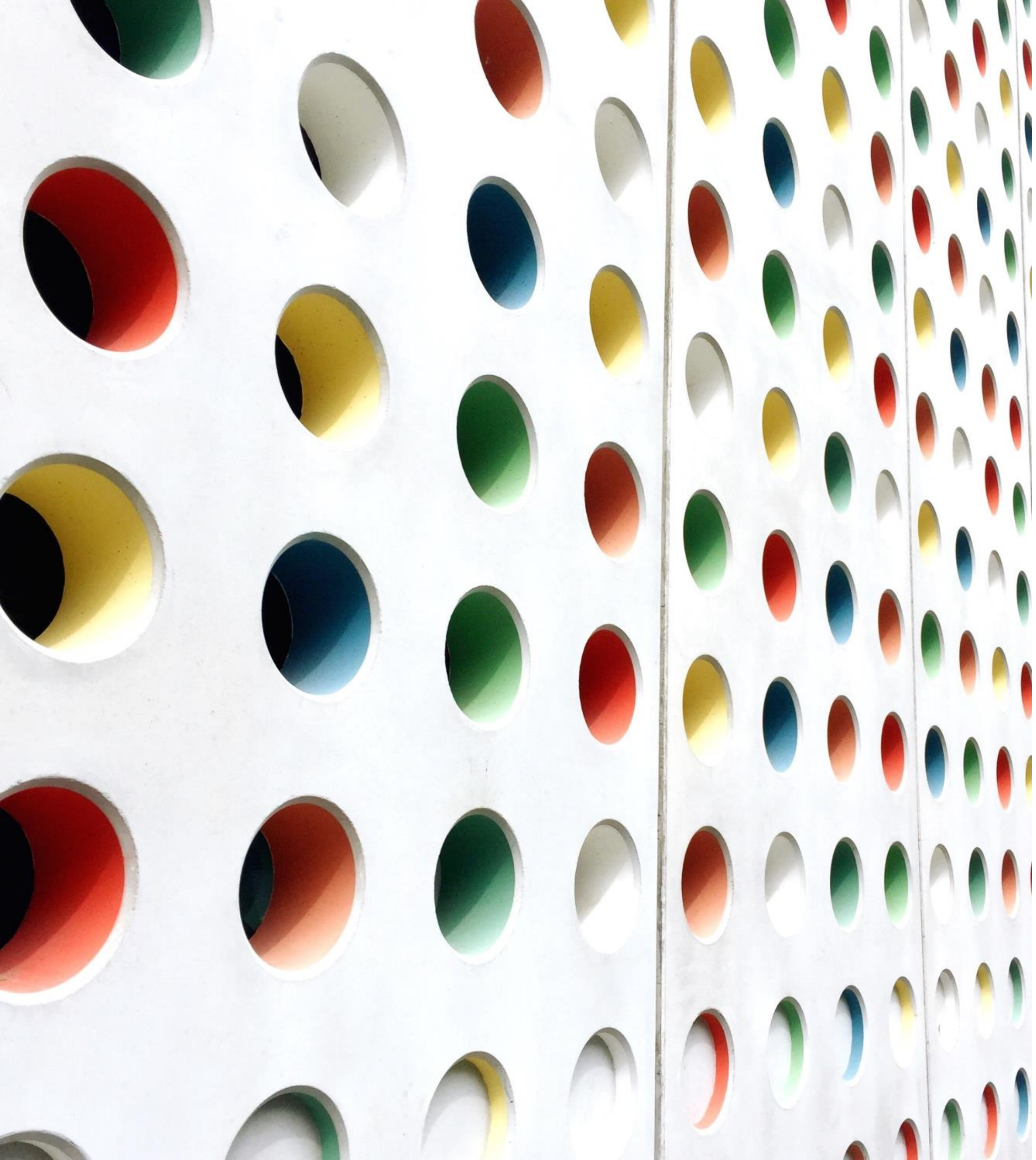


Market Research on AI Enablement in Digital Twins Implementation

O-DIGITAL UK

Executive Summary

KEY TAKEAWAYS

Key Takeaways from Market Assessment

Overview

System integrators play a pivotal role in the implementation of digital twin solutions, within large-scale EPCM projects. As asset owners and operators move toward data-centric operations, aligning digital twins with international standards like CFIHOS has become essential. Artificial Intelligence (AI) and Machine Learning (ML) technologies are increasingly embedded in these implementations to automate processes, improve data quality, and ensure semantic consistency.

AI and ML application

AI technologies are transforming how system integrators approach the implementation of digital twins, particularly when aligned with global standards like CFIHOS. By automating critical processes and enhancing data governance, AI enables faster, more reliable, and more scalable digital twin deployments. As adoption grows, system integrators will continue to play a key role in bridging the gap between engineering design and operational excellence.

Conclusion

The disruptive influence of AI will continue to reshape the digital twin and EPCM integration landscape. System integrators who embrace AI not only as a tool but as a collaborative partner will be better positioned to deliver scalable, future-ready solutions. In the next five years, AI is expected to become integral to automated handover packages, regulatory compliance monitoring, and even autonomous commissioning support.

Next steps

AI is both a challenge and a catalyst for system integrators working on CFIHOS-compliant digital twins. By shifting from execution-focused roles to innovation-driven positions, integrators can thrive in the new paradigm. The future of EPCM lies in intelligent, standardized, and continuously evolving digital ecosystems—and AI is at the core of this transformation. With AI handling lower-level tasks, system integrators can shift focus to strategic advisory, lifecycle optimization, AI governance, and AI system training for clients.

Industry Overview

INDUSTRY LANDSCAPE, TRENDS AND CHALLENGES

Industry Landscape & Overview of Key Stakeholders

Key Stakeholders	Owners/ Operators	EPC Firms	OEMs & Vendors	Technology Providers	System Integrators	Data Governance Bodies
Key roles	Set standards, drive digital twin scope, ensure handover readiness	Design, build, and tag asset data to match digital twin models	Provide equipment models with metadata and lifecycle data	Supply platforms and tools to build, visualize, and manage digital twins	Align tech stacks, build middleware, enable interoperability	Define common standards and ontologies (e.g., CFIHOS)
Sample companies	Shell, bp, aramco	Worley (energy | chemicals | resources), FLUOR, T.EN TECHNIP ENERGIES	Schneider Electric, ABB, SIEMENS	HEXAGON, AVEVA, MCDERMOTT TECHNOLOGY, DASSAULT SYSTEMES, Bentley	O-DIGITAL, Infosys, accenture, cognizant	CFIHOS, ISO, DEXPI Data Exchange in the Process Industry, MIMOSA

Focus of the presentation

Current State Assessment

OVERVIEW OF SYSTEM INTEGRATORS: TRENDS, CHALLENGES, CURRENT METHODOLOGY AND AI ENABLEMENT

System Integrators: Industry Trends

Focus on Data-Centric vs. Document-Centric Integration

The industry is moving from document-based information handovers to data-centric environments where structured information is prioritized over traditional files e.g., tags and metadata exported directly to digital twin platforms rather than shared as scanned PDFs or spreadsheets.

Cloud-Native Architectures & SaaS-Enabled Integration

Integrators are building cloud-first, SaaS-enabled integration strategies to scale digital twins, with Cloud-native CDEs integrating real-time design, procurement, and operations data through secure APIs. However, some EPCMs remain resistant to a 100% cloud deployment.

Emphasis on Talent Development in AI & Data Engineering

System integrators are investing in building hybrid teams that combine engineering, AI, data science, and software development skills, with Training programs in Python, semantic data modeling, and ML are being rolled out to engineers and PMs across integrator firms

Digital Twin Readiness from Day One

More system integrators are embedding digital twin enablement into the FEED (Front-End Engineering Design) phase, not just post-construction

Transition from Technical Executors to Strategic Advisors

System integrators are shifting away from being solely implementers of platforms to becoming strategic partners who advise on digital transformation, AI integration, and data governance.

Embedded Standards Compliance as a Service

System integrators now offer continuous compliance monitoring with CFIHOS (and other standards like ISO 15926) as an integrated service rather than a one-time setup.

Rise of Multi-Platform Ecosystems

Rather than working within a single vendor ecosystem, system integrators are becoming experts in multi-vendor, API-driven environments (e.g., AVEVA, Hexagon, Bentley, Cognite, Siemens).

Integration of AI-Driven Automation

Integrators are rapidly adopting AI to automate data extraction, tagging, compliance checks, and predictive analytics

System Integrators: Industry Challenges

Complexity of Standards Integration (CFIHOS + Others)

Harmonizing CFIHOS with other standards like ISO 15926, BIM standards (e.g., IFC), and proprietary client taxonomies is technically complex and labor-intensive.

Shortage of Skilled Talent

There's a growing need for professionals with cross-disciplinary skills—engineering knowledge, software integration, AI/ML fluency, and standards literacy

AI Trust, Explainability & Governance

Clients often resist adopting AI-based tools unless decisions can be explained and validated.

Difficulty in Maintaining Digital Twin Fidelity Post-Handover

After project completion, asset owners often lack the processes or incentives to maintain the twin, with over 50% of digital twins lose accuracy within 2 years due to lack of data updates

Legacy Systems and Data Silos

Many client environments still rely on outdated databases, spreadsheets, or proprietary engineering tools e.g., most brownfield projects have up to 40% of asset data which are unstructured, undocumented, or inconsistent with CFIHOS tags

Fragmented Project Stakeholder Ecosystems

EPCM projects involve multiple stakeholders (owners, vendors, contractors, operators) with varying digital maturity and objectives.

Inadequate Change Management

Rapid iterations in design or procurement are often poorly documented or communicated across teams. According to McKinsey Engineering 4.0 Report, rework due to undocumented changes adds an average of 9-12% to project costs.

Financial Constraints and ROI Justification

Digital twin investments often require significant upfront spending, and the ROI may not be immediately visible

Current Methodology of Implementing Digital Twins by System Integrators

1 Assessment & Scoping

- Identify scope of systems, disciplines, and project phases
- Assess existing data models and digital twin maturity
- Prepare framework for gap analysis and overlay EPCM way of working
- Evaluate current alignment with CFIHOS specifications

2 Mapping & Gap Analysis

- Map internal data structures to CFIHOS classes and attributes
- Identify gaps in taxonomy, metadata, and relationships
- Document deviations and requirements for extensions/custom rules

3 Configuration & Integration

- Configure digital twin platform to support CFIHOS-aligned data
- Develop data transformation scripts/APIs for legacy integration
- Establish middleware for EPCM toolchain interoperability

4 Governance & Quality Assurance

- Define roles, responsibilities, and validation checkpoints
- Implement data governance processes (e.g., versioning, audits)
- Create standardized templates and QA workflows

5 Pilot Implementation

- Deploy solution on a selected project or facility
- Monitor data flow, performance, and user interaction
- Refine mappings, interfaces, and governance as needed

6 Rollout & Training

- Scale implementation across disciplines and business units
- Conduct training for engineers, contractors, and IT teams
- Establish support mechanisms for long-term adoption

7 Continuous Improvement

- Monitor KPI performance (e.g., data handover efficiency)
- Incorporate feedback, standard updates (e.g., CFIHOS versions)
- Enable future integrations (AI/ML, predictive analytics)

Currently out of scope for O-Digital implementations

AI/ML- Enabled Methodology of Implementing Digital Twins

1 Assessment & Scoping

AI Use: Use Natural Language Processing (NLP) to scan and classify engineering documents for CFIHOS alignment

ML Use: Cluster legacy data to identify structural patterns

2 Mapping & Gap Analysis

AI Use: Semantic matching of internal tags with CFIHOS reference data

ML Use: Predict missing metadata using trained models

3 Configuration & Integration

AI Use: Smart mapping suggestions for complex system integrations

ML Use: Data validation models to detect anomalies in input data

4 Governance & Quality Assurance

AI Use: Automate rule-checking and compliance monitoring

ML Use: Data quality scoring and predictive issue flagging

5 Pilot Implementation

AI Use: Analyze user behavior for process optimization

ML Use: Learn from pilot performance to refine deployment models

6 Rollout & Training

AI Use: Intelligent training assistants for engineers and operators

ML Use: Adaptive learning content based on user performance

7 Continuous Improvement

AI/ML Use: Predictive analytics for asset behavior and data quality trends

Feedback loops to refine mappings and governance

Currently out of scope for O-Digital implementations

Current AI Use Cases in Digital Twin Implementation by System Integrators

Automated Tag Mapping and Classification

AI-driven Natural Language Processing (NLP) tools are used to scan engineering documents, tag lists, and P&IDs. These tools map unstructured data to CFIHOS-compliant classes and attributes, significantly reducing manual effort. For example, NLP algorithms can recognize various nomenclature styles and abbreviations for equipment like pumps and valves, aligning them to standardized tag formats and metadata structures.

Data Quality and Integrity Checks

ML models are trained to detect anomalies in engineering data, missing attributes, or inconsistent relationships. System integrators deploy these models during the data ingestion phase, enabling real-time validation of datasets. These tools can identify discrepancies in component specifications, flagging outdated or mismatched entries that could disrupt system integrity or compliance.

Semantic Matching and Ontology Alignment

System integrators use AI to perform semantic comparisons between proprietary data models and the CFIHOS ontology. This process enables automated alignment of different vendor data structures with standard CFIHOS entities. AI tools can suggest class-equivalent mappings, recognize synonyms, and harmonize naming conventions across asset hierarchies and engineering systems.

Predictive Analytics and Lifecycle Optimization

AI is used to analyze historical and real-time data for performance forecasting. Predictive maintenance models help in anticipating failures in rotating equipment or identifying operational inefficiencies. These insights are tagged to CFIHOS-defined asset identifiers, enabling root cause analysis, optimization of maintenance schedules, and extension of asset life.

AI-Assisted Dashboards and Decision Support

System integrators design intelligent dashboards that leverage AI to flag non-compliant data entries, suggest corrective actions, and assist stakeholders in strategic decision-making. These dashboards utilize ML to learn user behavior and prioritize critical issues. They also support scenario simulations, compliance scoring, and automated reporting for project governance.

Outlook of AI-Enabled Implementation

FUTURE USE CASES, BENEFITS, CHALLENGES AND OPPORTUNITIES

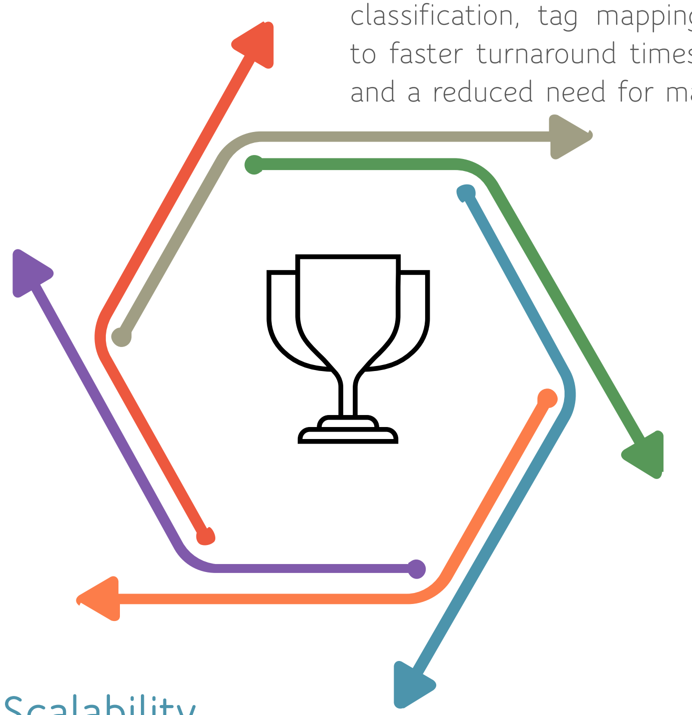
Outlook of AI Use in Digital Twin Implementation by System Integrators

S/N	Future use case	Description	Value	Examples
1	Autonomous Handover Generation	AI will auto-generate handover packages based on real-time progress, tagging, and validation against CFIHOS schemas.	Drastically reduces human error and shortens time to commissioning.	AI bots that continuously monitor documentation and data completeness can auto-compile handover-ready packages in a regulator-approved format.
2	Real-Time CFIHOS Compliance Auditing	ML models will continuously compare project data against CFIHOS taxonomies and flag inconsistencies or compliance gaps in real time	Enables “compliance-as-you-go,” avoiding rework and last-minute audits	AVEVA and Cognite are prototyping AI agents that validate engineering metadata against standard classes and attributes as it is entered or uploaded.
3	AI-Coordinated Asset Lifecycle Simulations	AI will run predictive simulations of asset behavior using digital twins enriched with real-time and historical data	Helps EPCM teams design with lifecycle cost, risk, and performance in mind	System integrators could offer “digital rehearsal” services—running AI simulations to test equipment reliability across scenarios before physical construction begins.
4	Natural Language Engineering Assistants	AI copilots will support engineers by interpreting, summarizing, and even generating engineering content (e.g., datasheets, P&IDs) using NLP tuned to CFIHOS terms.	Increases engineering productivity and ensures semantic alignment with CFIHOS vocabulary.	AI tools can extract and translate specifications from vendor manuals into CFIHOS-compliant data fields.
5	Predictive and Prescriptive Change Impact Analysis	AI will predict the downstream impacts of design or procurement changes across the project lifecycle and recommend optimal resolutions.	Reduces risk and improves response time during scope evolution.	A change in one vendor’s specification could trigger automatic downstream recalculations of weight, cost, and construction sequencing—with options provided by the AI.

Outlook of AI Use in Digital Twin Implementation by System Integrators

S/N	Future use case	Description	Value	Examples
6	Generative Engineering for Data Gap Filling	AI will infer missing data in asset registers or metadata tables by analyzing similar components or historical records.	Helps ensure completeness of digital twins when source data is fragmented or missing.	AI may auto-populate properties for a valve based on prior models, technical catalogs, or patterns across the asset hierarchy.
7	Interoperability Bots for Legacy Systems	AI agents will serve as middleware translators between legacy databases and modern digital twin platforms while preserving CFIHOS mapping fidelity.	Enables brownfield digital twin deployments with minimal rework of legacy structures.	An AI “interpreter” could align legacy tag structures with modern CFIHOS-compliant identifiers during migration.
8	AI Governance & Audit Trail Automation	AI will automatically maintain an audit trail of engineering changes, data lineage, and system decisions—aligned with CFIHOS attributes.	Builds client trust, supports regulatory audits, and enhances traceability.	A client can trace back any operational outcome to the data source and design decision that caused it, as recorded in the twin.

Benefits of AI/ML-Enabled Digital Twin Implementation



Better Compliance

Real-time monitoring of CFIHOS compliance through AI dashboards ensures that digital twin models are always aligned with the latest standards. This reduces regulatory risks and improves audit readiness.

·Reduced Engineering Hours

AI tools automate repetitive tasks such as data classification, tag mapping, and validation. This leads to faster turnaround times in digital twin development and a reduced need for manual data entry.

Improved Data Quality

AI-powered checks identify inconsistencies and gaps early, minimizing the risk of errors during construction and commissioning phases. This ensures that high-quality data is available for operational use.

Operational Insights

With AI-driven analytics, operators can move from reactive to predictive maintenance strategies. This enhances decision-making and supports continuous improvement of asset performance

Scalability

AI enables system integrators to replicate implementation frameworks across multiple projects or sites, improving consistency and reducing startup times for new digital twin deployments.

Faster Handover

Standardized and validated data allows for quicker and more efficient handovers from EPCM contractors to asset operators. AI supports data packaging in formats aligned with CFIHOS specifications

Challenges and Considerations of AI/ML-Enabled Digital Twin Implementation

Model Explainability and Validation

AI models, especially in critical infrastructure, must be explainable and validated. Operators and auditors require transparency in how AI decisions are made and justified

Integration Complexity

Combining legacy systems, engineering platforms, control systems, and cloud environments into a single digital twin framework is highly complex. System integrators must account for data security, latency, interoperability, and real-time synchronization challenges

CFIHOS Considerations

While CFIHOS adoption is growing, it is still maturing in terms of global industry uptake. Many organizations may only partially comply with CFIHOS, creating integration gaps and inconsistency. Further, over-reliance on AI can lead to deviations from strict CFIHOS compliance if not carefully monitored

Data Availability

AI models require access to large volumes of high-quality data for training. In many legacy environments, such data may be incomplete, poorly structured, or siloed across systems.

Customization Requirements

Each client project may require custom AI workflows due to differences in asset types, system architectures, and local regulations. This adds cost and time to project execution. In addition, many client environments rely on legacy systems, requiring custom connectors or APIs to enable AI functions.

Change Management

Engineering, operations, and IT teams may be resistant to adopting AI-enabled workflows. Effective training, stakeholder engagement, and phased implementation are essential to managing cultural and procedural change

Opportunities for System Integrators

Compliance Value Propositions

Continuous AI monitoring ensures ongoing alignment with CFIHOS standards and project requirements, creating opportunities for integrators to offer real-time compliance assurance as a service.

Competitive Differentiation

Early adopters of AI-integrated services gain a technological edge in bidding for complex projects, helping them win contracts where digital maturity is a key evaluation criterion.

Custom AI Model Development

As digital twin solutions become increasingly data-driven, integrators can specialize in developing custom AI models trained on client-specific datasets, ensuring high relevance and performance.

Training and Enablement Roles

Integrators can position themselves as enablers for client teams, offering training and consulting on the effective use of AI within engineering and operations environments.

AI-Enhanced Services

System integrators can bundle traditional services with AI-powered capabilities such as predictive maintenance analytics, anomaly detection, or digital assistant tools, offering end-to-end lifecycle intelligence.

Faster Project Delivery

AI accelerates many phases of digital twin implementation, enabling integrators to meet compressed timelines without compromising quality.

Case Studies

CURRENT USES OF AI IN DIGITAL TWIN IMPLEMENTATION

Case Studies of AI/ML Digital Twin Implementation: Project Phase

Project Summary	A major oil and gas company utilized AI-powered NLP tools to scan and classify engineering documents, aligning them with CFIHOS standards.
Implementation phase	2 - Mapping & Gap Analysis
Challenge	Inconsistent tagging and equipment naming conventions across legacy systems hindered standardization efforts
AI/ML application	NLP algorithms processed unstructured text from documents like Piping and Instrumentation Diagrams (P&IDs) and equipment lists, mapping them to standardized CFIHOS classes and attributes
Outcome	Achieved a significant reduction in manual effort required for data standardization, enhancing consistency across project data
Source	Parvin, S. (2022). "AVEVA Asset Information Management – Complying with a CFIHOS Handover Using Engineering Information Management Tools." AVEVA World Conference

Project Summary	An EPCM firm implemented ML models to predict and flag data quality issues during the handover phase to operations, ensuring compliance with CFIHOS standards
Implementation phase	2 - Mapping & Gap Analysis 6 – Rollout & Training
Challenge	Late discovery of incomplete or incorrect metadata during handover led to operational inefficiencies
AI/ML application	Trained models analyzed historical project data to predict potential data gaps or anomalies, allowing for early intervention.
Outcome	Improved data integrity during handover, leading to smoother transitions and reduced operational risks
Source	Parvin, S. (2022). "AVEVA Asset Information Management – Complying with a CFIHOS Handover Using Engineering Information Management Tools." AVEVA World Conference

Case Studies of AI/ML Digital Twin Implementation: Project Phase

Project Summary	A digital twin provider collaborated with a petrochemical client to standardize asset data using CFIHOS, employing semantic matching techniques
Implementation phase	2 - Mapping & Gap Analysis
Challenge	Diverse naming conventions and data structures from multiple vendors complicated data integration
AI/ML application	Diverse naming conventions and data structures from multiple vendors complicated data integration
Outcome	Accelerated data onboarding processes and enhanced consistency across integrated systems
Source	Zheng, Y., et al. (2023). "Ontology-Based Semantic Construction Image Interpretation." Buildings, 13(11), 2812.

Project Summary	An EPC firm deployed an AI-driven conversational assistant to help engineers navigate CFIHOS-aligned data repositories
Implementation phase	6 – Rollout & Training
Challenge	Engineers faced difficulties in retrieving specific asset or document information from extensive databases
AI/ML application	The chatbot, trained on CFIHOS-compliant datasets, responded to natural language queries, streamlining data access
Outcome	Enhanced user experience and efficiency in data retrieval, promoting better utilization of standardized data
Source	Parvin, S. (2022). "AVEVA Asset Information Management – Complying with a CFIHOS Handover Using Engineering Information Management Tools." AVEVA World Conference

Case Studies of AI/ML Digital Twin Implementation: Operations Phase

Project Summary	An LNG facility integrated predictive analytics into its digital twin, utilizing CFIHOS-standardized tags
Implementation phase	7 – Continuous improvement
Challenge	Maintenance data was not consistently linked to standardized tags, complicating predictive efforts
AI/ML application	ML models analyzed sensor data associated with CFIHOS tags to forecast equipment failures
Outcome	Enabled condition-based maintenance strategies, reducing unplanned downtime and maintenance costs
Source	Menges, D., et al. (2024). "Predictive Digital Twin for Condition Monitoring Using Thermal Imaging." arXiv preprint

Case Studies of AI/ML Digital Twin Implementation: Design Phase

Project Summary	Siemens Energy's AI-Driven Digital Twin Implementation
Objective	To enhance manufacturing efficiency and product lifecycle management by integrating AI with digital twin technology, adhering to CFIHOS standards.
Approach	Model-Based Definition (MBD): Siemens Energy transitioned from traditional 2D drawings to embedding Product Manufacturing Information (PMI) directly into 3D models using NX software. This shift ensured that all geometric dimensions, tolerances, and material specifications were digitally integrated, facilitating seamless data flow across design and manufacturing processes. Digital Thread Creation: By leveraging the Siemens Xcelerator platform, a comprehensive digital thread was established, connecting every phase from product ideation to service life. This integration allowed for real-time data access and collaboration across various departments and geographies.
AI/ML application	Artificial Intelligence was employed to analyze operational data, predict maintenance needs, and optimize performance parameters. This proactive approach enabled the identification of potential issues before they manifested, reducing downtime and maintenance costs.
Outcome	Increased Efficiency: Machine tool Overall Equipment Efficiency (OEE) improved from 65% to 85%, marking a 31% enhancement.Siemens Resources Reduced Machining Time: Part machining times decreased by 25% to 36%, accelerating production cycles.Siemens Resources Cost Reduction: Computer-Aided technologies (CAx) costs saw a reduction of nearly 26%, contributing to overall operational savings.
Source	Siemens Energy Resources https://resources.sw.siemens.com/en-US/case-study-siemensenergy/