



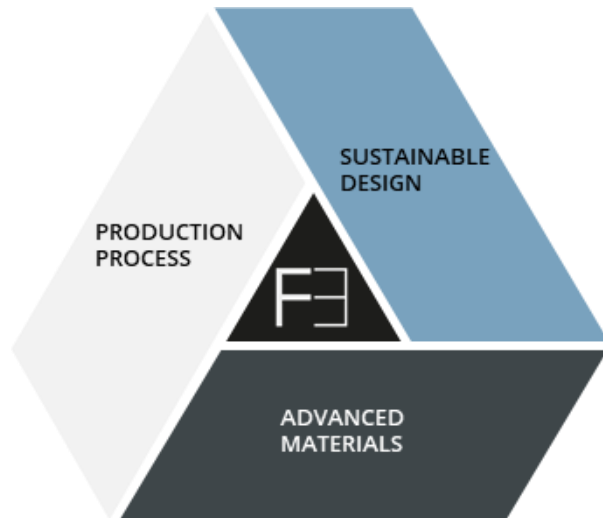
**FORWARD**  
ENGINEERING

# COMPANY INTRODUCTION

*2022 IACMI SUMMER MEETING*

June 29<sup>th</sup>, 2022 | Adam Halsband – Managing Director, Forward Engineering North America, LLC

# YOUR PARTNER FOR AUTOMOTIVE. COMPOSITE. SOLUTIONS.



Industry Leading Design & Engineering Partner for Sustainable Products and Economical Lightweight Solutions

- “Material & Production Based Engineering” – From concept to series production
- Accelerate product development with standardized development processes
- Increase confidence in performance & costs forecasts
- Reduce validation costs & time with target-oriented FEA
- Enable well-founded decisions & empower our customer with unique material know-how
- Offer independent & flexible service in a strong composite network in Germany and globally



# OUR HISTORY

**2008**  
**FORMATION**  
Roding Automobile  
GmbH



**2011**  
**LAUNCH OF**  
**ENGINEERING**  
**SERVICE**



**2013**  
**LAUNCH OF**  
**RODING**  
**ACADEMY**

Training and  
Consulting program



**2016**  
**FORWARD**  
**ENGINEERING**

FORMATION  
Munich  
Robert Maier,  
Georg Kaesmeier



**2018**  
**FORWARD**  
**ENGINEERING**  
**JAPAN**

FORMATION  
Nagoya  
Hiroaki Nagashima



**2020**  
**FORWARD**  
**ENGINEERING**  
**NORTH AMERICA**

FORMATION  
Detroit  
Adam Halsband



*roding*

**2009**  
**PRESENTATION**


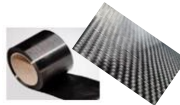
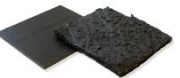
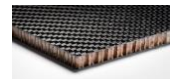
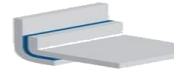


of first CFRP concept  
car at IAA



**2012**  
**WORLD PREMIER**  
of Roding Roadster at  
Geneva Motor Show

# PRODUCTION BASED ENGINEERING + SIMULATION DRIVEN DESIGN

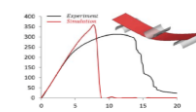
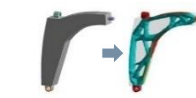
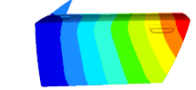
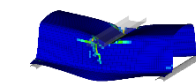

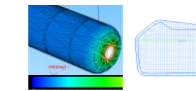
## MATERIAL & PROCESS

-  Continuous fiber, NCF, woven fabric, braiding, textile products
-  UD-Tape, Towpregs, Organo sheet, Prepreg
-  LFT/SMC
-  Sandwich
-  Adhesive, Inserts and mechanical fasteners
-  Lightweight metals
-  3D printing

## APPLICATION DESIGN

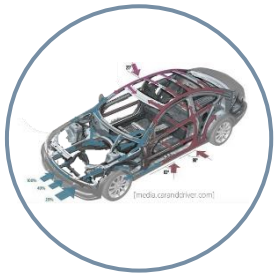
-  Multi-material BiW
-  CFRP Monocoque
-  Closures / body panels
-  Battery enclosure
-  Structural Thermoplastics/ Hybrid overmolding
-  Leaf spring, pressure vessels, others..

## SIMULATION (CAE) ANALYSIS

-  Material characterization & Material card calibration
-  Optimization (Topology, Thickness, Geometry, Layup)
-  Stiffness / NVH
-  Strength / durability
-  Crash/Impact
-  Process simulation

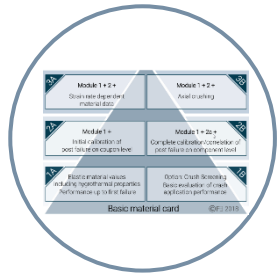
Software: Hypermesh, Optistruct, Ls-Dyna, Radioss, Abaqus, Pam-crash, CPD, Simlab, Moldex3D, Pam RTM, CADWind

# ENGINEERING AND CONSULTING SERVICES FOR YOUR SUCCESS



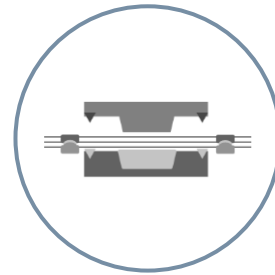
## DESIGN

- Methodical Multi-Material Design Optimization
- Optimization of Crash performance
- Evaluation of different Production Scenarios
- Definition of Joining Techniques
- Sustainability and cost Engineering



## MATERIAL

- Material Benchmark & Selection
- Feasibility Studies and Market Potential Analysis
- Standardized Composite Material Characterization & Testing
- Design for Sustainability



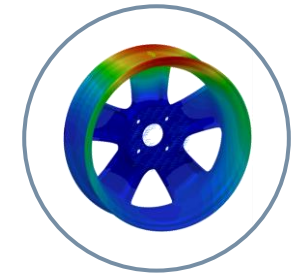
## PROCESS

- Technology Benchmark & Selection
- Feasibility Study and Market Potential Analysis
- Circular Economy Optimization
- Cost Evaluation entire Value chain
- Ramp-up trials & process validation



## SUSTAINABILITY

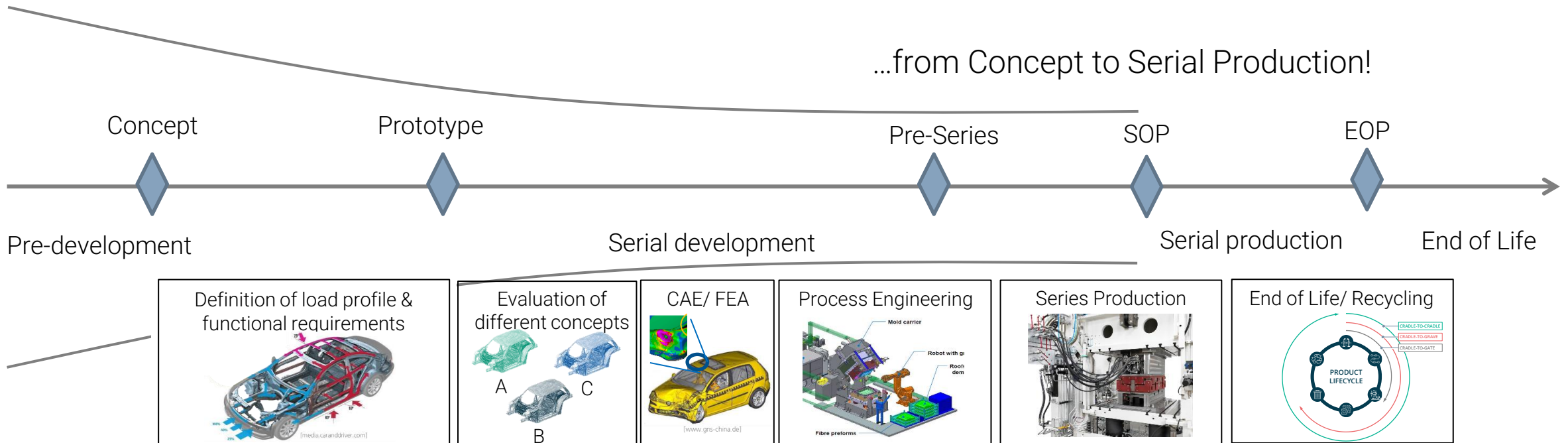
- Translate Reg & Tech Requirements to App Specific Requirements
- Sustainable Materials Development Prog's (Upstream Feedstock/ Downstream EoL Resource Recovery)
- LCA Analysis
- Design for Sustainability (Dfs)



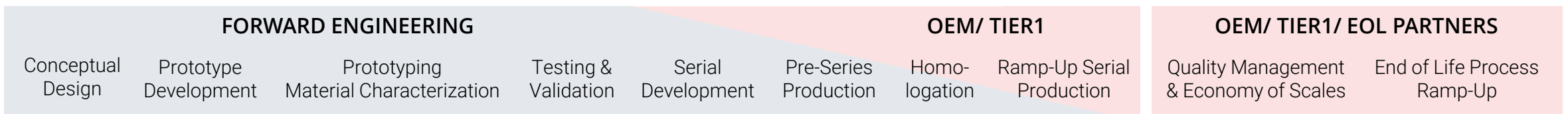
## VALIDATION

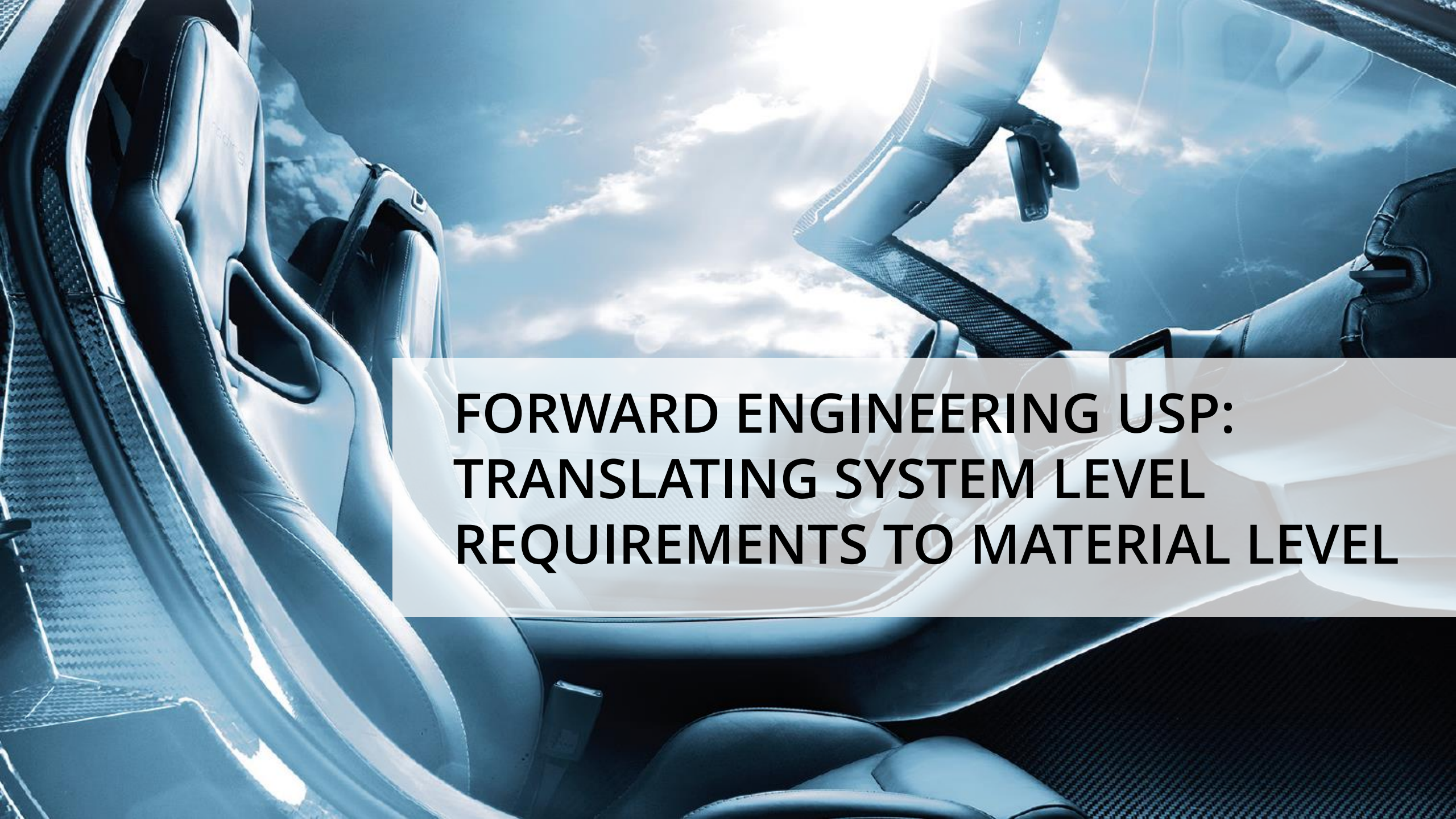
- FEA: Static-, Dynamic- and Crash Analysis on component and full vehicle level
- CAE Methodology for Composite materials and joining techniques
- Process Simulation
- Prototyping
- Hardware Testing

# HOLISTIC AND INTEGRATED CUSTOMER APPROACH



## WORKING TOGETHER WITH LEADING STAKEHOLDERS ALONG VALUE CHAIN

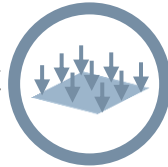




**FORWARD ENGINEERING USP:  
TRANSLATING SYSTEM LEVEL  
REQUIREMENTS TO MATERIAL LEVEL**

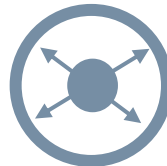
# MAIN REQUIREMENTS FOR HIGH VOLTAGE BATTERY ENCLOSURE

Global torsion & bending stiffness  
→ Intelligent load path management



Fire resistance (internal/external)  
→ FST-appropriate material & design  
→ Thermal Runaway appropriate design

Mechanical shock & Durability  
→ High strength attachments for modules & enclosure

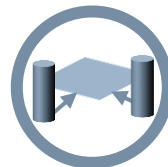


Thermal Management  
→ Appropriate Material Concept  
→ Cooling System Integration



Moisture/ Liquid Intrusion  
→ Sealing Layout  
→ Corrosion Resistance

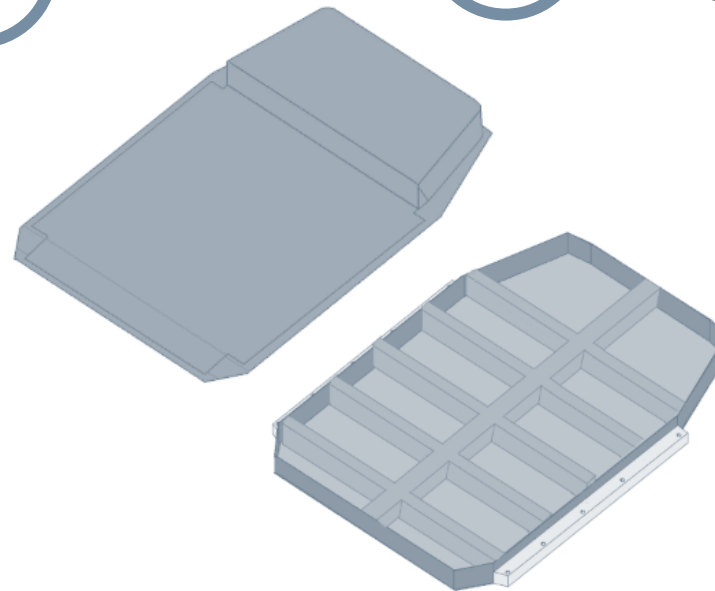
Side/Front/Rear Crash or Crush  
→ Structural integrity  
→ Energy absorbing structure



EMC & Grounding  
→ Electroconductive material & design



Ground impact  
→ Energy absorbing tray





# MAIN REQUIREMENTS FOR HIGH VOLTAGE BATTERY ENCLOSURE

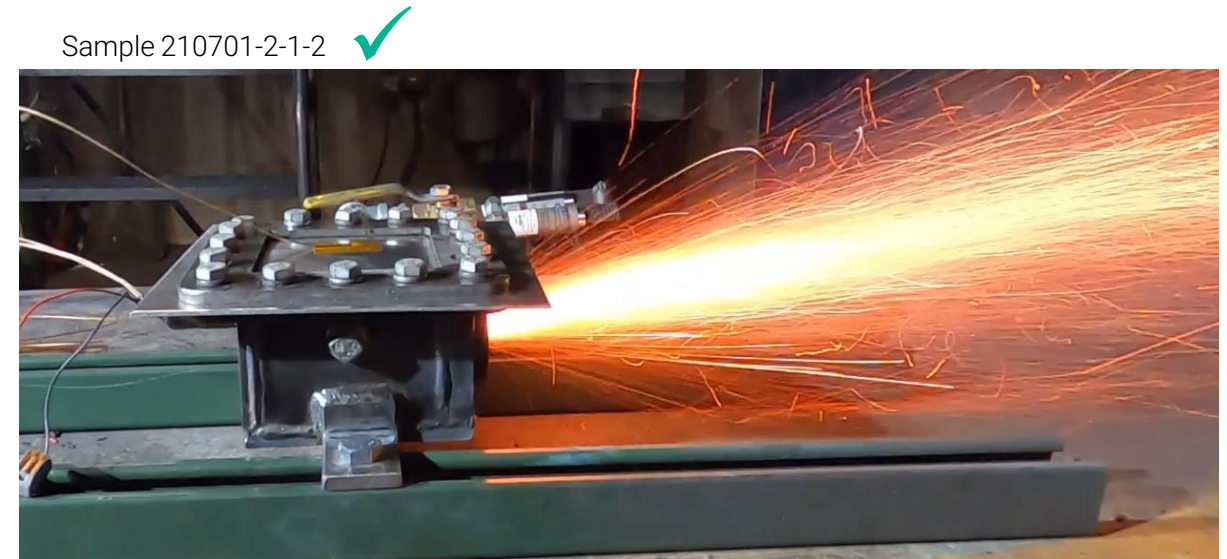
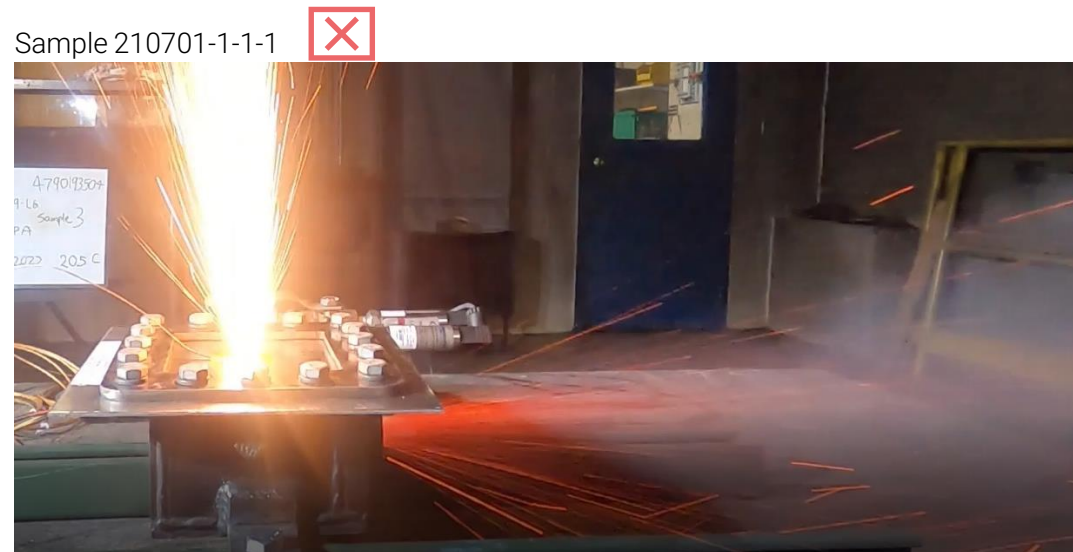
Requirement ID	Description	Reference	Category
REQ-001	...	...	...
REQ-002	...	...	...
REQ-003	...	...	...
REQ-004	...	...	...
REQ-005	...	...	...
REQ-006	...	...	...
REQ-007	...	...	...
REQ-008	...	...	...
REQ-009	...	...	...
REQ-010	...	...	...
REQ-011	...	...	...
REQ-012	...	...	...
REQ-013	...	...	...
REQ-014	...	...	...
REQ-015	...	...	...
REQ-016	...	...	...
REQ-017	...	...	...
REQ-018	...	...	...
REQ-019	...	...	...
REQ-020	...	...	...

- FE Translates Global Regulatory and Technical Requirements to derive most relevant set of design requirements for a given application
- FE's Database of Regulatory Requirements
  - Continuous update of global regulations for mechanical and functional safety
    - ECE
    - GB/T
    - NHTSA/MVSS
    - etc.
- Harmonize with OEM Technical Requirements
  - Integration of regulatory and OEM specific requirements
    - Identify key design criteria (i.e. boundary conditions)
    - Load case visualization

Requirement	ECER100	GB/T 31467.3	ECER100	GB/T 31467.3-2015	SAC J2464-2009
Test procedure					
SOH Safety	> 50%	100%	> 50%	100%	100%
Force impact	• 100kN • in collection chassis	• 100kN (one axial of 30kN, in reference 2000) • Force 300kN (one axial of 70kN) • in any direction (vertical / horizontal)			
Load application	• Increasing of frame max stress • constant $F_{max}$ for 10s	• on all covered 300kN • constant $F_{max}$ for 10 min	on the fixed side on dynamic systems	on the fixed side on dynamic systems	on the fixed side on dynamic systems
Observation time	3h	3h	3h	3h	3h
Criteria	• No mechanical flexibility • No fracture • No fire • No explosion • Radiation resistance > 100kGy	• No fire • No explosion	• No damage of electrolyte • No fracture • No fire • No explosion • Radiation resistance > 100kGy	• No fire • No explosion	• No fire • No explosion
SOH Safety	> 50%	100%	> 50%	100%	100%
Test procedure	• 500 pulses • 70% expansion of cell to free • equal above for 60s • $(T_1 - T_0)$ • $(T_2 - T_0)$	• 600 pulses • 70% expansion of cell to free • equal above for 60s • $(T_1 - T_0)$ • $(T_2 - T_0)$			
Observation time	3h	3h	3h	3h	3h
Criteria	No explosion	No explosion	No explosion	No explosion	No explosion

# TRANSLATING SYSTEM REQUIREMENTS TO MATERIAL LEVEL

Example: High Voltage Battery Enclosure Thermal Runaway Material Screening Program

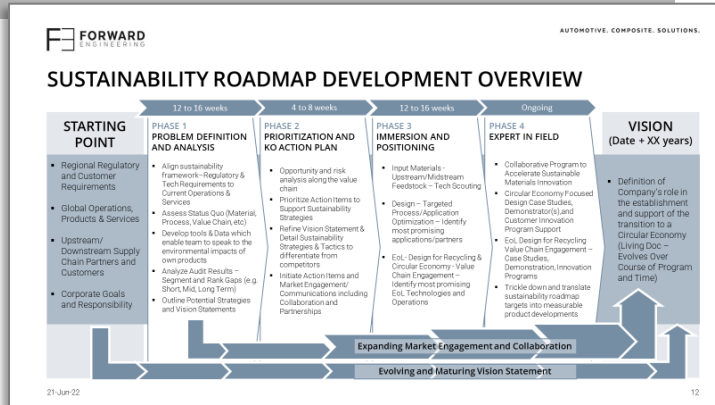




**FEATURED FORWARD ENGINEERING  
SERVICES PACKAGES**

# FEATURED FORWARD ENGINEERING SERVICES PACKAGES

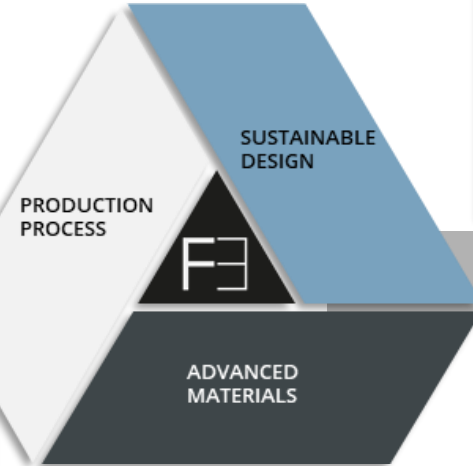
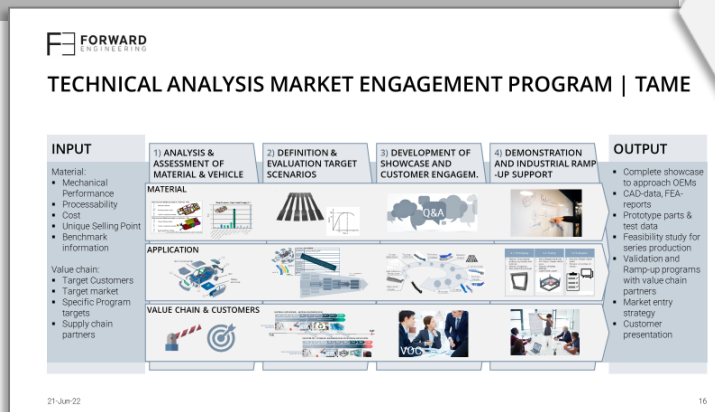
## SUSTAINABILITY/CIRCULAR ECONOMY



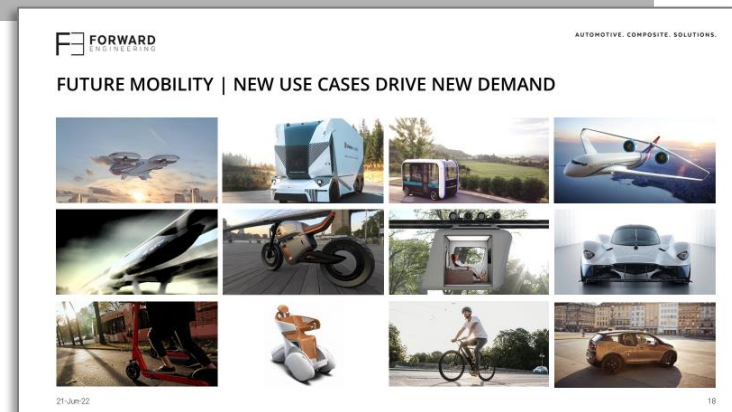
## BEV APPLICATION DEVELOPMENT



## MATERIAL & TECHNOLOGY



## FUTURE MOBILITY



# FORWARD ENGINEERING CONTACT INFORMATION



**FORWARD ENGINEERING NA LLC**  
Detroit | Michigan | United States  
Mr. Adam Halsband  
+1 (248) 838-8772  
[halsband@forward-engineering.com](mailto:halsband@forward-engineering.com)

**FORWARD ENGINEERING GMBH**  
Head Quarter Munich | Germany  
Mr. Georg Kaesmeier  
+49 (89) 12113289-502  
[kaesmeier@forward-engineering.com](mailto:kaesmeier@forward-engineering.com)

**FORWARD ENGINEERING JAPAN CO., LTD.**  
Nagoya | Japan  
Mr. Hiroaki Nagashima  
+81 (90) 6341-7905  
[nagashima@forward-engineering.com](mailto:nagashima@forward-engineering.com)



**FORWARD**  
ENGINEERING

© Forward Engineering North America  
718 W. 11 Mile Road  
Royal Oak, MI 48067-2411 | USA  
[www.forward-engineering.com](http://www.forward-engineering.com)

**FORWARD ENGINEERING NA LLC**  
Detroit | Michigan | United States  
Mr. Adam Halsband  
+1 (248) 838-8772  
[halsband@forward-engineering.com](mailto:halsband@forward-engineering.com)