



## The 23<sup>rd</sup> International Asset Facility and Maintenance Management Conference

# Digital Twin Technology with Big Data Analytics

Revolutionizing Performance Monitoring in the Energy Sector

ENG.Shima Fahima

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# Background and Motivation



## Reactive Approach

Traditional monitoring operates on historical data patterns, requiring manual interpretation and providing limited predictive capabilities.

## Isolated Systems

Monitoring systems operate independently with minimal cross-system correlation and integration capabilities.

## High Costs

Unplanned outages, unnecessary maintenance, and suboptimal performance lead to significant operational expenses.

## Limited Insights

Traditional methods cannot detect subtle correlations or predict complex failure modes effectively.

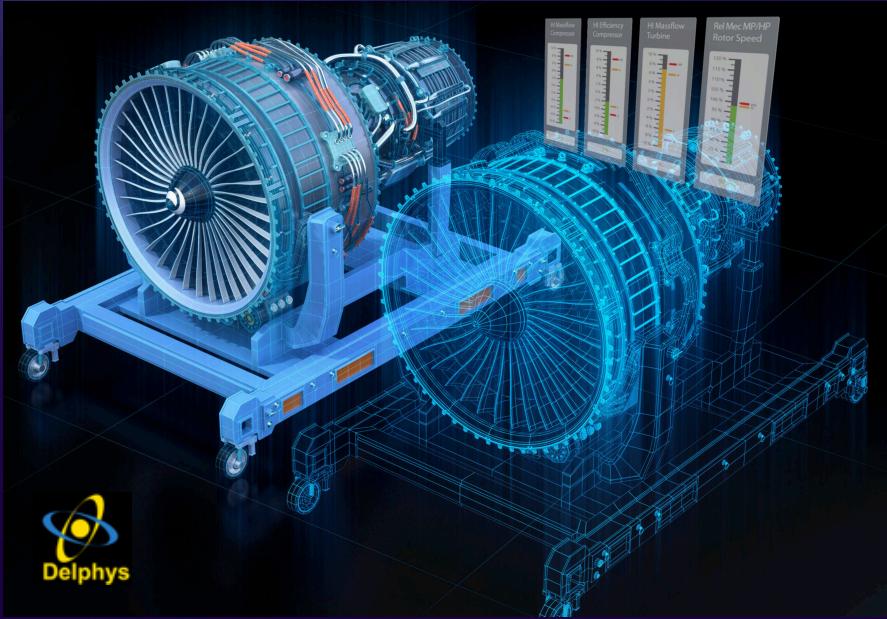
# Big Data Analytics in Digital Twins

## Digital Twin

- Virtual model of a physical asset
- Continuously updated with real-time data
- Integrates physics-based models + machine learning
- Enables simulation, prediction, optimization

## Big Data Analytics

- Large-scale sensor ingestion
- Pattern recognition
- Early anomaly detection
- Remaining useful life predictions
- Forecasting and optimization



# Enhanced Architecture Key Layers



## 1. Data Layer

Ingestion from sensors, SCADA, environment, maintenance logs

## 2. Analytics Engine

Supervised Machine learning, and deep learning networks for complex pattern recognition and predictive modeling.

## 3. Synchronization Layer (Digital Twin Core)

Real-time state synchronization with physics-based modeling integration including thermodynamics, CFD, and FEA analysis.

## 4. Visualization and Optimization Control

Real-time performance optimization using genetic algorithms and model predictive control for dynamic operational adjustments.

## 5. Cybersecurity Framework

Compliance with relevant global and local standards.

# Applied Machine Learning and Cybersecurity



## Machine Learning

- Regression for performance predictions
- Classification for fault detection
- Time series forecasting
- Anomaly detection (unsupervised)
- Deep learning for vibration/acoustic patterns

## Cybersecurity Integration:

- Increased attack surface with IoT
- Network segmentation
- Secure device management
- Threat monitoring & incident response
- Compliant with relevant global and local standards

# Case Study: 70MW Gas Turbine Key Results

## Predictive Maintenance Gains

- Bearing failure prediction accuracy: 60% → 87%
- Compressor fouling early warning: 2 → 6 weeks
- False positives reduced: 45%

## Operational Improvements

- Heat rate improvement: +1.2%
- Availability: 92% → 96%
- Load response capability: +25%

## Economic Value

- Fuel savings: \$450,000/year
- Availability revenue: \$280,000/year
- Maintenance cost reduction: \$320,000/year



# Challenges Identified

## Challenges:

- Sensor drift, failure, environmental interference
- Integration with legacy SCADA/DCS
- High computational demands
- Network limitations in remote sites
- Cybersecurity vulnerabilities
- High up-front costs & long ROI horizon

# Recommendations



## Best Practices:

1. Start with a focused pilot
2. Prioritize sensor reliability & calibration
3. Design for modularity & scalability
4. Invest in staff training & change management
5. Maintain parallel monitoring during transition
6. Develop strong data governance early

## Conclusion

- Digital twins + big data is a transformational shift to predictive, intelligent asset management
- Case study shows large technical & financial benefits
- Challenges exist but are manageable with proper planning
- This technology will play a critical role in the future of the energy sector
- Organizations adopting these tools will gain long-term competitive advantage





# The 23<sup>rd</sup> International Asset Facility and Maintenance Management Conference

**"Every minute of downtime costs you money.  
Every unmonitored asset is a hidden liability.  
Let's transform your asset into competitive advantage."**

# THANK YOU!



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