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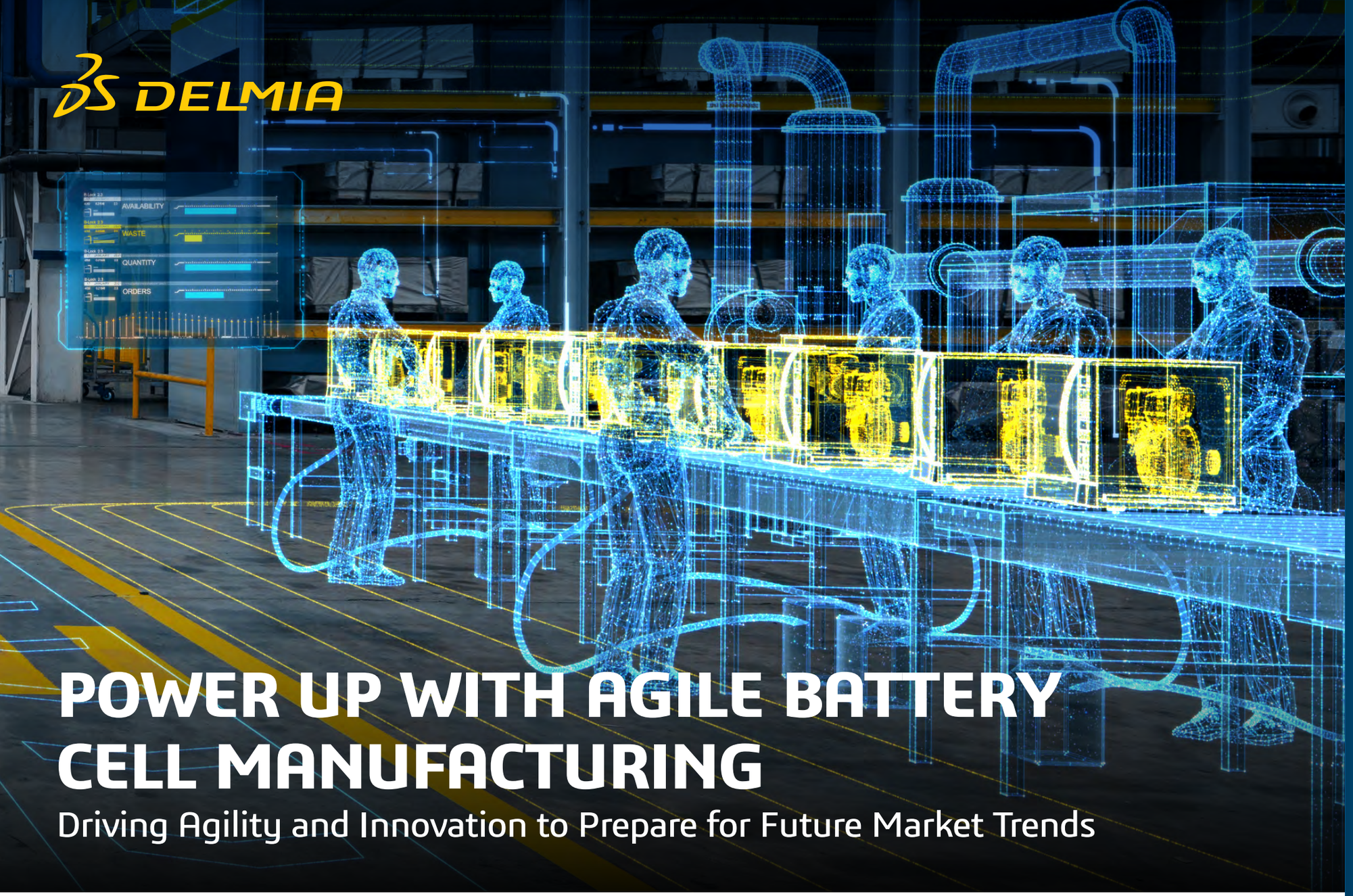


POWER UP WITH AGILE BATTERY CELL MANUFACTURING

Driving Agility and Innovation to Prepare for Future Market Trends

DASSAULT SYSTEMES

MEET THE EXPERTS

ADRIAN WOOD

Strategic Business Development Director, DELMIA

Adrian Wood has spent over 20 years in customer-facing positions, with a focus on problem solving and development within emerging and rapid growth segments across many industries from high-tech to retail and logistics, and across disciplines such as supply chain, manufacturing simulation and analytics.

WESLEY HERGERT

Simulation Specialist, ATS Automation Tooling Systems

Wesley Hergert has worked in all aspects of automation machine building, sales and applications, controls hardware and software design, mechanical design, and electrical build. His career focuses on the high impact of innovative technology while working in collaborative teams designing complex automation systems.

PROFESSOR ARNO KWADE

Director, Braunschweig Technical University & Coordinator for the LiPLANET Battery Consortium

Professor Arno Kwade currently holds multiple roles related to battery cell technology and production at Battery LabFactory Braunschweig Research Center, Fraunhofer Project Center for Energy Storage and Systems ZESS, German Battery Research and LiPlanet. He has also spoken as part of the German Competency Cluster on Battery Cell Production and has authored many articles on battery technology.

MICHAEL DOYLE

Technology Manager, Science & Corporate Research, Dassault Systèmes R&D

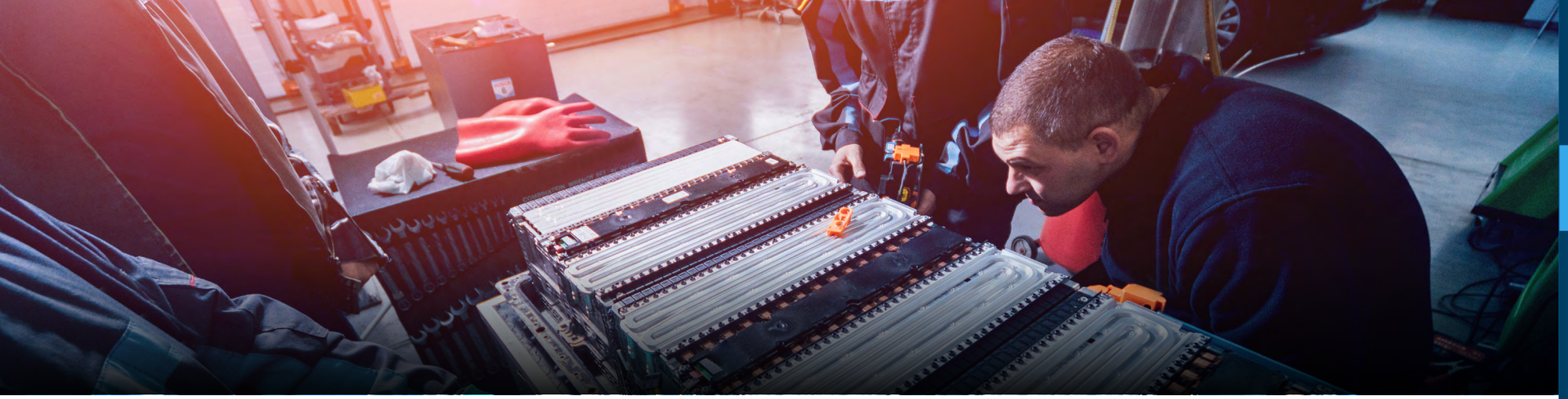
Michael Doyle holds the role of Senior Materials Scientist in the Dassault Systèmes Strategy and Research Team. His responsibility covers innovation and advanced materials portfolio, including Material Macro Trend Science & Technology Strategy for the eleven industries Dassault Systèmes covers and the cross-industry, cross-brand synergies.

MARKET TRENDS AND CHALLENGES IN BATTERY MANUFACTURING

The global battery market is rapidly expanding. In 2019, the global battery market value was reported to be at USD 108.4 billion—and it continues to grow at a compound annual growth rate of 14.1%[1]. There are currently around 4 million electric vehicles (EV) in use globally, but this number is predicted to rise to 13 million by 2024. To meet the growing demand for EV batteries, battery cell production capacity across Europe has risen by 43% since 2020. According to the International Energy Agency, this increased use of batteries can reduce CO2 emissions by 2-8% of global greenhouse gases.

Looking at battery production on a global scale, while Asia continues to be the market leader, more and more battery cell manufacturers are emerging in Europe and North America. These are significant market segments due to consumer attitudes towards sustainability and high consciousness regarding the need for energy-efficient batteries.

1 Grand View Research, Battery Market Size, Share & Trends Analysis Report By Product (Lead Acid, Li-ion, Nickle Metal Hydride, Ni-cd), By Application (Automotive, Industrial, Portable), By Region, And Segment Forecasts, 2020 – 2027 (2020).



However, production in these regions can be constrained due to limited local supply resulting from regulations or restricted supply of raw materials. This leads many EV manufacturers to enter long-term deals with Asian suppliers, creating distributed supply chains. As a result, EV manufacturers that are dependent on these long supply chains could end up with longer lead times.

This has led the industry to consider the idea of having local OEMs manufacture the batteries alongside the EVs so that EV manufacturers can lower their costs and remain competitive. But with high industry rivalry and unstable raw material prices, new players face significant entry barriers. This is why some industry players rely on joint ventures as well as mergers and acquisitions to increase their presence in the market.

The model for how to manufacture and supply batteries for EVs is increasingly critical since 10 OEMs—including GM, Honda and Ford—have committed to go all electric within the next 15-20 years. This will accelerate the demand in the global battery market, increasing stress on cell manufacturers and the supply chain.

For battery cell manufacturers to compete and ensure maximum profits, they need to push the limits of innovation to maximize battery cell capacity and production, include modular approaches for flexibility and engage with suppliers early in planning. This creates a lot of opportunities for manufacturers but also makes it necessary for them to move with agility and confidence to meet the high market demand against some of the key industry challenges.

> *"As we witness the continued evolution of battery cells, all those changes are massively transforming production on an almost yearly basis, so manufacturers always have to look to their next factory and think about the modularity of that factory."*
>
> *Michael Doyle*

KEY CHALLENGES FOR BATTERY CELL MANUFACTURERS

"One challenge the industry faces is that they require knowledge from a combination of different disciplines. When it comes to quality control, it's not just measuring things in micrometers. You have to know the structures, the electrodes and the chemistries."

Professor Arno Kwade

LARGE INVESTMENT AND RISK

Starting out requires a large capital investment. The amount of risk involved leads new players to start small with pilot plants before they can scale. The big challenge for manufacturers here is to figure out how to mitigate that risk.

PROCESSING AND YIELD RATE

Manufacturers typically produce high volumes, but due to the product complexity, quality problems and yield rate problems may arise. The process is typically not fully automated which can lead to quality issues where simple errors can impact yield. Production lines can often end up with wastage as high as 20%, so the challenge here is figuring out how manufacturers can execute flawlessly.

SUPPLY CHAIN INSTABILITY

Instability here refers to not just the production process, but also the supply chain. Battery cell manufacturers typically do not have integrated supply chains and are dependent on lead times for raw materials. In overcoming this challenge, manufacturers will need better visibility over their supply chains.

EVOLVING TECHNOLOGY

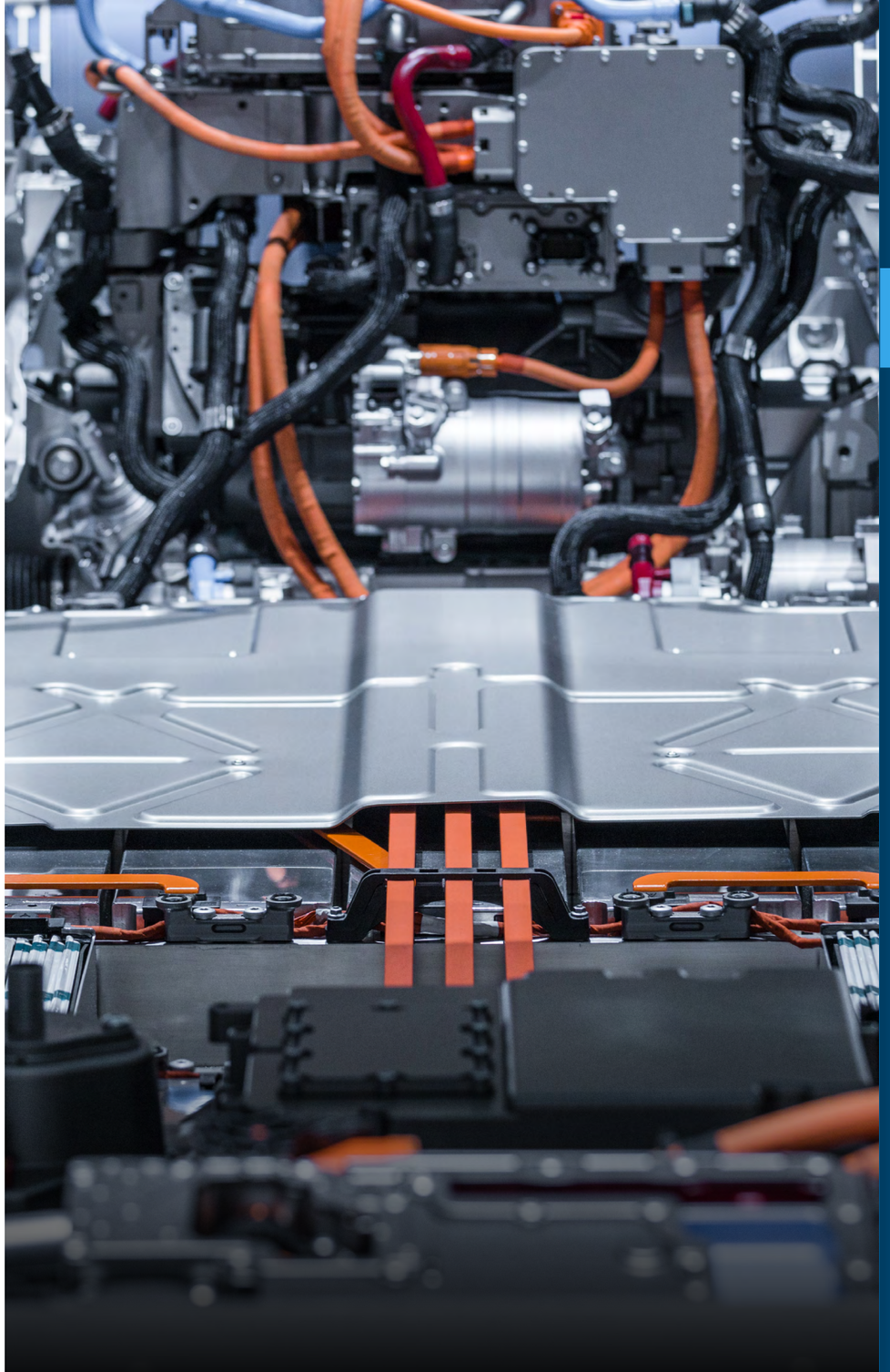
Battery cell technology changes at a rapid pace, which poses a problem to manufacturing plants that are set up to produce high volumes in a linear way—as opposed to having flexible or modular approaches to production lines. As the technology changes, so too will the production requirements, and manufacturers must be able to evaluate the impact of each new change in order to adapt.

PRODUCTION SCALE

There is also the question of whether it is possible to have high velocity, high volume, high yield and high flexibility in production at the same time. Manufacturers need to find a way to scale up production confidently while maintaining acceptable yields.

SHRINKING MARGINS AND SUSTAINABILITY

Sustainability is a high priority for battery cell manufacturers—not just from an ecocentric point of view, but also in terms of profitability. It is challenging to balance cost, flexibility and quality while operating sustainably.



ESSENTIAL CRITERIA FOR MANUFACTURING SUCCESS

In finding a solution that can address all the key challenges that battery cell manufacturers face, there are three dimensions to consider:

THE SOLUTION MUST SPAN THE VIRTUAL AND REAL WORLDS

Leveraging the virtual world allows manufacturers to plan and test everything from designs to work processes in a risk-free virtual environment before executing flawlessly in the real world

THE SOLUTION MUST ENABLE PLANNING ACROSS A WIDE TIME HORIZON

Success requires planning, and manufacturers need the ability to make strategic plans several years in advance while also managing the details in daily operations with confidence

THE SOLUTION MUST COVER MULTIPLE DISCIPLINES ACROSS OPERATIONS

Manufacturers need a holistic solution that helps them in various areas:

- Optimize physical space and lines to manufacture new cells
- Optimize processes to minimize cost and maximize efficiency, quality and safety
- Optimize production while managing constraints and disruptions
- Execute flawlessly and deliver at-scale, on-time with superior quality

At DELMIA, we believe that all these elements are encapsulated in what we call the **Virtual Twin Experience**. The broad scope of operations enabled through the **Virtual Twin Experience** are all carried out on a unified platform that we call **3D**EXPERIENCE.

This integrated solution facilitates closed-loop collaborative planning to evaluate product design impact in the real world. By integrating design, engineering and manufacturing in a collaborative environment, we eliminate data silos and ensure accurate flows of information across the different departments. The **Virtual Twin Experience** leverages the collection of real-world data to shape accurate virtual models that can be used to inform future decision-making, such as in the commissioning of plants and equipment to mitigate risk.

> *"There's a lot of complexity in battery cell supply chains, so the ability to manage that complexity and trace supply chain activities is very important. It's commensurate with integrated design space all the way from the pilot plant to recycling."*
>
> **Michael Doyle**

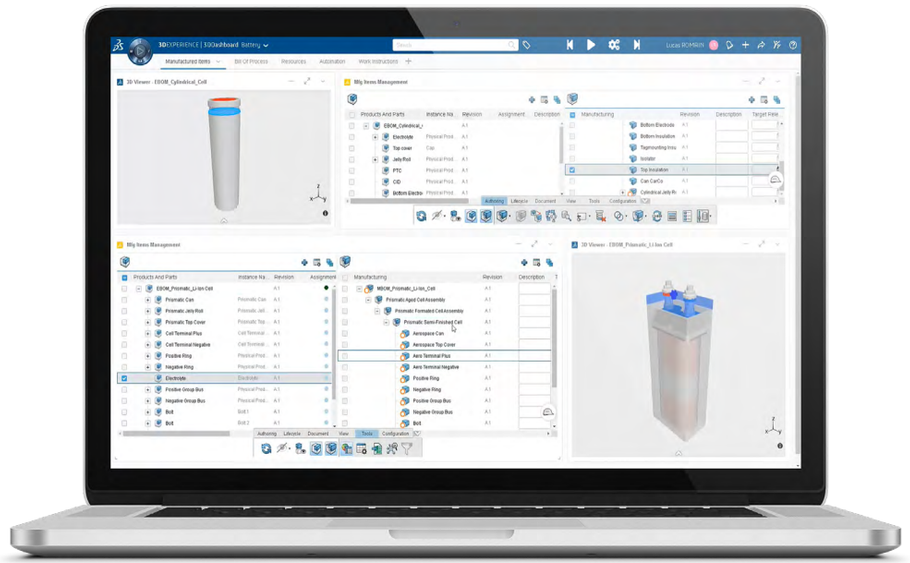
THE QUEST FOR SUSTAINABLE OPERATIONS
A SOLUTION PROCESS OVERVIEW

SITUATION:
Your company wants to introduce a new type of battery cell—a prismatic cell, which has a different shape from the cylindrical cells already being produced and is more sustainable. The design teams have just released the engineering bill of materials (EBOM) of the prismatic battery cell. The next step is to move the plans from design to manufacturing.

STEP 1: CREATE A MANUFACTURING BILL OF MATERIALS (MBOM)

The **3D**EXPERIENCE solution:

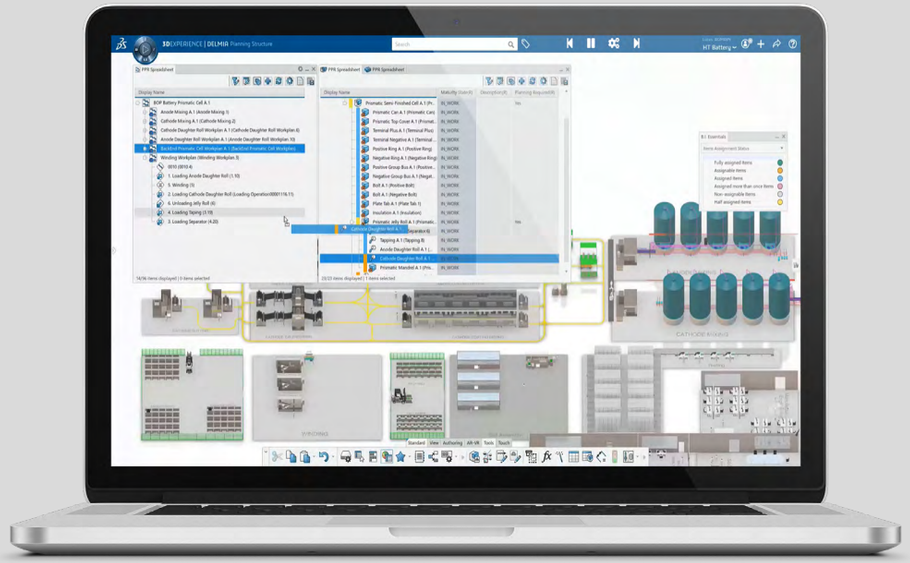
- Rapidly review the MBOM so the process engineer can take into account the latest engineering items released
- Explore existing manufacturing items and use visual tools to check the assignment status between EBOM and MBOM
- Visually alert the process engineer to components that are not yet assigned to the MBOM and allow "drag and drop" synchronization to align the MBOM and EBOM
- See elements that are common to both cells and leverage knowledge from previous experience with the cylindrical cell to rapidly develop the new MBOM



STEP 2: FIND THE MOST EFFICIENT WAY TO DEFINE THE BILL OF PROCESS (BOP)

The **3D**EXPERIENCE solution:

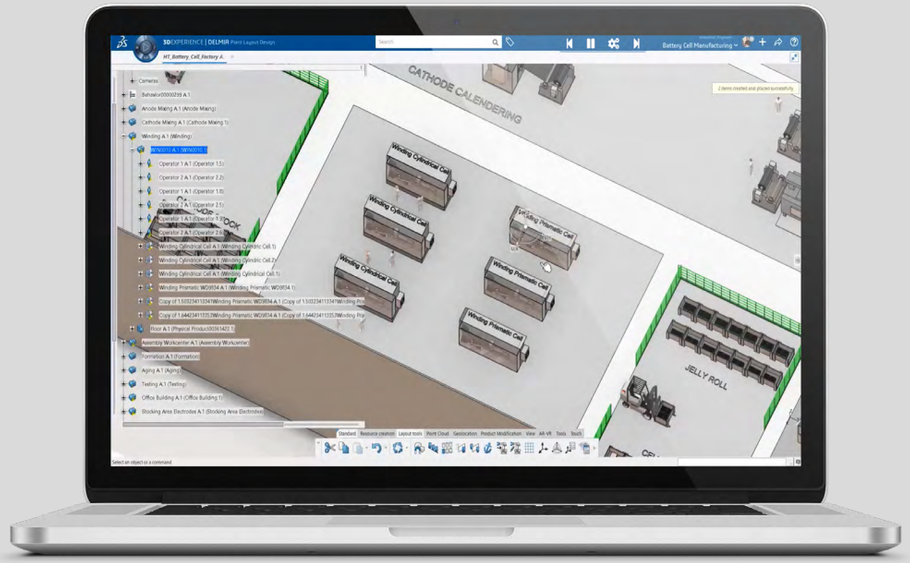
- Prepare the process plan based on previous experience, reusing templates from previous projects to expedite the process
- Common processes between the previous project and the new one can simply be dragged and dropped to match operations with items on the MBOM as the sequence is defined
- Upon encountering new MBOM items with no related operations available in the template, additional operations can be assigned as part of the new BOP
- Use visual Gantt charts to define the estimated duration for the new operation and develop the right sequence; the first layer of the process plan is now ready



STEP 3: PREPARE THE IMPLEMENTATION OF THE NEW MACHINES

The **3D**EXPERIENCE solution:

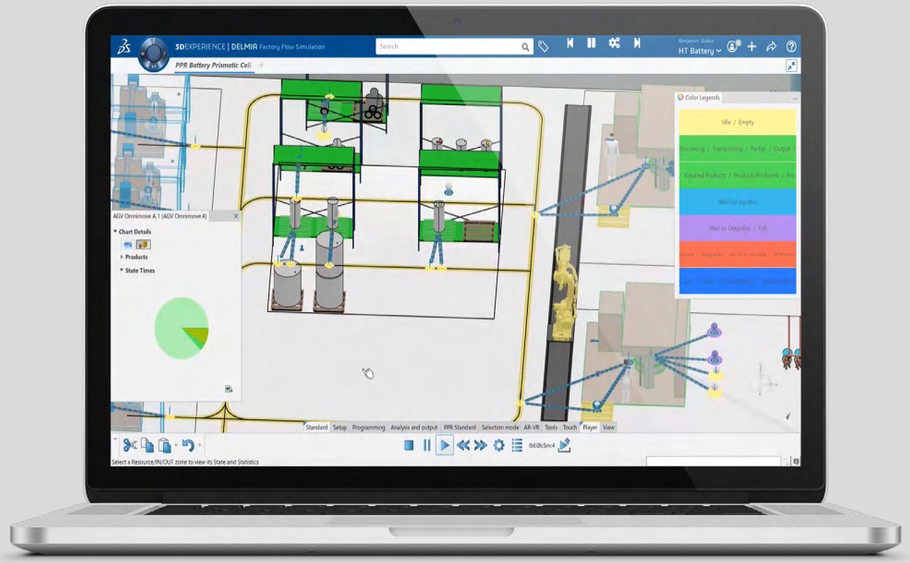
- Leverage the virtual twin of the factory in 3D to rapidly modify and validate new layouts
- Use 3D models of new machinery (from libraries of thousands shared by suppliers) to validate potential implementation strategies
- With the 3D model of the machine already in your catalog, it is possible to simulate how many machines will be needed, as well as where and how they should be positioned in the virtual twin of your factory



STEP 4: DEFINE PRODUCTION REQUIREMENTS AND GOALS

The **3D**EXPERIENCE solution:

- Run production flow simulations to ensure enough raw materials can be provided for the new machines to meet production requirements
- The simulation assesses how much of the required materials can be produced in the facility each day to be fed to the new machines
- Seamlessly leverage the previously defined BOP to simulate realistic production flow
- The simulation takes into account numerous other variables in the process such as potential failures, transportation of materials between machines, as well as preventative maintenance and downtime
- Run as many "what if" simulation scenarios as needed to get an accurate picture of the projected output of the new machines and ensure the scenario aligns with production goals



STEP 5: PREPARING THE WORKFORCE FOR EXECUTION

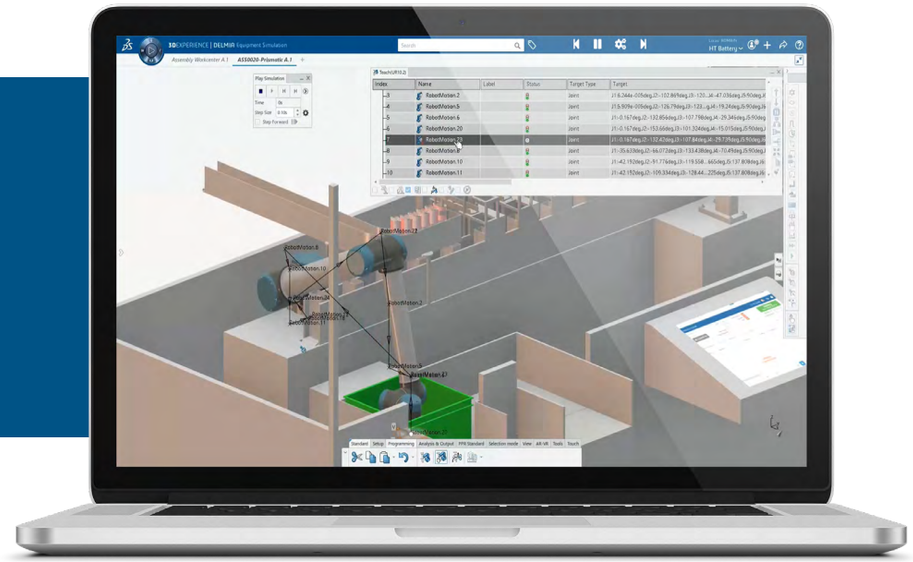
The **3D**EXPERIENCE solution:

- Easily define 3D work instructions on top of each step of the process plan
- Manipulate 3D models of materials, facilities and tools with pinpoint accuracy in the virtual twin and build snapshots of exactly what workers need to do at each step of the operation in context
- The 3D work instructions can include "what if" behaviors—for example, what the next step is when a product passes or fails a quality check
- Virtual 3D work instructions—as well as the actual processes and quality steps to be performed by the operator—can be published to the Manufacturing Operations Management (MOM) system, where it can be easily accessed and updated company-wide
- 3D instructions for best-in-class processes can even be shared with your other manufacturing facilities worldwide to drive consistent levels of quality, safety and efficiency

STEP 6: VALIDATE MACHINE BEHAVIOR VIRTUALLY

"There are a lot of chemistries or product variations that we allow for, but if there is a drastic change, it affects everything down the line from your welding processes to thermal transfer paste. To maintain production throughput, it's not realistic to stop the line and set up a new product."

Wesley Hergert



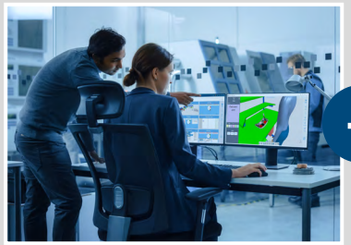
The **3D**EXPERIENCE solution:

- Even without access to the real device yet, the virtual twin enables the ability to run virtual simulations on the machine
- Leverage the virtual model of the assembly machine shared by the supplier with the jobs previously defined in the process flow simulation
- Easily add items and context to the virtual twin, review the simulation of the machine behavior down to the finest details and make unlimited modifications without risk and cost
- Ensure that the machine works in the right sequence, avoids any possible collisions or mishandling of materials and products
- Use the final results of the validated machine behavior to build the robot programming

THE RESULT:

With the behavior of your new machine validated virtually, you can be confident that it will behave exactly how you expect it to when executed in the real world. All the planning done on your product, manufacturing processes, facility, equipment, production output and workflows will ensure that your company now manufactures products of the highest quality without disruptions to meet your production goals.

CREATING THE FACTORY OF THE FUTURE

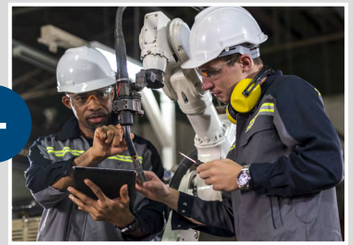


MODEL-BASED MANUFACTURING

LEAN MANAGEMENT

VALUE NETWORK OPTIMIZATION

IIoT & MANUFACTURING ANALYTICS



MANUFACTURING IN OPERATION

- Virtual Twin Experience
- MBOM & 3D work instructions
- Ergonomic workplace design
- Virtual training for stations

- Meeting management
- FLASH 5 meeting
- Problem solving meeting
- Data & knowledge share

- Review & analysis
- Visualisation & KPI's
- Optimisation
- Planner in control

- IIoT equipment integration
- Real-time machine monitoring
- Plan preventative maintenance
- Executive preventative maintenance

- Managing non-conformance
- 3D work instructions
- Synchronising material flow
- Real-time performance monitoring

PAVE THE WAY FOR EFFICIENT BATTERY CELL MANUFACTURING

Moving forward, battery cell manufacturers are well aware of the growing market opportunity in their industry, but there is also a lot of uncertainty—both in production and in the supply chain. And as battery cell technology continues to evolve rapidly, it has become clear that manufacturers will need an unparalleled level of agility and sustainable operations to effectively overcome these challenges and establish themselves as competitive players in the market.

Virtual twin solutions such as the **Virtual Twin Experience** will be the key to helping manufacturers reduce risk and establish battery cell operations that will scale up successfully. By choosing to adopt a digital transformation, battery cell manufacturers can seize a key opportunity to increase efficiency across their operations from R&D to engineering and manufacturing.

REDUCE COSTS

Orchestrate global end-to-end manufacturing process and asset management, and reduce cell production scrap rate as well as manufacturing costs

ACCELERATE INDUSTRIALIZATION

A tight connection between engineering, simulation and execution allows for maximum flexibility and an adaptable manufacturing process that can be easily replicated and scaled up

CONTINUOUSLY IMPROVE PROCESSES

Aggregate, analyze and visualize manufacturing data, and use the intelligence gained to work towards the continuous improvement of processes in a closed-loop system

Some of the world's leading producers and innovators of lithium-ion batteries in cell and pack production have leveraged DELMIA solutions to gain a competitive advantage through:

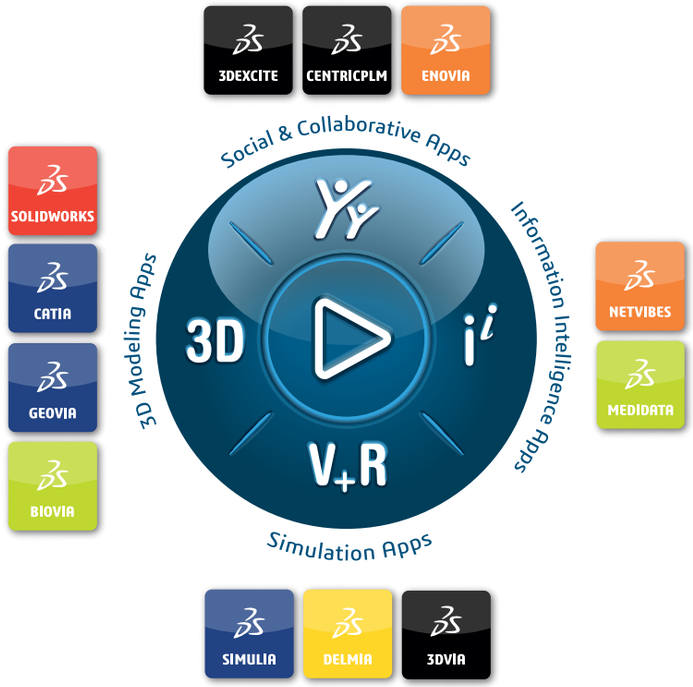
- Enabling mass customization to support production volumes of millions of cells daily
- Manufacturing operations intelligence, global production visibility, traceability and genealogy
- Warehouse and line supply management integrated with execution to optimize and manage the flow of materials

Discover more about our solutions and take the first step towards excellence in manufacturing and operations **by exploring DELMIA User Communities.**

Our **3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3DEXPERIENCE** Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3DEXPERIENCE** platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **www.3ds.com**.



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