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Forward Thinking

Simulation Applications for Industry 4.0

What it is and
How Simulation Can Help

Simulation in Industry 4.0

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- What is Industry 4.0?
- Digital Twin
- The Role of Design Simulation
- The Role of Simulation-based Scheduling
- Simulation as a Digital Twin

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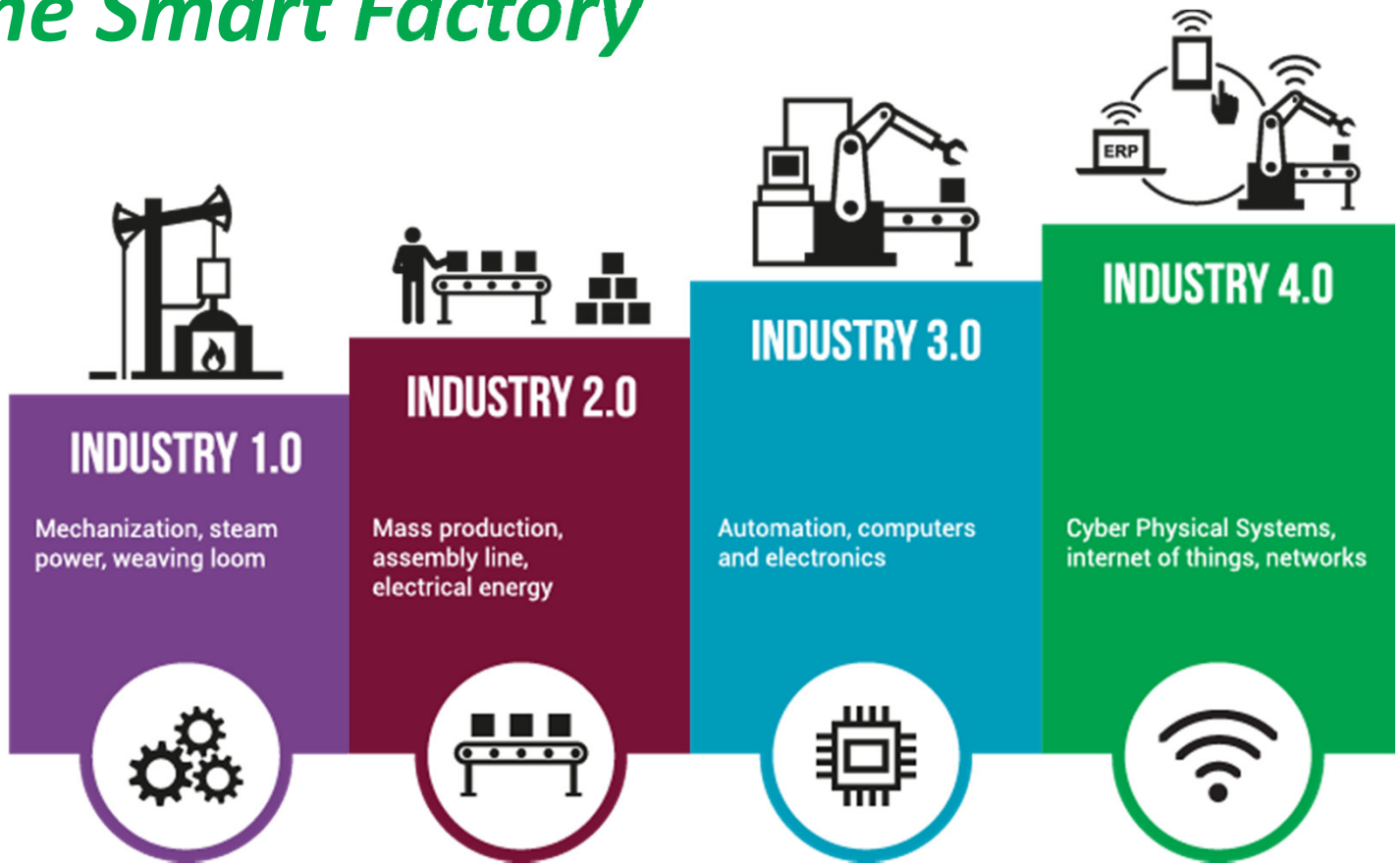
We stand on the brink of a technological revolution that will fundamentally alter the way we live, work and relate to one another.

Klaus Schwab,
Founder and Executive Chairman
World Economic Forum

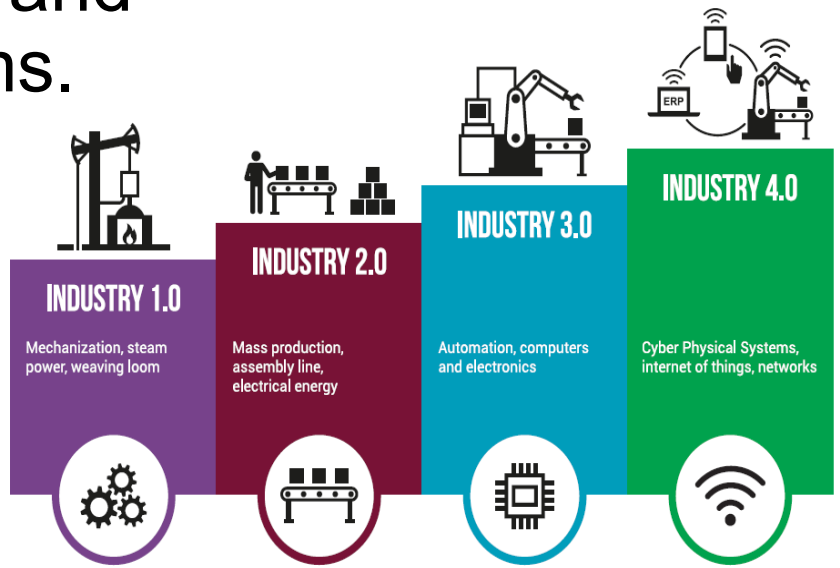
What is Industry 4.0?

Smart Manufacturing
The Smart Factory



Smart Factory/Industry 4.0

- Four design principles:
  - Interoperability of components and data (IoT)
  - Information transparency
  - Support systems help solve problems
  - System components perform autonomously
- Realization of this vision requires a tool that supports fully connected and automated production systems.
- Simulation is a key technology to support this vision.



Graphic from *Deliver on Your Promise, How Simulation-based Scheduling Will Change Your Business*

Digital Technologies Include

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- Internet of Things (IoT) and Industrial Internet of Things (IIoT)
- Robotics
- Cloud Computing/Software as a Service (SaaS)
- Big Data/Advanced Analytics
- Additive Manufacturing
- System Integration
- Augmented Reality
- Simulation
- IT/Cybersecurity

Current Systems & Data

Data Warehouses/analysis

MES Systems/SCADA

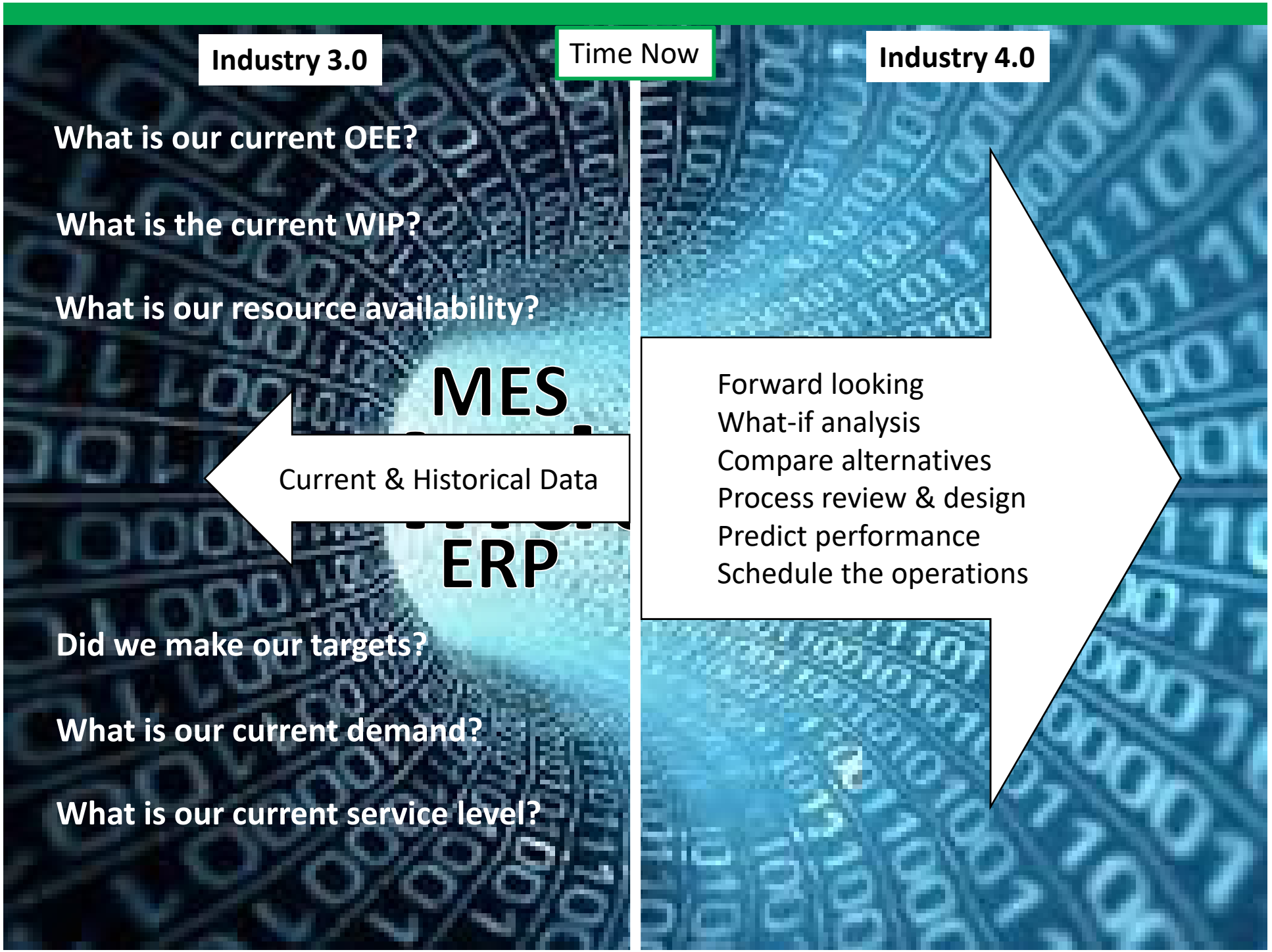
ERP Systems/SCP

This is still Industry 3.0

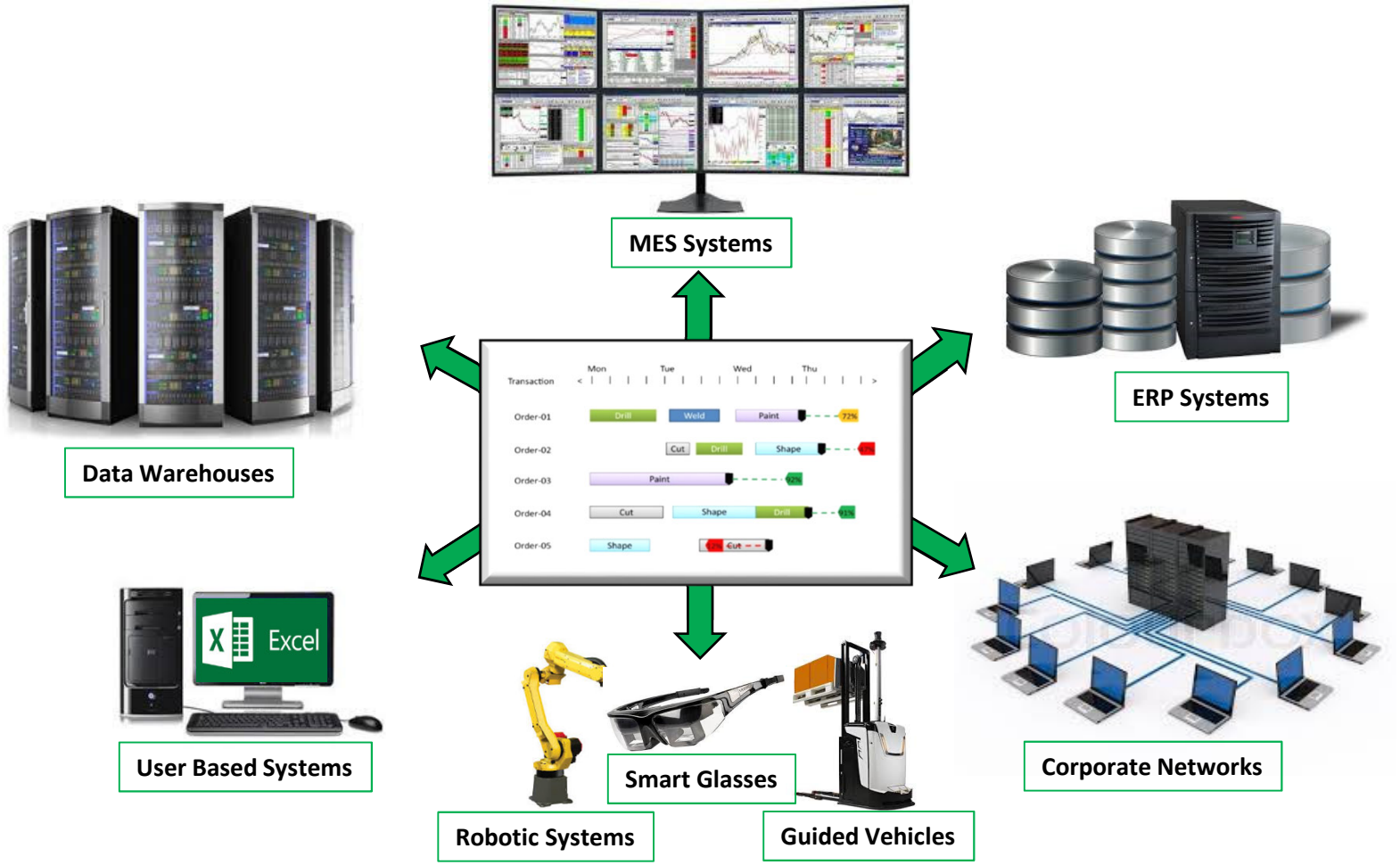
User Based/Custom Systems

Automation/Robotics

Corporate Networks/Portals


Industry 3.0
Time Now
Industry 4.0
What is our current OEE?
What is the current WIP?
What is our resource availability?
MES
ERP
Current & Historical Data
Forward looking
What-if analysis
Compare alternatives
Process review & design
Predict performance
Schedule the operations
Did we make our targets?
What is our current demand?
What is our current service level?

Enabling the Smart Factory



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Digital Twin

Addressing the challenges of increased digitalization

What are those Challenges?

Industrial Internet of Things (IIoT) allows machines and products to communicate with people and each other.

How can we
design, operate, and maintain
such a system
to optimize our production
while minimizing costs?

Enter the Digital Twin…

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- Virtual representation of a product, part, system or process that allows you to see how it will perform.
  - System may not yet even exist.
- A digital twin of a **device** will perform in a virtual world very similar to how the real device performs in the physical world.
- A digital twin of the **entire manufacturing facility** performs in a virtual world very similar to how the entire manufacturing facility performs in the physical world.

Facility Digital Twin

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- A standalone simulation model is referred to as a **virtual factory model**.
- Only becomes a **digital twin** when it is fully connected and runs in real-time, driven by data from the relevant ERP, MES, and other systems.
- Must be able to generate models from data to function effectively as a digital twin.

*While being **data-driven** is essential,*
***data-generated** models permit immediate reaction*
to even to fundamental changes like
adding machines, resources, and products.

How is a Facility Model Possible?

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- Technological advancements
  - Computational
  - Computing
  - Communication
  - Data Security
  - SaaS
  - Modeling
- Modeling concepts
  - Data-generated models
  - We don’t need a “perfect” model –”good enough” works!
  - Model can “learn” through data
  - Model can be “taught” by modeler

Digital Twin Benefits

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- Virtual representation of how all the elements involved in its operation dynamically interact with each other and their environment.
- Monitors these elements, improving diagnostics and prognostics, and investigating root causes of any issues in order to increase efficiencies and overall productivity.
- Dynamically calibrate the operational environment to positively impact every phase of the product lifecycle; through design, building and operation.

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The Role of Design Simulation in Industry 4.0

Why Traditional Simulation?

- A smart factory is a factory that has all the same problems as any other factory.
- Simulation can provide all of the same benefits in the same areas where simulation has traditionally been used.
- In general, simulation can be used to objectively evaluate the system and provide insight into it's optimal configuration and operation.

Traditional Simulation Benefits

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- **Supply Chain Logistics**: Just-in-time, risk reduction, reorder points, production allocation, inventory positioning, contingency planning, routing evaluations, information flow and data modeling
- **Transportation**: Material transfer, labor transportation, vehicle dispatching, traffic management (trains, vessels, trucks, cranes, and lift trucks)
- **Staffing**: Skill-level assessment, staffing levels and allocation, training plans, scheduling algorithms
- **Capital investments**: Determining the right investments in the right things, at the right time.
- **Investing for growth:** Objective evaluation of return on investment
- **Productivity**: Line optimization, product-mix changes, equipment allocation, labor reduction, capacity planning, predictive maintenance, variability analysis, decentralized decision-making

Smart Factory Challenge 1

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Challenge/Opportunity:

- Larger and more sophisticated components.
- It is difficult to assess the impact of any specific advanced feature.

Solution:

- Simulation is possibly the only tool to allow you to:
  - Objectively evaluate the interactions and contributions of each component.
  - Design a system that will work together.
  - Tune and optimize that system.

Smart Factory Challenge 2

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Challenge/Opportunity:

- IT innovations such as Big Data and Cloud Operation make real time data much more available.

Solution:

- Modern products allow incorporating such data into a model.
- Identifies points of failure and areas of risk before implementation.

Smart Factory Challenge 3

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Challenge/Opportunity:

- The dynamic processes in a smart factory enable operational flexibility such as intelligently responding to system failures and automatically taking corrective action both to correct the failure and to work around the failure with appropriate routing changes.

Solution:

- A simulation can help assess those actions by evaluating the performance of alternatives.

Smart Factory Challenge 4

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Challenge/Opportunity:

- Corporate goals for smart factories often include the following two key aspects:
  - Standardization of data and systems
  - Harmonization of people and processes

Solution:

- Use the virtual factory model to identify and address data inconsistencies and discrepancies
- Test different operational policies and decision rules to determine the single best global process and align all factories and their training accordingly.

Smart Factory Challenge 5

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Challenge/Opportunity:

- It is difficult to describe how a complex system works, and even more difficult to understand it.

Solution:

- The model itself becomes a knowledge repository - both direct knowledge embedded in its components and indirect knowledge that results from running it.
- Model animation helps stakeholders understand how the system works, so they can more effectively participate in problem resolution, and have better buy-in to the results.

Design Simulation Benefits

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In Summary:

- Provides a strong competitive advantage during development, deployment and execution of a smart factory.
- Yields a system that can be deployed in less time, with fewer problems, and yield a faster path to optimal profitability.

The Role of Simulation-based Scheduling in Industry 4.0

Industry 4.0 Modeling Demands

- Extend simulation beyond its traditional role of improving system design into the realm of providing **faster, more efficient process management** and **increased productivity**.
- Same model that was built for evaluating and generating the design of the system can be carried forward to become an **important business tool** in scheduling day to day operations in the Industry 4.0 environment.

Industry 4.0 Objectives

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- **Accuracy**: Model must accurately enough to reflect key constraints and system performance.
- **Speed**: Must be responsive to system changes to work in (near) real time.
- **Visualization**: Must allow developers, analysts, and stakeholders to understand and experiment with the system.

Other scheduling approaches

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- Manual scheduling doesn't scale well to larger, more complex operations.
- Lead time-based scheduling generates optimistic and unrealistic schedules.
- Constraint-based scheduling is highly complicated and often requires much too long to execute.
- Custom, purpose-built, schedulers are slow and expensive to implement and difficult to change as the system evolves.

Industry 4.0 Objectives Met

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Simulation-based scheduling provides:

- Accurate modeling of all elements - a flexible model is generated from computerized information, including full representation of operating constraints as well as custom rules.
- Fast computation of schedules - calculation of schedules and scheduling alternatives, comparison and distribution is carried out quickly and precisely.
- Easily visualized - computerized simulation allows the schedule to be communicated clearly and effectively across all organizational levels.

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Simulation as a Digital Twin

Smart Factory Missing Piece

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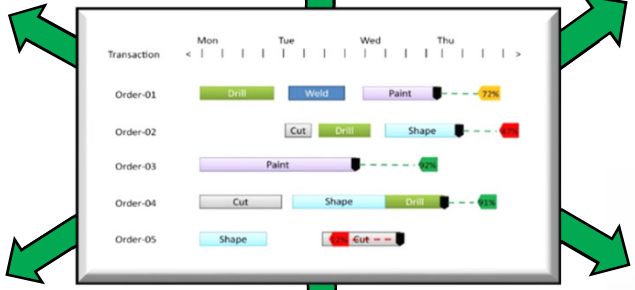
Enabling the Smart Factory

- Data generated detail simulation model
- Creating the “Digital Process Twin”.
- Analyze system performance.
- Integrated real-time scheduling.

MES Systems

Data Warehouses

ERP Systems



User Based Systems

Corporate Networks

Smart Glasses

Robotic Systems

Guided Vehicles

Utilizing the Simio Schedule

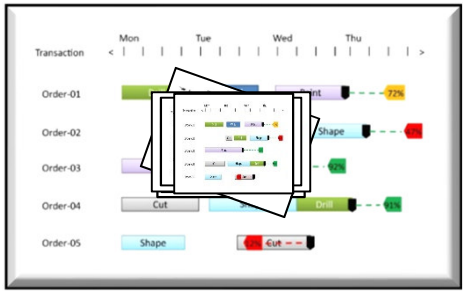
Public Portal

MES Systems

Printer

Data Warehouses

ERP Systems



User Based Systems

Automation

Corporate Networks/Private Portal

Functions at the Core

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- Real time information on inventory levels, component histories, expiration dates, transport, logistics and much more can be fed into the model, developing different plans and schedules.
- Evaluate alternative sources of supply against each other while minimizing potential loss and disruption.
- When change happens simulation models can show how downstream services will be affected and the impact on production.
- Revised courses of action can be manually or automatically assessed and a solution implemented.
- Assure consistent production where costs are controlled and quality is maintained under any set of circumstances.

The Core of a Digital Twin

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- By leveraging scheduling, highly data-driven simulation models can fill the role of a Digital Twin.
- A simulation model can sit at the core of a smart factory:
  - Communicate with all of the critical sub-systems
  - Collect planning and real-time execution information
  - Automatically create a short-term schedule
  - Distribute the components and results of that schedule back to sub-systems

The Core of a Digital Twin

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- Advanced simulation-based scheduling software is uniquely suited for this:
  - Ability to communicate in batch or real-time with any sub-system
  - Model the complex behavior required to represent the factory
  - Execute sophisticated techniques to generate a suitably ‘optimal’ schedule
  - Respond to deviations from plan to be reported which could cause a repeat of the process.
- This fills an important gap left in most smart factory plans.

Enabling the Smart Factory