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Data Analytics & Data Management (DA&DM) Solutions to Manage Pipeline Integrity and Comply with New PHMSA Regulations

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Abstract

*The potential of **Data Analytics (DA)** has become apparent because of the 'Big Data' phenomenon. Business analytics is becoming commonplace where companies use historical business performance data and predictive modeling to gain new insight to drive their business planning. DA for the more technical applications (e.g., engineering, operations, and maintenance) in oil & gas sectors are less mature and are, often by necessity, more customized. However, forward-leaning companies are recognizing that applying incisive analytics has the potential to deliver significant performance improvements. **Data Management (DM)** is a key enabler of not only DA, but also of critical decisions made every day in a wide array of work processes.*

This paper addresses the regulatory and industrial context of DA&DM, the evolution of DA&DM solutions, the solutions frameworks for DA&DM, with focus on midstream. It also presents suggestions on how midstream companies can get started in achieving efficiency and effectiveness in DA&DM.

1.0 ***The Regulatory and Industrial Context***

There are strong drivers to improve asset performance in the midstream sector. Operators obviously want to (a) reduce the frequency of incidents and (b) improve operational availability. These efforts help prevent personnel injuries and avoid environmental impacts. They also help optimize asset performance, increasing the return on the investment (ROI). This is why leading companies are pursuing Operational Excellence Management Systems (OEMS). Just to illustrate the potential benefits of these improvements, Table 1 presents many incidents that happened involving US gas and hazardous liquid pipelines in 2016.[1] Obviously, reducing the frequency of these incidents will have a significant impact on pipeline safety, the environment and a company's ROI.
In addition to these internal motivators, the regulatory compliance requirements are also

[1] Because of its large size, Table 1 appears at the end of the paper.

increasing. For example, PHMSA recently proposed regulations for hazardous liquid pipelines, which will require pipeline operators to submit vast amounts of pipeline component/network data (equipment pedigree, inspection history, current condition, risk attribute data etc.). The requirements include providing data to a GIS platform, which will enable PHMSA to create a multi-layer virtual national pipeline network.

Table 2 presents key changes related to PHMSA regulations for both gas transmission and hazardous liquid pipelines. It is clear that much more detailed information is required, including historical and future data.

While they are lower complexity assets compared to the assets of the other sectors of oil & gas (e.g., refining and offshore production), pipelines are unique in the sense that they are distributed over vast areas – about 2.2 million miles globally! Midstream processing plants & terminals are of slightly more complexity, and the number of such assets is impressive – 6,500 globally). Downstream and offshore assets, on the other hand, are large, complex, typically multi-billion dollar capital projects, and they contain large numbers of complex equipment. Nevertheless, there are common features of up-, mid- and downstream oil & gas (O&G) assets:

- Large amounts of component inspection data being created - some streaming
- Large amount of SCADA-available component process condition data streaming
- Need to be able to make better decisions based upon asset integrity and risk information

2.0 The Evolution of DA&DM Solutions

Data Analytics *is the science of examining the available data to inform and improve business and technical decisions*. It is a promising field emerging from the hype of "big data" and the "internet of things (IoT)," and it has been transforming industries by improving safety, environmental protection, operational efficiency and profitability.

Data Analytics requires ***Data Management***, *the activity of maintaining and increasing the value of an organization's data*. Managing underlying data better provides a reliable, high potential platform for effective data analytics. In the past, Data Management was simply a discipline tasked with ensuring the organization could access their data, or had simply enough disk space to store it. As the value of data has increased for organizations, so too has the importance of the role of Data Management.

To understand the value of Data Management, the significant value of data must first be understood and fully appreciated. Figure 1 depicts a simple value model for data. It illustrates four ways that data can provide value to an organization (Frost C. , 2015):

- **Cost to Acquire Data.** A typical integrated oil company invests $2 to $3 billion per year in acquiring data (from seismic to real time operations data and much more). Applying a straight-line depreciation of the value of that data over 10 years, gives an asset which is worth $10 to $15 billion. A physical asset worth the same amount would not be neglected
- **Cost to Manage Data.** A supermajor oil company may spend well over $1 million per annum centrally managing data. If regional costs are added, then annual operating costs for data management can easily exceed $10 million per year. Improving the way data is managed and avoiding re-work can reduce associated costs by at least 2%

Table 2 Key Aspects of New/Modified PHMSA Regulations

Gas Transmission Pipelines

- Integrity Management Program (IMP) Expansion and Class Location Replacement
- Strengthening/expanding non-IM requirements
- Revise the definition of an HCA
- Restrict use of specific pipeline assessment methods
- Revise requirements on new construction or existing pipelines concerning mainline valves, including valve spacing and installation of remotely operated or automatically operated valves
- Revise requirements for corrosion control of steel pipelines
- New regulations are needed to govern the safety of gathering lines and underground gas storage facilities

Hazardous Liquid Pipelines

- Extend reporting to all hazardous liquid gravity and gathering lines
- Require increased inspections of pipelines in areas affected by extreme weather, natural disasters, and other similar events
- Require periodic inline integrity assessments of non-HCA hazardous liquid pipelines (HCA means High Consequence Area)
- Require the use of leak detection systems
- Modify the provisions for making pipeline repairs - criteria and an adjusted schedule
- Require IM-subject pipelines be capable of accommodating inline inspection tools within 20 years, if feasible (IM means Integrity Management)
- 1.5 MAWP testing requirement for compressor/metering stations and other Class 3/4 locations
- Inspection of new construction welds for transmission pipelines and distribution mains by independent people
- Expand the Use of Excess Flow Valves in Gas Distribution Systems to Applications Other Than Single-Family Residences
- Pipeline Safety: Operator Qualification, Cost Recovery, Accident and Incident Notification, and Other Pipeline Safety

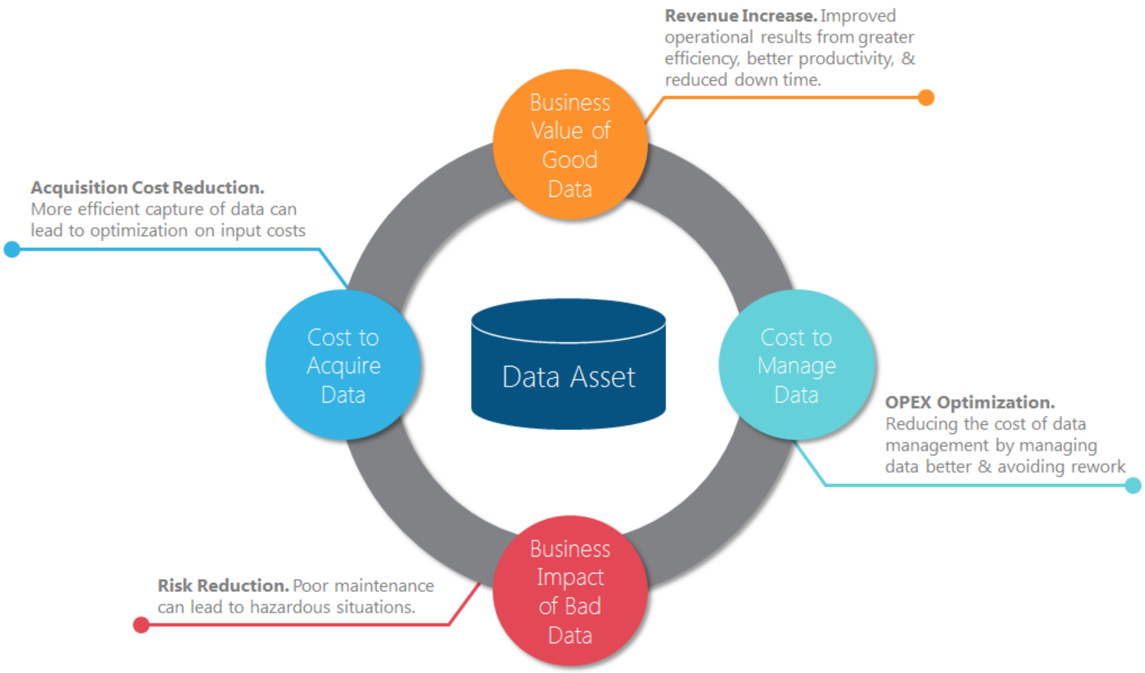

Figure 1 – Data Value Model

- **Business Value of Good Data.** Critical decision makers typically spend 50 – 75% of their time looking for the data they need and confirming its validity and provenance before actually using it. Increasing trust in the data will make decisions makers much more efficient, focusing on activities which deliver true value rather than just gathering data, and the quality of their analysis work and decision-making will improve significantly as a result
- **Business Impact of Bad Data.** Making decisions on bad data exposes operators to significant risk and potentially negative impacts running into billions of dollars; e.g. bidding too much (or too little) in a competitive bid for a license block, pulling an anchor of a supply boat through a pipeline, mismanaging safety critical drilling operations, misjudging requirements for midstream capacity related to new production, missing conditions which could cause non-compliance with regulations, etc.

DA&DM are gaining a strong signature on the radar of the O&G sector because of a number of contemporaneous trends in sensor, communication, storage and processing capabilities (see Figure 2). There has been a proliferation of small, intelligent sensors, which measure changes in physical attributes, and transmit the resulting data through extensive, easily accessible, and fast wide area communication networks. The data can be stored in massive data centers, and subsequently processed and analyzed by extremely powerful computers and processors to deliver critical insights. Those insights can then be acted upon and facilitated by computer-aided interventions. *A key point is that today all this can be done at a relatively low cost*.

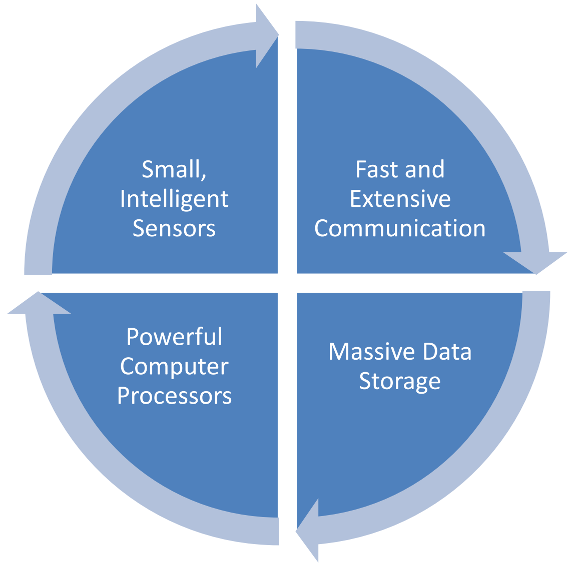

Figure 2 Enablers of Effective Data Analytics

While the midstream is still maturing in its path to fully benefit from DA&DM, there are several applications of DA&DM in the O&G sector. Specifically, the technology already allows the design of data-driven, self-aware, physical assets, whose performance and state of health is being continually and holistically monitored and predicted. A continuous state of situational awareness is possible. Assets can be designed with sensors and analytic capabilities from the outset. Metrics and sensors can be carefully selected to allow optimization of the asset through predictive DA. Sensitive 'hot spots', where risks to business and operations objectives are perhaps higher, can be proactively identified. These 'hot spots' can then be outfitted to provide continuous predictive insights and anticipate issues, both short term ('engine about to fail') or long term ('fleet fuel usage is not as efficient as it should be'). Actions can then be taken to avoid the identified issues. This intelligent data-driven asset could come with a total service package – much of it automated – to optimize the asset's performance over its whole life, designed from the outset with that objective in mind.

The O&G shipping sector is at the beginning of its journey to develop such advanced DA-enabled assets. The offshore sector is more advanced, with MODUs and FPSOs already having real time analytics capabilities in place. However, today these are generally found in closed control systems, perhaps provided by different vendors of individual systems, such as for drilling control or dynamic positioning, rather than a fully integrated, DA-enabled asset.

Allianz Global Corporate & Specialty SE (AGCS), the industrial insurance company whose sectors include maritime and offshore, anticipates extensive analysis of voyage data and data from ship/asset structures, components and machinery to enhance safety, performance, and productivity. In its essay on *How Big Data Will Transform Shipping*, AGCS foresees smart ships that can "talk" through technological advances such as nanotechnology in paints/coatings/materials and acoustic fibers that help detect vibrations (Gerhard, Kinsey, & Klimczak, 2015). Technology and data analytics will allow tailored predictive maintenance and will reduce risk and improve cost efficiency. There are still technological challenges to fully benefit from the new technology, from data analytics and from the efficient and effective use of "big data."

Cost, too, is still a hurdle. However, AGCS argues that early adopters are already applying these techniques. These applications include the use of acceleration gauges to help monitor hull behavior. One practical example of this type of monitoring is measuring hull and propeller fouling over time which increase resistance and thus fuel consumption. Proper DA can use this as an input to indicate the optimal schedule for hull cleaning and propeller polishing. Adding additional sensors, such as those monitoring the power plant, can contribute to a data model which can be used to target the root cause of loss of efficiency. Rolls-Royce President, Marine, Mikael Makinen describes this as a "truly exciting period in the history of shipping". He says: "Technology, and in particular, the smart use of big data is going to drive the next generation of ships. Over the next 10 to 20 years we believe ship intelligence is going to be the driving force that will determine the future of our industry, the type of ships at sea, and the competence levels required from tomorrow's seafarers" (Prigg, 2014).

Offshore physical assets are a special and complex case, including marine pipelines. Unlike their onshore counterparts, they are remote and isolated most of their operating life and there are limited pre-scheduled times when repairs and maintenance can be undertaken (e.g., when a MODU is dry-docked or when an FPSO has its production reduced or stopped for repair). Unlike the aviation industry where equipment may be more mass-produced, the equipment onboard may be unique or from a small production run, meaning repair and maintenance procedures may have to be more customized and specific to a vessel or asset.

Today, operators conduct routine inspections and collect data to determine the condition of the asset as well as specific structures and equipment. They then develop estimates for remedial work and solicit proposals from repair and maintenance facilities. Sometimes, hidden damage will be discovered during repair or maintenance work, which may cause costly delays in returning to operation. Collecting and analyzing more data while a remote equipment or asset is operating can provide more knowledge, better planning, and reduced maintenance down time. The same applies if deficiencies are uncovered during an internal or regulatory audit – previously unknown conditions are generally more costly and take longer to repair.

Data Analytics may also reduce loss during operations. For example, avoidance of non-productive time on drillship operations can save $1 million per day when considering potential losses for both the drilling contractor and the operator (Brekke, 2015). As another example, the lost revenue from an out-of-commission FPSO producing 100,000 barrels per day at $40/barrel can be $4 million per day. The average cost for a mid-sized LNG facility due to unplanned down time is $100 million per year (GE Oil & Gas, 2015). Today, according to a recent analysis, the marine sector has the potential to benefit from $20 billion in value from remote monitoring and data analytics in terms of reductions in fuel consumption, downtime, maintenance expenses, and environmental fines (Keefe, 2014).

The last example in this section highlights the importance of capturing, monitoring, using, reliable data to help ensure safety and environmental impacts. The *Deep Water Horizon* was the state-of-the-art deep-water offshore drilling platform which suffered a blow-out in April 2010. While other factors were also critical, government and independent incident investigations consistently suggested that more or improved DA&DM may help reduce the frequency or consequences of similar events in the future. These quotes from key incident investigation reports illustrate this point (italics and underline added for emphasis):

- The Agency [BOEMRE] should consider promulgating regulations that would *require real-time, remote capture of BOP function data* … Having the data that show which rams have been activated would help analyze intervention options (BOEMRE, 2011, p. 209)
- The simulation was *flawed in that it did not use the most accurate data set available from the well* ... A final simulation on the basis of the most accurate well data followed by a discussion of the results to make a decision on the final centralizer placement would have been prudent (NAS, 2012, p. 37)
- The *real-time data from the rig were being recorded but not monitored on shore*. Even with the negative test having been accepted, subsequent data showing that the reservoir and well were in communication might have been discovered by personnel on shore in time to take the appropriate control action (NAS, 2012, p. 39)
- Although data were being transmitted to shore, it appears that *no one in authority (from BP onshore management or a regulatory agency) was required to examine test results and other critical data* and render an opinion to the personnel on the rig before operations could continue (NAS, 2012, p. 39)
- Overall, the *regulatory community has not made effective use of real-time data analysis*, information on precursor incidents or near misses, or lessons learned in the Gulf of Mexico and worldwide to adjust practices and standards appropriately (NAS, 2012, p. 114)
- Because of the simultaneous offloading and cleaning operations, the mud levels in the tank were changing, making it difficult to monitor whether the well was flowing. As a result, the *recorded flow data is believed to be unreliable* during this period (DHSG, 2011, p. 40)
- This abnormality could have been detected from monitoring the drill pipe pressure data, and could have been *the first clear indication of the flow of hydrocarbons into the well, visible to the crew* (DHSG, 2011, p. 43)

One key observation is that DA&DM have the potential to create *extensive* benefits to the O&G sector and, in particular the midstream. Figure 3 shows the world-wide number of assets in the O&G sector. If DA&DM can generate even small benefits through more efficient and effective management of the assets, the economic benefits are amplified by factors of thousands. For example, if the average benefit for an O&G terminal is $200,000/year, the savings for the sector would exceed $1 billion.

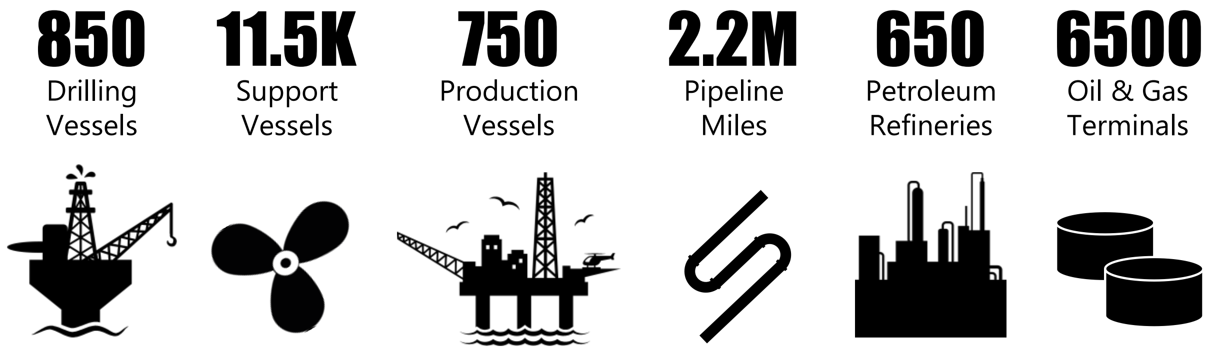

Figure 3 The Multiplying Effect of Efficient

3.0 Solution Frameworks of Data Analytics & Data Management

Figure 4 shows a solutions framework to help succeed in DA (Paula, Mowrer, & Roberts, Data Analytics: Setting the Foundation for a Data-driven Business, 2016). The first two components are concerned with establishing the vision and capability for DA in the enterprise and putting in place a strategic planning process. The next four components concern the execution of individual DA functional tasks. They focus on assessing the best DA approach to solving a problem, gathering the appropriate data, analyzing it, and executing the appropriate response to the insights found. The final component is continuous improvement, a critical process that will help ensure the ongoing success of DA within an organization.

Figure 4 Data Analytics Framework

A holistic approach to DM includes 9 elements which are introduced in Figure 5 and detailed in Table 3 (Paula, Mowrer, & Roberts, Data Management Framework, 2016).

Figure 5 Data Management Framework

4.0 How to Get Started – Achieving Efficiency and Effectiveness in DA & DM

There is no doubt that DA will help to transform the way the midstream industry operates, becoming even safer and more efficient. There will be an early mover advantage for some – those who embrace DA and extract value early. Eventually application of DA will become the norm, and companies will differentiate themselves on how well they apply it.

A concept of maturity and expertise already exists, which can help Operators to differentiate themselves. Figure 6 illustrates this concept (Frost C. , 2015). Operators can assess where they are today and decide where they want to be to benefit most from DA&DM. A typical maturity assessment will evaluate the existing capacity to gain an accurate and deep intuitive understanding of the assets as well as the broadness of the application from component to enterprise level. The basis for this assessment are the solutions frameworks presented earlier for DA&DM. A fully mature company operates in the greener portion in Figure 6.

Table 3 Data Management Framework Elements	
1	**Strategic Alignment of Data with Business Priorities** Formalizing approach to align Data Management activity planning (e.g. 3 – 5 year plan) to business priorities (safety, environmental protection, reliability, regulatory compliance, optimized asset operations etc.)
2	**Business Ownership of Data and Data Governance** Formalized business executive champion, governance, clear accountabilities, business ownership of data – both structured and unstructured, defining policies and standards
3	**Defining the role of Data in Key Work Processes** Documented interplay and interdependency between critical work processes and data and clear definitions of the process requirements of Data
4	**Data Management Organization and People** Clearly defined roles, accountabilities and responsibilities, formally defined skills and competency requirements, career development paths etc.
5	**Data Management Processes** Putting in place standard definitions of key processes such as Data Cataloguing, Data Migration, Data Security, Master Data Management, Data Quality Management, etc. and ensuring compliance with those processes.
6	**Performance Management** Putting in place performance management KPIs, metrics and associated processes and systems specifically for monitoring and managing performance in Data Management (e.g. around data quality or OPEX spend on DM)
7	**Data Management Systems and Infrastructure** Ensuring there is a formalized approach to promoting standardized and optimized key DM systems and tools e.g., for storing master data, migrating data between systems, cleaning data to standards, archiving to secure storage, ensuring easy access, etc.
8	**Data Security** Systems and human process safeguards put into place to ensure correct data is available only as expected; that confidentiality of data is maintained in all circumstances; and that integrity of data is assured through all operations.
9	**Change Management** Recognizing the diversity and abundance of stakeholders who have a dependence on quality data, understanding the impact of changing the way data is managed and ensuring a proactive approach to stakeholder management and change management to secure support and minimize disruption.

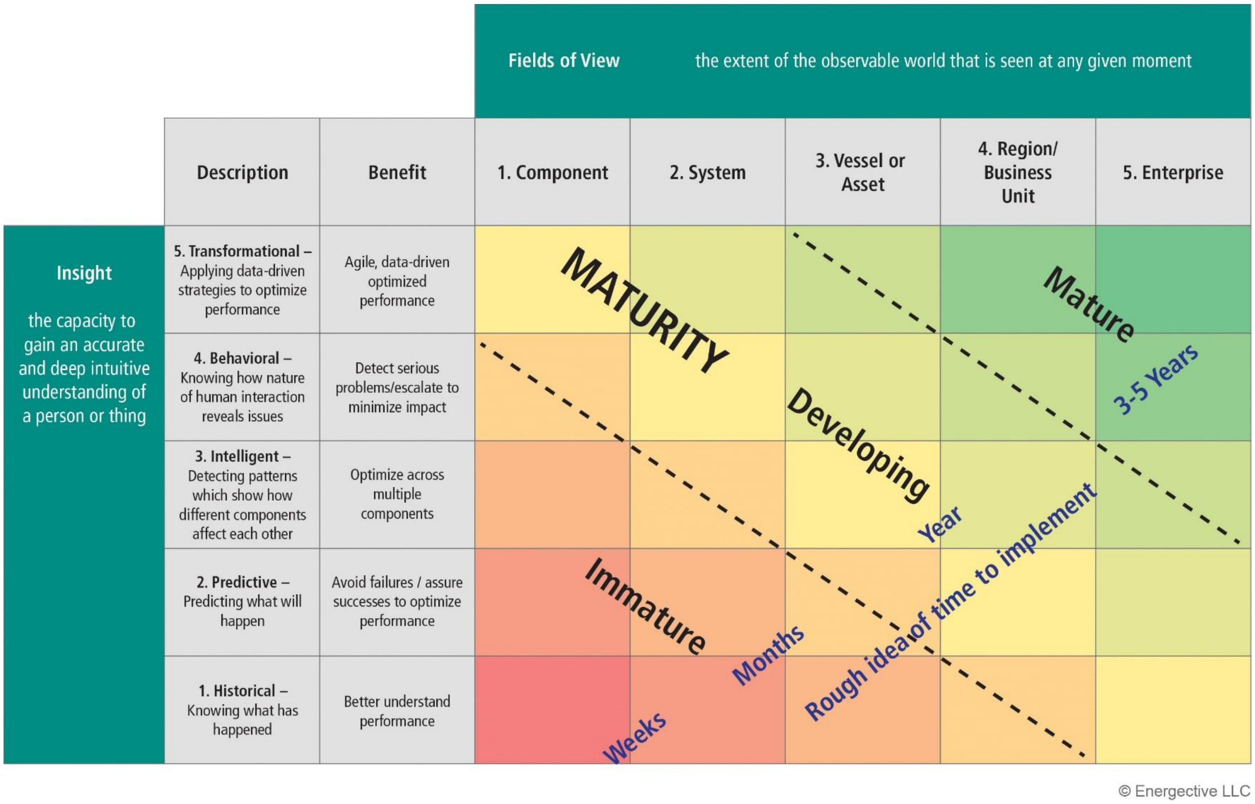

Figure 6 Maturity Spectrum

While we believe it is best to start with a maturity assessment, there are alternative ways of jumping right into the benefits from DA&DM. Figure 7 shows an approach that ABS Group suggests for the O&G industry. You should start with the identification of the business processes and key decisions that need to be made by each stakeholder, which typically includes organizations related to planning, financial, operations, maintenance, inspection etc. Once the data-driven needs are known, you can identify the analytics that can provide the best insights to address these needs. DA requires data, which will typically come from existing device management systems (e.g., PLC), SCADA and other control systems (e.g., DCS), manual and electronic logging systems etc. These, in turn, receive the data from field equipment. The evaluation process will help identify cost-effective modifications to the existing data gathering, processing and storage.

5.0 Concluding Remarks

The benefits of DA&DM have the industry-wide potential to run into the billions of dollars per year, with applications ranging from basic equipment optimization to enterprise-wide asset performance improvement. However, companies need to understand the value of data and recognize DA&DM as "good investment" vs. "cost of doing business." It is fundamental that they consider questions such as "where are we today, what are the asset management needs, what are the regulatory compliance needs, how can we use data as an asset?" Also, they need to be proactive in getting started or stepping up the pace on the data journey.

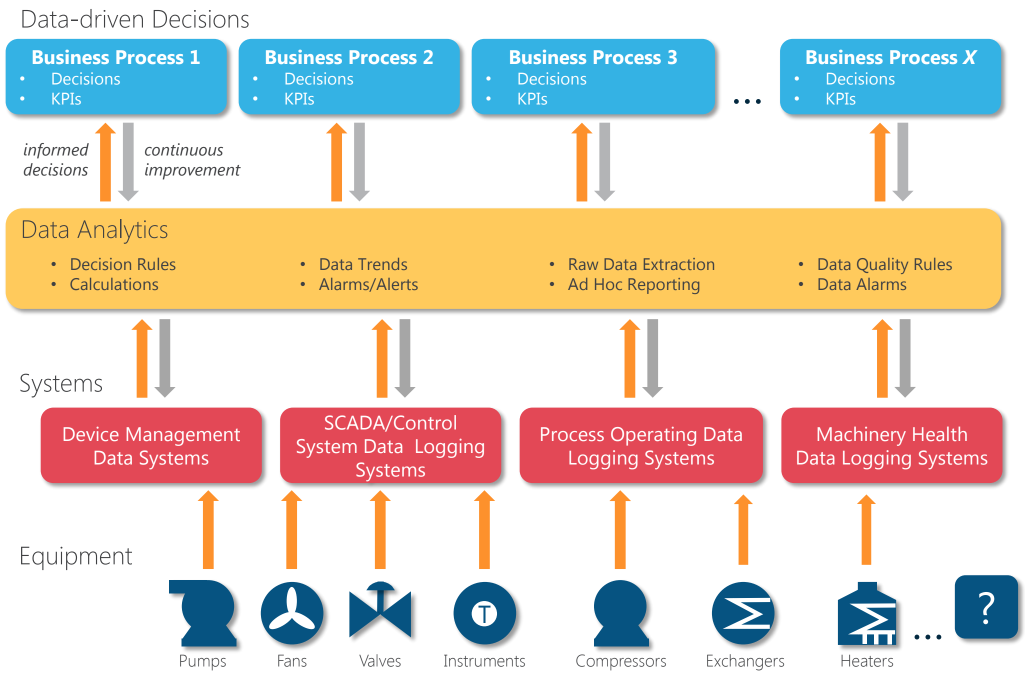

Figure 7 Maturity Spectrum

6.0 Acknowledgement

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Table 1 – Selected 2016 Pipeline Incidents in the US[a,b]	
Month and Day	***Description***
Jan. 3	Approximately 77,800 gallons of crude oil was released due to vandalism. The estimated cost was about $450,000.
Jan. 9	The report submitted to PHMSA still indicates that the incident is under investigation and metallurgical testing is being conducted to determine the cause of the rupture of a gas pipeline, which resulted in a fire.
Jan. 15	A unit inboard bearing failed, resulting in the failure of the inboard seal and subsequent gasoline leak and fire.
Feb. 16	Product release discovery from an electrical facility underground vault structure, located 28 ft. from the pipeline. The pipeline was shut down. The leak was from pinholes of a buried pipeline elbow. The release was 10,458 gallons with total damage reported at $1.2 million.
Feb. 16	While responding to operational upset conditions, personnel found the top of an 18” pine tree laying on top of the exposed creek crossing and oil leaking out. The release was 13,860 gallons of crude oil with an estimated total cost of $1.8 million.
Feb. 18	While using a grinder, a welder saw an instantaneous flash and glow moving away from him inside an idled segment of piping. The cause of the flash fire was failure to recognize the hazard of potential trapped gas in a low spot.
Feb. 22	Oil was seeping up from the ground in a public park near a tank yard. The Operator confirmed that there was an existing underground pipeline in the area. The cause of the leak was that a contractor scraped the pipeline during a previous tie-in activity. The release was about 15,000 gallons with an estimated total cost of $2.6 million.
Feb. 23	A pump seal failure spilled 6,300 gallons of crude oil onto the ground, and the spill eventually reached a creek tributary. The preliminary investigation indicated the evidence of vandalism, but his could not be proven or denied. The total cost was about $1.1 million.
Feb. 24	A pipeline failed, resulting in a fire and release of about 208,000 gallons of liquid propane. There were no injuries or impact to waterways. A metallurgical analysis indicated that the failure was the result of the interaction of an external hook crack and an external thumbnail feature on the longitudinal seam. The total damage was just under $600K.
Mar. 8	Upon returning a tank to light crude oil service, operations identified crude oil at the ring wall in the soil/rock tank dike. Investigation revealed two pinholes in the floor. Total cost reported was $1 million.
Mar. 31	A release of ultra-low sulfur diesel (ULSD) was identified from a mainline pump unit at a pump station. The pipeline was shut down and the station isolated. The source of the release was a ¾-in stainless steel tubing and fitting in the seal flush system. The release was approximately 40,320 gallons, and the estimated total cost was $2 million.
Apr. 2	A local resident reported a leak, which was confirmed by the Operator. A contributing factor appears to be construction related and associated with a failed pipeline girth weld. The leak was about 9,240 gallons with an estimated total cost of $13 million.

Table 1 – Selected 2016 Pipeline Incidents in the US[a,b]	
Month and Day	***Description***
Apr. 6	A third party excavator using a Caterpillar road re-claimer machine struck a 10” transmission gas main. The blowing gas injured the operator who later passed away due to the burn injuries. The total cost was $2.1 million.
Apr. 12	A pipeline at a gas plant in Woodsboro, Texas exploded, killing 2 men, and injured another worker. The incident occurred during the completion of an 8” hot-tap and pig-guide-bars insertion procedure. The total cost was an estimated $1.8 million.
Apr. 16	The fire department notified the Operator of an apparent diesel sheen on the river. The pipeline was isolated with an estimated release of 35,868 gallons and total cost of $9 million. Preliminary investigation indicates that there was scouring of the river due to natural forces, which caused an unsupported span.
Apr. 19	Approximately 123 barrels of crude oil were released from a segment of pipe as a result of internal corrosion. A third-party analysis indicated that the pit morphologies observed on this pipe sample are consistent with sulfate reducing bacteria (SRB) induced corrosion. The majority of the released crude was contained within the manifold area.
Apr. 20	Personnel were preparing for an annual tank inspection at a pump station. An individual was on top of the tank when vapors ignited. The individual evacuated and reported the fire. The pipeline was shut down, the tank isolated, and the fire extinguished. The cause of the incident was sparking during preparation for a vent valve inspection.
Apr. 29	A 30-inch pipeline exploded, injuring one man, destroying his home and damaging several others. The total estimated cost was $3 million (Tribune-Review, 2016).
May 10	A small fire occurred during maintenance work inside a tank. A contractor was removing tank leg bolts with a grinder, which was not permitted in the safe work permit. The leg shifted allowing a small amount of crude to escape and ignite by the sparks. The small fire was quickly extinguished with a hand-held extinguisher.
May 20	A pipe segment ruptured, which was detected at the control center. The pump station shut down automatically, and the controller shut down the entire pipeline system. The failed pipe was examined at a metallurgical laboratory. The release was about 21,000 gallons of crude oil with an estimated total cost of $4.5 million.
May 24	A worker was grinding inside a tank when sparks ignited some residual crude oil that leaked from the floating roof leg weep hole. There were no injuries and no impacts to the environment.
May 27	An Operator employee arrived at location to perform maintenance and noticed a small fire in the vent piping outside the pump station. The flame extinguished when the employee shut the valve coming from the pump seal. It is believed that lightning ignited vapors emitting from the vent piping.

Table 1 – Selected 2016 Pipeline Incidents in the US[a,b]	
Month and Day	***Description***
Jun. 3	An equipment operator was moving trees near the ROW. He called the pipeline Operator to report that he got stuck over the pipeline and after getting unstuck he noticed what looked like diesel fuel coming out of the ground. The pipeline was shut down. The release was about 11,760 gallons with an estimated total cost of $1.4 million.
Jun. 5	The Operator was notified of a transmission line leak. A service representative was dispatched and reported gas blowing from the 12" line. The apparent cause is stress corrosion cracking. There were no injuries or fatalities or ignition, but the estimated total cost as $ 1.1 million.
Jun. 11	A threaded water/sediment sampler plug failed at the bottom of the debris/coupon holder, resulting in a release. The failure was due to corrosion, and it resulted in approximately 20 cubic yards of impacted soil, which was remediated.
Jun. 17	The pipeline control received a fire alarm for one of the pump stations. A technician was dispatched and confirmed that an inboard seal of a unit had caught fire. A fire extinguisher was used to put out the small fire. The investigation of the cause of the ignition was inconclusive.
Jun. 23	After a shut down for maintenance, the pipeline was being filled with crude oil when a nearby resident reported a leak. The line was shut down, and employees built an earthen berm/dam, which prevented the crude from traveling any further or reaching the beach/pacific ocean about a mile away. The total release was about 45,000 gallons with and estimated total cost of $6.2 million.
Jul. 1	The Operator discovered refined products exiting a valve vault. The pump was shut down and emergency response activities initiated. The source of the release was a damaged dielectric tubing fitting. A metallurgical analysis concluded a high probability of damage from high voltage or lightning. The release was about 5,460 gallons of gasoline with an estimated total cost of $2.2 million.
Jul. 6	Company personnel along with right-of-way (ROW) mowers, came upon a location on the ROW where the soil was moist and it had an unusual odor. The pipeline was shut down, excavated, and a small crack in the long seam of the pipe segment was discovered. The failed pipe segment was replaced.
Jul. 14	Lightning struck a pump station, damaging the PLC, which caused the ESD valves to close. The strike also caused loss of communication with the controller. The unit remained running against the closed valves, which led to a fire.

Table 1 – Selected 2016 Pipeline Incidents in the US[a,b]	
Month and Day	***Description***
Jul. 18	Operators observed a fire east of and adjacent to a gas plant. The fire was within a fenced pipeline terminal facility containing incoming gathering pipelines, scrubbers, measurement equipment and departing residue pipelines. Plant personnel were evacuated. No injuries were reported but the incident had an estimated total cost of $2.4 million.
Jul. 18	An Operator manager reported fire in the distance approximately in the vicinity of a company's facility. The inlets and outlets were isolated. It is believed that the incident began within the facilities of an adjacent third party. The estimated total cost was $3.4 million.
Jul. 20	A small amount of condensate was released through a flare. As it exited the flare tower, it ignited and fell to the surface waters of the Gulf of Mexico. It self-extinguished within 2-3 minutes. A malfunctioning level switch in a scrubber is believed to have caused this spill.
Aug. 12	Contractors were working on one of the main lines in a terminal when crude oil burst through a plug that was supposed to hold the oil back in the pipeline and ignited. The contractors were knocked off the platform to the ground, suffering injuries from the fall and severe burns. Seven contractors were injured (Wray, 2016).
Aug. 17	A Contractor hit a pipeline with the ROW clearing equipment. The Contractor was transported to a hospital and diagnosed with broken bones, abrasions and contusions.