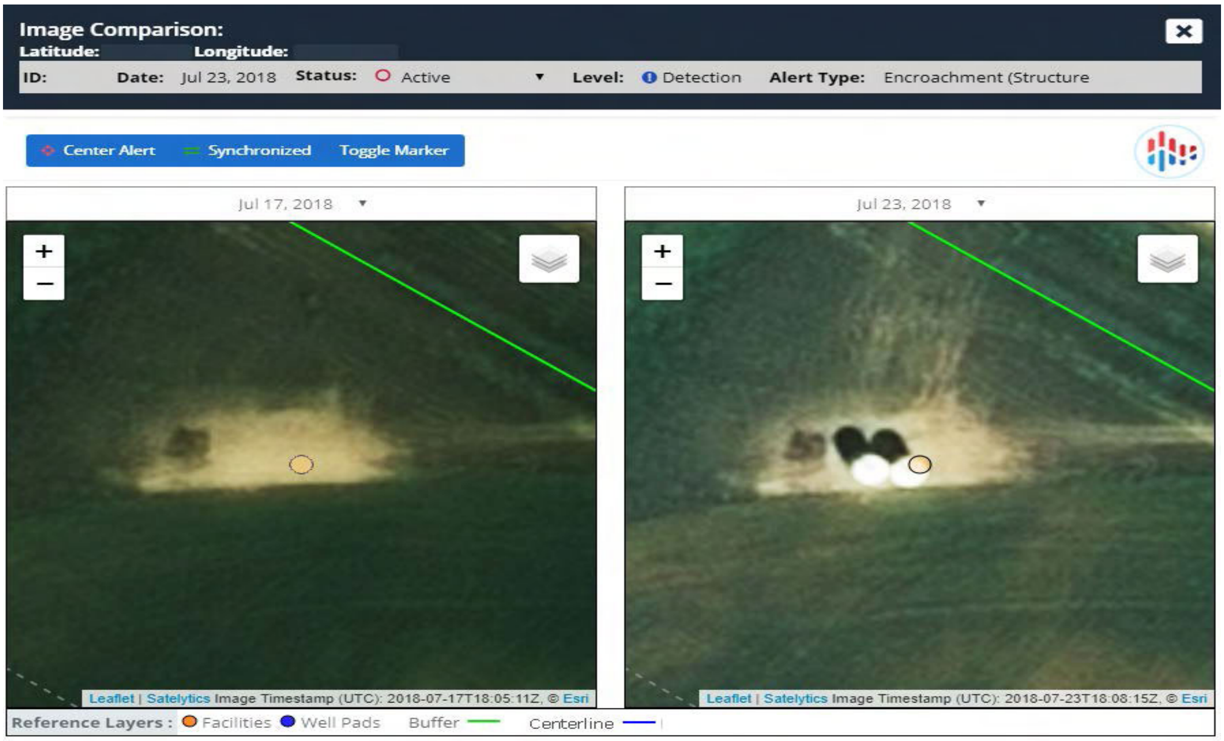

Figure 6: New structure detected within the right of way

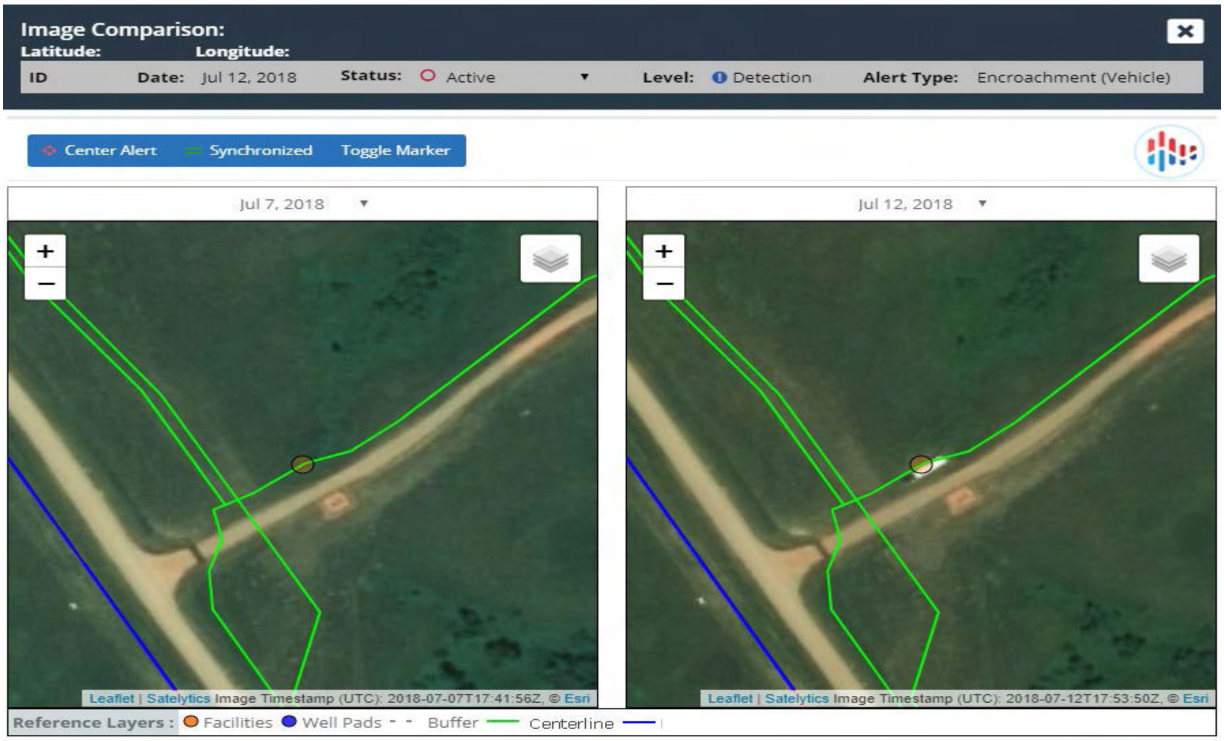

Figure 7: New vehicle detected within the right of way

CONCLUSION

We are at an age where two major technologies (Internet of Things and Cloud Computing) are quickly converging. The Internet of Things connects all types of sensors and collects a huge amount of data at break-neck speed.
For remote sensing technology, we have various spectral data sources from diverse platforms: satellites, nano-satellites, drones/UAV, fixed platforms and airplane. Besides those, there are also consistent data streams from weather data and operational telemetric systems. Cloud computing provides on-demand vast computation power which makes it possible to process large volumes of geospatial data through complex models (such as Artificial Intelligence) at a very fast speed. Advancement in those two technologies drive data collection and computation cost down and enable pipeline operators to make data-driven decisions. Data-driven decisions help pipeline operators increase system reliability while reducing liability by discovering and mitigating potential issues at a very early stage.

On the flip side of the coin, opportunities also bring challenges. The volume, velocity and variation of big data is overwhelming. Armed with proper analytical tools to distill data and visualize insights, one can harvest tremendous value offered in the gold mine of big data. Powerful digital technology involves leveraging the appropriate combination of spectral and other contextual data and analytical systems to produce actionable insight which is critical to keeping cost, time, and operational disruption to a minimum.

We have identified four A's that will help your team win with big data:

- Aspiration: an organization needs to have the desire to harness the power of big data to develop a clear roadmap and promote a champion to lead the course.

- Affordability: while data cost is progressively reduced over time, it is still the biggest expenditure in the entire ecosystem. Choosing the right spectral data platform is crucial for success.

- Availability: analytic results should be available in different hardware platforms (the smartphone, a tablet and or in browsers) and software forms. The system should be designed in a way that proper assumptions are made so that majority use cases are met with simple and uncluttered interfaces while it is flexible enough for the user to easily make customizations. It should also allow machine-to-machine communications via API so that analytic results can be consumed by other enterprise systems.

- Automation: traditional remote sensing is based on linear regressions due to many constraints we had before. While linear regression is simple, it is not adequate and robust and requires frequent calibrations. This inhibits the automation of the process. Models based on Artificial Intelligence algorithms such as Artificial Neural Network require a lot of data to train, but they are more robust and adapt very well with changes. This makes it is possible to automate the entire production chain from data collection to results delivery.

Satelytics is chosen by our customers as a partner on their journey to utilize big data in supporting their operations because they consider us the expert in the "Four A's" and we treat their goal –to minimize problems and maximize sustainability – as ours. Will we be fortunate enough to team up with you?

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Best Practices for Cybersecurity Diagnosis in Industrial Environments

Ernesto Landa > Compania Operadora de Gas del Amazonas

Abstract

In recent years attacks against information infrastructures have become ever more frequent and complex, while at the same time perpetrators have become more professional.

Every day the mass media around the world releases news related to cyber activities, which report the attempts of one country trying to get advantage over another country using cyber tools. Stuxnet is an example of this type of activities. This is a cyber weapon designed for a very particular objective. It can alter physical processes by taking advantage of the logical vulnerabilities information systems have. The Stuxnet attack was a turning point for Governments who witnessed for the first time how physical infrastructures can be altered from the cyber space. This fact forced them to take measures to improve the resilience of their infrastructures.

Most Governments have decided to protect their Critical Infrastructures since they are an essential element of their National Security Strategies. Even industries that for many years had not paid any attention to the cyber security principles, have been forced to consider them in their operations security strategies. In fact, it is increasingly common to find cybersecurity requirements as part of customer demands or in national laws.

Before designing an effective cybersecurity strategy, we have to fully understand the entire technological industrial architecture of our company. We cannot protect what we cannot see o what we do not know. It is useless to implement cybersecurity controls in one part of the infrastructure if we do not protect the other part due to ignorance or negligence. Sooner or later the attackers will discover the unprotected part and at that moment all the efforts invested in the protection of the other part will be in vain.

The main objectives of the industrial cybersecurity diagnosis are to assess the cybersecurity of industrial plants identifying the vulnerabilities and risks they are facing. It proposes as well actions to overcome such risks. To achieve such objective, it must be taken into consideration the specific requirements for this type of environments assuring the operation of the productive process.

1. INTRODUCTION

Cybersecurity is a set of processes that aim to protect the technological infrastructure of an organization. Cyber security is a well-known field in the corporate world but is new to traditional industrial environments. There It faces new problems because the cyber security techniques and tools commonly used in corporate environments could cause several damages to the industrial infrastructure.

Industrial Cybersecurity covers many of the critical infrastructures organizations, but there are also other elements that must be included even if they do not belong to critical sectors.

Cybersecurity diagnosis for industrial environments is a very specialized service highly valued by the customers and with a short market offering. This is a complex, specialized process including several disciplines covering areas such as technical considerations, administrative, organizational and compliance process as well as a physical access to the industrial plant.

Taking into account that the final purpose of the service is assuring the industrial process security, this may be requested from many areas inside the organization, such as plant and operations responsible, security or IT managers, as well as from the top management.

A cybersecurity diagnosis may be requested for several reasons. One of the most common situations for requesting a cybersecurity diagnosis is an incident, or the awareness raised by a responsible about obsolete cybersecurity principles and measures. In this case, the company does not have a true view of what is happening in its industrial systems. Even it may be possible that a customer demands cybersecurity components or that these components must be present to face a compliance issue.

Knowledge related to cybersecurity is usually disseminated inside the organization which makes cyber security diagnosis a difficult task. To achieve such objective, different profiles must be contacted that will not always cooperate since they may feel their jobs at risk. However, and above everything that has been said so far, there is an essential element in this type of activities: to assure the production of the industrial plant. This means that usual operations for IT environment such as a network scan, cannot be used at all in an industrial environment, for the undesired results that such action may generate.

2. MANDATORY DOCUMENTS

Before starting a cyber security diagnosis for industrial environments, the following documents must be signed:

- Rules of Engagement:
  The supplier and the customer agree on how the jobs are going to be executed, the scope, timing, contact persons on both sides, methods for information exchange and how the results will be presented.

- Non-Disclosure Agreement:
  Its objective is protecting both sides for disclosing sensible or classified information. During the time the work is executed, both sides must share technical details such as configurations, customer equipment and supplier methodologies.

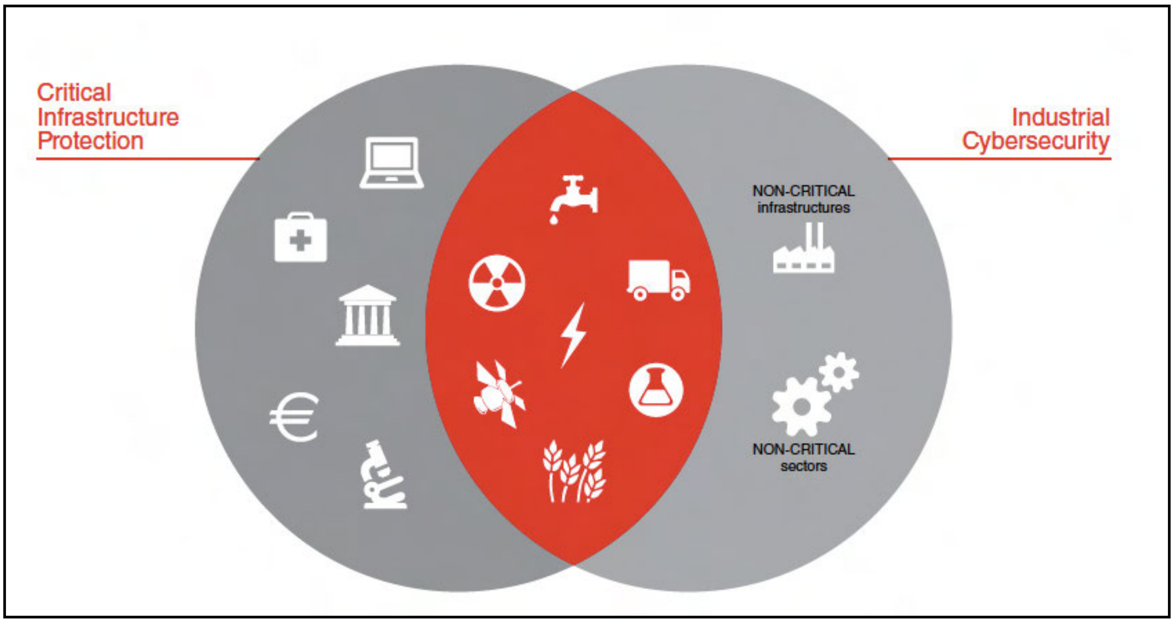

Figure 1: Industrial Cybersecurity and Critical Infrastructures

- Non-responsibility clauses:
  The supplier agrees before starting the activities, to identify the tasks and the impact that those may have in industrial processes. From this point on, it must be agreed contingency actions between the customer and the supplier. The customer must understand that this type of activities have an inherent risks and agree on the actions and limits in the case that this happens.

3. METHODOLOGY

Cybersecurity diagnosis in industrial environments has four parts:

3.1 PREPARATION

The preparation phase must offer detailed information on the environment, the production process and the physical locations where these processes take place. This is very important information to optimize the time for the visits. If the installations are in remote places, there are usually restrictions for visits and access.

During this phase, it is requested the following information:

- Network maps
- System inventories
- Addressing plans
- Policies and procedures
- Organization charts
- General information on the installation
- Third party agreements
- Cybersecurity reported incidents.
- Antecedentes de Incidentes de Ciberseguridad.

3.2 FIELD WORK

The field work means to physically visit the installations on which the diagnosis will be performed. Information must be compiled that will be presented during the report phase.

Information is compiled during this phase through personal one-to-one meetings. These meetings take place with key installation staff such as the plant responsible, the process owner, the security responsible, the Chief Engineer, the maintenance responsible, and plant operation personnel in general. One of the main problems in this phase is that of staff availability, since they usually work in shifts with busy working scheduled and they are not available for the meetings when they are requested.

For this reason, it is very important to assign a Point of Contact (PoC) during this phase; this is someone belonging to the Company and that helps in identifying the appropriate persons to interview. Many of these installations have complex work safety processes and procedures that may interfere in third party visits.

Very often the people interviewed will not cooperate, in particular if they perceive the diagnosis job as a threat. A way to face with this situation and get a closer involvement is explaining why the information is needed and the objectives of the job assigned. This phase is very important because the diagnosis will depend on the information gathered during this phase.

The role of the PoC at this point is very important; this person will be in charge of assuring that the person to be interviewed schedules the meeting, prepare in advance the questions and how long the meeting will be. The interviewer will have an outline to be adapted to the specific situation and to be modified in the circumstances request to do so. There is valuable information inferred between lines during the conversation. Some specific aspects will be covered and the interviewed person may not want to answer to some of the questions that could enclose any type of damage.

Once the interviews finish there will be may information available from reliable sources. However, this information does not offer either an integral or accurate view. Therefore, the information collected should be reviewed accessing the installation systems. At this point, there are two main problems: the large amount of industrial systems and the risks for accessing to them while on production.

Discovering and inventorying the industrial network systems must be done using passive techniques. These techniques are process and procedures that cannot potentially influence the appropriate operation of the inspected systems. The baseline principle for this type of environments is to never interfere with the industrial process.

3.3 REPORTING

Once the verification phase is completed, the collected information must be organized. The organization that acquires this type of services will get accurate and updated information on their systems. Reporting the results is, as a consequence, an essential task. The reports must contain organized information, research of events discovered during the field work, review of configuration files, data correlation and consolidation from different sources, and updating the network configurations.

When doubts emerge during the report, the Point of Contact may arrange some type of communication with the appropriate person and even, given the case to visit again the installation.

The report must contain three parts:

3.3.1 EXECUTIVE SUMMARY

The executive summary must present the most important discoveries related to the installation's cybersecurity. It must contain as well a valuation of the risk and effort needed for implementing the measures that may prevent such risks. The target audience for this part of the document is the management; therefore, the language used must not contain technical terms and specifications.

3.3.2 CURRENT SITUATION

This item is a summary of the current situation of the networks, systems and installations under study. It describes accurately the installation and it may be used as the starting point for the gap analysis. This Chapter will be used as well as the starting point for the recommendations proposed.

3.3.3 RECOMMENDATIONS

The Chapter for Recommendations will propose modifications to the current systems or implementing countermeasures that may improve the installation's cyber security. Special attention must be for the quick wins, that is low effort and budget actions but with a substantial improvement in the plant's cybersecurity. These quick wins can be quickly identified given the immaturity related to cybersecurity in this type of organizations. The Recommendations Chapter must include budge estimates, material and human resources requirements as well as how long will take implementing the proposed measures. Many of these measures will generate new projects.

3.4 PRESENTATION OF RESULTS.

Presenting the results is the final step of the service delivered. It will show the most meaningful results avoiding using technical or negative terms since very likely part of the staff will not agree on the information presented.

The presenter must be ready to show evidences and proofs on the results presented and to exchange information and points of view with the customer to get a full understanding about the cybersecurity situation of the installation.

4. NETWORK ARCHITECTURE

Network architecture is a key element of the diagnosis service. Their configuration conditions the cybersecurity of the installation's system. Special attention must be paid to identify the existing security areas and if those are enough to assure the security level demanded by the installation.

It usually exists enough documentation on the physical architecture, wiring and connection maps between different devices and places. However, the documentation related to logical architecture (security zones, local network addressing, routing, etc.) is usually very limited or it does not exist at all.

When the network architecture is reviewed, one of the main objectives will be to identify the potential communication lines, from the corporate network to the lower levels belonging to control and process networks. It is important as well to identify the services available through the network and the used protocols.

These discovery activities, usual in corporate networks, can be difficult to execute in industrial environments because the use of automation tools may affect the operation of the network systems.

4.2 COMMON ERRORS

- Dual-homed Servers
  It is very common to find in industrial environments dual-homed servers, these are servers with two interfaces connected to networks. These servers, are placed usually at the third network level, corresponding to the centralized control and supervision functions. These servers have been usually implemented by integrators and vendors to offer specific functionalities and at the same time being secure.

  The main objective of these servers is offering access to the lower system levels of the industrial process from the upper levels, avoiding a direct connection. A typical situation is that of the operator with its working station attached to the corporate network but that needs to access the process networks. When dualhomed servers are installed, the operator may access from its working station to one of the servers through the network interface. Once connected to the server, the operator may use it as a proxy to access through another interface, the systems at lower levels. This configuration that may be found often in industrial organizations must be avoided; the reason is that the malware may scan the systems compromised and discover other networks inside the organization through which they may propagate.

  In addition, it is very simple to configure the operating sytems of devices to be used as routers; then, the security incidents of the corporate network may disseminate with no resistance inside the process networks.

- Limited Segmentation and Filtering
  In general, industrial networks are not highly segmented and there are very few filtering devices installed in them. Very often, this filtering device is a router or general purpose firewall that isolates the corporate network from the rest of the networks related to the industrial process.

- Non-controlled Direct Accesses
  One of the main cybersecurity risks at industrial networks are devices that can be accessed directly from Internet.

  Bob Radvanovsky has used the Shodan Internet searching engine to develop the SHINE project (Shodan Intelligence Extraction) (3).

  This project has identified more than a million of industrial control directly connected to Internet. As a consequence, a main task will be to identify if there are control network devices directly connected to Internet, for eventually analyze them and define the access and security measures to be implemented.

  The final objective of these measures is assuring the security of the devices themselves as well as of the installation.

- Non-controlled Devices
  External non-controlled storage units or units belonging to third parties are one of the main vectors for entering malware to the industrial installations. These no controlled devices are usually USB units and suppliers' personal computers or working stations, connected directly to the industrial network with non-security measures.

  Actually, industrial networks must exchange information with other networks inside the organization, and in many cases this task must be done through mobile USBs, because both environments are isolated for security reasons.

  While developing the diagnosis service, it must be identified if the industrial network is applying this type of practices, the real need for them, and if there are other alternatives to develop such tasks in a secure way.

  It must be defined as well if there is a common practice inside the organization, connecting devices belonging to third parties, the real need for this and the inherent risks.

5. VULNERABILITY ASSESSMENT

Once the network systems are identified, it is very important to identify vulnerabilities that may affect the installation security. When dealing with a corporate network, the tool used is a vulnerability scanner that identifies the existing weak points in the different systems; it generates reports on results and recommendations as well. However, in industrial environments again, this type of automated tools is not recommended for the potentially damaging traffic they may generate. Again, passive techniques must be used. These techniques will have the following phases:

1. To select a representative system sample
2. To store the software and firmware versions existing in the simple.
3. To search manually vulnerabilities in public repositories such as:
   - National Vulnerability Database http://nvd.nist.gov/
   - Open Source Vulnerability Database http://www.osvdb.org/

This is a tedious task that takes time; it may cause as well false positives. However, it will not damage the operation of any system.

The false positives must also be taken into account since it is better to solve them beforehand that once they have happened. When found a false positive this must be reported and discarded at a later phase if appropriate.

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750 PARTICIPANTS **78** EXHIBITORS **54** DIFFERENT NATIONS

80 Pipeline System Operators from Europe, Asia, MENA and South America Ensure Success for Exhibitors during 14th ptc in Berlin

Dr. Klaus Ritter
President EITEP Institute
Outgoing ptc Chairman

Dennis Fandrich
Director Conferences
New ptc Chairman

Europe's leading pipeline conference and exhibition, the Pipeline Technology Conference (ptc), has been held successfully from 18 to 21 March 2019 in Berlin, Germany.

The outgoing Conference Chairman Dr. Klaus Ritter emphasized at the handover of this function to Dennis Fandrich the following: 750 participants from 54 different nations, and delegations from almost 80 different pipeline system operators as well as 78 exhibitors have joined and contributed to the event. This makes ptc 2019 the biggest and most successful event so far.

It enables technology and service providers from all over the world to get in direct contact with many potential clients and to show them new products and solutions. Exhibiting companies went home with folders full of notes and orders.

ptc's attractiveness results especially from the insightful plenary sessions and panel discussions. The event tackled some of the most important challenges for pipeline system operators, providing them with important impulses and suggestions for the fulfilment of their tasks - and making ptc to an attractive address for pipeline system operators.

The topics were:

- Eurasian Pipeline Forum: Linking East and West
- Digital Transformation & Cyber Security in the Pipeline Industry
- Pipelines 2050: From Fossil Fuels to Renewable Fuels
- Illegal Tapping
- Public Perception of Pipelines and Pipeline Projects
- Qualification and Recruitment of Pipeline Personnel

The core of the ptc have again been 25 Technical Sessions with more than 80 lectures reviewed by the members of the ptc Advisory Committee. All abstracts and papers are accessible through the Pipeline Open Knowledge Base for future reference and research purposes.

ptc has targeted key areas of all developments in the onshore and offshore pipeline industry – covering planning & design, construction, operation and maintenance. Also, the industrywide challenge regarding "Qualification and Recruitment" has been addressed in the conference.

For the first time, the ptc Side Conference "Public Perception" has been conducted. This ptc Side Conference addressed relevant questions about the perception of pipelines in the population and the problems resulting from a negative view of future pipeline projects.

In addition to all these program items, the 14th Pipeline Technology Conferences offered several social events which provided plenty of networking opportunities. The Get-Together-Party on Thursday evening and the Dinner Invitation within the Classic Remise, a center for vintage cars, on Wednesday evening provided memorable experiences for the participants.

Three seminars on "Inline Inspection", "Life Cycle Extension Strategies" and "Geohazards in Pipeline Engineering" have supplemented the program with experienced lecturers and interesting topics. Additionally, the ptc Round Table "Illegal Tapping" took pace, an informal exchange of experiences between pipeline operators only.

The winner photo of the ptc-photo contest under the motto "What is it like to work in the pipeline industry?" has been awarded on Thursday. Winners of the competition were the pipeline system operators TANAP and TurkStream.

80 Pipeline Operators

Association

IAOT - International Association of Oil Transporters
Czech Republic
www.iaot.eu/

DVGW - German Technical and Scientific Association for Gas and Water
Germany
www.dvgw.de

Automation

Siemens
Germany
www.siemens.com

Yokogawa
Japan
www.yokogawa.com

Certification

Bureau Veritas
Germany
www.bureauveritas.de

DNV GL
Norway
www.dnvgl.com

TÜV SÜD Indutrie Service
Germany
www.tuev-sued.de/is

Cleaning

Reinhart Hydrocleaning
Switzerland
www.rhc-sa.ch/rhc/

Coating 1/2

Denso
Germany
www.denso.de

Kebulin-gesellschaft Kettler
Germany
www.kebu.de

POLINOM
Russia
www.rikol.ru

Coating 2/2

Polyguard Products
United States
www.polyguard.com

Premier Coatings
United Kingdom
www.premiercoatings.com/

RPR Technologies
Norway
www.rprtech.com/

Shawcor
United States
www.shawcor.com

Sulzer Mixpac
Switzerland
www.sulzer.com

TDC International
Switzerland
www.tdc-int.com

TIAL
Russia
www.tial.ru

TIB Chemicals
Germany
www.tib-chemicals.com

Construction 1/2

BIL - Federal German Construction Enquiry Portal
Germany
www.bil-leitungsauskunft.de

Herrenknecht
Germany
www.herrenknecht.com

IPLOCA - International Pipe Line & Offshore Contractors Association
Switzerland
www.iploca.com

Liderroll
Brasil
www.liderroll.com.br

LogIC
France
www.logic-sas.com

Construction 2/2

MAX STREICHER
Germany
www.streicher.de/en

Petro IT
Ireland
www.petroit.com

VACUWORX
Netherlands
www.vacuworx.com

Vintri Technologies
Canada
www.vintritech.com

Vlentec
Netherlands
www.vlentec.com

Construction Machinery

Maats
Netherlands
www.maats.com

Worldwide Group
Germany
www.worldwidemachinery.com

VIETZ
Germany
www.vietz.de

Engineering

ILF Consulting Engineers
Germany
www.ilf.com

KÖTTER Consulting Engineers
Germany
www.koetter-consulting.com

Inline Inspection 1/2

3P Services
Germany
www.3p-services.com

Inline Inspection 2/2

A.Hak Industrial Services
Netherlands
www.a-hak-is.com

Baker Hughes, a GE company
United States
www.bakerhughes.com

Intero Integrity Services
Netherlands
www.intero-integrity.com/

Kontrolltechnik
Germany
www.kontrolltechnik.com

KTN AS
Norway
www.ktn.no

LIN SCAN
United Arab Emirates
www.linscaninspection.com

NDT Global
Germany
www.ndt-global.com

Pipesurvey International
Netherlands
www.pipesurveyinternational.com

PPSA - Pigging Products and Services Association
United Kingdom
www.ppsa-online.com

Romstar
Malaysia
www.romstargroup.com

Rosen
Switzerland
www.rosen-group.com

Inspection 1/2

Ametek – Division Creaform
Germany
www.creaform3d.com

Applus RTD
Germany
www.applusrtd.com

Inspection 2/2

EMPIT
Germany
www.empit.com

Integrity Management

Metegrity
Canada
www.metegrity.com

Pipeline Innovations
United Kingdom
www.pipeline-innovations.com

Leak Detection 1/2

Asel-Tech
Brazil
www.asel-tech.com

Atmos International
United Kingdom
www.atmosi.com

Direct-C
Canada
www.direct-c.ca

Entegra
United States
www.entegrasolutions.com

Fotech Solutions
United Kingdom
www.fotech.com

GOTTSBERG Leak Detection
Germany
www.leak-detection.de

Liwacom
Germany
www.liwacom.de

MSA
Germany
www.MSAsafety.com/detection

Leak Detection 2/2

OptaSense
United Kingdom
www.optasense.com

Pergam Suisse
Switzerland
www.pergam-suisse.ch

PSI Software
Germany
www.psioilandgas.com

sebaKMT
Germany
www.sebakmt.com

SolAres (Solgeo / Aresys)
Italy
www.solaresweb.com

VEGASE
France
www.vegase.fr

Monitoring

Airborne Technologies
Austria
www.airbornetechnologies.at

Krohne Messtechnik
Germany
www.krohne.com

PHOENIX CONTACT
Germany
www.phoenixcontact.de/prozess

SolSpec
United States
www.solspec.solutions

Operators 1/2

Transneft
Russia
www.en.transneft.ru/

Operators 2/2

TRAPIL
France
www.trapil.com/en/

Qualification & Recruitment

YPPE - Young Pipeline Professionals Europe
International

Pump and Compressor Stations

TNO
The Netherlands
www.pulsim.tno.nl

Repair

CITADEL TECHNOLOGIES
United States
www.cittech.com

Clock Spring NRI
United States
www.clockspring.com

RAM-100
United States
www.ram100intl.com

T.D. Williamson
United States
www.tdwilliamson.com

Research & Development

Pipeline Transport Institute (PTI LLC)
Russia
www.en.niitn.transneft.ru

Safety 1/2

DEHN & SÖHNE
Germany
www.dehn-international.com/en

Safety 2/2

HIMA
Germany
www.hima.de

Signage

Franken Plastik
Germany
www.frankenplastik.de/en

Surface Preparation

MONTI - Werkzeuge GmbH
Germany
www.monti.de

Trenchless Technologies

Bohrtec
Germany
www.bohrtec.com

GSTT - German Society for Trenchless Technology
Germany
www.gstt.de

Rädlinger Primus Line
Germany
www.primusline.com

Valves & Fittings

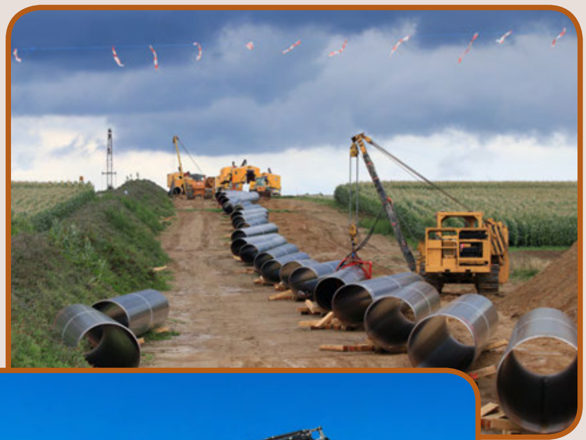
AUMA
Germany
www.auma.com

Zwick Armaturen
Germany
www.zwick-armaturen.de

JULY 2019

In the next Edition of ptj:

Pipeline Planning & Construction



The next issue of Pipeline Technology Journal (ptj) will address Pipeline Planning & Construction

This is a great opportunity for skilled authors to submit insightful papers and to contribute to the global pipeline industry's constant professional exchange.

Event Calendar		
Offshore MENA Congress 2019	11 - 12 June 2019	Cairo, Egypt
LNG Western Africa Conference 2019	8 - 9 July 2019	Accra, Ghana
UESI Pipelines 2019 Conference	21 July 2019	Nashville, Tennessee, USA
Rio Pipeline - Conference & Exhibition	3 - 5 September 2019	Rio de Janeiro, Brazil
Commercial UAV Expo Americas	28 - 30 October 2019	Las Vegas, USA
15th Pipeline Technology Conference	**30 March - 2 April 2020**	**Berlin, Germany**

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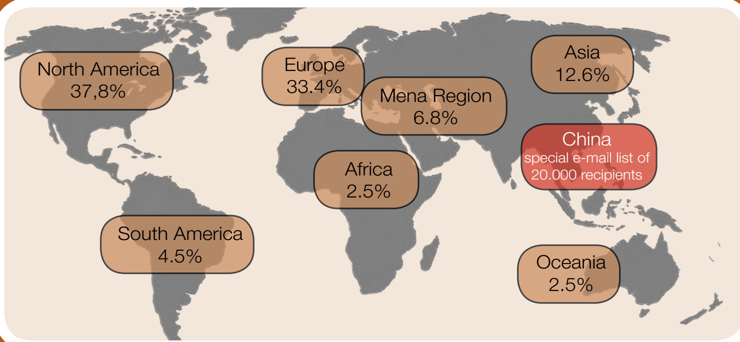

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