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Intel: Optimizing Factory Performance with Digital Twin Technology

- Jean-Laurent PHILIPPE, Intel EMEA CTO
  with great support from the Intel IT Manufacturing Team

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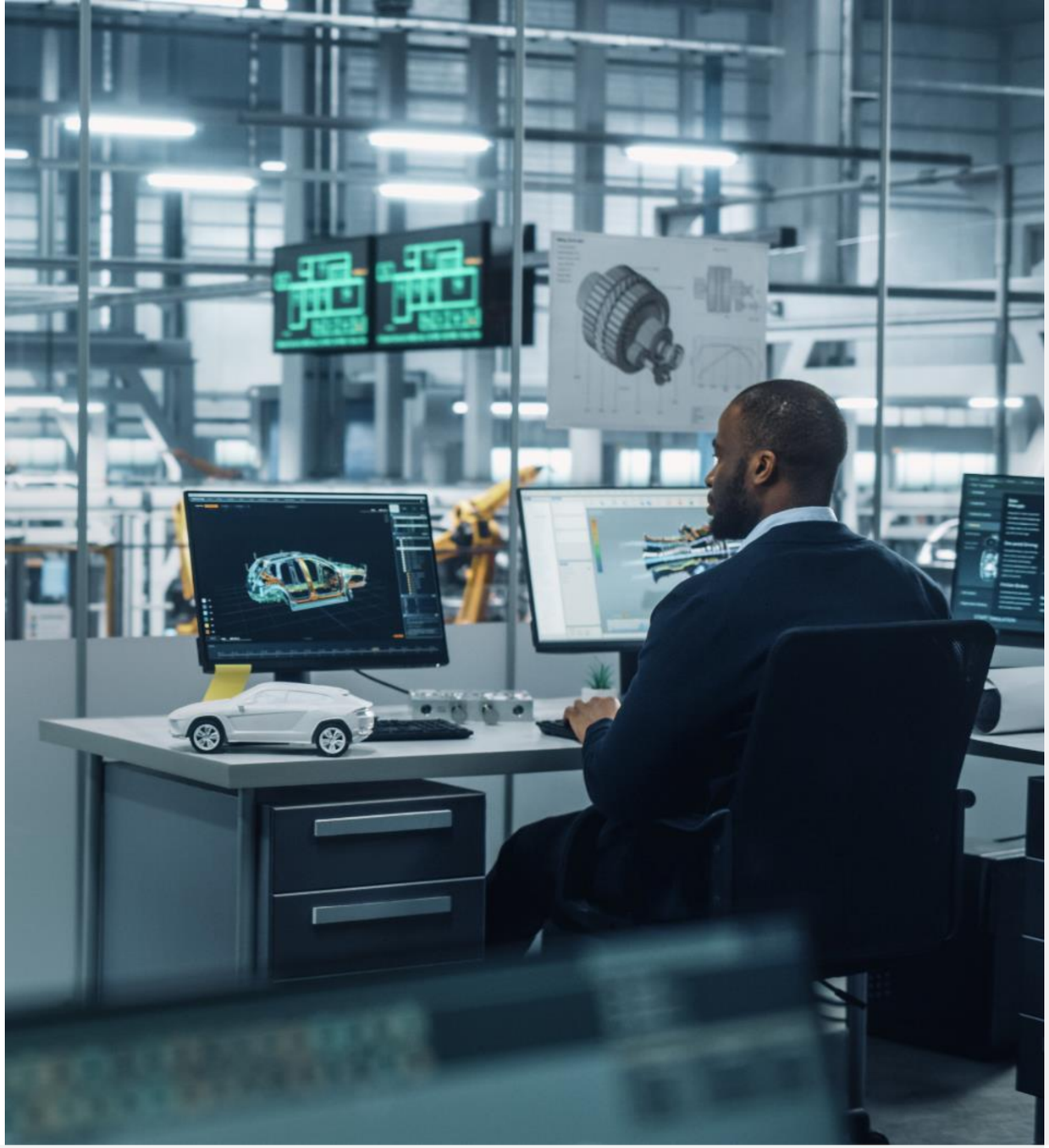
Replicas of real-world objects are nothing new

- Architectural models
- Machine blueprints
- Maps
- Prototypes
- Etc.

Digital Twins go further

A Digital Twin is a digitized model, raised to a new, dynamic level:

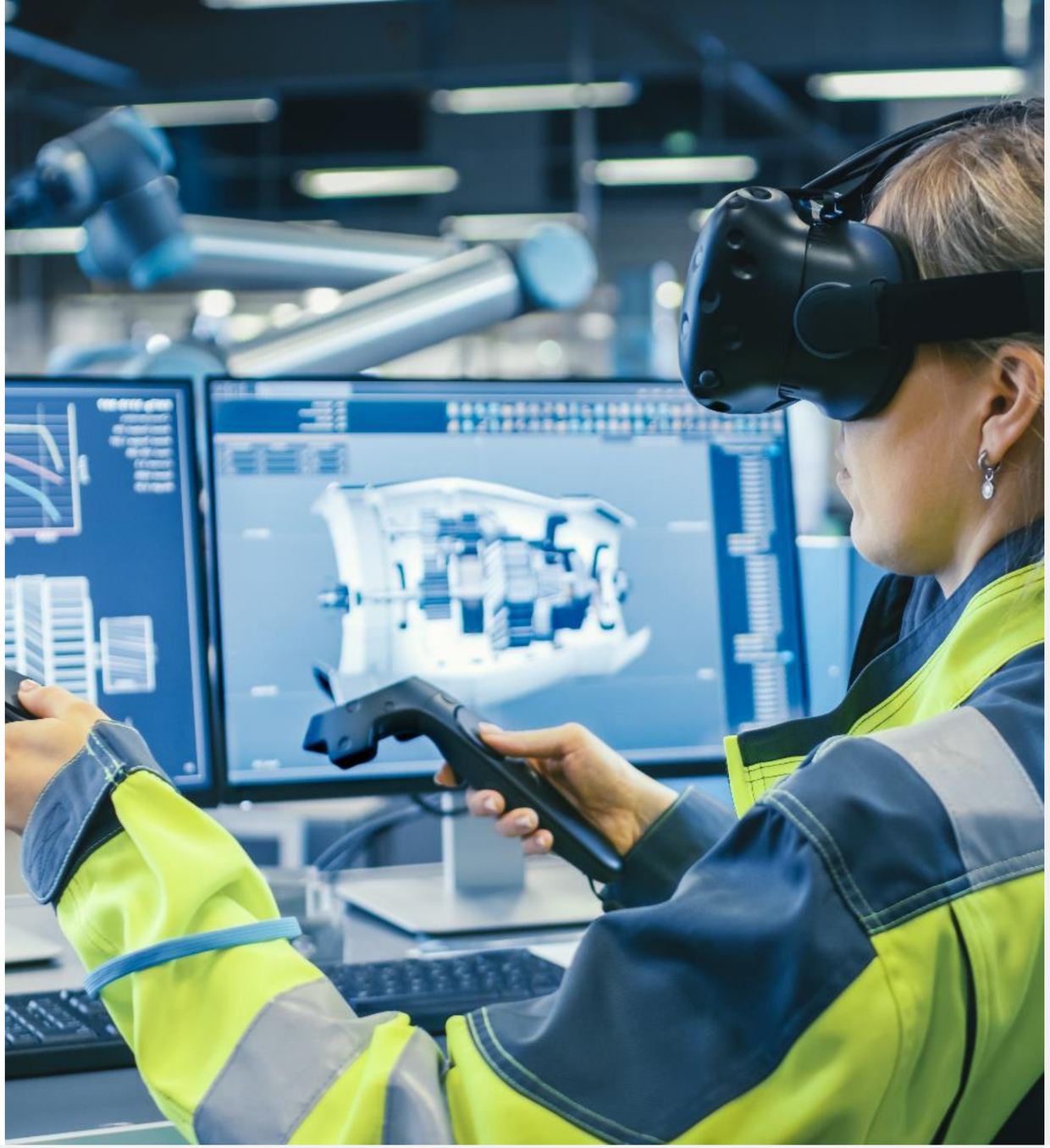
- Basic physical attributes of objects (shapes, color, size, etc.)
- Descriptive attributes (strength, elasticity, conductivity, and many, many more)



Digital Twins work together

Digital Twins of different objects can be combined into digital systems whose behavior mimics their real-world counterparts.

That behavior can be recorded, analyzed, tested, and revised efficiently and effectively.



Digital Twin technology

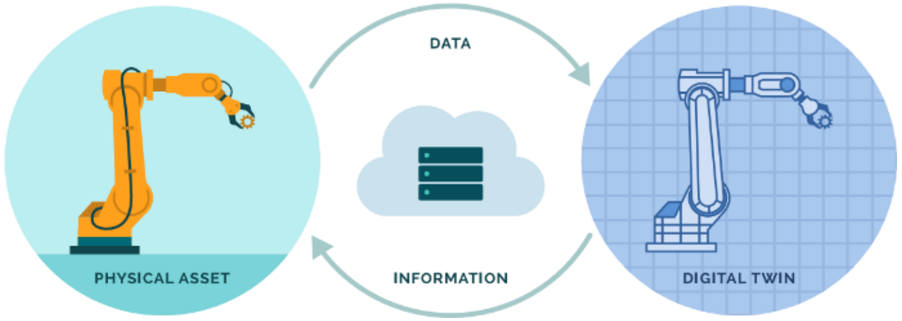
With Digital Twins, manufacturers can:

- Design new systems, such as complex factory operations, and study their behavior and capabilities with much more flexibility.
- Experiment with Digital Twins of existing systems to understand the ramifications and risks of changes prior to implementing in the real world.
- Learn how to carry out physical tasks using Digital Twins instead of actual objects, simplifying and accelerating training courses.

Digital Twin technology

Ideal for manufacturing

- Digital Twin technology is used by leading manufacturers around the world.
- The ability to represent objects and functions digitally has opened an enormous range of new possibilities for manufacturing engineers and technicians, who can now simulate a wide variety of operations quickly and without risk of damage or disruption of operations.

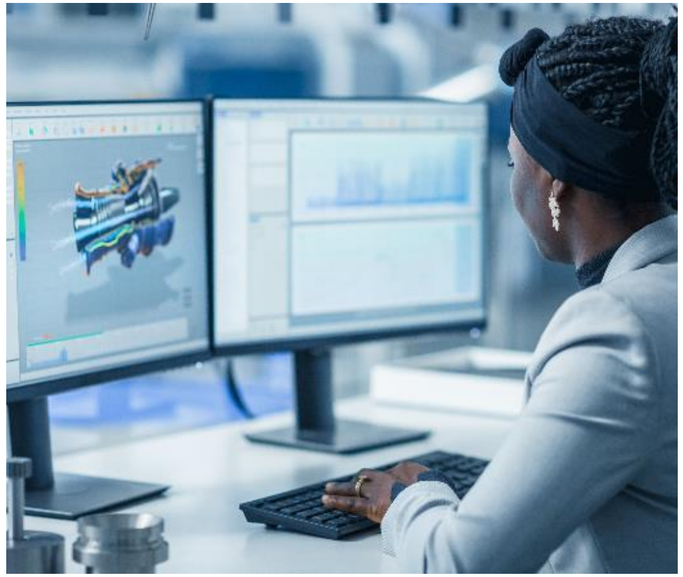


The US National Aeronautics and Space Administration (NASA) was one of the first organizations to make use of Digital Twins. By replicating systems built to be used in space, Apollo 13 engineers famously solved problems encountered in space by creating digital models to simulate them on the ground.

Digital Twin technology

How manufacturers can benefit from Digital Twins technology

- Product designers can create highly accurate 3D digital models of components, from a single screw to an entire factory floor plan.
- Engineers can build simulations to predict outcomes of processes even when there are variations in the process. They can simulate actual plant operations using real-time data and introduce data representation of the what-if scenarios to produce the end results.
- Companies can plan new factory installations or modify existing ones to improve production and lower costs.



Digital Twin technology

How manufacturers can benefit from Digital Twins technology

- Factories can centralize data into a single hub, with the Digital Twins connecting every production machine in the plant through data sensors. This virtual model can receive and act on real-time feedback and store important data for analysis.
- Digital Twin users can view operations parameters via software dashboards or websites in real time, quickly reacting as necessary.
- Back-office operations can be simplified. For example, Digital Twins can drastically reduce manual data collection and paper-based procedures.

Digital Twin technology

Cross-industry use cases

- Digital Twins of buildings can be proactively monitored using IoT sensors to check for signs of wear or damage.
- A Digital Twin of an air-conditioning unit can be tested to see what thermal conditions will result in overheating.
- On-site repair crews can use Digital Twins on mobile workstations to pinpoint components in a manufacturing facility that are malfunctioning.
- Digital Twins can improve the efficiency of supply chains by more accurately forecasting scheduling and logistic demands.

Digital Twin technology

Digital Twin software

- **Level 1:** Descriptive Digital Twins
- **Level 2:** Informative Digital Twins
- **Level 3:** Predictive/Autonomous Digital Twins

Digital Twin technology

Level 1: Descriptive Digital Twins

A Descriptive Digital Twin is an engineering design and visual representation that embodies knowledge of a physical object or set of objects. As humans often benefit from visually perceiving an object, Descriptive Twins can be implemented in a variety of use cases.

A Descriptive Digital Twin can provide viewpoints prior to construction to enable fast design revisions, as with this retail layout.

One example of Descriptive Digital Twin technology involves factory use of Augmented Reality (AR).

Descriptive Digital Twin benefits:

- Less time needed to deal with tool errors.
- Faster time to training completion for technicians.
- Reduced machine time devoted to training, resulting in increased production uptime.
- Increased technician flexibility that enables technicians to handle a wide range of tasks.

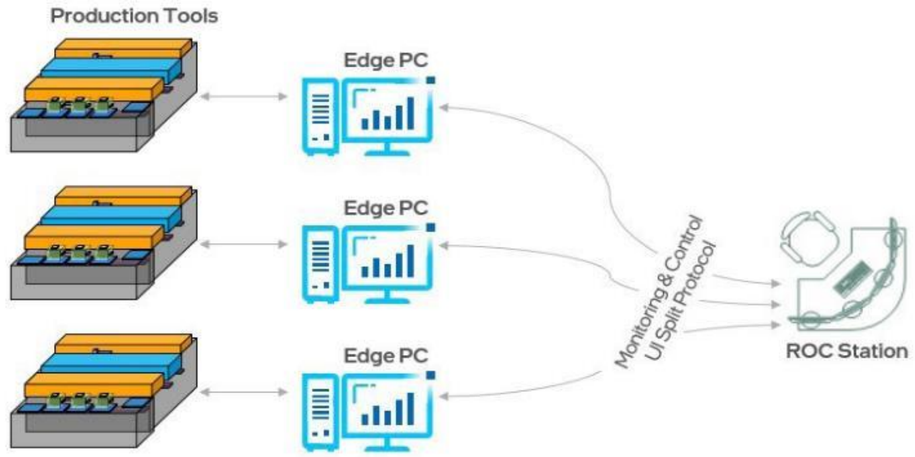
Digital Twin technology

Level 2: Informative Digital Twins

An Informative Digital Twin includes an additional layer of operational and sensory data. This enriched data enables users to extract insights about how the object will perform in the real world.

Remote Operations Centers (ROCs) made possible by Informative Digital Twins enable technicians to control and manage the factory floor from anywhere, including from home.

A single ROC station can monitor and control hundreds of production tools and can collect input from numerous edge PCs and incorporate it into a detailed picture of the current status of the factory floor.



Many tools, one workstation:

One example is Intel's creation of Informative Digital Twins of processor fabs, complete with equipment, material handling systems, and computer-integrated manufacturing systems. These capabilities enable a "lights-out" factory, where the entire operation is monitored and managed remotely—without direct human interaction. A single process technician can manage hundreds of different machines and devices from a single remote operations terminal.

Digital Twin technology

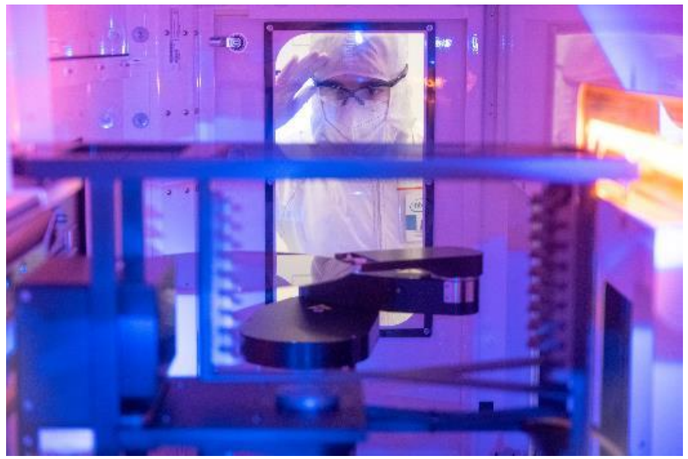
Level 3: Predictive/Autonomous Digital Twins

Predictive/Autonomous Digital Twins incorporate updatable models that can be used to drive actionable tasks. This type of Digital Twin can learn, make decisions, and act on behalf of users, with or without human interaction. The status of the Digital Twins can be continuously monitored, and actions taken to correct problems or to coordinate continuous processes, such as the systematic feeding of materials to a machine tool.

To keep things running smoothly, the software can execute what-if scenarios through a simulation engine, adjusting workflows as needed. This results in more efficient use of materials and helps prevent supply chain inefficiencies.

Benefits:

- High-resolution monitoring
- What-if planning
- Reduced downtime



Predictive/Autonomous Digital Twins enable users to make accurate predictions of unmeasured quantities and future states, based on historical data. A good example is an Automated Material Handling System (AMHS) Digital Twin at an Intel fab. The primary role of the AMHS is to load, transport, store, and unload silicon wafers efficiently and effectively from one machine to another.

Digital Twins and semiconductors

Digital Twin capabilities are highly relevant to the semiconductor industry.

- 1980s: Digital transformation begins.
- 1990s: Intel massively digitized wafer production by implementing highly integrated factory systems, including tool controllers, manufacturing execution systems, advanced process control, and automated material handling systems.
- Early 2000s: Remote operations centers enabled a fab to be monitored and managed from off-site.

Today:
Harnessing the power of Digital Twins has been a true game changer, streamlining processes and reducing costs. Intel has increased per-person productivity and reduced unit throughput time while maintaining outstanding product quality, even as microprocessor manufacturing procedures have exponentially increased in complexity.

Intel® Automated Factory Solutions (Intel® AFS)

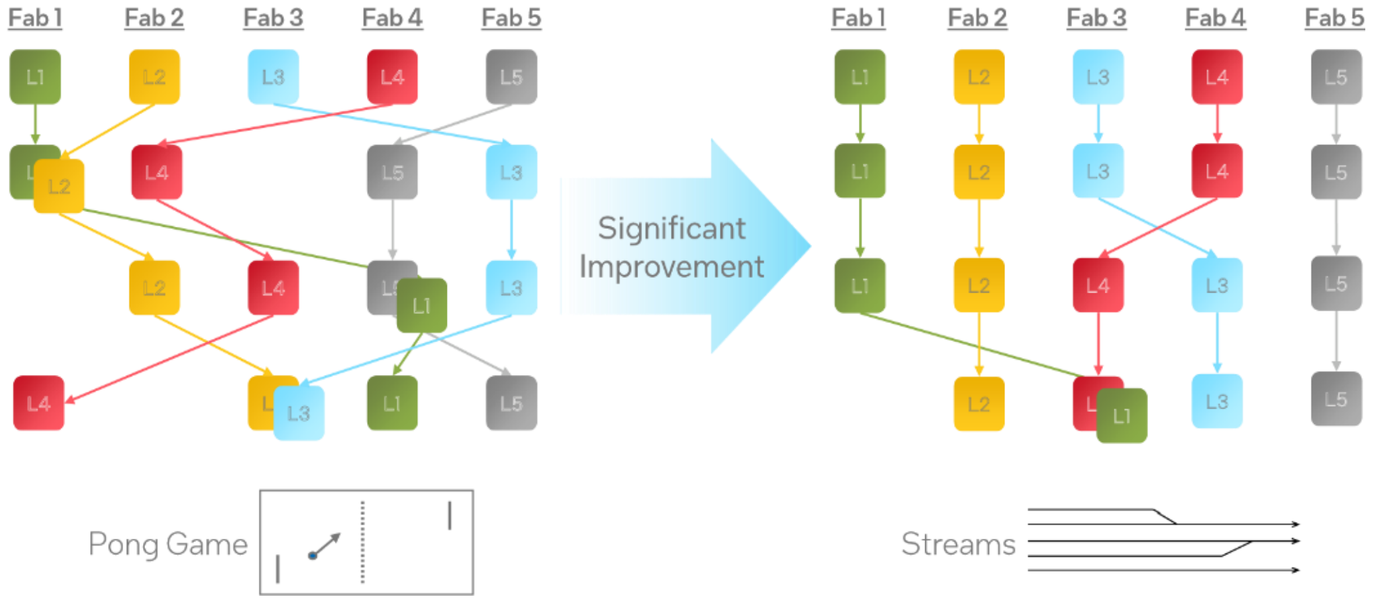
With the promise of Digital Twins firmly established, Intel formed the Automated Factory Solutions team in 2019.

Intel Automated Factory Solutions	
Intel® Factory Pathfinder	High-speed discrete event simulator for factory optimization.
Intel® Factory Pathfinder for Enterprise	Moving Factory Pathfinder simulations into the enterprise layer to enable rapid product allocation and customer order response times.
Intel® Factory Recon	Full graphical Digital Twin of factory production equipment and automated material handling system.
Intel® Factory Optimizer	An AI-based control layer for Factory Pathfinder.
Intel® Factory Adapter	Adapting the factory process to the environment in two specific ways: (1) Automated measurement step-skipping and job parameter processing engine with decisions based on quality or other relevant data. (2) Dynamic equipment process job customization necessary to meet specific process rules in the factory.

Mission:
Intel AFS Digital Twin software inspired by solutions implemented in Intel fabs has delivered major benefits. Now these solutions are available for use by other discrete manufacturing companies.

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Pathfinder

Intel Factory Pathfinder delivers advanced simulation and scheduling capabilities for manufacturing. It uses Digital Twin technology to provide manufacturers with critical capabilities designed to improve processes, increase efficiency, and reduce costs.



Streamlining materials handling

With Factory Pathfinder, companies can turn disorganized and wasteful processes into organized systems, reducing “ping pong” problems and increasing productivity, as shown here.

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Pathfinder

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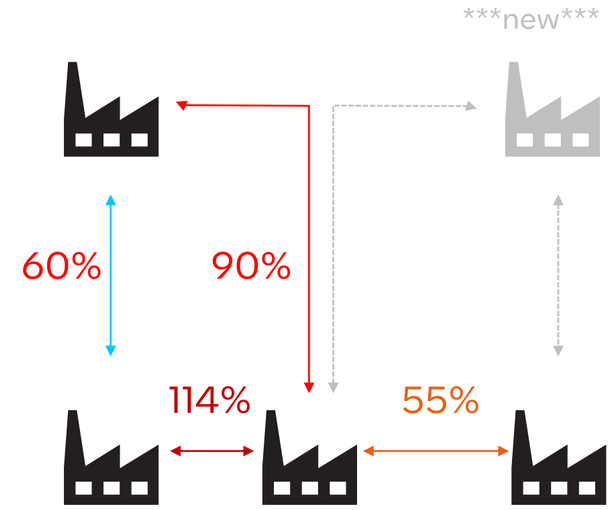
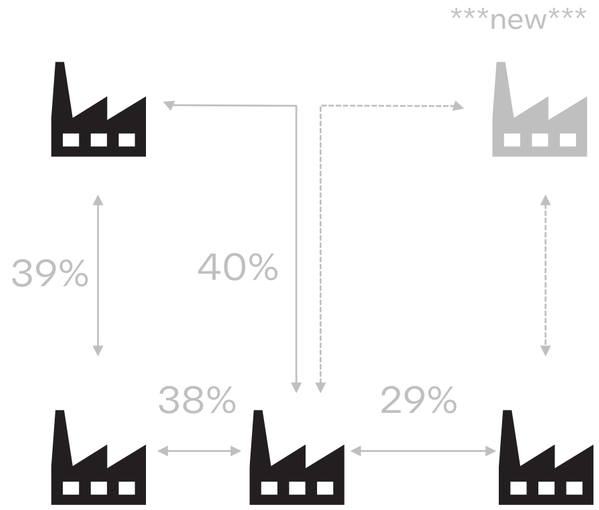
Existing Utilization



*Utilization/Capacity is measured in product moves per day

Simulation Utilization



Greatly optimized product movement

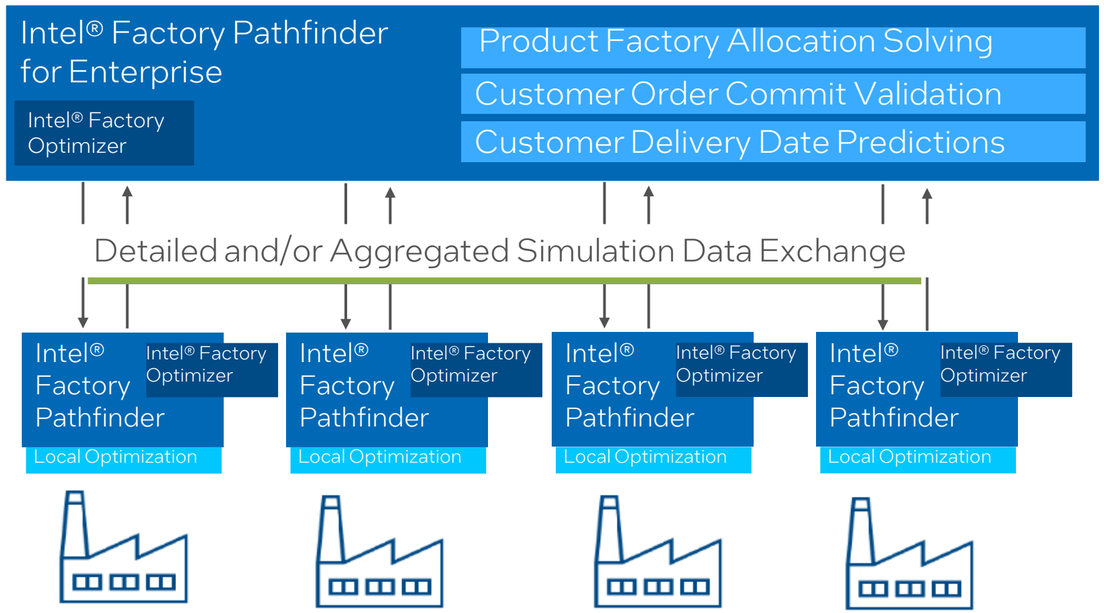
Problem:
Multi-factory campus Automated Material Handling System (AMHS) building link capacity is stressed ahead of expansion.

Solution:
Intel Factory Pathfinder greatly reduces product movement, saving tens of millions of dollars (and more).

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Pathfinder for Enterprise

Planned for release soon, Intel Factory Pathfinder for Enterprise delivers extended factory management capabilities.

Implementation of Intel® Factory Pathfinder for Enterprise



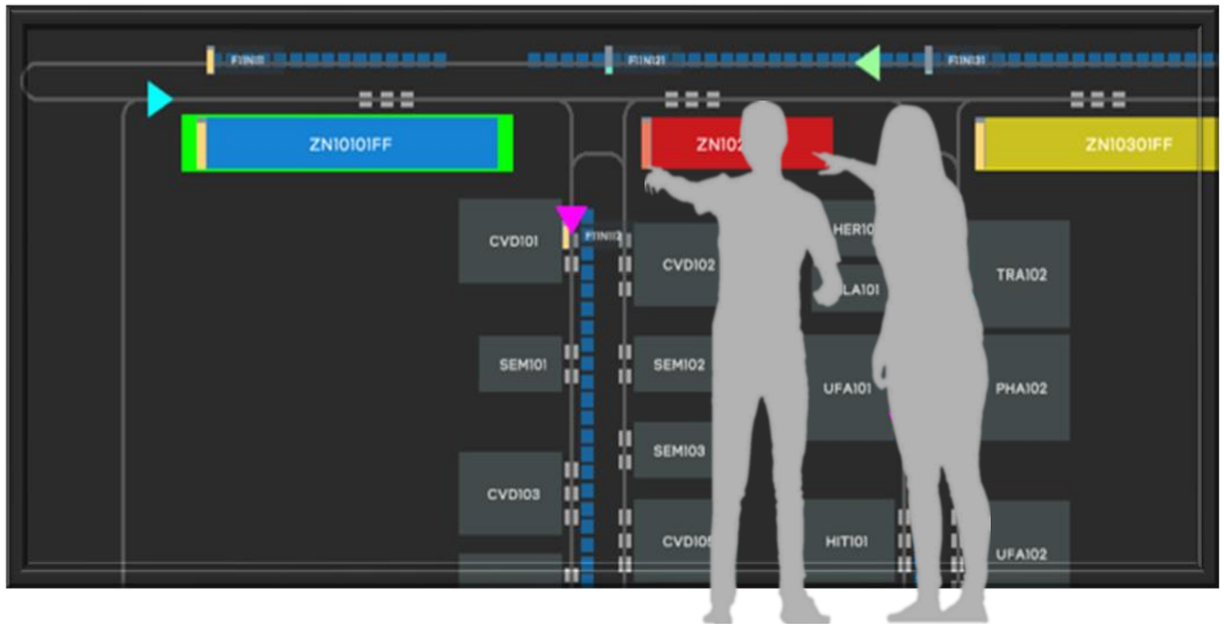
Manufacturers can:

- Optimize factory output
- Streamline product assignment
- Reduce order fulfillment times
- Balance factory floor conditions to match product demand and material availability

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Recon

Intel® Factory Recon enables manufacturers to use game-like, immersive graphics capabilities to instantly visualize their operations better than ever before.

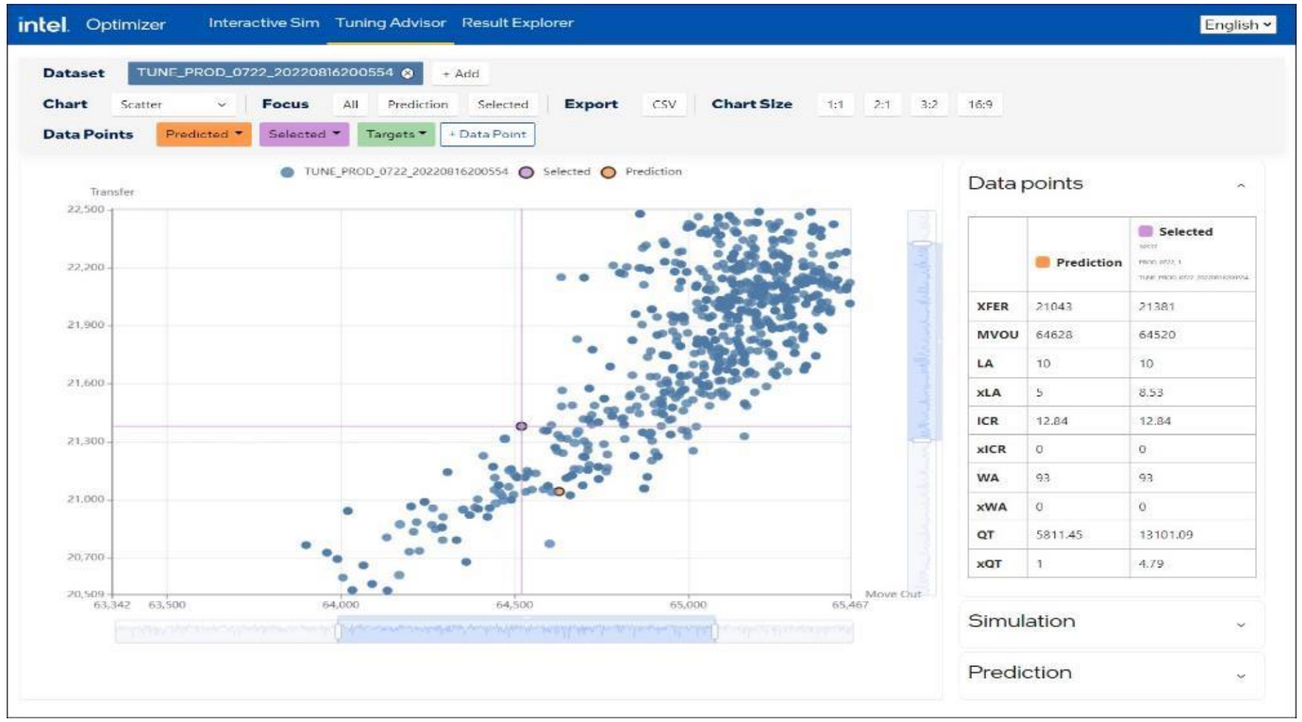
Playback mode: rewind to view activity.
Simulation mode: What-if scenarios.



Enhanced visibility into operations lets companies dramatically reduce Mean Time to Repair, and much more.

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Optimizer

An AI-based control layer for simulation optimization and offline analysis, Factory Optimizer is a powerful tool that allows engineers to quickly and easily test changes to factory assets or conditions.



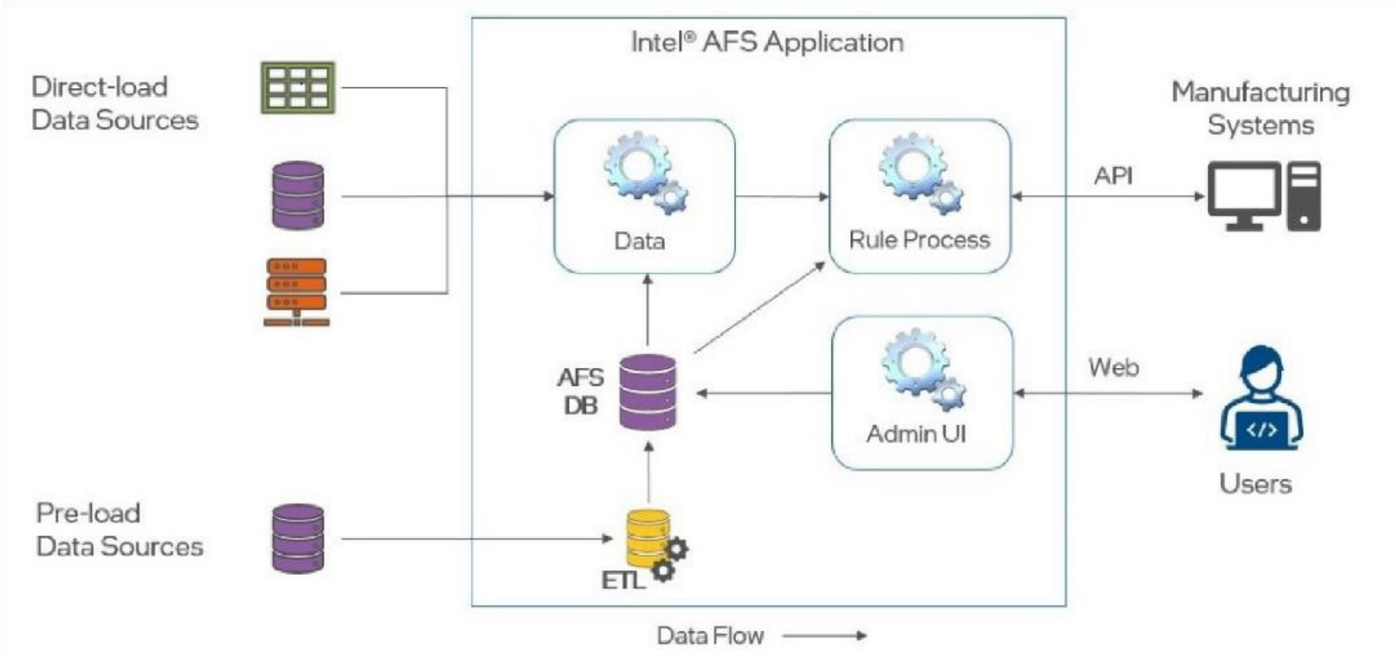
Comparing results between generated datasets and prediction results

Engineers can:

- Compare two different devices to see how they perform in the real world, or modify machine layouts to minimize materials transfer times.
- Run thousands of simulations in parallel to generate datasets for AI and ML.

Intel® Automated Factory Solutions (Intel® AFS)
Intel® Factory Adapter

Factory Adapter is an automated measurement step-skipping engine that makes decisions and builds intelligent sample plans based on factory quality data.



Helps increase product throughput by reducing redundant or unneeded steps in the manufacturing process, thereby optimizing the use of capital assets.

Enables companies to adjust the manufacturing process as needed in real time.

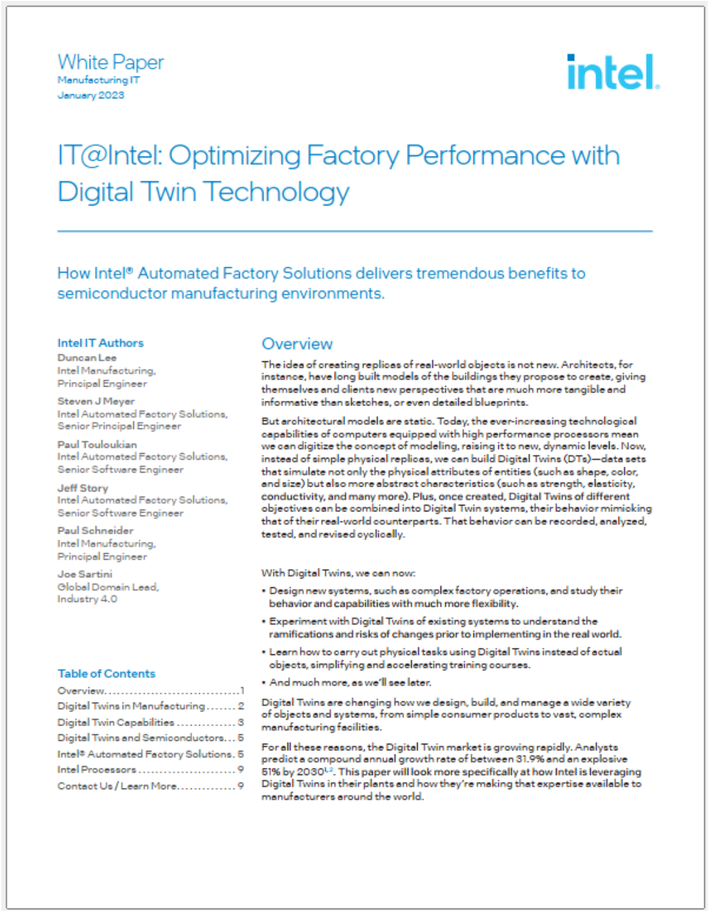
Optimize Factory Performance with Digital Twin technology

Changing the way manufacturing engineers conceptualize their world

Intel Corporation embraced Digital Twins to transform their microprocessor fabs. Now Intel engineers have packaged this technology and made it available to manufacturers around the world.

As Intel’s successful adoption has proved, Digital Twin technology can deliver tremendous benefits and cost savings for manufacturers today, and tomorrow.

Read The Full Story:
Optimizing Factory Performance with Digital Twin technology



White Paper
Manufacturing IT
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intel

IT@Intel: Optimizing Factory Performance with Digital Twin Technology

How Intel® Automated Factory Solutions delivers tremendous benefits to semiconductor manufacturing environments.

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Overview

The idea of creating replicas of real-world objects is not new. Architects, for instance, have long built models of the buildings they propose to create, giving themselves and clients new perspectives that are much more tangible and informative than sketches, or even detailed blueprints.

But architectural models are static. Today, the ever-increasing technological capabilities of computers equipped with high performance processors mean we can digitize the concept of modeling, raising it to new, dynamic levels. Now, instead of simple physical replicas, we can build Digital Twins (DTs)—data sets that simulate not only the physical attributes of entities (such as shape, color, and size) but also more abstract characteristics (such as strength, elasticity, conductivity, and many more). Plus, once created, Digital Twins of different objectives can be combined into Digital Twin systems, their behavior mimicking that of their real-world counterparts. That behavior can be recorded, analyzed, tested, and revised cyclically.

With Digital Twins, we can now:

- Design new systems, such as complex factory operations, and study their behavior and capabilities with much more flexibility.
- Experiment with Digital Twins of existing systems to understand the ramifications and risks of changes prior to implementing in the real world.
- Learn how to carry out physical tasks using Digital Twins instead of actual objects, simplifying and accelerating training courses.
- And much more, as we'll see later.

Digital Twins are changing how we design, build, and manage a wide variety of objects and systems, from simple consumer products to vast, complex manufacturing facilities.

For all these reasons, the Digital Twin market is growing rapidly. Analysts predict a compound annual growth rate of between 31.9% and an explosive 51% by 2030[1,2]. This paper will look more specifically at how Intel is leveraging Digital Twins in their plants and how they're making that expertise available to manufacturers around the world.

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