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Leveraging the Power of Industry 4.0: Orm Digital Twin for Process Industry

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" Houston, we've had a problem here."[1]

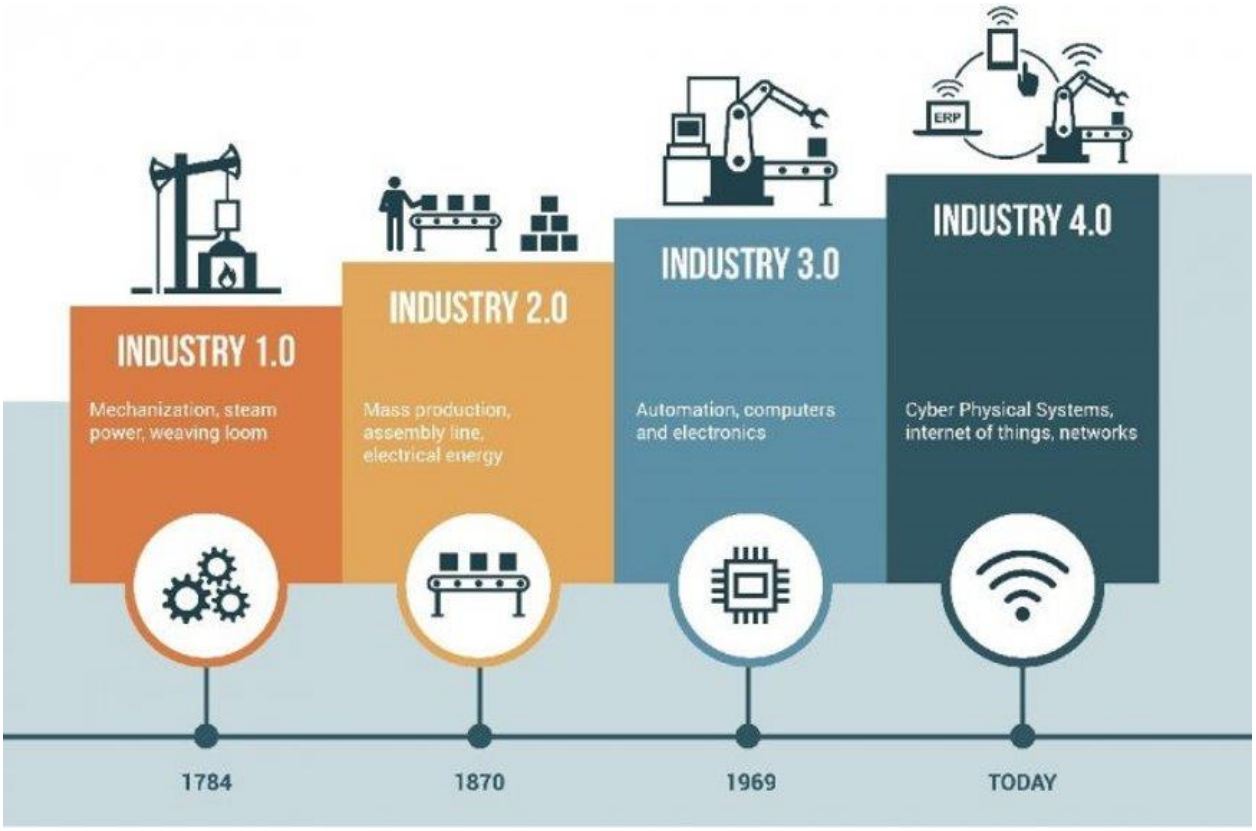
When astronaut John Swigert sent this message from the Apollo 13 in 1970 during their attempt to land on the moon, NASA had to find a way for the three astronauts to fix the space vessel quickly before they ran out of oxygen. The team in Houston had to find a way to visualize the exact issue based on the description that the team in space relayed to them from the vessel, and then they had to find a way to help the team in space fix the problem so they could return to earth safely.

It is interesting to imagine how the scientists and engineers at NASA used a physical twin of the Apollo 13 module to conjure up the solution. Since that incident, NASA has invested more and more in technologies that can predict the risk of different failures and the potential resolutions for the same.

As an engineer, one of the subjects I studied in school was about Finite Element Methods for design purposes. Working as an engineer and building process equipment for the Oil & Gas industry, I now know how equipment is supposed to behave in its operating environment and as part of its operating standards. However, the real-world situation for that well-designed pressure vessel or heat exchanger is very different. Not only does the equipment have differing operating environments, but also they must be able to interact with other equipment, which likely has been designed and engineered in a different way. Once a process plant is operational, the asset is introduced to a variety of risks and uncertainties that, again, were never part of the original design.

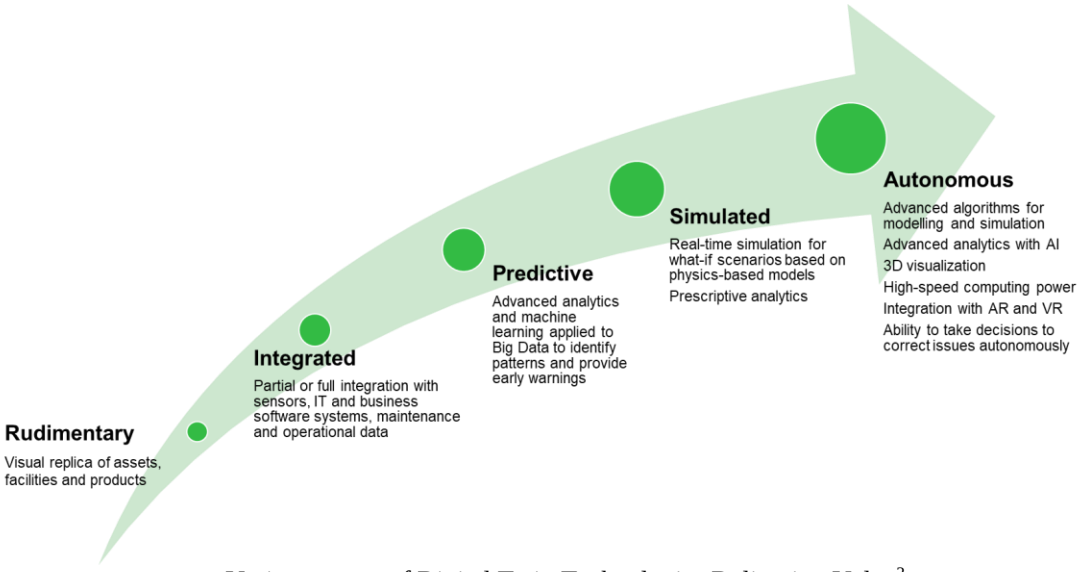
The asset has software available that can provide information about the changing parameters for the individual equipment. Engineers can use this data to modify work environments or consider maintenance for the various parts. In the past few decades, Industry 3.0, which is the revolution of automation and computer-operated systems have given plant operators in the hazardous industries a good understanding of what needs to be done for the individual equipment's safety and performance. However, experience has shown that the majority of incidents do not occur because one particular piece of equipment failed or performed out of its operating window. Accidents and

disasters happen when a series of infractions (big and small) come together lining up to make and create a situation where an accident is triggered.



Timeline of the Evolution to Industry 4.0.[2]

Hence, it is important that the asset operators get an overall view of the entire asset and understand how the interaction of the various automated equipment, sensors, probes, etc., along with the human maintenance and operational tasks have a combined effect on the safe working of the asset. Industry 4.0 has emerged and is now at a stage to deliver the promise of the true deployment of the Industrial Internet of Things (IIoT). Using all the information available from the individual sensors and equipment, we can now draw a virtual picture of what the real-life plant status is. We can then overlay information on what human interactions need to happen in the plant to then start to get a better picture of what is the true operational reality of the plant. Once we start to get the picture and we plan our operations, first in the digital space and then in the physical asset, we can start to manage the real Operational Risk of the asset.



Various stages of Digital Twin Technologies Delivering Value[3]

Today's technology allows us to predict and plan for risk at the asset location based on the digital information acquired from it. We can now deliver a true Operational Risk Management Digital Twin of the asset, and operators in the hazardous industries can start to predict what is going to happen in the asset, simulate the changes based on planned operations and then offer a prescriptive behavior of what needs to be managed at the asset to ensure the planned operations are carried out in a safe manner and minimize the chances of a disaster occurring at the asset.

2019 Operational Risk and Process Safety Management Survey

Sphera performed our annual survey of process safety engineers from global organizations and have found some important messages with regards to the state of process safety and operational risk management in the industry. The 2019 Sphera PSM/ORM[4] survey found that most companies do have safety inherent in their DNA. It appears in their corporate culture and includes defined safety goals even though technological shortcomings sometimes cause organizations to spin their wheels when it comes to mitigating risk. Companies understand that a strong safety culture is important to manage Operational Risk and Process Safety.

A significant number of respondents said that there was an increased focus on Operational Risk at their organization. However, oftentimes approaches to managing Operational Risk are too static and not able to connect to the day-to-day challenges organizations need to overcome. Just 40% of respondents said that their organization proactively manages Process Safety, and 77% said that risk increases in some capacity between periodic safety review periods, which is up a robust 21 percentage points from 56% in the previous survey. The numbers indicate that progressively there is an increase in awareness of risk increasing during periodic safety studies.

What organizations need to do next is identify ways to be more proactive in spotting the real-time risks at the asset so that the issues are identified earlier in its lifecycle and clear mitigating measures

can be put into place. The results from the PSM/ORM survey, however, suggest that there hasn't been much improvement year over year in terms of companies' ability to manage risks proactively. And in a typical month, only 69% of scheduled asset integrity inspections were achieved, according to the survey.

It is imperative that companies move to a more proactive approach to manage risks at their assets and change the way things are done to change the current status quo. The power of IIoT needs to be leveraged, and companies need to start connecting disparate data systems and the people to enable new end-to-end business processes to help people shift from a reactive approach to enabling operators with real-time insights.

When Dr. Michael Grieves first spoke about the concept of the digital twin in 2002[5], he envisioned a product lifecyle management (PLM) system in a virtual space to analyze and predict the multiple outcomes of a physical entity. During the entire PLM, the physical and digital version would be linked, and the digital version would mirror the processes. Applying this concept to the process industry, you can visualize the entire refinery or a chemical plant with the different processes in a digital space. The data that is provided to the control panel is then translated to a visual means, and you are able to make a prescriptive approach to managing the asset. But now you are able to plan the multiple outcomes that the asset may have based on the planned activities in the future. This digital presence is what enables the frontline operator to be more proactive in their activities and truly delivering the Operational Risk Management Digital Twin for the asset.

The PSM/ORM survey also reveals that companies are taking steps in this direction to ensure the frontline operator is enabled. Four out of five (82%) of the respondents said that their organizations understand the importance of Operational Excellence and continuous process improvement. The key aspect for implementing any program at an organization is to know the people accountable and need to be empowered to proactively manage Operational Risk. he survey found that 57% of

the respondents believe the frontline operations and maintenance staff need better information to manage risk. A little less than half (44%) said empowering department heads should be high on the agenda for mitigating risk.

The real world of operations is neither simple nor static. The effects of aging assets, interventions in the plant to operate it or perform maintenance all come together day in and day out to affect the process safety risk on the assets. With risks unavoidably managed in different parts of the organization, the information has become siloed. Dots are not connected and decisions are made without the full context. So, if companies can provide the right information to the right people at the right time, they can make the right decisions.

Implementing Digital Twins may be in the relatively nascent stages within organizations, but the implementation of digital transformation projects is not. But organizations are struggling to get going at any scale with their digital transformation. In Gartner's 2019 CIO survey, a full 63% of Oil & Gas companies indicated that they have yet to move beyond the ambition or design phases of their Digital Transformation journey. These numbers mirror Sphera's own numbers from the 2018-19 Operational Excellence survey, which found that nearly 70% of operators are only just starting or beginning to implement their Digital Transformation projects.

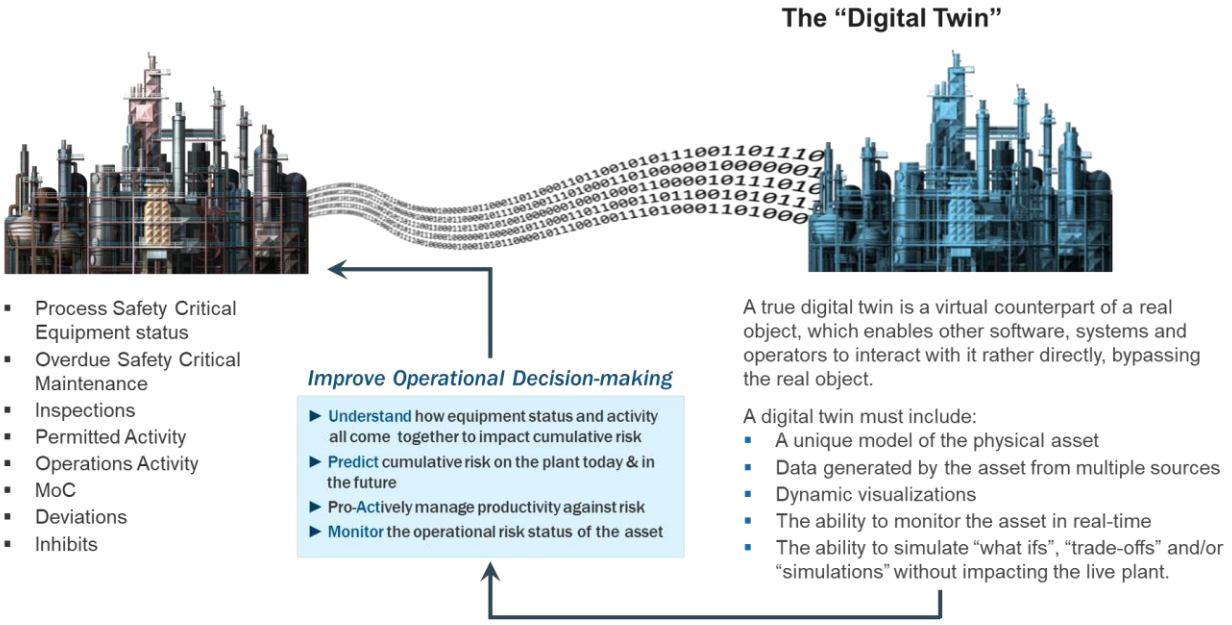
One of the biggest reasons why organizations struggle in those areas is because of siloed information, and the numbers back that up. Three-quarters of respondents (75%) said their companies are operating with siloed data and piecemeal insights. And only 10% of the respondents said that they have deployed integrated, digital solutions that record risk-relevant data and execute predictive algorithms for real-time risk identification and management.

An Operational Risk Management Digital Twin Is a Step Toward Closing the Gap

There is increasing focus and attention on the potential for new digitalization technologies to deliver increased value and sustainability in the energy and petrochemicals sectors. Over 90% of industry leaders recognize the power of digitalization to accelerate and provide sustainable Operational Excellence[6]. A reduction in operating costs, broader operational efficiencies and a

fundamental transformation of the business are expected. The promises of data connectivity and analytics include continuous uptime, rapid response to risk exposure, incremental revenue gains, opportunities to better utilize assets, ways to coordinate operating and business needs, and opportunities to improve the efficiency of field service groups.

An ORM Digital Twin brings together human, system and sensor-derived inputs in a combined way to provide a continuously updated picture of operational risk on the specific asset.



An ORM Digital Twin Connects Operational Risks to a Fundamental Barrier Model

As hazardous industry operators move toward a fundamental barrier model, based on multiple layers of protection/mitigation, an ORM Digital Twin can bring all the risks together to understand their potential cumulative impact in a practical and tangible manner. The idea is simple: If you have impairments in several barrier groups, risk increases because a major accident is more likely to occur. Note that these barrier groups are not singular barriers; each is a collection of equipment, instrumentation or people-driven processes that collectively fulfill the function of the barrier.

The fundamental barrier model has its origins in James Reason's Swiss Cheese metaphor; the holes in the barriers represent impairments, and when the holes line up, an event can occur and escalate into a major accident. The degree to which risk pathways develop represents the potential level of risk.

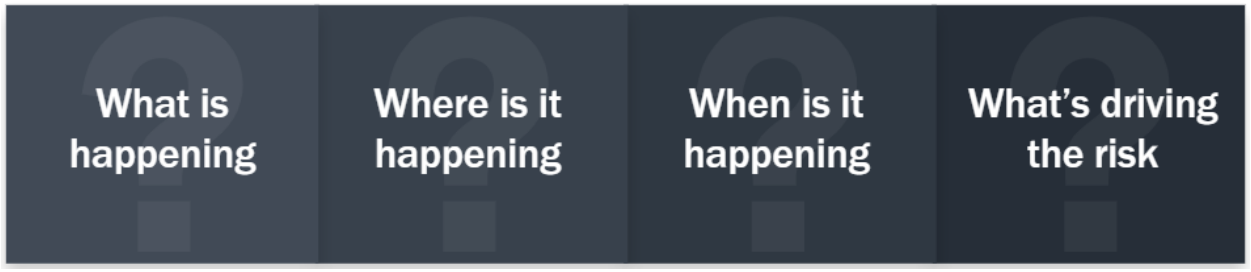
The grouping of the barrier systems is important because it allows work teams and process safety engineers to see how the impairment of barriers can line up sequentially with others with the potential to compound risk. For example, if there is an impairment on the *containment* barrier happening at the same time and within the same location as impairment in the *ignition control* barrier, the risk of having an uncontrolled release of hydrocarbons to the atmosphere is higher as is the risk of ignition. Combined, they can result in a fire or explosion from the subsequent failure

of more than one barrier group. If the *detect* barrier (e.g., gas and fire detector) is also compromised, and the ability to protect it is compromised as well (e.g., because the water deluge system is inoperable), these additional breaches can result in the potential occurrence of a major event. The degree of escalation and the scale of the consequences will depend on the mitigation barriers or the ability to respond to the incident.

Planned activity on the facility can also introduce risk as it often includes the introduction of hazards into a process plant whether it's work involving spark potential, breaking containment, startups, shutdowns, isolations, de-isolations. All these activities have the potential to increase risk and impact process safety barriers. These activities are typically planned and scheduled in a maintenance management system, and their execution is managed via a work permit processes and supported by task risk assessment or job safety analysis (JSA). In addition, operational activities are managed through a combination of operational procedures and operator rounds practices. The potential barrier impact of this activity can be modeled. For instance, if a planned positive isolation is needed to prepare for a confined space entry, it is reasonable to assume that there is a potential impact on the process containment barrier for the period in which the first line break is undertaken. Similarly, open flame hot work in a unit represents a degradation of the ignition control barrier for the period the permit is issued.

An ORM Digital Twin Provides a Single, Shared View of the Operational Reality

Capturing all the process safety risk data isn't enough. It needs to be connected to the operational reality in a practical and routine way for everyone. An ORM Digital twin can do just that by delivering real-time insights to support daily operational decision-making on the ground. With a single, shared view of the operational reality everyone can make better, more informed decisions because they can see:



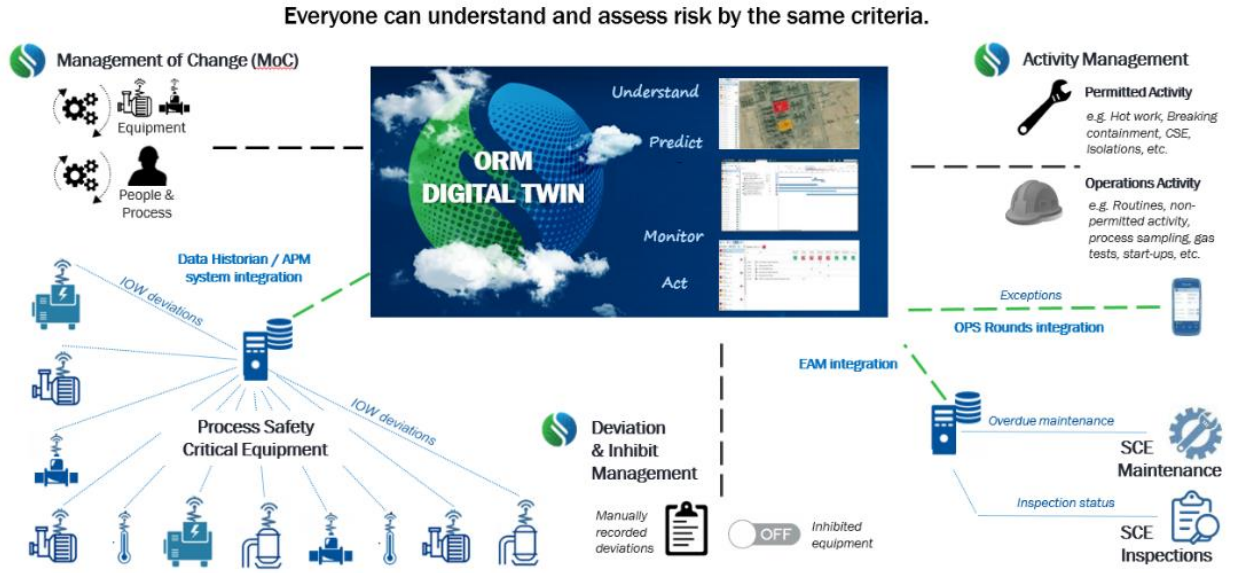
If we think about the daily activities of the frontline worker, there are many situations where providing a common view of the operational reality of the facility—that is, an understanding of where equipment conditions or planned activities may impact operational risk—will help support effective decision-making. By bringing all human and sensor-derived inputs together in a combined way to see their cumulative risk impact on the operational reality of the plant, operators can understand the health status of process safety-critical equipment and the impact of performance deviations and abnormal conditions. With a common view of risk,
everyone can understand and assess risk by the same criteria. This provides a holistic and common means of balancing risk against production at all levels of the operation.

Major accident hazard risk exposure can be made visible, prominent and available in real time. It can be viewed in time, location and in a dynamic process safety barrier model with drill-down capabilities to quickly understand what's driving the risk. Everyone can understand what activities or conditions drive risk and which process safety barriers are affected or impaired by specific work activities, actions and operational requirements. This allows you to proactively manage the health status of safety-critical equipment and the impact of performance deviations and abnormal conditions.

Knowing what is happening, when it is happening and where it is located allows operations staff to understand better how the state of the plant potentially can impact planned activity and how planned activity could potentially impact the state of the plant.

How Does Data Get Into the ORM Digital Twin?

An ORM Digital Twin allows us to connect disparate sources of data that represent all activity, deviations and nonconformances on the facility and generate a "common currency of risk." The cumulative impact of these risks can be modeled to help everyone understand and assess risk by the same criteria, to make better operational decisions, and to proactively intervene to prevent major hazard events. Support for diverse integration needs, ranging from direct point-to-point integration with third-party systems to robust involvement with integration middleware via RESTful Web Service API, Plugins, Messaging (MQ) and custom connectors is key. The diagram below illustrates how insights can be created with the help of an ORM Digital Twin by extracting, translating and aggregating data from sensors, systems and human activity.

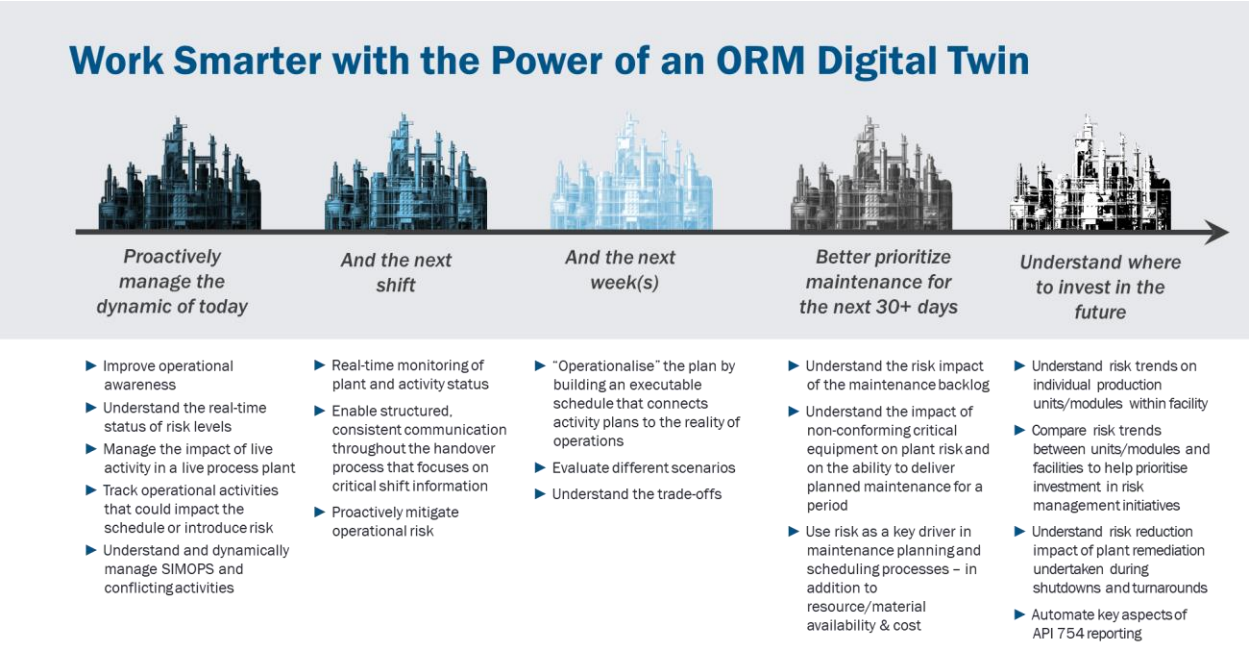


- Make the IIoT operational by connecting the status of process safety-critical equipment sensor (e.g., temperature, pressure, vibration sensors) data to its impact on cumulative Operational Risk with real-time or near-time integration to Historians and APM systems using time-weighted averages.

- Automatically connect overdue and planned maintenance and inspection data with integration to EAM/CMMS and Inspection systems.
- Automatically capture process- and people-related "risk" data with real-time integration of EPTW-CoW, Environmental Health & Safety and other systems.
- Automatically capture the Operational Risk impact of Management of Change (MoC), inspection data, inhibits, emergency-critical and environmental control system statuses.
- Manually raise, risk assess and manage performance deviations for impairments, deferrals, overrides, MoCs or even how well processes, procedures, and drills are followed.

Leverage the Power of IIoT and Manage Process Safety With an ORM Digital Twin

Digital Transformation/Industry 4.0 done right is an ongoing process that will change the way hazardous industries operate. It's fundamentally about new end-to-end business processes empowered by technology to produce positive business outcomes. As we have demonstrated, an ORM Digital Twin with its digital representation of the operational reality can unlock a radically different, far more effective way to visualize and manage activity and risk. By connecting people and processes and closing the loop between operations; maintenance; engineering, Environmental Health & Safety; and other functions, digital solutions can deliver meaningful, actionable insights with powerful visualizations of risk and activity. An ORM Digital Twin can help connect previously disparate business processes in ways that just haven't been possible until now. It can relate the collective performance of your process safety systems to the real, cumulative risk impact on operations at any given point in time.



[1] https://en.wikipedia.org/wiki/Houston,_we_have_a_problem

[2] Founder Institute

[3] Verdantix
[4] 2019 Sphera PSM/ORM Survey – Part 1: The State of Process Safety and Operational Risk Management
[5] Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems (Excerpt) https://www.researchgate.net/publication/307509727_Origins_of_the_Digital_Twin_Concept
[6] Operational Excellence Index 2018/2019