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# Data Quality Improvement Levels within the Operations Digital Twin (ODT) Solutions

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## Table of Contents



## Introduction

In the era of digital transformation, process industries - like oil and gas, petrochemicals, and refining- rely heavily on Operational Technology (OT) digital solutions, such as the Operations Digital Twin (ODT) -also known as the Integrated Manufacturing Operations Management Systems (IMOMS)-, to drive operational excellence. ODT serves as a critical backbone that integrates process control, asset management, production planning, safety, reliability, and sustainability functions into a cohesive ecosystem. At the heart of this integration lies data; the raw material that enables analytics, automation, and informed decision-making.

The value of ODT is determined not only by the availability of data but also by the quality of that data. Poor-quality data erodes trust in

digital tools, introduces hidden costs that often outweigh the initial investment in systems, and ultimately prevents the ROI promised by digital transformation. In contrast, high-quality data enhances digital solutions by facilitating precise performance calculations, predictive modeling, regulatory compliance, and operational optimization, thereby improving overall organizational performance.

In this technical analysis, we examine the impact of data quality on ODT applications and propose a novel analogy, which we refer to as ODT Data Quality Improvement Levels (ODT-DQIL). This analysis demonstrates how ODT, by design, is an excellent example and practical solution for addressing data issues within process-based operations and, most importantly, how it adds value by improving the data quality through such digital solutions.

## Highlighted Topics

Data Sources, Data Quality, Data Cost, Data Quality Improvement Levels, Process Data, ODT, IMOMS, OT, GenAI.

## ODT Ecosystem

The ODT data ecosystem operates in layers, as illustrated in Figure 1 below, which highlights both the sources and the pathways through which the data becomes actionable intelligence. At the base are data sources, which include field sensors, control systems (DCS/SCADA), process data, and laboratory analysis. Additionally, business systems and maintenance records are provided throughout enterprise systems, depending on the organization's IT setup and infrastructure.

The operations' raw data streams feed into the ODT architecture, where they undergo steps of data integration, validation, and contextualization.

The middle tier emphasizes data quality dimensions: accuracy, completeness, timeliness, consistency, and relevance. At the top are applications such as performance management, quality

management, energy management, reliability management, etc., where the value of data quality is clear and can be easily identified by its impact on major Key Performance Indicators (KPIs) and Key Operating Parameters (KOPs) associated with these solutions.

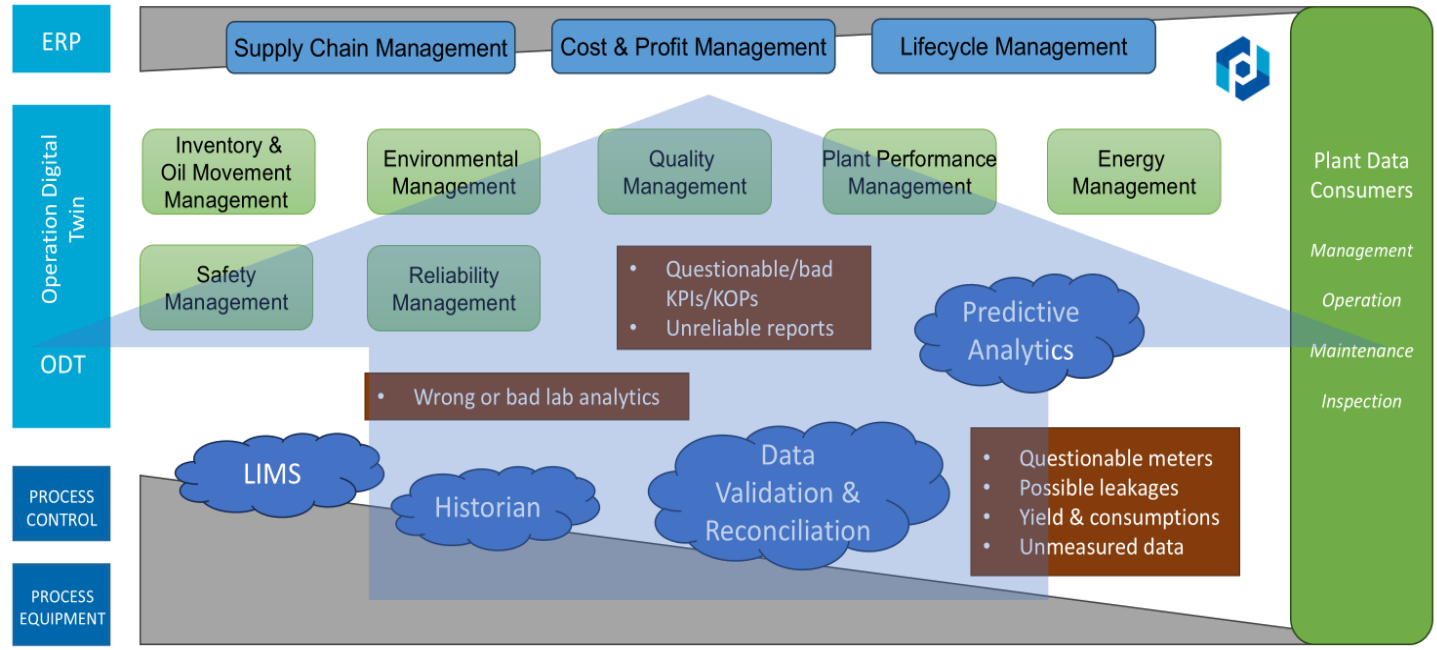


*Figure 1: Data Quality Improvement Levels within ODT*

In practical cases, these early-stage and first-line applications are receiving the raw data from the sources; each will run many types of verification and data quality checks, whether it is a simple value range that is within the physical boundaries of the instrument, operating limits from the design sheets, a mathematical mass and energy conservation equation, or all the way to a very advanced deep learning models that produces estimations of a parameter and tests its value validity; all in all, they are creating what we could call multiple layers of data quality checks or Data Quality Improvement Levels (DQIL).

## VALUE OF DATA QUALITY IN ODT

The value of high-quality data in ODT can be demonstrated across multiple dimensions, including operational efficiency, safety and compliance, financial performance, decision-making quality, and enabling digital transformation. For example, accurate data ensures predictive analytics can detect early warning signs, reliable data strengthens compliance reporting, and consistent data builds trust in digital systems and keeps users believing in the value of such solutions. High-quality data also supports digital twin technologies and advanced analytics, enabling organizations to have complete visibility and a 360-degree level of granularity in their operations.

Data quality is one of the major enablers for ODT applications to more accurately capture the true values. Plant.Digital is uniquely positioned to address industry imperatives and realize benefits from digital solutions. Table 1 below shows several examples of proven value gained of ODT applications with general values created based on industry best practices and proved use cases. In addition, Figure 2, below shows the relative value added into the by having higher Data Quality with base being ODT with standard IMOMS

*Table 1: Examples of ODT Applications and Their Benefits (Estimated from best practices and actual use cases)*

| Solution Name | Description | Major Benefits | Potential Value Created |
|---|---|---|---|
| **Energy Performance Management (EPM)** | A Digital solution to track, optimize, and reconcile plant-wide energy consumption. | Reduced fuel use, improved energy efficiency, and sustainability gains. | 5–10% reduction in energy costs, improved environmental footprint. |
| **Environmental Management System (EMS)** | End-to-end monitoring and management of emissions, energy, waste, and water. | Regulatory compliance, improved sustainability metrics, and reduced environmental risk. | Lower environmental penalties, enhanced ESG performance, and operational sustainability. |
| **Production Accounting System (PAS)** | Provides accurate, reconciled mass and energy balances across refinery and petrochemical assets. | Accurate yield tracking, loss minimization, and improved decision-making. | 2–5% efficiency improvement, millions in avoided product losses. |
| **Predictive Analytics (PA)** | Uses advanced analytics and models to detect early signs of failures before they occur. | Early fault detection, reduced downtime, and proactive intervention. | Millions in avoided equipment failure costs and extended uptime. 20–40% reduction in maintenance costs, 25% less downtime. |

implementation contrasted with additional ODT solutions on top of the base ODT (aka IMOMS).

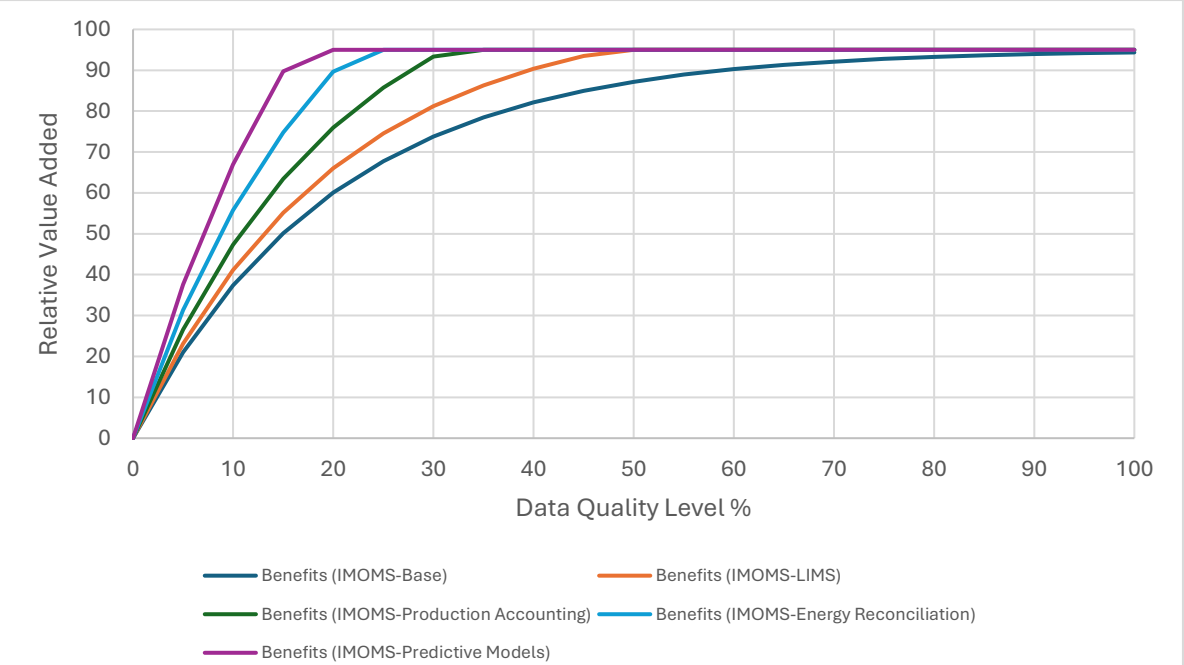


*Figure 2: Each added level of ODT applications cumulatively boosts benefits and cuts risks with Data Quality Improvements*

Moreover, stacking ODT applications amplifies value and suppresses risk as data quality improves. Each added level of ODT applications cumulatively boosts benefits and cuts the risk of Data Quality by up to 20%, so every step shifts the benefits curve upward and the risks curve downward across the entire quality range. Figure 3 below combines both benefits and risks).

Compounding effects mean you receive more value at the same level of data quality—or one reaches the same value at a lower quality level—once additional ODT applications are deployed. The early ODT deployments (e.g., data validation and reconciliation (DVR) and predictive analytics models) quickly improve the plant's data quality and reduce exposure to associated risks by proving more accurate asset/process health predictions and reconciled KPIs. Every single corrected reading will have a multiplier impact on many other solutions calculations and insights. Subsequent ODT applications continue to add value and yield incremental gains.

## Cost of Poor Data Quality

Poor-quality data results in inefficiencies, hidden costs, safety risks, compliance failures, and financial losses. Actual use cases have shown that inadequate data quality can lead organizations to forfeit opportunities for cost savings in maintenance and experience operational losses, among other consequences as highlighted in Table 1. In capital-intensive industries like O&G, even minor discrepancies can translate into millions of dollars lost annually. The most damaging impact, however, is the loss of trust in ODT applications, which dramatically reduces adoption and undermines digital transformation.

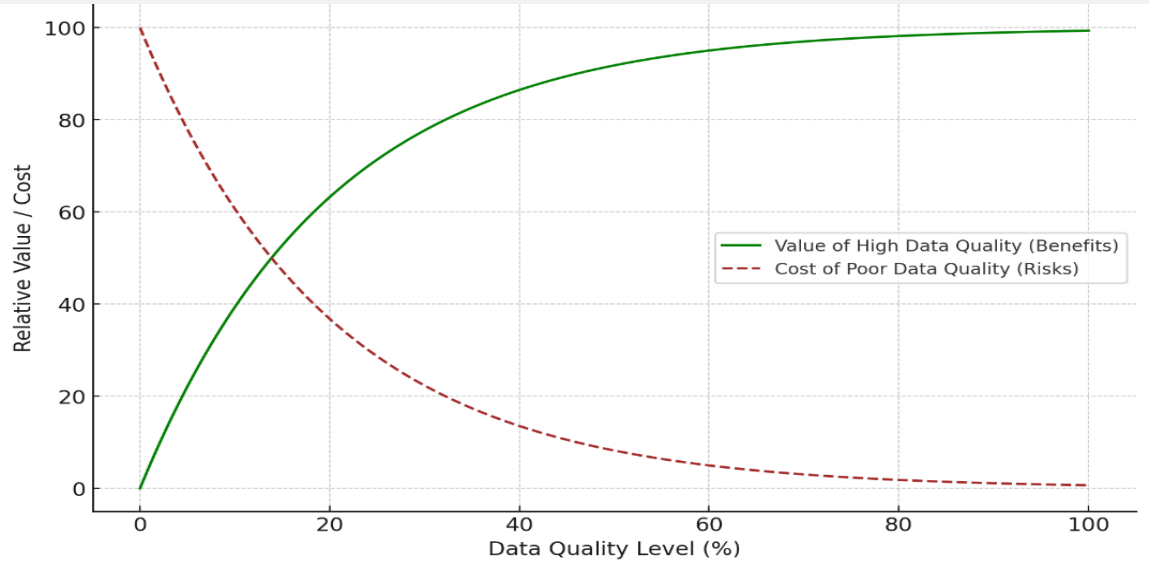


*Figure 3: The two curves show that as data quality improves, the value/benefits from collective ODT applications using that data rise while the costs of poor data quality decrease.*

## Balancing Value and Cost of Data Quality

Achieving high data quality requires investments in sensors, governance, and skilled personnel. The challenge lies in balancing these costs with the value generated. Best practices include implementing data governance frameworks, continuous monitoring, prioritizing high-value data, and justifying initiatives based on ROI. The cost of ensuring data quality is far less than the cost of ignoring it.

## GenAI For Data Quality

The advancement of generative AI (GenAI) and its new applications significantly impact data quality. GenAI is reshaping data quality by turning static rules into adaptive and domain-aware auditors. AI agents can profile historian and Lab data streams in natural language, then auto-derive tests from prompts. In addition, paired with time-series foundation models, they can detect sensor drift, stuck values, and context anomalies. When issues arise, the agent proposes fixes and opens a ticket for calibration or maintenance for example. Moreover, multimodal GenAI can even read P&IDs, loop sheets, and procedures to auto-link tags to assets and infer constraints, while embedded knowledge graphs reconcile messy tag names across historian, LIMS, and CMMS for consistent asset and process master data.

For operating facilities, these approaches enable plants to rapidly move up the data-quality curve, resulting in fewer false alarms, earlier drift detection, and increased trust in ODT applications. Practically, this translates to cleaner input parameters for predictive maintenance, tighter alarm rationalization, faster root-cause analysis for upset events, and actionable data for compliance. Furthermore, professionals can easily describe rules in plain language while the AI maintains thousands of checks, monitors them continuously, and explains failures with evidence. As a result, you could achieve higher effective data quality with the same or reduced effort. This yields many benefits such as more reliable optimization and planning while also reducing risks associated with poor data decisions—this aligns perfectly with the goal to enhance operational decision quality through ODT implementations.

## Conclusion

Plant.Digital has experience with many actual cases the direct and compounded values of ODT solutions and can help organizations assist your organization and facilitate the process with ease and confidence by having a trusted partner. The ODT has a bidirectional impact on data quality as it highlights the key role of data in transforming operations. High-quality data enables efficiency, safety, compliance, financial performance, and digital

transformation. Poor data quality, by contrast, imposes risks and hidden costs that undermine the value that one can achieve from ODT and thus limiting the improvements that digital can bring to operational excellence. Process industries must treat data as a strategic asset and, most importantly, ensure good data quality throughout the implementation of multiple layers of digital solutions, such as ODT, making it a board-level priority.

Every single addition of ODT application is another layer of data quality value-adding step. The more complete the ODT architecture an organization implements and operates, the greater its chances are to improve and catch issues with data quality.

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## Author Bio

Rayan Hafiz is an Engineering Consultant with about 25 years of experience in providing technical engineering services and supporting advanced analytics applications, decision analysis, technology development, deployment and management. He is currently leading solution consulting at Plant.Digital with the goal of providing the integrated manufacturing operations management solutions (iMOMS) -aka ODT- to Oil and Gas, Petrochemicals and utilities' industries. Rayan is a Certified Analytics Professional (CAP) from INFORMS, and holds a M.Sc. in Systems & Entrepreneurial Engineering from University of Illinois at Urbana-Champaign (UIUC), an Executive MBA in Innovation Management from University of Prince Edward Island, and a B.Sc. in Industrial Engineering & Operations Research from King Fahd University of Petroleum & Minerals. Connect with Rayan at https://www.linkedin.com/in/rayanhafiz/.

## About Plant.Digital

Plant.Digital, an Aramco & Honeywell joint venture, is a service company providing end-to-end digital OT services, including consultancy, project execution, solution implementation, support, and adoption management. We specialize in business process automation, leveraging agile project management for seamless and successful digital transformation - and deliver the promised ROI of digital transformation.

Our integrated digital solution suite and services enhance automation by digitalizing workflows and processes with high-quality, tailored data. By integrating multiple software systems, we turn complex data into clear, actionable insights, driving efficiency, profitability, safety, reliability and smarter decision-making.

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