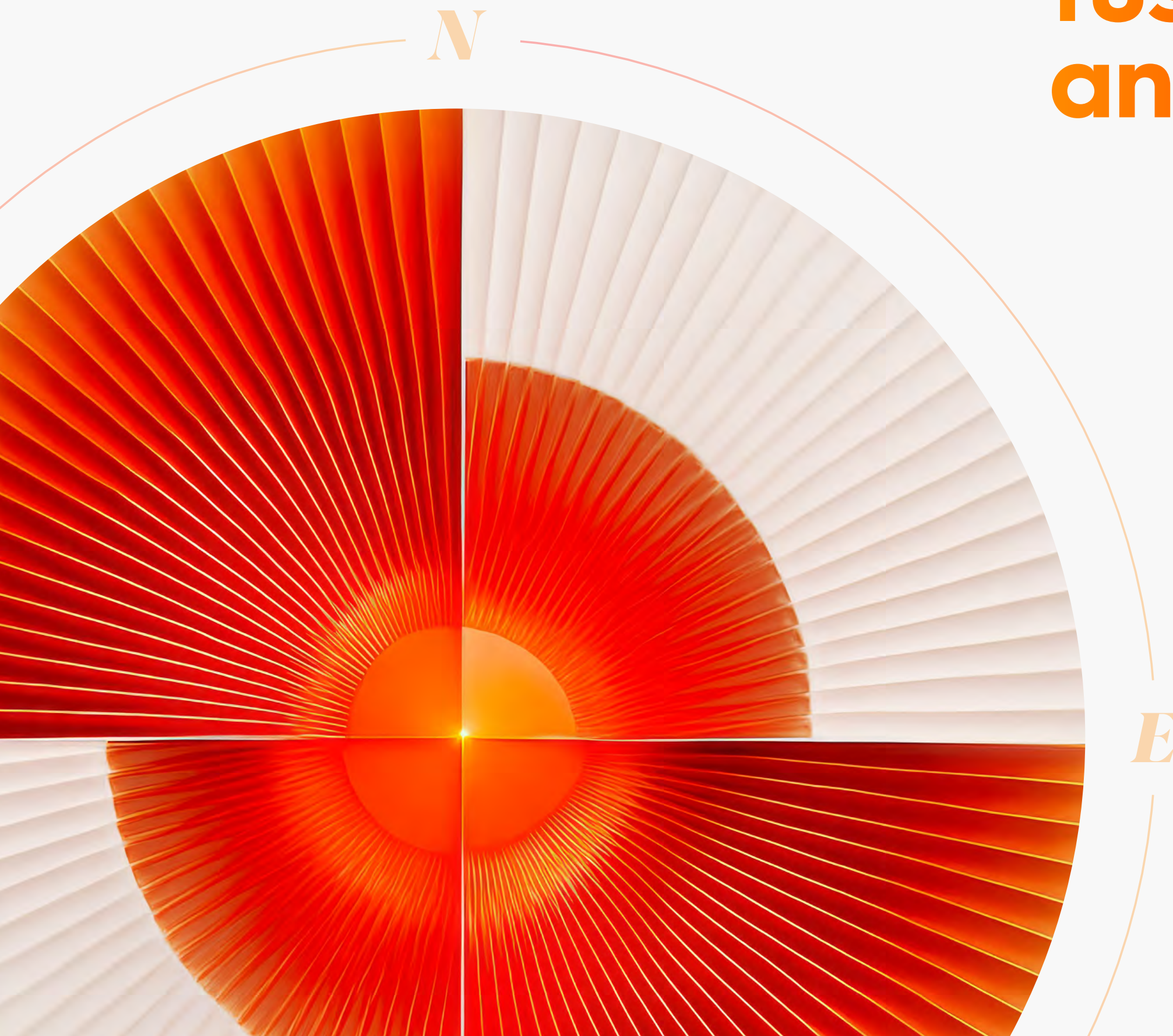


Innovation fusing digital and physical

**Harness
Digital Twins
to Streamline
and Perfect
Industrial
Processes**

CIO Compass Series



Introduction

Digital twins are no longer a technology topic – they are becoming an operating model decision.

By connecting physical assets, operational data and decision intelligence, they redefine how industrial organisations plan, arbitrate and execute change – across engineering, operations and partners.

In the next 18–24 months, the game changer is the convergence of three AI layers: decision intelligence and analytics, agentic AI to orchestrate workflows, and Physical AI (robotics, vision, autonomy) that acts in the real world. Together, they turn the twin into an execution-ready ‘industrial brain’ rather than a digital display – but only when embedded into governance, workflows and accountability.

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Trust is not a slogan: it is configuration control, evidence and a time-aware operating model.”

This shift is also geopolitical. Supply chains, energy constraints and strategic dependencies are forcing European industries to regain control over how they design, build and operate critical assets – with stronger requirements on sovereignty, cybersecurity and interoperability.

This explains why most organisations remain stuck at pilot stage. The technology is ready. The operating model is not. Fragmented ownership between IT, OT and engineering, weak configuration control, unclear decision rights, and slow change management prevent scale.

The opportunity is to make the industrial IT system a ‘nervous system’: dynamic steering, shared situational understanding, predictive capabilities for anticipation, and faster action across engineering, operations and partners.

Context & Challenges⁽¹⁾



Industrial performance has reached *a new ceiling*

Traditional efficiency optimization levers — lean programs, incremental automation, isolated analytics — still matter, but they struggle to keep pace with today's volatility: supply shocks, price and cost pressure, stricter safety constraints, ageing assets, and the acceleration of re-industrialisation. Industrial executives need a way to test disruptive change without 'breaking the line'.

The real transformation *is a new way to run industrial change*

A digital twin becomes strategic when it operates as an accurate 'digital representation' of the physical world: a place where engineering, operations, maintenance and safety converge on the same reality, share decisions, and learn from outcomes.

The twin is not a model; it is an operating loop.

This topic is *broader than 'digital twin'*

We use 'digital twin' as a shorthand for a spectrum of digital representations: asset twins, process twins, supply-chain twins and site-scale industrial metaverse environments. The common denominator is the **fusion of physical reality, operational data, simulation and AI into a shared decision space.**

Q Trap 1

Believing that 'real-time' is mandatory

Many use cases do not require millisecond updates. The right refresh rate depends on the decision you want to support. Over-engineering 'real-time everywhere' increases cost and complexity, and can delay value. Define 'right-time' per workflow (engineering review, work preparation, monitoring, incident analysis).

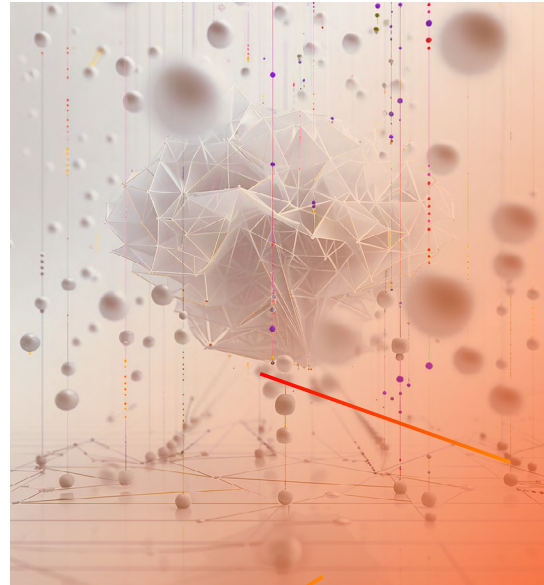
“Digital twins are becoming *the operating model of industry* — not an innovation lab topic.”

(1) World Economic Forum — *Navigating the Industrial Metaverse: A Blueprint for Future Innovations* (2024) - Capgemini Research Institute — *Digital twins: Adding intelligence to the real world* (2022), Top tech trends 2025 (AI-powered robotics) - McKinsey — *What is digital-twin technology?* Technology trends outlook 2025 (robotics) - Sopra Steria Next internal materials — *ESA Argonaut digital twin proposal*; Laval Virtual keynote and demos; WNE briefings; EDF 'digital common' platform work; aerospace digital twin proposal patterns.

CIOs sit at the intersection of IT, OT and engineering

— *and industrial data is extreme*

Industrial data governance must manage two extremes at once: heavy 3D/engineering data (large volumes, specific expertise, strict configuration requirements) and OT signals (light payloads, very high frequency, real-time constraints). The challenge for CIOs is to orchestrate data platforms, critical data distribution across the value chain, connectivity, cybersecurity, and governance on a large scale in areas that were previously siloed.



Q Client case

Rail infrastructure

From paper plans to ground-truth work preparation

A European rail infrastructure manager uses a ground-truth digital twin to prepare signalling works before intervention. By combining field scans and engineering data in a shared 3D environment, teams validate constraints, visibility and safety conditions upstream.

Operational benefits

- Shortened study and preparation cycles through earlier validation of constraints
- Fewer late design changes once on site
- Reduced rework and preparation errors
- Better alignment between engineering and field teams

The new constraint is trust: *safety, sovereignty and auditability*

In regulated industries (industry, rail, energy, aerospace), digital representations must produce evidence: traceable data lineage, configuration control, and repeatable simulations. Without strong governance, the model becomes a 'beautiful lie' — impressive to watch, risky to use.

Q Trap 2

Weak configuration and 3D governance

If teams simulate on an outdated model, the digital representation becomes dangerous. You need a controlled single source of truth: versioning, approvals, traceability between as-designed / as-built / as-maintained, and clear ownership of 3D assets and metadata.

Why most companies remain stuck at pilot stage

Despite strong interest, **industrial digital twins often fail to reach scale for non-technical reasons.**

- Organisations lack a clear business anchor and baseline KPIs to demonstrate value.
- IT, OT and Engineering teams operate in disconnected governance frameworks.
- OT systems impose strong security and sovereignty constraints that slow integration.
- Skills in simulation, data semantics and Physical AI remain scarce.
- Workflows are not ready for continuous iteration, which is central to closed-loop optimisation.

Scaling requires organisational readiness as much as technological readiness.

Market Trends & Key Figures

Digital twins are scaling fast — *and the economics are becoming measurable.*

Digital twin adoption is moving from experimentation to industrialisation, and the definition is expanding: from single-asset monitoring to multi-physics simulation, portfolio management, and closed-loop optimisation. At the same time, industrial AI and robotics are becoming inseparable from digital twins, because the twin is increasingly the training and validation ground for Physical AI.

Q Trap 3

Treating the twin as a standalone tool

Value comes from integration: PLM/BIM, MES, EAM, SCADA, GIS, documents, and planning. Without interoperability, users duplicate data and trust erodes. Design for integration patterns and data contracts from day one.

→ Adoption & business impact:

In a 2024 S&P Global Market Intelligence / 451 Research survey (n=907), **81%** of respondents report they are **using, piloting, or planning** industrial metaverse technologies. The same study reports broad deployment across high-impact use cases such as model-based systems engineering, workforce operations, predictive maintenance and manufacturing process planning.

→ **Market size:** The global digital-twin industry was valued at about US\$6.5B in 2021 and is projected to exceed US\$125B by 2030 (Copenhagen Institute for Futures Studies / Dansk Industri).

→ **Investment momentum:** Market estimates for digital-twin investments exceed US\$48B by 2026 (McKinsey).

Robotic, Physical & smart assets: *why it accelerates now*

- **Robotic & Physical AI momentum:** The International Federation of Robotics reports 4.28 million industrial robots operating worldwide (2023, +10%) and 541,302 new installations in 2023, illustrating sustained acceleration of automation in factories.
- McKinsey estimates the market opportunity for AI-driven robotics could reach up to ~\$900B by 2040, while highlighting challenges on capability development, IT/OT infrastructure and scaling playbooks.

Q Client case

Utilities & Manufacturing projects Building a sovereign 'digital common' to break 3D silos

Industrial operators launched platform initiatives to federate 3D, engineering and business data across long-cycle programs (new builds, life-extension, maintenance). The objective is to establish a shared and governed foundation that aggregates heterogeneous sources (BIM, CAD/CAE, scans, sensors) and supports multiple industrial use cases over time.

Operational benefits

- Elimination of duplicated 3D environments and disconnected silos
- Faster onboarding of new use cases on a common, reusable foundation
- Improved sovereignty, governance and long-term control over industrial data

What is *changing right now (18–24 months)?*

- Simulation is moving from expert engineering teams to daily operational use. “What-if” analysis becomes a standard decision support for work preparation, capacity planning and risk analysis — not an occasional study.
- Synthetic data is becoming a practical accelerator for industrial AI, especially where real data is scarce, hazardous or expensive to collect (quality defects, safety incidents, robotic edge cases).
- Open and composable 3D foundations are replacing proprietary stacks. OpenUSD and semantic layers allow enterprises to connect geometry, behaviour and business meaning — and to avoid long-term vendor lock-in.
- Organisations are replacing isolated pilots with shared industrial platforms. These ‘digital commons’ are designed to serve multiple business units and accumulate value across use cases, instead of restarting from scratch each time.

Q Client case

Aerospace Virtual validation of assembly and maintenance procedures

Major aerospace manufacturers use physics-aware digital twins to virtually validate assembly and maintenance procedures before physical execution. Ergonomics, accessibility, safety envelopes and task sequences are simulated collaboratively by engineering, manufacturing and maintenance teams.

Operational benefits

- Early detection of design and process inconsistencies before prototyping
- Reduced physical rework and late corrective actions
- Safer and more efficient industrialisation of complex procedures

From Representation to Orchestration: *our seven convictions*

Conviction 1

Industrial digital representations *are becoming the operational ‘nervous system’.*

The value of industrial digital representations is not the 3D itself. It lies in the ability to steer: understand the current situation, anticipate impacts, arbitrate options and coordinate execution across teams. Digital twins, process twins and industrial metaverse environments converge into a shared decision cockpit — where engineering, operations and partners work on the same, trusted version of reality.



Conviction 2

Trust requires a Single Source of Truth *plus a time dimension (past/present/future).*

The most expensive errors come from misalignment between the digital representation and the field. 'Trust' is an engineering property: configuration control, traceable evidence, and repeatable simulations. The winning approach is a collaborative foundation that links requirements,

configurations, scenarios and evidence in one place — and supports three temporal modes: PAST ('**TimeMachine**') for traceability and root-cause, PRESENT ('**Living Mirror**') for situational awareness, and FUTURE ('**Crystal Ball**') for what-if decisions and planning.

Conviction 3

Close the loop: *observe* *→ simulate → decide → act.*

A twin creates value when it continuously feeds operations and learning. IoT sensors and enterprise data update the model; simulation tests scenarios; decision intelligence recommends actions; and

execution (people, automation, actuators) changes the real system. The loop then captures outcomes to improve the next decision. This is how automation becomes self-optimization.

Conviction 4

The Industrial Metaverse *is the 'DevOps platform'* *of industry.*

When collaboration, traceability and interoperability are embedded, the environment becomes a shared engineering and operations workspace. Stakeholders rehearse changes, validate procedures, and generate evidence before applying modifications to the field. This expands value beyond a control tower: it becomes a place to 'test and learn' at industrial scale — safely.



The industrial metaverse is the DevOps platform for the physical world: *test, trace, collaborate* — *then execute.*

Trap 4

Ignoring industrial data extremes (3D vs OT)

Industrial programs fail when the architecture cannot handle both ends of the data spectrum: large engineering/3D data with strict configuration needs, and high-frequency OT signals with operational constraints. Without clear governance and platform engineering, organisations accumulate brittle pipelines and the twin cannot scale.

Conviction 5

Physical AI will be industrialised in the virtual world
— and specialised models will outperform generic ones.

Industrial AI (vision, robotics, autonomy) often lacks balanced, labelled data — especially for rare events and hazardous situations. A physically-accurate environment enables synthetic data generation, edge-case stress testing, and model validation before deployment. As general-purpose World Foundation Models emerge, enterprises will still need domain-specific systems tuned to their assets, rules and context; smaller specialised models can be more cost-efficient and more reliable than generic models when the context is constrained and well governed.

“

Physical AI will be trained and validated in the virtual world
— and specialised models will win in governed contexts.”

Trap 5

No economic narrative and no KPIs

Executives will not fund ‘nice 3D’. Anchor the platform to measurable outcomes: cycle time reduction, downtime avoided, rework reduction, safety incident reduction, and compliance lead time. Make value visible with a small set of agreed KPIs and baseline measurement.



Conviction 6

Open standards across 3D and OT unlock scale and sovereignty.

3D and simulation data are trapped when they remain tied to a single vendor format. OpenUSD enables a neutral, extensible resilient scene graph carrying geometry, materials, behaviors and metadata. In parallel, OT interoperability relies on industrial standards (e.g., OPC-UA) to collect,

contextualise and connect high-frequency signals to the enterprise layer. Scale also requires shared meaning: ontologies and knowledge graphs align business terms (assets, zones, rules) so that humans and AI agents can query and act consistently across systems.

Q Client case

Construction & maintenance Coordinating complex activities and ensuring regulatory evidence

On complex industrial sites, teams rely on digital twins to prepare and validate high-risk or highly constrained operations such as heavy lifting, multi-trade co-activity or interventions in restricted zones. Scenarios are simulated and reviewed collaboratively before execution.

Operational benefits

- Improved safety margins through anticipation of interferences and risk situations
- Better coordination between multiple stakeholders and contractors
- Production of traceable evidence for internal governance and regulatory reviews

Conviction 7

Democratise adoption: *turn twins into collective innovation engines.*

If only a few experts can access the environment, it stays a lab. Adoption requires simple access (browser, thin client, streaming), role-based views, and integration into workflows (work preparation, maintenance planning, safety reviews). The deeper shift is

organisational: by providing a trusted foundation, the enterprise can move from isolated innovation labs to a continuous improvement loop ('smart lean') where operational teams propose, test and deploy improvements faster.

Recommendations — Call to action: *A Pragmatic 5-Sprint Path to Adoption*

To help CIOs move from ambition to execution, we recommend a structured 5-sprint journey that blends architecture, governance and value realisation:

- **Sprint 1**
Align executives on value and decision scope
 - **Outcome:** a shared priority on where the twin will change decisions, with clear KPIs and sponsorship.
- **Sprint 2**
Clarify governance across IT, OT and engineering
 - **Outcome:** explicit ownership, decision rights and configuration rules
 - no grey zones.
- **Sprint 3**
Define a common reference architecture
 - **Outcome:** one coherent foundation for data, 3D, OT and security that all use cases will reuse.
- **Sprint 4**
Prove value on a lighthouse use case
 - **Outcome:** measurable operational impact on a real process that forces integration across silos.
- **Sprint 5**
Prepare scale and replication
 - **Outcome:** an industrialisation roadmap, an operating model and a clear business case for rollout.

For CIOs, the priority is no longer building digital twins.

It is building a trusted industrial decision system — where observation, simulation, AI and execution operate as one governed loop.

KPIs

THE MEASURABLE IMPACT OF SMART OPERATIONS

Efficiency



Improved OEE (Overall Equipment Effectiveness): companies adopting smart operations approaches typically observe **a 15–30% improvement in equipment effectiveness**, reflecting better asset utilization and more reliable production⁽²⁾.

Control



Forecast accuracy: smart operations initiatives leveraging AI and data analytics can **improve demand or production forecasting accuracy by 20–30%**, strengthening the ability to anticipate business needs⁽³⁾.

Resilience



Faster order fulfillment: in real-world cases, companies modernizing their operations with advanced technologies **have achieved up to 25% faster order processing**, increasing agility in the face of disruptions⁽⁴⁾.

Sustainability



Reduced energy consumption: the integration of data and AI enables significant energy optimization, **with reductions in consumption ranging from 10–20%**, contributing to more sustainable facility operations⁽⁵⁾.

(2) Smart Manufacturing: Industry 4.0 Transformation Guide

(3) Boost ROI with Predictive Analytics in Manufacturing

(4) Industry 4.0 and What It Means for Your Business | Uptimize Solutions

(5) <https://jarkoindustry.com/en/blog-en/industry-4-0-how-smart-technologies-are-changing-manufacturing>; Industrie 4.0 : l'avenir de la production | SAP

Contacts



David MAURANGE

*Director – Smart Operations
Head of Digital Interaction & Industrial Metaverse,
NVIDIA Alliance Manager – Group CTO Office*

→ david.maurange@soprasterianext.com



Guillaume ROY

Director, Head of Smart Industry & IoT

→ guillaume.roy@soprasterianext.com

Contributors of our European Network



Olivier BROUSSEAU

Architecture & Tech

→ olivier.brousseau@soprasterianext.com

Isabelle PONS

Data & AI

→ isabelle.pons@soprasterianext.com

Valérie THIBLET

Data & AI

→ valerie.thiblet@soprasterianext.com

Axelle ROESCH

CIO Advisory

→ axelle.roesch@soprasterianext.com



Thomas OTTO

CIO Advisory

→ thomas.otto@soprasteria.com

Philipp MAIER

CIO Advisory

→ philipp.maier@soprasteria.com



Simon KAYE

Architecture & Tech

→ simon.kaye@soprasteria.com



Ray BAKER

Architecture & Tech

→ ray.baker@soprasteria.com

Andy WHITEHURST

Architecture & Tech

→ andy.whitehurst@soprasteria.com



Jahn-Fredrik SJOVIK

CIO Advisory

→ jahn-fredrik.sjovik@soprasteria.com

Tor NESET

Architecture & Tech

→ tor.neset@soprasteria.com

Marius SANDBU

Data & AI

→ marius.sandbu@soprasteria.com



Robert HEXSPOOR

Architecture & Tech

→ robert.hexspoor@soprasteria.com

Hugo HERMSEN

CIO Advisory

→ hugo.hermesen@soprasteria.com



Juan Antonio MARTINEZ SANCHEZ

Architecture & Tech

→ juanantonio.martinezsanchez@soprasterianext.com



Mauro PALMARINI

CIO Advisory

→ mauro.palmarini@soprasterianext.com