



Process and Product Design for xEV Low Voltage Applications

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AGENDA

- **Introduction**
- **Defining the Design**
 - Understanding New Use Cases and Evaluation Techniques
 - Safety State of Function
 - Defining Requirements and Selecting Design Characteristics
 - Prototyping and Refining
- **Process Development**
 - Tools and Methods
 - Lessons learned and field experience
 - Renewed evaluation of process robustness
 - Next steps in new technology and systems
- **Conclusion**



INTRODUCTION



- Largest single-site and privately-held battery company
- 2 Battery Manufacturing Locations
 - Lyon Station, PA - 520 Acres
 - Corydon, IA
- 80 Distribution Locations (US, Canada)
- Aaron Bollinger
 - Background in Battery Testing, Application Engineering, Product Engineering, Process Engineering
 - Assistant Vice President of Automotive and Diversified Engineering



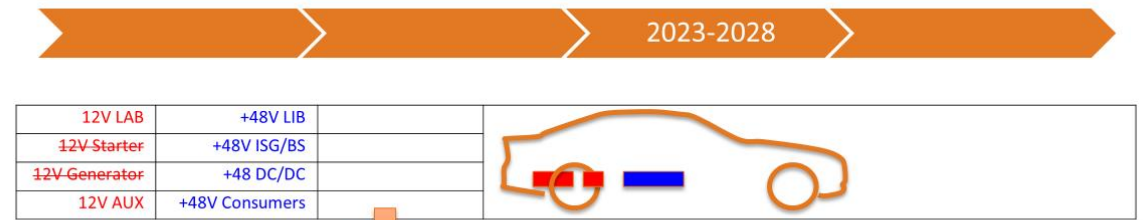
DEFINING THE DESIGN

UNDERSTANDING NEW USE CASES AND EVALUATION TECHNIQUES

- Original Equipment Manufacturer create New “Use Cases”
 - New requirements are being actively derived
 - Risk for fragmented requirements based upon specific vehicles
- Industry Standardization Activities
 - IEC 60095-8
 - Automotive Lead Battery Advancements

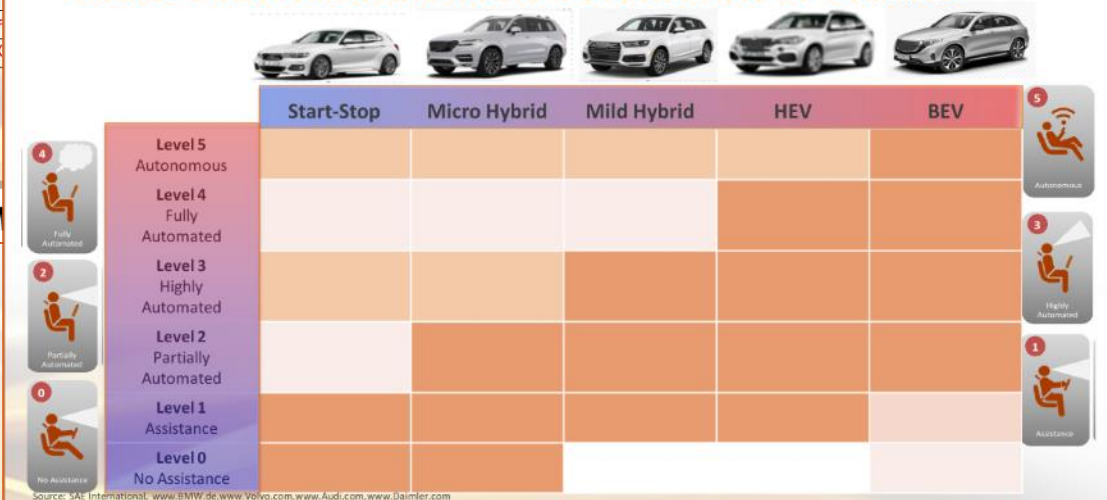
EFFECT TO THE ENERGY STORAGE

ARCHITECTURAL IMPLICATIONS EXAMPLE 48V MIGRATION



12V LAB
12V-Starter
12V-Generator
12V AUX

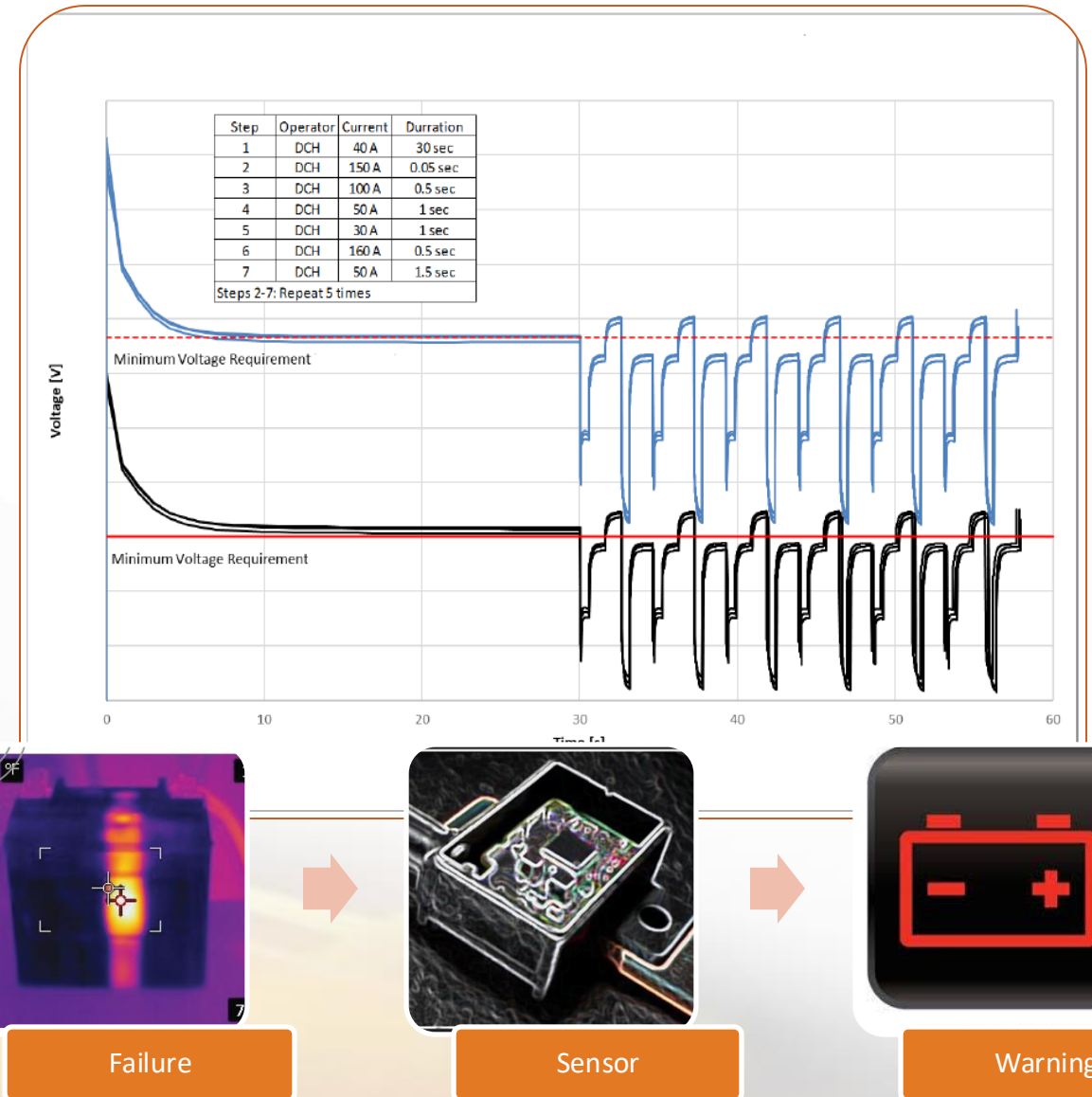
BLEND ELECTRIFICATION AND AUTOMATION OF DRIVING



DEFINING THE DESIGN

SAFETY STATE OF FUNCTION (SSOF)

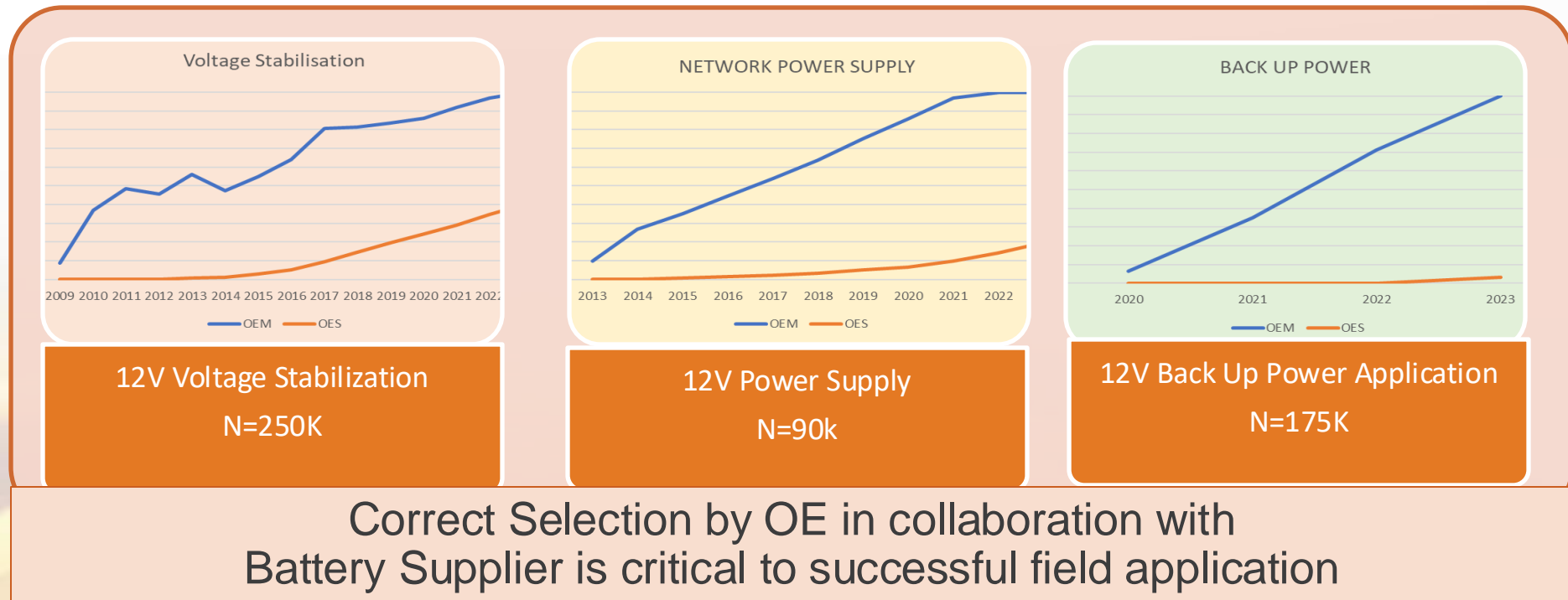
- SSOF Function Test Description
 - Maintaining a minimum voltage during varying discharge rates and varying SOC and temperature conditions
- SSOF Use Case #1
 - Battery can support safety relevant vehicle loads when required
- SSOF Use Case #2
 - Battery can be effectively evaluated for ability to perform Use Case #1



DEFINING THE DESIGN

DEFINING REQUIREMENTS AND SELECTING DESIGN CHARACTERISTICS

- Design selection according:
 - Use Cases
 - Critical Requirements



DEFINING THE DESIGN

PROTOTYPING AND REFINING

- Advanced development techniques needs to be utilized more readily in the Lead Battery Industry
 - Cell Testing
 - 3D Printing
 - Simulation
 - Characterization
 - Shorter Testing Protocols
- Faster “turnaround” on R&D with faster times to commercialization are opportunities for lead products
- Partnering with Research Institutions



PROCESS DEVELOPMENT

TOOLS AND METHODS

- Modern Quality Standards and Techniques
 - FMEA
 - Total Quality Management
 - Process Validations
 - Critical Characteristics Documentation and Control
- Alignment to Automotive Standards Governing Organizations
 - IATF, VDA, and AIAG

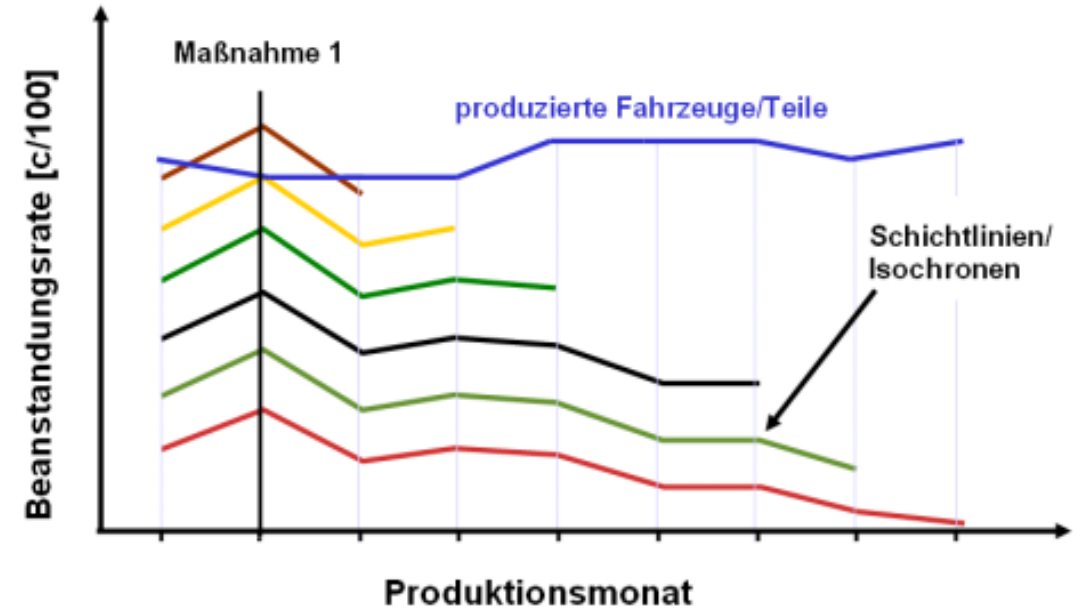
Sources: www.vda.de/de, www.aiag.org/, www.iatfglobaloversight.org/



PROCESS DEVELOPMENT

LESSONS LEARNED AND FIELD EXPERIENCE

- Field data and failure modes should be evaluated with new scrutiny
 - More Stringent Requirements
 - Proven Technology/Designs
- Design for manufacturability
 - Lessons Learned

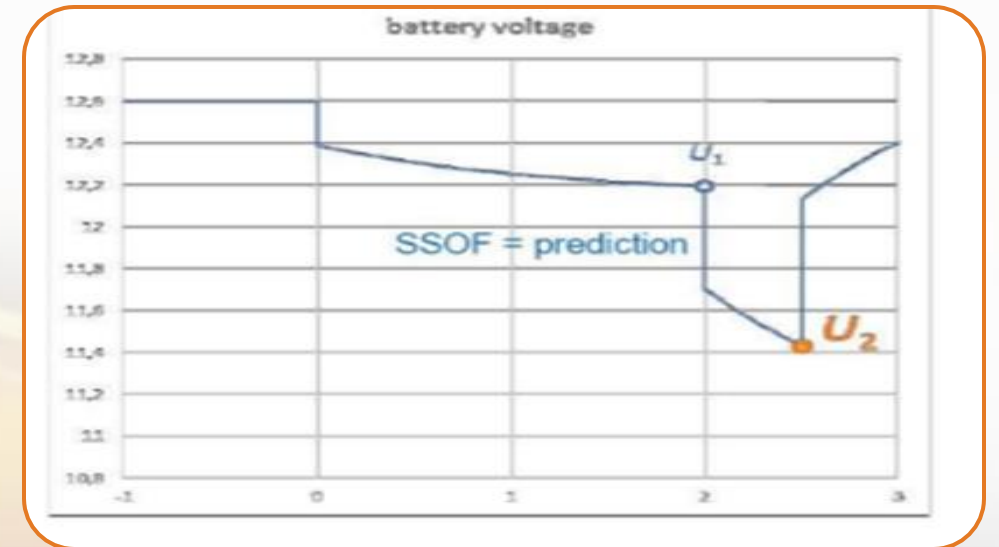
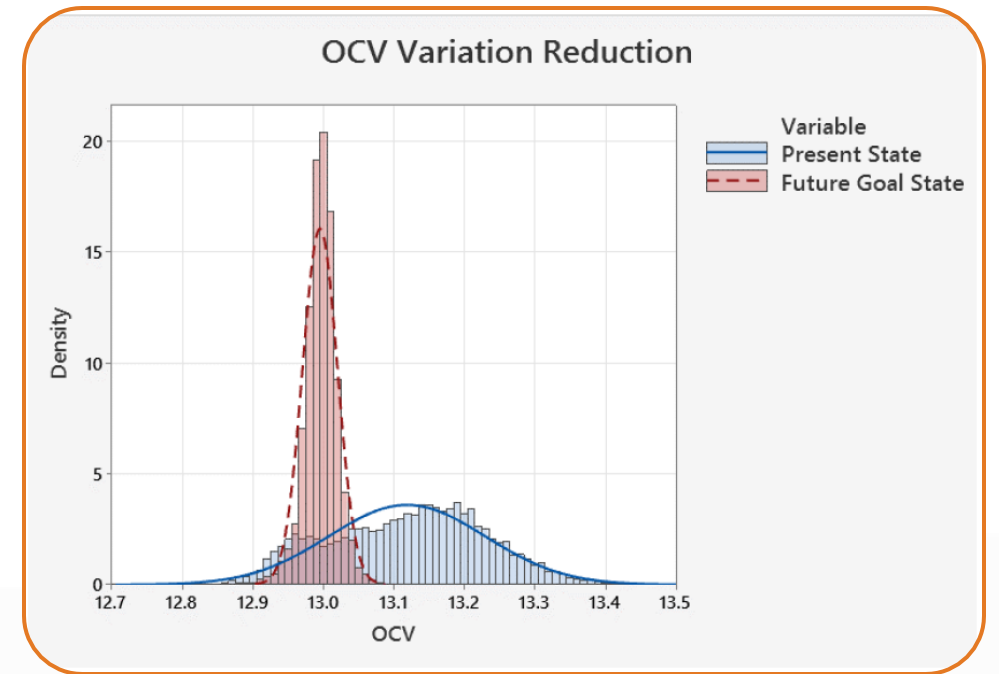


Source: www.vda.de/de

PROCESS DEVELOPMENT

RENEWED EVALUATION OF PROCESS ROBUSTNESS

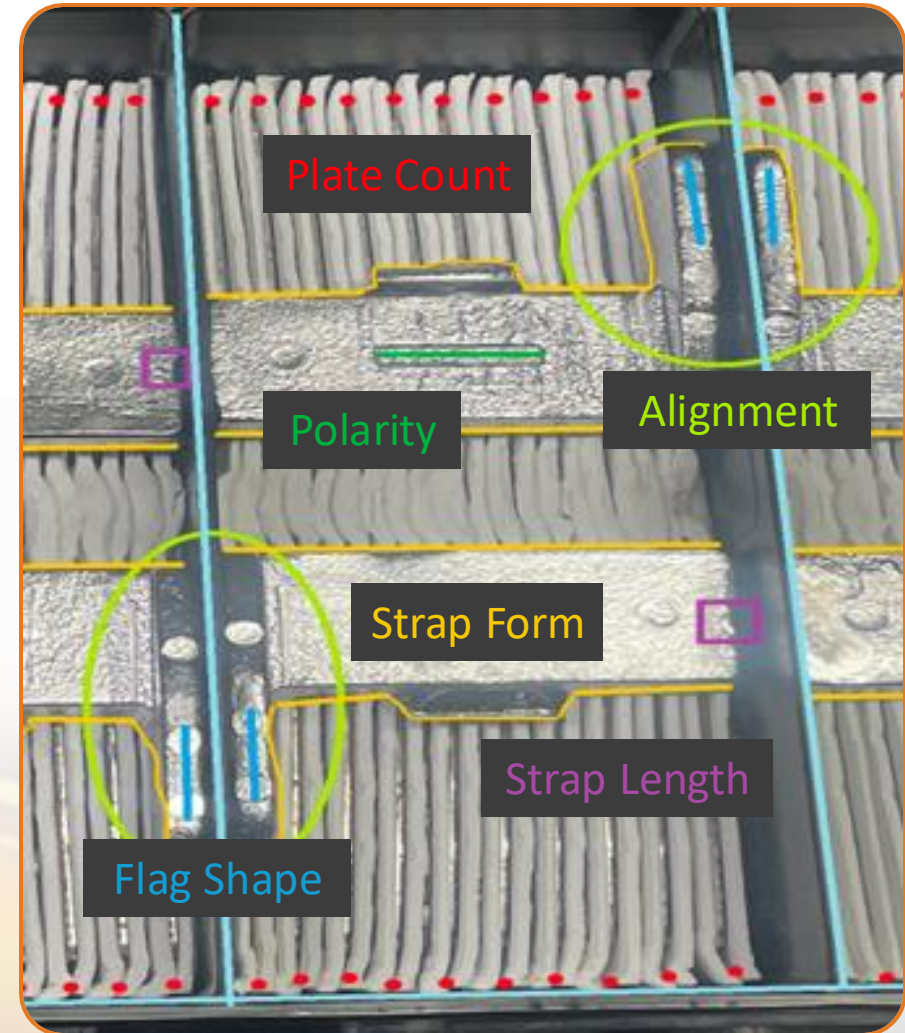
- Prior design standards are not adequate
 - Equipment and Process
- High repeatability and consistency for defect detection
- Immediate failure defects must be eliminated



PROCESS DEVELOPMENT

NEXT STEPS IN NEW TECHNOLOGY AND SYSTEMS

- Computer Vision and Advanced Data Analytics
 - DUF Manufacturing
- Fast adoption of these technologies is warranted
 - Has been adopted in other industries
- A holistic view is necessary for optimization
 - Streamlined and codependent



CONCLUSION

- The Lead Battery industry will be challenged in the Electrification of the Drivetrain to participate in rapidly changing global industry
- To remain competitive, the advantages of the technology in the new applications must be demonstrated
- Legacy product design and processes need to be challenged to develop an ecosystem for advanced lead products



PROCESS AND PRODUCT DESIGN FOR XEV LOW VOLTAGE APPLICATIONS

THANK YOU FOR YOUR KIND ATTENTION

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