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ASSET INTEGRITY INTELLIGENCE

A Data-Driven Approach to Sustaining and Improving Your Mechanical Integrity Program

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Introduction

Because you are reading this article, you already know that running an effective mechanical integrity (MI) program is critical to sustaining successful operations. An ineffective program can significantly impact your business, ranging from lost production to overspending on maintenance and, in some cases, major loss of containment, Health, Safety, and Environment (HSE), or business risks.

An effective and competitive MI program must be anchored on data-driven decisions. We've seen many facilities focus more than 90% of their investments and effort on implementing step-change program improvements that will help them make more data-driven decisions, such as piping programs, risk-based inspection, and integrity operating window (IOW) management. However, sustaining and incorporating these step-change improvements into the MI program and continuously improving the actual performance of these programs is challenging. Many owner-operators do not recognize the full value of their programs and waste millions of dollars implementing improvements that do not impact their bottom line.

The recent Inspectioneering webinar, "A Data-Driven Approach to Sustaining and Improving Your MI Program," focused on the challenges many owner-operators have regarding the ongoing continuous improvement of their MI programs. In this article, we're going to further explore three key elements for successfully sustaining and improving your MI program:

1. **Begin step-change improvements with the end in mind.**
2. **Incorporate comprehensive analytics that drive sustainable decisions.**
3. **Build your MI program to get smarter over time.**

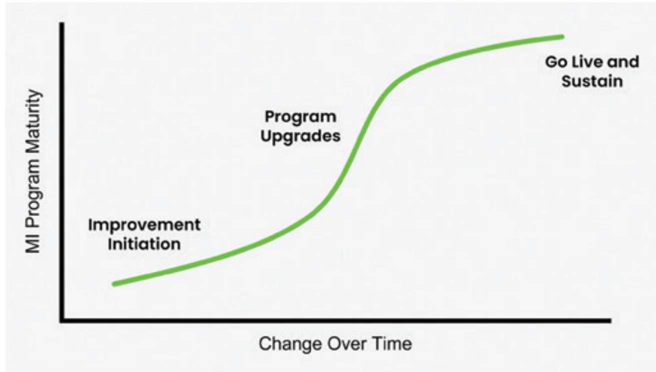

Figure 1. The Three Phases of Continuous Improvement.

Begin Step-Change Improvements with the End in Mind

We've seen hundreds of millions of dollars dedicated to improving MI programs wasted over the past decade due to poor planning. Rather than focusing on value-based performance outcomes like reducing the number of leaks or maintenance or inspection spending, many facilities focus on implementing initiatives to check a box. Apart from whether those activities were the right things to do in the first place, in many cases, when facilities implement initiatives simply to check a box, their MI team is left with another program to manage with little understanding of how to maintain, improve, and connect the program to the facility's performance over time.

Figure 1 shows the three phases of the continuous improvement process for an MI program: improvement initiation, program upgrades, and go-live and sustain. It's common for facilities to focus most of their efforts on programmatic upgrades without focusing as heavily on the other phases. When these upgrades are handed over to the end stakeholders to manage, there is typically a lack of buy-in, frustration due to poor change management, and additional work that doesn't align with existing MI program activities. In many cases, these program improvements also do not result in a value-based performance outcome like the reduction of the number of leaks or maintenance/inspection spending.

Practically, the operators that effectively prepare for the transition from the program upgrades to the go-live and sustain phases begin with the end in mind. Preparing for this transition includes developing new work processes, accounting for change management, and equipping existing or new roles with the upskilling needed to effectively abide by the new work processes.

For example, suppose a facility has a goal to drive better inspection strategies across its fixed equipment and piping. In that case, it will spend time digitizing inspection documentation, data mining key fields, and building a proactive damage model. After the program goes live, users need to know how to keep this documentation, data, model, and inspection strategies up to date as new inspection findings come in, assets are removed or added, or management of change occurs.

Your facility can put significant effort into an improvement initiative or program, and still, without beginning with the end in mind, the value of your program will decrease after going live. Positioning and prioritizing your program for proper sustainability and continuous improvement will significantly impact your bottom line, including reducing risk, improving production, and optimizing spending.

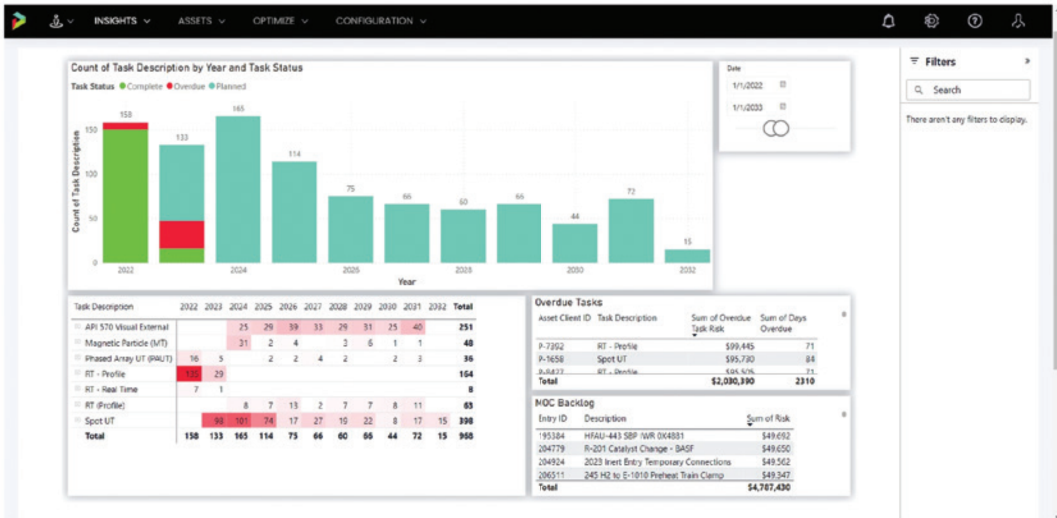

Figure 2. Program Compliance Dashboard.

Incorporate Comprehensive Analytics to Drive Sustainable Decisions

Continuously improving your MI program must be based on data and not just qualitative storytelling. To ensure your program's continuous improvements are driven by data, incorporating dashboards that include critical key performance indicators (KPIs) empowers users with the information and value cases they need to invest in the right areas and drive sustainable decisions.

An effective MI dashboard will help decision-makers intuitively understand two primary items. First, these dashboards should help leaders understand the historical performance of their facility and how it will likely perform in the future. Second, leaders should be able to identify where their issues are and the areas they need to focus on from a compliance, risk, and cost perspective.

Most programs already operate using some type of dashboard. However, many of these dashboards are outdated, contain too much data, or are heavily focused on compliance instead of focusing on the true effectiveness of an MI program. As a result, many facilities do not trust their dashboards to drive their reliability decisions. Dashboards that primarily focus on compliance and ensuring inspections are completed per regulatory or internally set inspection procedures and often do not include the analytics leaders need to make data-driven decisions.

It's important to remember that the effectiveness of dashboards is based on the health and organization of the data feeding them and their regular use to drive decisions based on the insights they bring to light. Dashboards that help facility leaders drive sustainable decisions for their MI programs typically include insights from the following categories:

- Program Compliance
- Program Data Health
- Program Effectiveness
- Program Leading Indicators

Figure 2 shows an example of a dashboard focused on program compliance. This dashboard shows compliance-based inspection lookaheads by year that can be filtered by targeted timeframes and inspection types. In this specific example, most of the future tasks are API 570 external visuals and spot ultrasonic testing (UT), and many UT surveys have been flagged in 2023 and 2024. Additionally, a cumulative risk value is associated with all overdue inspection task events alongside their aging factor to drive appropriate responses. With this specific dashboard, facility leaders can quickly identify overdue tasks with associated risks and the management of change backlog that needs to be processed by the MI team and incorporated into the program.

Dashboards that include insights from a program data health perspective help decision-makers highlight potential gaps in data or where data may be questionable. These types of dashboards are especially helpful when a facility appears to not have any overdue inspections or major risks above the acceptable threshold. However, even in these cases, facilities could still have major gaps in their program data. With the plethora of data available to facilities today, it can be very challenging to identify potential data gaps and, as a result, make sustainable, data-driven decisions. For example, suppose a program has 1,000 pieces of fixed equipment and 3,000 piping circuits. In that case, it's likely that over a 10-year inspection history, this program will have over 15,000 inspection records, 100,000 UT readings, and 50,000 other data points that relate to the MI health of the assets under purview. An effective dashboard connects its users to a system that can efficiently sort through this large amount of data and highlights potential gaps or discrepancies to the decision-maker, particularly in areas of high risk, to make corrections and help increase confidence in the data-driven decisions made by the team.

In **Figure 3**, a dashboard showcases a living data health audit summary for common data gaps, assumptions, and errors, prioritized based on the impact on assets' health analysis. These can include simple flags, reading growths, or missing design conditions and more advanced anomaly escalation using an intelligence model, such as flagging a component listed as carbon steel where typically this system would have stainless steel. In this asset's case, carbon steel significantly impacts sulfidation rates. Because users can easily identify this difference in material within the dashboard, subject matter experts can adjust prediction rates to

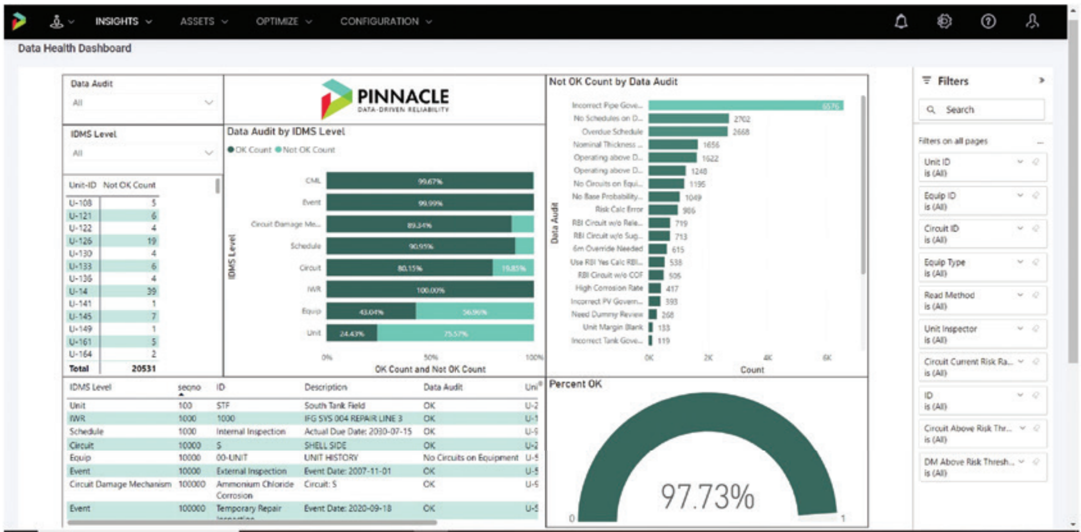

Figure 3. Data Health Dashboard.

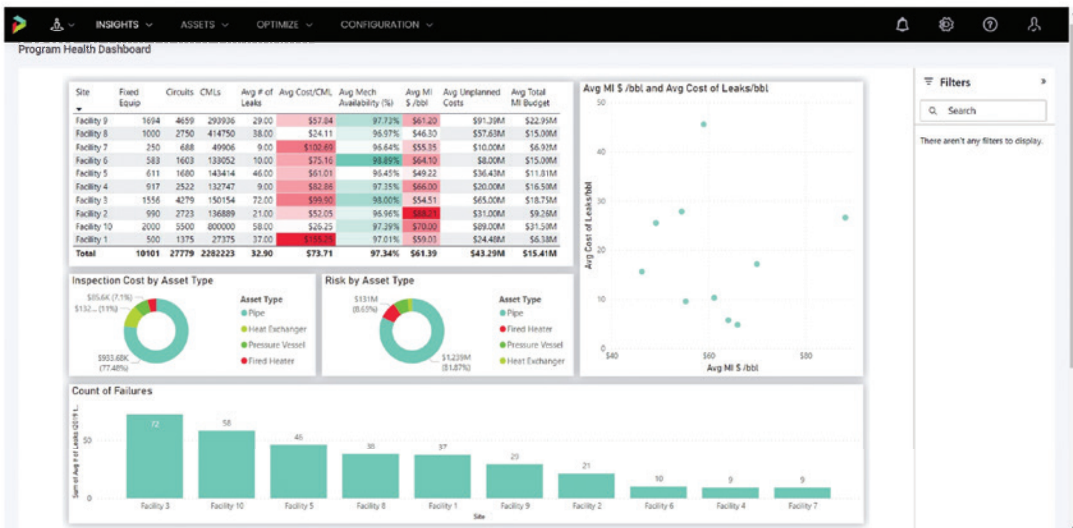

Figure 4. Program Health Dashboard.

appropriately capture risk. In addition to allowing manual detection of anomalous data through better dashboards, users can apply intelligent models that use data science, machine learning, and good engineering principles to recognize patterns and trigger responses to outlier data in real time. Treat MI program data like you treat your assets, using data uncertainty, impacts, and detection systems for the data itself.

In addition to leveraging a dashboard that helps you make decisions to meet compliance and identify the health of your data, dashboards should illustrate the effectiveness of your program from a cost and benefits perspective. The dashboard in **Figure 4** shows a fleet of facilities and compares each facility's performance, including inspection cost by asset type, number of failures, and the average cost of leaks normalized by production volume. At a single-site level, this is extremely valuable to identify areas of focused spend and defend the MI costs based on measured benefits to plant production as a lagging indicator of success. Additionally, the user can drill down into the different inspection costs and leak causes, comparing those two variables across multiple facilities to see if one facility outperforms others in areas such as piping failures. This dashboard can be used in conjunction with other programmatic data to understand why specific facilities perform better than others in certain areas.

By leveraging this type of dashboard, you can identify the tradeoffs between your investments and their impacts to build value cases around continuous improvement areas, either in areas where the return on investment (ROI) of a prior implementation is not yet being realized, potentially overspending on specific activities seeing diminishing returns, or areas where additional investments may be worthwhile.

While helpful from an overall performance benchmarking perspective, the performance plot above does not allow the decision-maker to understand what to do next or provide insights into the impacts of planned activities on future performance. There should be dashboards that focus on performance-leading indicators. **Figure 5**, a variance on a typical relative risk matrix, depicts a data-driven MI model that shows availability and HSE risk forecasted over time for the unit or facility.

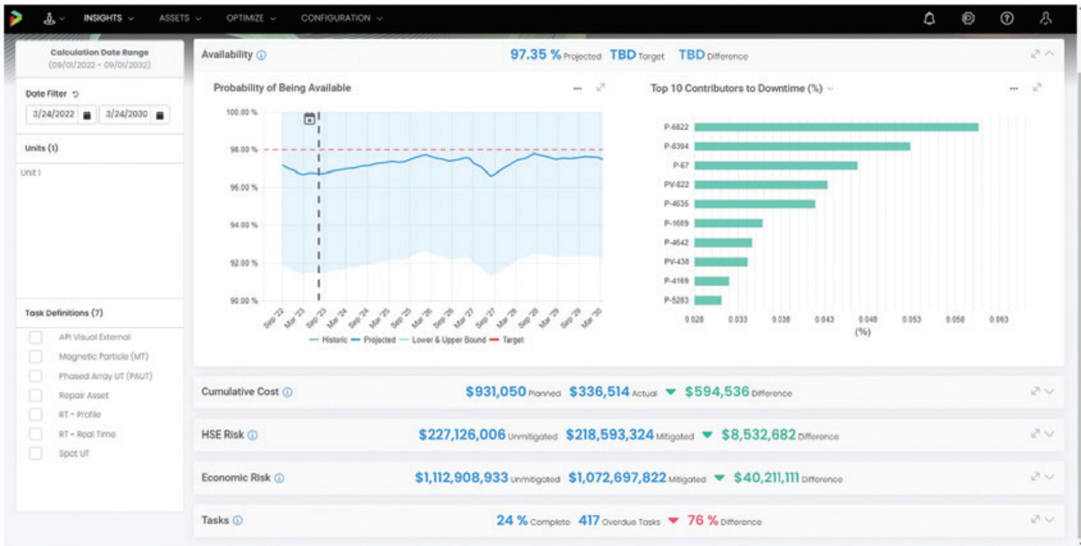

Figure 5. Dashboard Illustrating Unit Availability and Top Ten Contributors to Downtime.

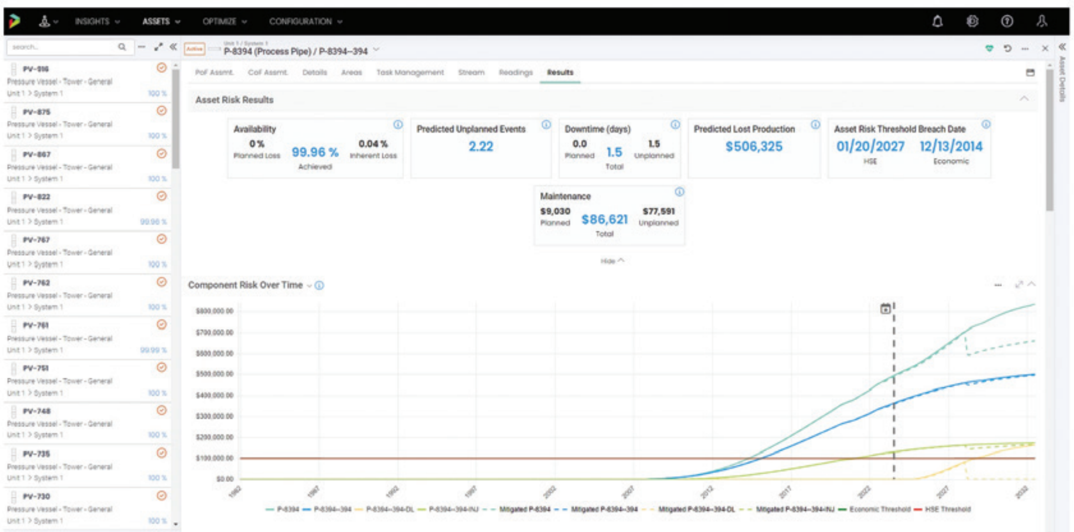

Figure 6. Risk-Based Model of Specific Piping Circuit.

This type of dashboard is helpful for situations in which decision-makers want to drill down into a specific asset to identify the top contributors to downtime and project the future availability of the asset. For example, suppose the decision-maker sees that the historical leak profile for a particular facility is high in the performance plot in **Figure 4**. In that case, they can use the model in **Figure 5** to identify the top contributors to future risk based on forward-looking inspection and reliability actions. If the existing plan, including compliance-based inspections, leaves major outstanding risks for leaks, the decision-maker can quickly identify the top threats and address them by reducing uncertainty through inspections, performing maintenance, or executing reliability-based re-designs. With each action, the model provides the decision-maker with the cost-benefit of completing these actions to quantitatively improve MI performance for this facility over the targeted time frame.

Driving down from the dashboard in **Figure 5**, if an asset is identified as a future problematic asset in the top contributor list above, the decision-maker can drill down into that specific asset to see the risk-based model for that asset. The example piping circuit in **Figure 6** shows the availability for that asset, the planned inspection and maintenance spend, and the asset risk threshold breach date. The user can then use this model to understand the risk drivers and again de-risk by reducing uncertainty through inspections, performing maintenance, or performing reliability-based re-designs.

Incorporating dashboards that showcase analytics from program compliance, data health, effectiveness, and leading indicators perspectives can help you drive more sustainable decisions for your MI program over time.

Build Your MI Program to Get Smarter Over Time

Incorporating a combination of technology and processes into your MI program that allows your facility to learn from the data it's collecting will help your program get smarter over time and

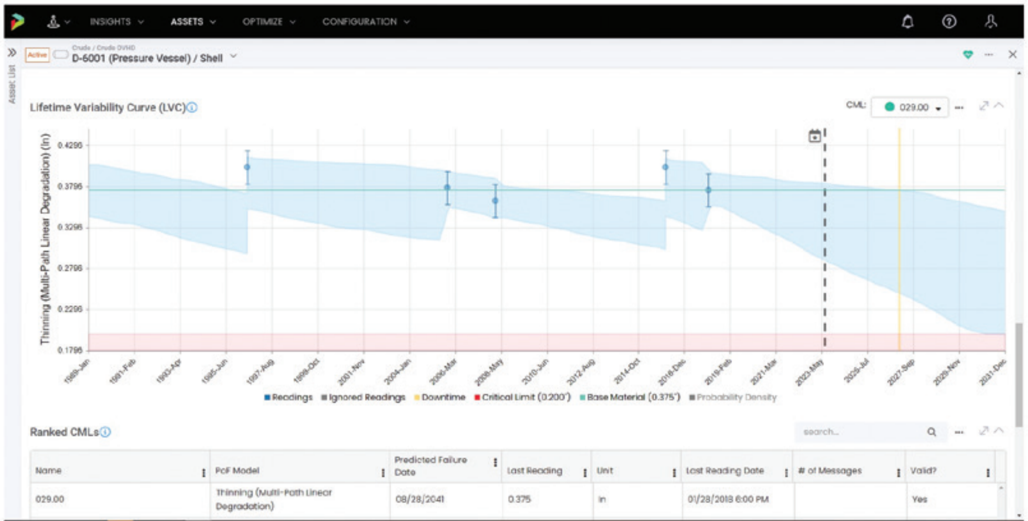

Figure 7. Lifetime Variability Curve (LVC).

Figure 8. Updated Lifetime Variability Curve.

sustain the value of your improvement initiatives. Whether the new data comes from the management of change, new inspections, process data, failure data, or benchmarking damage/risk data from other sites in your fleet, this data should fuel better decisions through your intelligence models.

One example of a model that can make your MI program smarter is a lifetime variability curve (LVC), shown in **Figure 7**. An LVC is a data-driven model that leverages a facility's reliability data to estimate asset performance, predict failure, and quantify uncertainty. The LVC illustrated in **Figure 7** shows UT point thickness readings taken in 2016 and 2019, an update to the corrosion rate profile, including uncertainty, relating to an updated probability of failure (POF) curve for the asset. This example showcases an uncertainty-based approach to modeling an asset's risk at each CML data point. The impacts of an additional reading would greatly impact the current band of uncertainty, likely push out the earliest forecasted failure dates, and have a relatively large impact on overall bottom-line projections, justifying the inspection data collection cost for this CML.

Compared to another CML on the same asset (**Figure 8**), which has reinforced its expected corrosion rate curve with data that meets expectations, the uncertainty bands narrow, and the probability of failure due to thinning drops significantly. When looking to the future, the impact of an additional reading would only further confirm this proven trendline and does not reduce uncertainty significantly more than what has already been demonstrated to date.

Barring any type of facility changes or IOW process excursions, it would be reasonable to reduce the inspection frequency for this more "trusted" CML. Future inspection scenarios can be planned that focus only on those targeted CMLs with significantly larger contributions to risk mitigation while proving that extending or excluding large sections of data-proven CMLs provides little contribution to uncertainty-based risk forecasts. In this way, CML optimization can ensure that at the end of a major

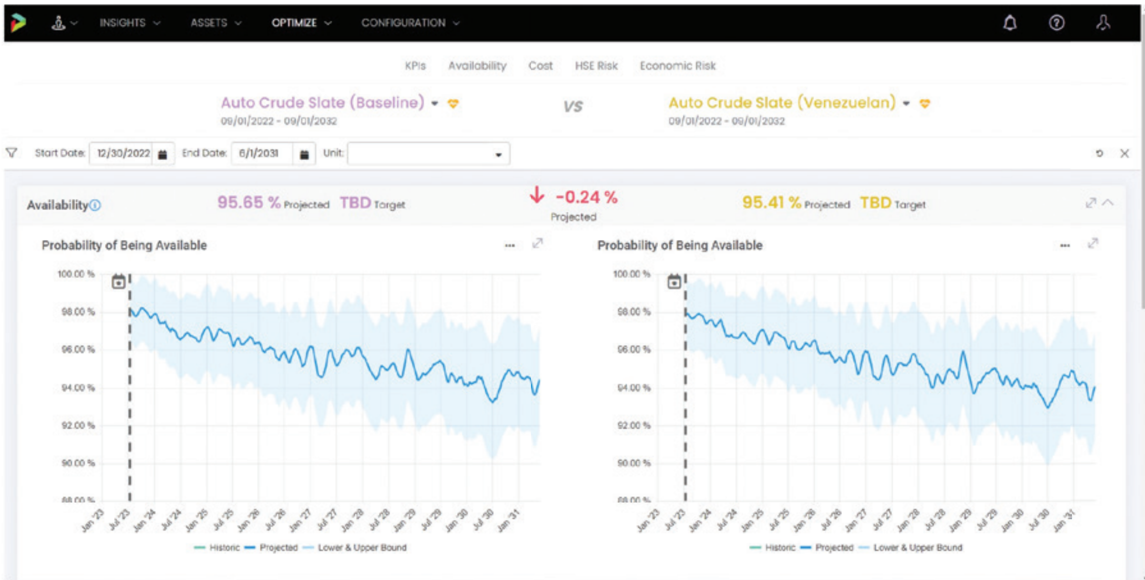

Figure 9. Availability Comparison.

implementation, the investments in further data collection work on a feedback loop to justify the ones where data is most needed and provide value-based opportunities where a site MI team's work to date is sufficient.

In a different scenario, a facility may be deciding whether to run an opportunity crude which will impact asset health and resulting MI program tactics. By having a data-driven model incorporating leading indicators for asset reliability across the system, the rolled-up dashboards in **Figure 9** show that this change in crude slate will likely reduce availability by 0.24% in the next ten years, given the increased asset risks and the current maintenance tactics. An MI leader can then dive into the future contributors to this reduction, escalate the need for further investments with senior leadership to offset the trade-off, and start to plan alternative maintenance or targeted inspections to reduce uncertainty and still hit former availability targets. With this ongoing, data-driven analysis and a common language of economic impacts of reliability, the strategic investments across the whole facility can rapidly be made with a high degree of confidence while ensuring integrity and reliability impacts are well-communicated as a shared win when considering potential improvements and changes to the site.

Conclusion

Beginning with the end in mind, incorporating comprehensive analytics that help you make sustainable decisions, and building your MI program so it gets smarter over time will help you sustain and improve your MI program while ensuring it is set up for success in the long run. These three elements will help you improve your data quality and reliability, enhancing the foundation for making informed decisions and developing continuous improvement value cases. This, in turn, can enable you to focus on the right aspects and allocate resources effectively, freeing up time and energy for continuous improvement and ensuring focus after a major implementation.

Investing in continuous improvement and encouraging team performance and adoption creates a positive feedback loop. Innovation drives improvements in processes and outcomes, while enhanced team performance fosters a culture of continuous improvement. The success and positive impact of these innovations and improvements further justify the need for ongoing enhancements and the sustainability of the existing ones.

For more information on how a data-driven approach continuously enhances the value of your programs, check out Inspectioneering's recent webinar, "A Data-Driven Approach to Sustaining and Improving Your MI Program." ■

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Michael Wallace, Senior Solutions Engineer at Pinnacle, collaborates and develops best-in-class solutions to make heavy processing facilities more reliable. Michael manages Pinnacle's sales process from detailed scope development to setting up projects for successful execution and is passionate about finding creative approaches to accomplish greater results than were originally imagined to improve our industry's safety and to help facilities run more reliably. Michael is also an experienced quality manager with a demonstrated history of working in the oil and energy engineering service industry as well as leading special-emphasis projects in mining, agricultural chemical, and nitrogen products facilities. Michael obtained his Bachelor of Science in Mechanical Engineering from Texas A&M University.