TR463351 – Get Up To Speed With Automotive Manufacturing

Rob Walker
Sr. Technical Marketing Manager
About the speaker

Rob Walker

Rob is a Sr. Technical Marketing Manager at Autodesk, where he and his team are responsible for helping customers understand how they can achieve their manufacturing goals, using the advanced manufacturing solutions that Autodesk offers.

Rob graduated from the University of Liverpool with a Bachelor's degree in Aerospace Engineering and a Masters in Product Design and Management before embarking on a career with Delcam as an Applications Engineer. Initially starting in the UK department, he trained and supported UK customers, before moving into an international role, where he assisted the global network of subsidiaries and resellers in both pre- and post-sales activities. Following the acquisition of Delcam by Autodesk in 2014, he moved to Technical Marketing, and is now in his 17th year of service.
Agenda

01 Introduction
02 Mold and Die Manufacturing
03 Factory Planning
04 Automated Manufacturing
05 Emerging Technology
06 Summary
Introduction
Introduction

- Many aspects to automotive manufacturing
- **4 key topics**
  - Mold and Die Manufacturing
  - Factory Planning
  - Automated Manufacturing
  - Emerging Technology
Learning Objectives

1. Explain the technological solutions that can be used to improve the quality of automotive tooling and the parts they produce.
2. Define the challenges that drive change in manufacturing facilities, and explain the use of a unified digital model, to manage projects, equipment and production.
3. Identify where automation can be utilized in manufacturing processes to improve production consistency.
4. Describe generative design, additive and hybrid manufacturing processes, and explain how they can be used to improve component performance and efficiency.
Mass-Produced Component

- Water pump cover
- Plastic injection molded

Low-Volume Component

- Performance car upright
- Billet machined
Mold and Die Manufacturing
Introduction

• A highly competitive industry
• Constant challenges

- Quality
- On-Time
- On-Budget
- Profitably

• Use new technology and increase machine utilization
Mold Simulation
What Could Possibly Go Wrong?

- Warpage & Shrinkage
- Solidification failure
- Weld marks
- Sink marks
- Air traps
- Short shots
- Core Shifts
Traditional Mold Design Workflow

Full Design → Manufacture → Try-out → Re-design & Re-build → Use
What Can We Do?

• Use simulation
• Review wall thicknesses, gating locations, undercuts, draft angles
• Identify part quality
• Provide costing and design advice
• Analyse advanced tooling options
• Test part and mold material types
• Export results
• Optimize for quality and cycle time
• Reduce defects and get to market faster
Mold Design Workflow With Simulation

Design cavity/core → Simulate → Detail → Manufacture → Use
Mold Machining

• Traditional 3-axis machining
• More profitable molds, are often more complex
• Use 5-axis to address mold complexity
  o Fewer setups, reduce time and increase accuracy
  o Better access
  o Shorter tools have improved rigidity and increase accuracy further
• Minimizes hand finishing
Expert CAM Software

• **High-speed machining capabilities**
  o Reduce load
  o Minimize wear
  o More aggressive, optimized feedrates

• **Advanced finishing strategies**

• **Tool and Toolpath Control**
  o Toolpath editing without recalculation
  o Dynamic axis manipulation
  o Improved surface finish, tool life and time savings
Expert CAM Software

• Accurate simulation and verification
• Better machine utilization
• Optimized setup for each machine
• Collision detection and avoidance
• Inspire confidence, maximize existing capacity and increase productivity
• Save time and money
Factory Planning for the Automotive Supply Chain
Manufacturing is Constantly Changing

- New Product Introduction
- Demand Changes
- Cost Cutting Initiatives
- Quality Initiatives
- Sourcing Changes
Top 10 Drivers of Change in the Factory

1. Product quality
2. Production efficiency / cost
3. New product introduction
4. New product variants
5. Changes in demand
6. Continuous improvement / Kaizen
7. Replace / repair / modernize equipment
8. Change product mix
9. Capacity / throughput
10. Ergonomics / operator environment

Source: "Best Practices for Managing Change in the Factory," Tech-Clarity
In manufacturing, the ability to adapt quickly to change is critical for long-term business growth.
Revenue
Expenses
Assets
Liabilities
Market Share

Increase Operational Efficiency
Common Outcomes of Factory Change

- Cost overruns
- Unplanned project hours / overtime
- Missed due dates
- Finished good quality problems
- In process scrap or rework
- Low productivity or throughput
- Low equipment utilization

Source: "Best Practices for Managing Change in the Factory," Tech-Clarity
Challenges
Due to poor integration between process planning, production layout, facilities design, installation, and operation, projects often struggle to stay on schedule and on budget.

Production lines might not even perform at optimal efficiency
And many times, the cost and impact of changes are unclear
## Example: Impact of Cost & Schedule Overruns

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project delay</strong> $100,000/day</td>
<td>Opportunity cost of project taking longer than planned</td>
</tr>
<tr>
<td><strong>Field check</strong> $10,000/incident</td>
<td>Time required to measure factory environment</td>
</tr>
<tr>
<td><strong>Field change order</strong> $20,000/incident</td>
<td>Fix issues found during build out</td>
</tr>
<tr>
<td><strong>Major interference</strong> $100,000+/incident</td>
<td>Collision between machine and environment</td>
</tr>
</tbody>
</table>
Plan, Commission and Operate
3 Key Areas – Plan, Commission and Operate

Plan and Design

Construct and Commission

Operating Factory Efficiently
Plan and Design
Plan

Ensure factory changes are for the better

Bring together your manufacturing and building operation teams to **collaborate** on an integrated factory model and help deliver a fully optimized production at lower risk—and often lower cost.
Plan and Design a More Efficient Factory

Create one integrated model that includes 3D equipment lines with the building systems such as BIM models for structural, architectural and MEP components.

3D virtual walkthroughs help stakeholders (including operations, facilities, and industrial and manufacturing engineering) easily understand design intent so they can provide feedback and identify potential issues early in the design process.

Improve design efficiency during process, production, and site planning and identify opportunities to improve overall factory efficiency.
Plan and Design a More Efficient Factory

Improve design efficiency during process, production, and site planning and identify opportunities to improve overall factory efficiency

Create one integrated model that includes 3D equipment lines with the building systems such as BIM models for structural, architectural and MEP components

- **3D virtual walkthroughs** help stakeholders (including operations, facilities, and industrial and manufacturing engineering) easily understand design intent so they can provide feedback and identify potential issues early in the design process

- **Laser scanning** accurately documents the as-is state of your facility to build 3D models, providing high-resolution representations of the space. This is less expensive, less time consuming, and more accurate than manual field checking
Plan and Design a More Efficient Factory

Improve design efficiency during process, production, and site planning and identify opportunities to improve overall factory efficiency.

Create one integrated model that includes 3D equipment lines with the building systems such as BIM models for structural, architectural and MEP components.

- **3D virtual walkthroughs** help stakeholders (including operations, facilities, and industrial and manufacturing engineering) easily understand design intent so they can provide feedback and identify potential issues early in the design process.

- **Laser scanning** accurately documents the as-is state of your facility to build 3D models, providing high-resolution representations of the space. This is less expensive, less time consuming, and more accurate than manual field checking.

- **Analyze and Visualize** the sequence of operations in your manufacturing process, identify bottlenecks, and stations exceeding Takt time, optimize work distribution across stations, and improve workflows.
Plan and Design a More Efficient Factory

Create one integrated model that includes 3D equipment lines with the building systems such as BIM models for structural, architectural and MEP components.

<table>
<thead>
<tr>
<th><strong>3D virtual walkthroughs</strong></th>
<th>Help stakeholders (including operations, facilities, and industrial and manufacturing engineering) easily understand design intent so they can provide feedback and identify potential issues early in the design process.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laser scanning</strong></td>
<td>Accurately documents the as-is state of your facility to build 3D models, providing high-resolution representations of the space. This is less expensive, less time consuming, and more accurate than manual field checking.</td>
</tr>
<tr>
<td><strong>Analyze and Visualize</strong></td>
<td>The sequence of operations in your manufacturing process, identify bottlenecks, and stations exceeding Takt time, optimize work distribution across stations, and improve workflows.</td>
</tr>
<tr>
<td><strong>Digital simulation</strong></td>
<td>Analyzes material and facility flow so you can fully optimize equipment placement.</td>
</tr>
<tr>
<td><strong>Provide the most efficient work environment</strong></td>
<td>For designers to layout production lines in 2D while using an asset library to create 3D factory models. Integrate production lines into your BIM model of the facility.</td>
</tr>
</tbody>
</table>
# Plan and Design a More Efficient Factory

## Improve design efficiency during process, production, and site planning and identify opportunities to improve overall factory efficiency

### Create one integrated model that includes 3D equipment lines with the building systems such as BIM models for structural, architectural and MEP components

| ✔ | **3D virtual walkthroughs** help stakeholders (including operations, facilities, and industrial and manufacturing engineering) easily understand design intent so they can provide feedback and identify potential issues early in the design process |
| ✔ | **Laser scanning** accurately documents the as-is state of your facility to build 3D models, providing high-resolution representations of the space. This is less expensive, less time consuming, and more accurate than manual field checking |
| ✔ | **Analyze and Visualize** the sequence of operations in your manufacturing process, identify bottlenecks, and stations exceeding Takt time, optimize work distribution across stations, and improve workflows |
| ✔ | **Digital simulation analyzes material and facility flow** so you can fully optimize equipment placement |
| ✔ | **Provide the most efficient work environment** for designers to layout production lines in 2D while using an asset library to create 3D factory models. Integrate production lines into your BIM model of the facility |
Construct and Commission
Commission

Ensure factory changes are communicated effectively

Communicate design decisions across the entire project team using a single digital model that integrates equipment, production line layouts, building designs, and reality capture data as a single database of project information.
Stay on schedule and on budget during factory change projects by integrating building planning and production line design.

- **Integrated factory model of the existing/new facility and production systems**, allows the project coordinator to identify issues prior to installation, when on-site changes become costly and time consuming.

- **Detect clashes and collisions before project starts**, identify areas with potential clearance issues that can be addressed and tracked prior to installation.

- **Pre-construction planning and sequencing** provides project teams with insights into any potential scheduling issues that could delay production kick off.
## Make Better Decisions During Construction and Installation

Stay on schedule and on budget during factory change projects by integrating building planning and production line design.

<table>
<thead>
<tr>
<th>✔️ Integrated factory model of the existing/new facility and production systems, allows the project coordinator to identify issues prior to installation, when on-site changes become costly and time consuming.</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ Detect clashes and collisions before project starts, identify areas with potential clearance issues that can be addressed and tracked prior to installation.</td>
</tr>
<tr>
<td>✔️ Pre-construction planning and sequencing provides project teams with insights into any potential scheduling issues that could delay production kick off.</td>
</tr>
<tr>
<td>✔️ Seamless exchange of data between factory equipment and the BIM model allows manufacturing engineers to design in context of the facility and building designers to accurately place structural and MEP features to support the production line.</td>
</tr>
<tr>
<td>✔️ Leverage your integrated factory model, to extract required views and relevant documentation for installation, easily generated from 3D representations, reducing manual effort and showing production equipment in the context of the building systems.</td>
</tr>
</tbody>
</table>
Make Better Decisions During Construction and Installation

Stay on schedule and on budget during factory change projects by integrating building planning and production line design.

- Integrated factory model of the existing/new facility and production systems, allows the project coordinator to identify issues prior to installation, when on-site changes become costly and time consuming.

- Detect clashes and collisions before project starts, identify areas with potential clearance issues that can be addressed and tracked prior to installation.

- Pre-construction planning and sequencing provides project teams with insights into any potential scheduling issues that could delay production kick off.

- Seamless exchange of data between factory equipment and the BIM model allows manufacturing engineers to design in context of the facility and building designers to accurately place structural and MEP features to support the production line.

- Leverage your integrated factory model, to extract required views and relevant documentation for installation, easily generated from 3D representations, reducing manual effort and showing production equipment in the context of the building systems.
Operate
Operate

Continuously improve factory operations

Make the most of your integrated factory model to manage equipment, production changes, and product quality.
Operate Efficiently While Managing Changes and Risk

Determine the cost and impact of factory change projects, coordinate engineering and manufacturing, and improve documentation of changes

| ✔ | Centralized data management allows everyone to access the right information at the right time |
| ✔ | Manage change process and multiple workflows saving time during production |
| ✔ | More quickly plan and implement adjustments to production line by leveraging existing 3D representations of both the building and production line |
| ✔ | Deliver accurate work instructions and quality procedures to each task in the production process plan, so they are automatically updated as changes are made and delivered to the production floor |
Phases of a Factory Lifecycle

Plan
- Process Concept
- Rough Layout
- Site Knowledge

Design
- 2D & 3D Design
- As built scanning
- Optimization
- Supplier Integration

Operate
- Connected Assets
- Predictive Maintenance
- Manufacturing Change Management
- Local Update

Build
- 4D & 5D Planning
- Virtual Commissioning
- Asset Sign Off
- Site Management

Validate
- Design Review
- Clash Management
- Factory Sustainability Simulation
- Virtual Manufacture/Assembly
Automated Manufacturing
Automated Manufacturing

- Reliability and time to market are critical to success
- Utilize Automation
- Deliver repeatability and consistency
- Improve quality and reliability
Automated Manufacturing

• What do we mean by “Automated”?
• Many types of automation
  o Assembly lines, industrial robots, automated guided vehicles (AGV), etc.
• Focus on automation within design and manufacturing software
Guiding Principles and Challenges
Lean Manufacturing

- Originating in Japan
  - Minimize waste
  - Maintain productivity
  - Focus on what adds value
- Improves quality
- Reduces production time and cost
- Same principles can be used across many manufacturing processes
Challenges

• **Skills Gap**
  o Gap between skilled jobs and the skilled workforce available

• **Skilled but aging workforce**
  o Capturing knowledge is vital

• **Use software which can capture this knowledge**
  o Train others to follow the best practices
  o Refine over time
Manufacturing Shift

- Embrace advanced technologies and automation
  - Changes required skills

- Software with reduced learning curve
  - Become productive sooner
Intelligent Automation

- Many manual decisions required
- Repetitive decision making wastes valuable time
- Intelligent automation can automate repetitive tasks to speed up part programming
- Programmer can add more value to the process
Intelligent Automation

• Program parts entirely
• Automated part programming technologies
  o Can identify machinable part features
  o Use same automated decision tools
• Fine-tune results if needed
• Consistent and repeatable
Customized Automation
Customized Automation

- Decision Settings can be customized
  - Modifying default values
  - Saving process templates
- “Best practice” knowledge is captured
  - Helps less experienced users
  - Improves programming consistency, repeatability and quality
- Can be referred to by intelligent automation processes
Consumer Customization

- Consumer customization can be aided by automation
- Automation can be used to reprogram parts
- Features and processes can be saved to databases and recalled later
- Minimal programmer input required
Automated Part Setup & Verification
Manual Setup

• Need to locate stock or mold tool
  o Difficult to locate accurately
  o Time-consuming

• Machine is under-utilized

• Taking the mold off the machine?
  o Problems repositioning mold tool
  o Poor repeatability

• Part accuracy suffers
Automated Setup & Verification

• Use machine tool probe
  o Combine with software to create measurement sequence
  o Allows automated setups and verification
  o Measure complex free-form and prismatic parts, including multi-axis
• Setup time significantly reduced
  o Accurate and repeatable
  o Machine tool capacity is utilized for production
• Verification of part accuracy
  o Maximizes machine productivity
  o Reduces potential expensive rework
• Mold and final part accuracy increased
Electrical Discharge Machining (EDM)

• Machining process using sparks
• Used to add detail to mold tools
• Necessary where conventional machining cannot be used

• Challenges
  o Electrode accuracy
  o Human error with data entry
Design and Manufacturing Processes

DESIGN
EXTRACT FROM CAD

STAGE 1

CAM
CNC MACHINING

STAGE 2

INSPECT
CMM OR ON-MACHINE

STAGE 3

EDM
ELECTRODE POSITIONING

STAGE 4
How Does Software Help?

• Design
  o Conventional, direct and assembly modelling
  o Measurement and EDM use information
  o Single file

• CAM
  o Automated electrode programming

• INSPECT
  o Measure electrode and update EDM usage

• EDM
  o Customisable data entered automatically
  o Easily transferred to the EDM machine

• Closed-loop workflow
Emerging Technology
Emerging Technology

- Constant pressures
  - Performance
  - Efficiency
  - Sustainability
  - Regulations

- Look to new design and manufacturing technology to address these pressures
Traditional Approach
Traditional Approach

• How might we manufacture serviceable components?
  o Molding, Casting, Forging, etc.?
• Performance car suspension upright
  o How might we manufacture this part?
• Considerations
  o High accuracy method
  o Material to withstand loads
  o Smaller production volume
  o Avoid the costs of tooling
Generative Design
Challenges

When designing automotive parts...

- Limited time to conceptualize
- Increasing demand for engineering expertise
- Design and manufacturing disconnect
- Late-stage changes are cost prohibitive
Autodesk Generative Design Technology

- 1 Designer
- Hours vs Days/Weeks
- Fraction of the Cost
- A design exploration and manufacturing solutions technology
- Multiple CAD-ready solutions
- Real-world manufacturing constraints & performance requirements
Relatable Process

- Solving problems the way we were trained:
  - What is my performance criteria?
  - What constraints need to be considered?
  - What are my fabrication options?
Project Objectives

• Innovation
• Performance
• Process Improvement
• Cost Improvements
How it’s different
Multiple Outcomes
Multiple Manufacturing Methods
The Traditional Product Development Process
Autodesk Generative Design: Improved Productivity
Additive Manufacturing
Challenges

• Improve part performance
• Need to address more complex parts
• Shorter lead times
• Minimizing tooling costs
• Reduction in labor costs from assembly
How Can Additive Manufacturing Help?

• Builds parts layer by layer
• Can exploit Lattice Optimization
  o Maximize stiffness
  o Minimize mass
• Part consolidation
• Part built directly from CAD design
  o Minimize lead time
  o Reduced costs associated with tooling
Additive Manufacturing - What do we need to be successful?

Orientation & Nesting

Toolpath Creation

Part Support

Build Simulation
Hybrid Manufacturing
Challenges

• Adequate part accuracy
  o Mating faces
  o Sealing faces
  o Tapped holes
• Stock allowances
• Factory floor space
Hybrid Manufacturing

• What do we mean by Hybrid Manufacturing?

• Combination of Additive and Subtractive manufacturing
Automotive Upright Results - How do the parts compare?

Original Design
Subtractively Machined From Solid Billet

1693 grams

Generative Design
Subtractively Machined From Solid Billet

1365 grams
(19% Lighter)

Latticed Prismatic
Additive/Subtractive (Hybrid) Manufacture

924 grams
(45% Lighter)

Generative Design Latticed Additive Manufacture

692 grams
(59% Lighter)
Conformal Cooling
Considerations

• Molds traditionally cooled using simple water circuits
• Most heat expected around the ribs and cylindrical feature
  o Also near gating location
• Consider other cooling options?
  o Cost of production versus reduction in cycle time
  o What additional processes will be needed?
Conformal Cooling

• What is it?
  o Cooling channels that conform to the shape of a mold

• Why use it?
  o Temperature uniformity for the purpose of minimizing cycle time

• How do we manufacture it?
  o Previously difficult, costly and time consuming
  o The growth of 3D metal printing is increasing flexibility of designs
  o Still costly, so must simulate
Simulation Results

- **Simple Channels**: TRE Temp. 248 s
- **Complex Machined Channels**: TRE Temp. 134 s
- **Conformal Channels**: TRE Temp. 124.4 s
Comparing Results

Basic Cooling
TRE: 248.1 s
Queried Spot: 185.2 s

Complex Cooling
TRE: 134.0 s
Queried Spot: 100.3 s

Conformal Cooling
TRE: 124.4 s
Queried Spot: 75.0 s
Conformal Cooling
Insert Manufacturing

• Use additive to builds inserts layer by layer

• Add machining allowances at the design stage

• Machined to produce desired surface quality
Additive Repair
Challenges

• Molds, tools and dies can suffer from wear or damage
• Replacing can be costly
  o New tooling
  o Loss of production
• Mold repair
  o Accuracy & repeatability
• Manually intensive
  o Growing skills gap
Directed Energy Deposition (DED)

Arc & Wire
EBM & Wire
Laser & Powder
Laser & Wire
Summary

• Software solutions can improve the quality of automotive tooling and the parts they produce
• Challenges that drive change in manufacturing facilities
  o Unified digital model to manage projects, equipment and production
• Automation can be utilized in manufacturing processes to improve production consistency
• Emerging technology can be used to improve component performance and efficiency
Summary

• Autodesk Product Design and Manufacturing Collection, which includes Autodesk Inventor, and the Factory Design Utilities
• Autodesk Vault Professional for data management and collaboration
• Autodesk Fusion 360 for generative design, but which also unifies design, engineering and manufacturing into a single platform
Summary

• Autodesk Moldflow for advanced simulation of injection and compression molded parts

• Autodesk FeatureCAM for automated CNC programming

• Autodesk Netfabb for additive part manufacturing, lattice optimization and build simulation
Summary

• Autodesk **PowerShape** for mold tool creation and modelling for manufacture
• Autodesk **PowerMill** for 3 to 5 axis subtractive milling, and additive manufacturing using directed energy deposition
• Autodesk **PowerInspect** for hardware independent automated setup and 3D measurement
• Autodesk **Electrode** for a closed-loop system between electrode design, manufacture and metrology
Want To Know More?

• Visit the dedicated Autodesk Automotive Manufacturing page:

http://autodesk.com/automotive-make

• See how Autodesk can help you reach your automotive manufacturing goals