DIGITAL TWIN AND DATA BASED RISK EVALUATION AND CLAIMS ADJUSTMENT IN ENGINEERING INSURANCES

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Abstract

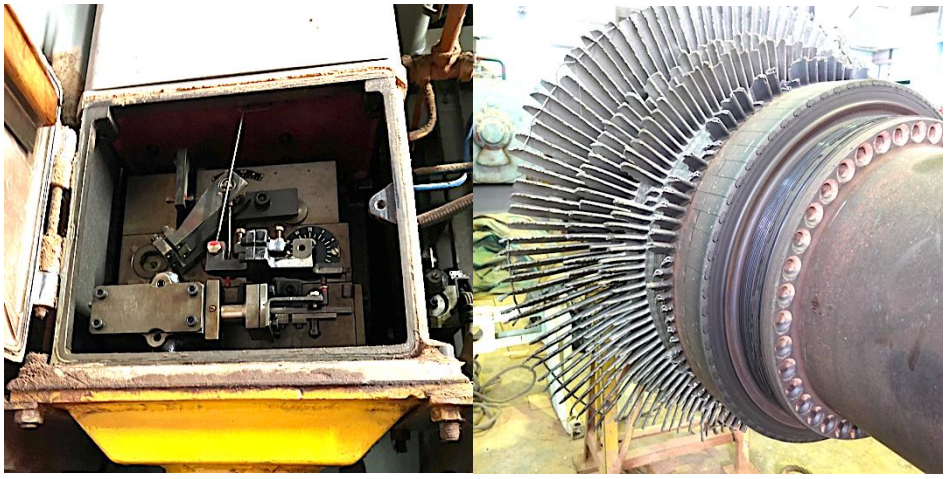
Engineering insurance claims, particularly those arising from Machinery Breakdown (MB) and Business Interruption (BI), are frequently hampered by fragmented documentation and outdated asset management practices. The digitalization of asset management—through solutions such as—offers a transformative pathway for more transparent, efficient, and evidence-based claims handling. This paper examines the critical role of digital tools in improving claims processing, addresses the fundamental challenges posed by legacy equipment and insufficient data for risk engineering, explores how digital twins enable parametric insurance solutions, and quantifies potential savings in both premium calculation and loss adjustment processes. The analysis demonstrates that while conventional insurance struggles with incomplete information leading to inaccurate pricing and prolonged claims processing, digital asset management can create the foundation for innovative insurance products and dramatically reduces Loss Adjustment and Root Cause Analysis (RCA) time and costs.

1 Introduction

Industrial and energy assets are increasingly sophisticated, integrating complex mechanical, electrical, and control systems that are vital to maintaining production and safety. When unexpected failures occur—whether from fire, mechanical breakdown, or natural catastrophe—engineering insurance is called upon to indemnify losses and facilitate recovery. However, the claims process itself often suffers from the same legacy issues that plague plant operations, including inconsistent documentation, poor traceability of maintenance activities, and a lack of real-time visibility into equipment health. These limitations extend the time required to assess the root cause, verify damages, and estimate the impact on production continuity.

1.1 The Legacy Equipment Challenge

A significant portion of industrial infrastructure worldwide consists of legacy equipment installed ip to several decades ago, some times predating modern digital monitoring systems[1]. This creates a fundamental information asymmetry problem where risk engineers lack sufficient data for accurate hazard assessment during underwriting, premium calculations become speculative rather than data-driven, claims investigations rely heavily on post-incident forensics rather than pre-loss evidence, and Root Cause Analysis becomes time-intensive and costly due to limited historical data. This information deficit has historically forced insurers to apply conservative risk margins, leading to higher premiums for insureds and suboptimal capital allocation across portfolios. The pictures below shows an example of a hydromechanical turbine governor and on the right side the result of its malfunction. Typically no information on device settings, maintenance as well as no trend of the behaviour are available for this kind of eqipment. The result may be catastrophic failure of system relevant equipment.

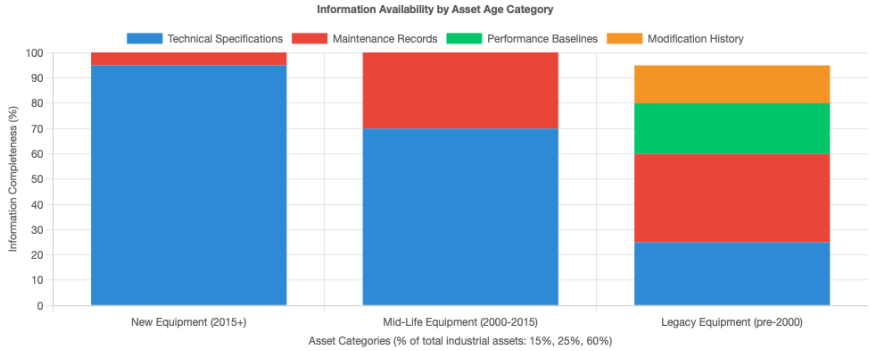


1.2 The Promise of Digital Transformation

Digitalization of asset management represents an opportunity to modernize this paradigm by combining data-rich tools and connected technologies to create a continuous and verifiable record of the asset lifecycle [2,3]. This transformation addresses both sides of the insurance equation, enabling more accurate risk assessment and premium calculation while simultaneously streamlining claims handling and loss adjustment.

Figure 1: Legacy Equipment Information Gap Analysis

Information availability across different asset categories showing the dramatic data deficit for legacy equipment that comprises 40-60% of industrial assets.



The emergence of parametric insurance solutions, pioneered by Reinsurances like Swiss Re [4], demonstrates the industry's recognition that traditional coverage models struggle with insufficient data. However, these innovative products can only reach their full potential when supported by comprehensive digital asset management systems that provide the reliable data streams necessary for effective parametric triggers and transparent payout mechanisms.

2 Limitations of Conventional Asset Management in Claims

Historically, asset management in industrial facilities has been dominated by paper records, spreadsheets, and fragmented digital repositories that evolved incrementally over decades. As a result, claims investigations frequently encounter significant obstacles that impede efficient resolution and accurate assessment.

2.1 Information Fragmentation

The most pervasive challenge facing claims professionals is the siloed nature of information storage, where documents such as P&IDs, wiring diagrams, and maintenance logs are stored in separate systems or even physically dispersed locations. This fragmentation is compounded by inconsistent data management practices, where updates to equipment configurations, capacity changes, and retrofits are not always reflected in master records, creating discrepancies that can take weeks to reconcile during claims investigations.

Manual evidence collection remains the norm in most facilities, requiring loss adjusters and forensic engineers to rely on time-consuming site visits to gather evidence, interview operators, and photograph damage. This process is further hampered by limited historical visibility into equipment performance, as operating parameters before a failure are often undocumented, making it difficult to determine whether damage was sudden and accidental or the result of progressive deterioration.

2.2 Legacy Equipment Documentation Gaps

The challenge is particularly acute for legacy equipment, which often suffers from missing or outdated technical documentation as original manufacturers may no longer exist or have been acquired multiple times. Incomplete maintenance records due to historical paper-based systems create additional complexity, as does unknown modification history where changes were implemented without proper documentation over decades of operation.

The absence of performance baselines makes it impossible to detect gradual degradation or establish normal operating parameters, while the lack of design specifications complicates replacement value assessments and repair planning. These

documentation gaps represent more than administrative inconveniences; they create fundamental barriers to accurate risk assessment and efficient claims resolution.

2.3 Impact on Insurance Processes

This lack of consolidated, accurate data leads to cascading problems throughout the insurance value chain. Delays in establishing causation and validating coverage become routine, while higher expenses associated with forensic consultants and multiple site visits drive up overall claims costs [5]. Disputes over the scope and quantum of loss, especially for Business Interruption claims where production capacity and performance are critical, become more frequent and contentious when objective data is unavailable.

The cumulative effect is reduced trust and transparency among stakeholders, conservative risk assessment and premium setting due to information uncertainty, and limited ability to offer innovative insurance products such as parametric coverage. This creates a vicious cycle where information scarcity leads to higher costs and reduced innovation, perpetuating the industry's reliance on outdated practices [6].

3 Digital Solutions Transforming Claims Management

Digital asset management combines several complementary technologies that together build a rich and structured dataset around the insured asset. These technologies work synergistically to create comprehensive visibility into asset performance, condition, and operational history, fundamentally transforming how claims are investigated and resolved.

digitalized Piping and Instrumentation Diagrams (P&IDs), advanced performance monitoring platforms (e.g., GE APM, Siemens Xcelerator, Eschertec Delphys), sensors, and Augmented Reality

3.1 Digitalized Process Documentation

Digitalized Piping and Instrumentation Diagrams represent a step-change improvement over static PDFs or scanned drawings. These dynamic, interactive diagrams integrate live data feeds from sensors, Distributed Control Systems (DCS), or historians, creating real-time visibility into system operations. Each component can be tagged with comprehensive metadata including serial numbers, maintenance history, and warranty information, while hyperlinks provide immediate access to design specifications, calibration certificates, and operational manuals.

Consider the case of a fire in a compressor station, where adjusters traditionally would require multiple site visits and extensive documentation review to understand the scope of impact. With digitalized P&IDs, adjusters can immediately identify affected circuits, confirm design capacities, and map dependencies without manual cross-referencing. This capability enables faster identification of impacted equipment, reduces ambiguity over equipment condition pre-loss, and provides immediate validation of operating parameters.

3.2 Performance Monitoring Platforms and Digital Twins

Platforms such as Delphys [7] and other advanced condition monitoring systems build digital twins of equipment, enabling continuous tracking of health indicators through real-time data collection of temperature, pressure, vibration, and flow parameters. AI-driven anomaly detection algorithms highlight deviations from normal operation, while historical performance trending provides benchmarks for normal operation. Predictive maintenance algorithms forecast equipment life expectancy, and virtual testing capabilities enable "what-if" scenario modeling.

Digital twins provide particular advantages for insurance applications by enabling accurate risk modeling based on actual equipment performance rather than generic industry data. They create the foundation for parametric insurance triggers based on real-time sensor data and performance metrics, enable immediate post-incident analysis using pre-loss operational data, and support precise business interruption calculations based on actual production capacity and efficiency metrics.

When a turbine fails, for example, adjusters can access comprehensive trend data demonstrating whether the machine was operating within Original Equipment Manufacturer (OEM) parameters, providing objective evidence for causation and limiting disputes. The digital twin can also model alternative operating scenarios to quantify the true impact of the loss on production capacity and efficiency.

3.3 Augmented Reality (AR)

Augmented Reality offers immersive capabilities for claims and maintenance workflows that extend beyond traditional inspection methods. Remote experts can virtually "walk through" a facility by overlaying digital data on live video streams, enabling collaborative damage assessments that can be annotated in real time. Training modules can use AR to teach staff how to document incidents correctly, while integration with digital twins allows real-time overlay of operational data during inspections.

Following an incident in a confined area, AR can enable claims professionals to inspect damage remotely without physical entry, accelerating documentation and reducing exposure risks. This capability delivers faster initial damage assessment, lower travel costs, faster response times, and enhanced communication between stakeholders who can collaborate virtually regardless of geographic location.

3.4 Additional Tools

Several other digital technologies contribute to the comprehensive transformation of claims management. IoT sensors and wireless data acquisition systems allow continuous condition monitoring of parameters, particularly valuable for retrofitting legacy equipment where traditional monitoring was not feasible. Drone-based inspections enable safe, rapid documentation of damage in inaccessible areas such as roofs, stacks, and remote pipelines.

Computerized Maintenance Management Systems (CMMS) provide traceable maintenance logs, spare part usage records, and compliance evidence, creating an auditable trail of asset care and maintenance activities [9]. Blockchain-based asset ledgers create tamper-proof records of inspections, repairs, and certifications, addressing concerns about data integrity and authenticity. 3D laser scanning digitizes the plant layout and damage geometry for precise loss quantification, while machine learning algorithms analyze patterns in equipment failures to improve risk assessment and predict future claims.

Together, these solutions offer an integrated toolkit for transforming the claims process from reactive and manual to proactive and data-driven, creating unprecedented visibility into asset condition and performance throughout the entire lifecycle.

4 Addressing Legacy Equipment Challenges

4.1 The Legacy Equipment Dilemma

Industrial facilities worldwide operate substantial amounts of legacy equipment, often representing 40-60% of total asset value. This equipment typically suffers from documentation gaps where original specifications are outdated, unknown modification history accumulated over decades of operation, inconsistent maintenance records due to historical paper-based systems, absence of performance monitoring and in worst cases documents are lost that makes condition assessment difficult.

The challenge extends beyond simple documentation issues to fundamental questions about insurability and risk assessment. Without reliable information about equipment condition, maintenance history, and performance characteristics, insurers must rely on conservative assumptions that may not reflect actual risk levels. This creates inefficiencies for both insurers, who may be over-reserving for some risks while under-pricing others, and insureds, who may pay premiums that don't accurately reflect their actual risk profile.

4.2 Digital Retrofit Strategies

Modernizing legacy equipment for digital asset management requires targeted approaches that acknowledge both technical constraints and economic realities. The process typically begins with documentation recovery, including 3D laser scanning to create accurate as-built drawings, reverse engineering to determine actual specifications, digital conversion of historical maintenance records, and comprehensive component identification and cataloging.

Sensor integration follows, involving retrofitting critical measurement points with IoT sensors, implementing wireless data collection systems to minimize installation costs, integrating with existing control systems where possible, and establishing performance baselines for future monitoring. The final phase involves digital twin development, creating simplified digital twins based on available data, gradually enhancing models as more operational data becomes available, and integrating with predictive maintenance algorithms to maximize value.

Figure 2: Digital Twin Architecture for Engineering Insurance

System architecture showing how digital twins create comprehensive data foundation enabling both accurate risk assessment and parametric insurance products.

4.3 Benefits for Legacy Assets

Even partial digitalization of legacy equipment provides significant benefits that justify the investment. Improved risk assessment through actual performance data rather than generic industry statistics enables more accurate pricing and better risk selection. Enhanced maintenance planning reduces the likelihood of unexpected failures, while faster claims processing when incidents do occur minimizes business disruption. Most importantly, digitalization creates the foundation for parametric insurance products even with limited data sets, opening new possibilities for risk transfer and coverage innovation.

5 Enhanced Claims Processing and Root Cause Analysis

5.1 Traditional RCA Limitations

Conventional Root Cause Analysis in engineering insurance claims faces significant challenges that often lead to extended investigation timelines and increased costs. Limited pre-incident data makes timeline reconstruction difficult, while reliance on witness testimony, which may be incomplete or biased, creates additional uncertainty. Extensive forensic investigation requiring specialized experts and equipment drives up costs, while time-intensive evidence gathering delays claim resolution. Perhaps most problematically, subjective interpretation of available evidence often leads to disputes over causation that can extend resolution timelines significantly.

These limitations are not merely procedural inconveniences; they represent fundamental barriers to efficient claims resolution that increase costs for all stakeholders while delaying recovery for insureds. The traditional approach essentially requires reconstructing the failure sequence after the fact, often with incomplete information and under time pressure.

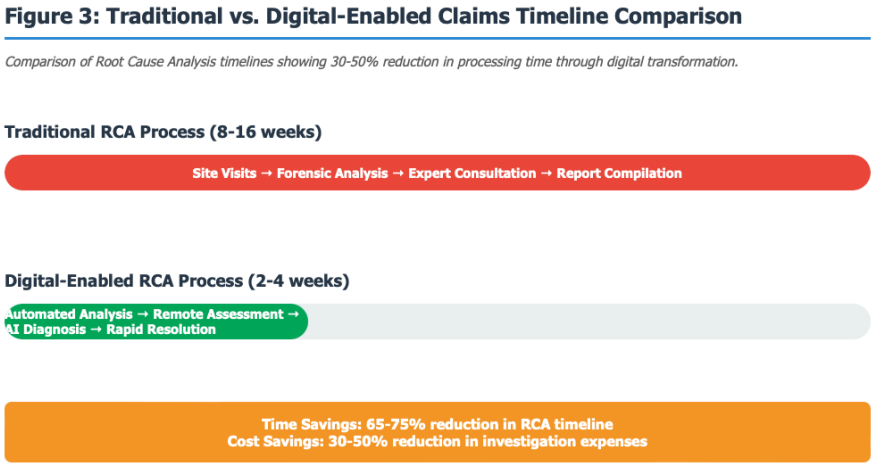
5.2 Digital-Enabled RCA

Digital asset management transforms RCA by providing comprehensive pre-incident data that shows equipment behavior leading up to failure, complete maintenance history and performance trends, operating parameter deviations and alarm logs, and detailed environmental condition records. This rich data foundation enables automated analysis capabilities including AI-driven pattern recognition that identifies failure precursors, correlation analysis between multiple data streams, predictive models that highlight probable failure modes, and automated timeline reconstruction that eliminates much of the manual investigation work.

The objective evidence base created by digital systems includes sensor data providing factual operating conditions, digital maintenance logs showing actual work performed, performance monitoring demonstrating equipment health trends, and immutable data records that prevent post-incident disputes about what actually occurred.

5.3 RCA Time and Cost Reduction

Digital-enabled RCA delivers measurable improvements across multiple dimensions. Timeline reductions see RCA investigations completed in days or weeks rather than weeks or months, with immediate access to relevant data eliminating information gathering delays, automated analysis providing initial findings within hours, and remote analysis capabilities reducing site visit requirements.



Cost reductions include 30-50% reduction in forensic engineering fees, decreased reliance on external specialists, lower travel and accommodation costs, and reduced business interruption duration through faster resolution. Quality improvements encompass more accurate causation determination, reduced dispute potential through objective evidence, enhanced learning for risk management improvements, and better correlation between claims experience and risk assessment for future underwriting decisions.

6 7. Economic Impact and Business Case

Property Damage claims show 10-20% reduction in adjustment expenses and 30-50% RCA cost reduction. Digital SOP management contributes 15-25% incident severity reduction through consistent emergency responses. Business Interruption claims demonstrate 8-15% payment reduction and 25-40% timeline reduction. Risk assessment improvements include 15-25% accuracy enhancement and parametric product foundations with 60-80% faster payouts.

A mid-sized manufacturing facility with $1.5M annual premium could realize $150K-250K in direct claims savings, 5-15% premium reductions, parametric coverage administrative savings of 40-60%, and operational efficiency gains of $50K-100K annually from digital SOP management, yielding total economic benefits of $350K-600K annually.

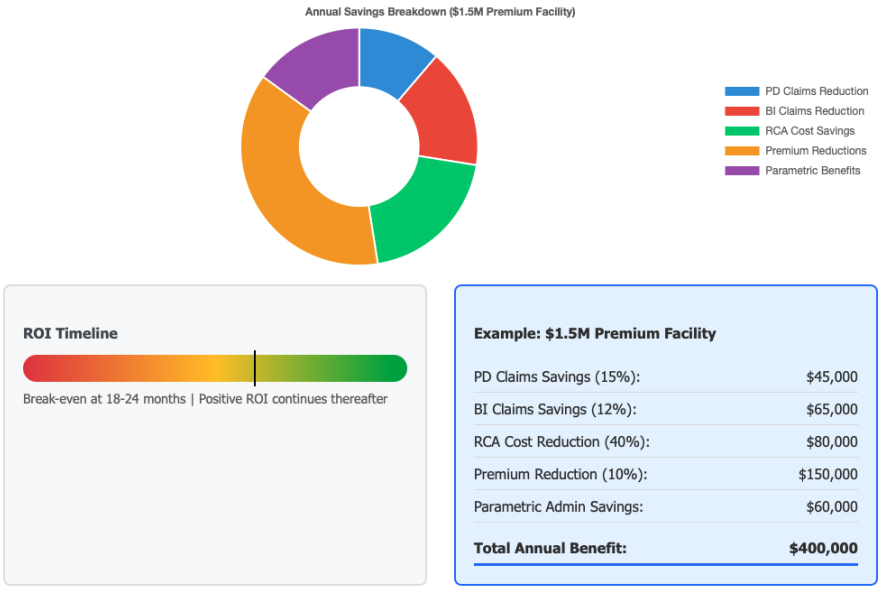
7 8. Economic Impact and Business Case

7.1 8.1 Technological Feasibility

Current market readiness indicates that cloud-based monitoring platforms are commercially mature, with modular deployment options that can accommodate various facility sizes and complexity levels. Many industrial operators already possess partial sensor networks and CMMS systems that can be integrated into comprehensive digital asset management frameworks. Deployment timelines typically range from 6-12 months for medium-scale facilities, with faster rollout possible for targeted pilot programs that focus on critical equipment.

Figure 4: Economic Impact Model for Digital Asset Management

Financial benefits breakdown showing comprehensive economic impact with ROI timeline and real facility example.



Implementation pathways generally follow a phased approach beginning with critical equipment deployment, followed by integration with existing control systems, gradual expansion of monitoring coverage, and development of facility-specific digital twins. This staged approach allows organizations to demonstrate value early while building capabilities incrementally.

7.2 8.2 Estimated Savings

Analysis of published case studies, pilot projects, and insurer internal estimates reveals significant potential savings across multiple dimensions. Property Damage claims show 10-20% reduction in adjustment expenses, faster damage verification that reduces forensic engineering costs, 30-50% reduction in RCA time and associated costs, and improved accuracy in damage assessment that reduces disputes and associated legal expenses.

Business Interruption claims demonstrate 8-15% reduction in claim payments due to expedited repair and restart timelines, improved clarity on production capacity that reduces disputes over lost profit calculations, enhanced ability to model alternative operating scenarios, and 25-40% reduction in BI adjustment timeline. Risk assessment and pricing improvements include 15-25% improvement in risk assessment accuracy, reduced premium volatility through better data, enhanced ability to offer competitive pricing for well-monitored risks, and foundation for parametric products with 60-80% faster payout times.

Consider a mid-sized manufacturing facility with an annual premium of USD 1.5 million. Such a facility could realize direct annual savings of USD 150,000-250,000 in claims costs, premium reductions of 5-15% due to improved risk profile, parametric coverage options reducing administrative costs by 40-60%, yielding total economic benefits of USD 300,000-500,000 annually.

7.3 8.3 Industry-Wide Impact

Widespread adoption of digital asset management could fundamentally transform the engineering insurance market through market expansion enabled by improved risk assessment capabilities, product innovation enabling new coverage types and structures, competitive differentiation for early adopters, capital efficiency through better risk selection and pricing, reduced combined ratios across the industry [11], and enhanced customer satisfaction through faster, more transparent claims handling.

8 7. Cybersecurity and Data Ownership

The digitalization of asset management, while providing compelling benefits, introduces critical questions around data security, privacy, and control that must be addressed for successful implementation. Real-time data platforms and cloud integrations expand the attack surface for malicious actors, while unauthorized access could compromise production integrity or allow manipulation of claims evidence. Ransomware attacks targeting asset data can halt recovery efforts, and data breaches could expose competitive operational information.

Data ownership and privacy concerns add another layer of complexity. Original Equipment Manufacturers may claim ownership over certain operational datasets, insureds may restrict access due to competitive or regulatory concerns, insurers require access to validate claims creating tension over control, and regulatory compliance requirements may limit data sharing options.

Effective mitigation requires role-based access controls and encryption of sensitive data, third-party security audits and compliance with cybersecurity frameworks such as ISO/IEC 27001, data-sharing agreements embedded in insurance contracts clarifying permissible use and retention periods, multi-factor authentication and immutable logs to verify data provenance, blockchain-based data integrity verification, and air-gapped systems for critical operational data. Robust governance frameworks are essential to balance innovation with risk management while maintaining stakeholder trust.

9 Conclusion

The claims process for engineering insurance remains constrained by outdated asset management practices and fragmented information systems. This challenge is particularly acute for legacy equipment, where insufficient data hampers both accurate risk assessment and efficient claims handling. The resulting information deficit has historically limited the insurance industry's ability to offer innovative products such as parametric coverage, despite their clear benefits for both insurers and insureds.

Digitalization of asset management, encompassing digitalized P&IDs, real-time performance monitoring, digital twins, Augmented Reality, IoT technologies, and comprehensive Standard Operating Procedures management platforms, creates transformative possibilities for streamlining evidence collection, improving transparency, and accelerating recovery. More importantly, it addresses the fundamental data scarcity that has constrained traditional insurance models, enabling more accurate risk engineering, precise premium calculation, and innovative parametric insurance products.

The integration of digital SOP management represents a crucial component of comprehensive digital asset management that extends beyond equipment monitoring to encompass operational excellence and procedural compliance. Platforms like Actarion demonstrate how digitalization can capture and preserve institutional knowledge while creating comprehensive audit trails that prove invaluable for insurance applications. The ability to document exactly which procedures were followed, how operators responded to abnormal conditions, and whether proper protocols were maintained provides objective evidence that can significantly streamline claims investigations and improve risk assessment accuracy.

Digital twins, enhanced by comprehensive SOP management, represent the ultimate solution for providing the comprehensive, real-time data foundation that enables accurate risk engineering, precise premium calculation, and innovative parametric insurance products. When equipped with both equipment monitoring and procedural documentation capabilities, insurers can move beyond speculative risk assessment to data-driven decision making, while parametric solutions like those offered by Swiss Re can achieve their full potential through reliable trigger mechanisms and transparent payout processes.

The transformation of Root Cause Analysis through digital technologies, including SOP audit trails and procedural documentation, offers immediate and measurable benefits, with potential reductions of 30-50% in investigation time and associated costs. The addition of comprehensive procedural documentation can further reduce investigation complexity by providing clear evidence of operational compliance and response protocols. This improvement alone justifies

investment in digital asset management, while the broader benefits of enhanced risk assessment and parametric insurance capabilities provide additional value that compounds over time.

The economic case for digital transformation is compelling, with potential savings of 10-20% in Property Damage claims, 8-15% in Business Interruption payments, 15-25% improvements in risk assessment accuracy, and additional operational benefits from digital SOP management. These benefits translate to significant economic value for both insurers and insureds, creating a positive-sum outcome that drives industry evolution.

The comprehensive approach to digitalization that includes both equipment monitoring and procedural management creates synergies that amplify the benefits of each individual component. When equipment performance data is combined with detailed procedural execution records, the resulting insights provide unprecedented visibility into operational performance and risk factors. This integrated approach enables more sophisticated risk assessment, more accurate pricing, and more effective claims management than either capability would provide independently.

Insurers can reduce the costs and processing time of engineering claims by systematically implementing comprehensive digital asset management across their portfolios. This transformation will be reflected in cost savings for insureds through reduced premiums and faster claims resolution, while providing insurers with enhanced flexibility to offer innovative insurance products. The industry must embrace this holistic digital transformation to remain competitive and serve the evolving needs of industrial clients in an increasingly connected world.

The future of engineering insurance lies not in managing information scarcity, but in leveraging information abundance through comprehensive digital asset management that encompasses equipment monitoring, digital twins, and operational procedure management. Organizations that invest in this integrated transformation today will shape the industry's evolution and capture the benefits of more accurate, efficient, and innovative insurance solutions. The question is not whether this transformation will occur, but rather how quickly organizations can adapt to capitalize on the comprehensive opportunities it creates for operational excellence and risk management.

10 Key Take-Aways

The convergence of engineering digitalization and financial risk transfer mechanisms establishes a new paradigm where underwriting precision, capital efficiency, and operational resilience reinforce each other.
The industry’s competitive trajectory will be defined by its ability to integrate digital asset management into both risk engineering and claims practices.

Key Take-Aways:

1. Digital twins and real-time monitoring transform risk assessment by eliminating information asymmetry and enabling parametric triggers.
2. Comprehensive digital asset management reduces RCA costs by up to 50% and accelerates claims resolution, directly lowering combined ratios.
3. Cybersecure, data-driven infrastructures create the foundation for premium adequacy, capital efficiency, and innovative product development.

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