STEEL E-MOTIVE

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Steel Vehicle Structures for Autonomous MaaS

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May 19, 2021 | Great Designs in Steel

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voestalpine ONE STEP AHEAD.

Today's Presentation

1. Market Influencers
2. The Future Mobility Challenge
3. Steel E-Motive Vehicle Program

Legacy of Steel Demonstrations

1998

ULSAB

UltraLight Steel Auto Body

2000

ULSAC

UltraLight Steel Auto Closures

2002

ULSAS

UltraLight Steel Auto Suspensions

2003

ULSAB-AVC

Advanced Vehicle Concepts

2011

Future Steel Vehicle

Steel Structures for Electrified Vehicles

2020-22

STEEL E-MOTIVE

Steel Structures for Mobility as a Service Vehicles

Mobility as a Service (MaaS) vehicles are shifting the way we think about designing vehicle architectures, from focusing on the vehicle itself to the wider concept of supporting the movement of people and goods.

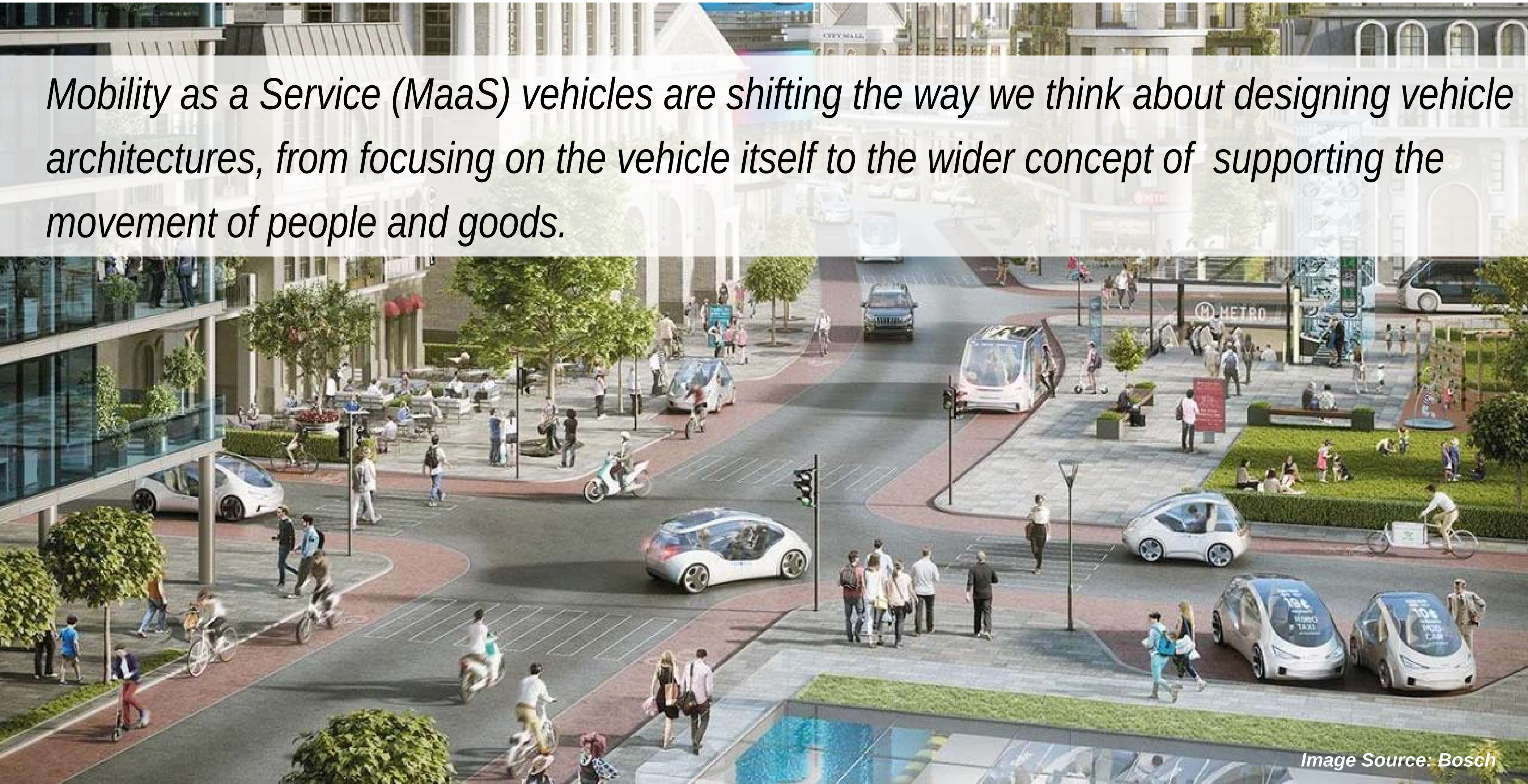

Image Source: Bosch

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A global steel industry program to demonstrate that *Advanced High-Strength Steel (AHSS)* products and technologies can solve the unique architectural challenges of Mobility as a Service (MaaS) vehicles.

MaaS Key attributes and functions

Space Efficiency

- Minimization of vehicle footprint increases utility, but with safety complexity
- More comfort for passengers

Flexibility

- Vehicle automatization is an enabler for increasing the vehicle interior flexibility, both in private use and in (semi-) public transport or movement of goods.
- Higher awareness for comfort factors in electrified and automated vehicles
- Comfortable environment provides additional value for passengers

Total Costs of Ownership

- TCO are the central factor for a positive business case and thus the most important characteristic of automated vehicles in fleet operations.

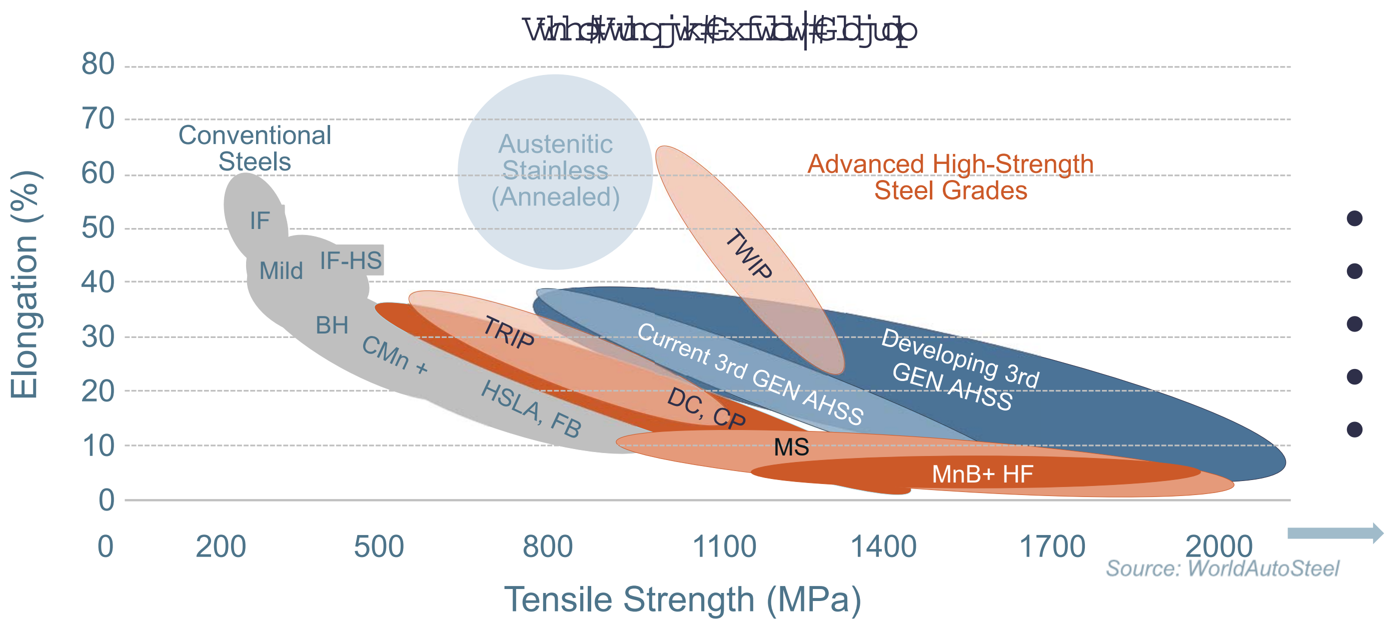
1. Reduction of Vehicle Front-end and Rear-end
2. Comfortable Vehicle Access Concepts
3. Variable Seating Configurations
4. Battery Integration
5. Reparability and Maintenance
6. Optimized Vehicle Lifetime
7. Efficient Packaging of Drivetrain Components
8. Improved Assembly Processes
9. NVH Comfort
10. Hygienic Interior Surfaces
11. Increase of Vehicle Height
12. Infotainment

12 key considerations for future electrified and automated mobility

Baseline requirement for each function / module

Passive Safety, Lightweight Design, LCA, Material Cost

Steel E-Motive steel portfolio

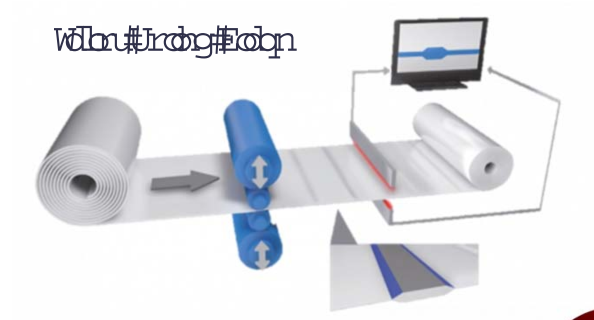


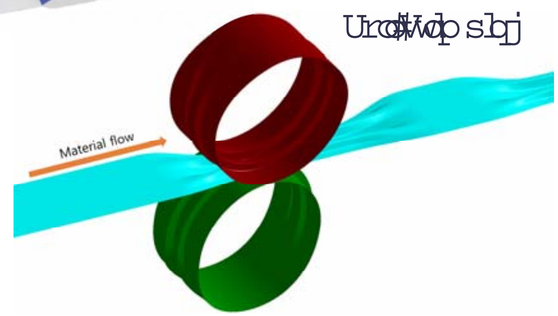
Example Steel Grades for Steel E-Motive

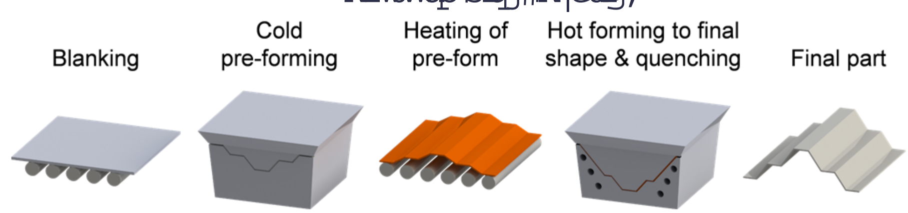
- Complex Phase
- Dual Phase, High Formability
- Quench and Partitioned
- Ferrite-Bainite
- Manganese-Boron

Steel E-Motive steel technologies

- Laser Welded Blanks
- Tailor Welded Blanks
- Tailor Rolled Blanks (quenched steel)
- Laser Welded Coil
- Laser Welded Hydroformed Tubes
- Sheet Hydroforming
- Tube Hydroforming
- Roll Forming
- Roll Stamping
- Press Hardening
- Laser Welded Tube Profiled Sections
- Multi-Walled Hydroformed Tubes
- Multi-Walled Tubes







Steel E-Motive Vehicle Program

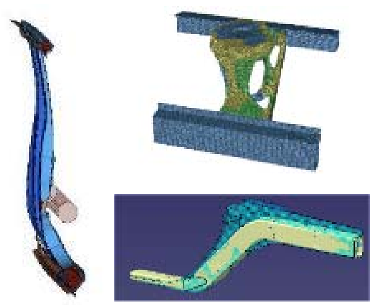
Neil McGregor
Ricardo's Chief Engineer for
Steel E-Motive

Steel E-Motive: Project timing and key activities

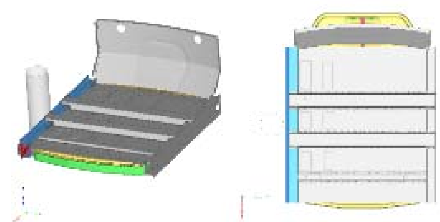
	July 2020		2021				2022			
Task/Project Months	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project Engineering Phases	Phase 0	Phase 1				Phase 2			Phase 3	

Phase 0: Pre-study
- ✓ Confirmed vehicle targets
- ✓ Exterior vehicle style
- ✓ Vehicle package
- ✓ Body architecture layout
- ✓ LCA & cost tools
- ✓ Marketing & Comms plan
- ✓ Competitor material benchmark study

Phase 1: Concept Design
- ✓ Development of innovative steel body structure concepts for Future Mobility Vehicle
- ✓ Engineering evaluation and selection of concepts. Virtual validation at body system and vehicle level (ie. crash)



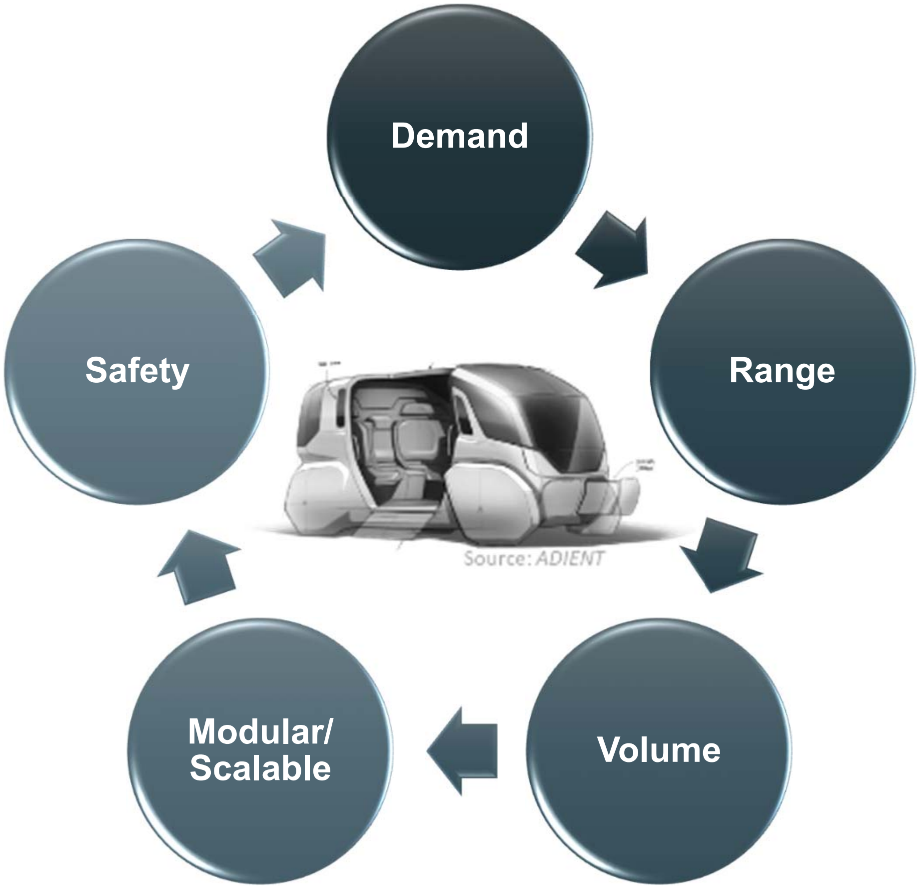
Phase 2: Design Validation
- ✓ Design optimisation of Urban and Extra-Urban vehicle derivatives
- ✓ Creation of 3d printed underbody demonstrator



Phase 3: Dissemination
- ✓ Technical papers
- ✓ Conference presentation
- ✓ Concept launch event
- ✓ Virtual Reality Demo

Vehicle Mission, Base Requirements

- Multi-Passenger Autonomous Battery Electric Vehicle
- Urban / Extra-urban variants
- Level 5 autonomy
- Optimized for Mobility Service Providers
- Global applicability & demand
- High volume & configurable
- Production viable, 2030
- Scalable / modular design
- Solutions that demonstrate Steel innovation
  - Low environmental footprint
  - Compliant to global crash standards
  - Lowest *Total Cost of Ownership* (TCO)

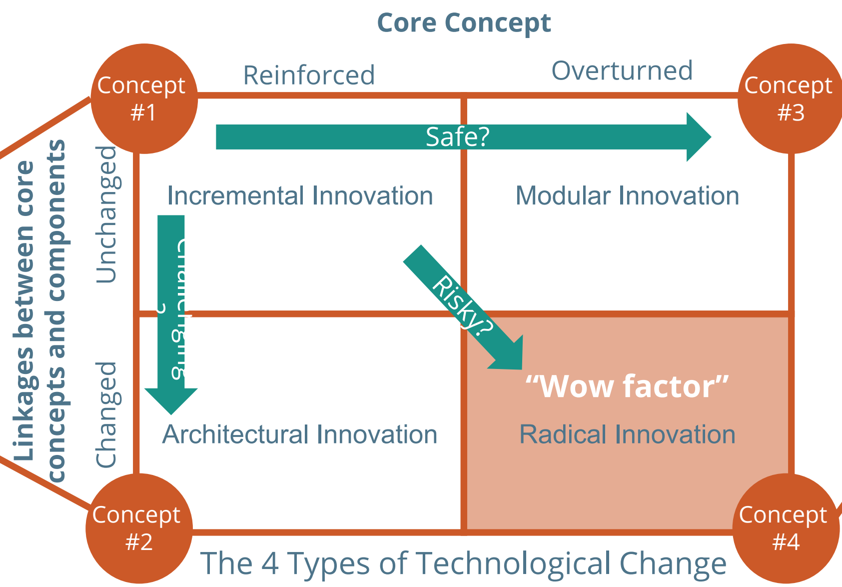


Steel E-Motive explores and demonstrates steel innovation.
Exploring “modular” and “architectural” innovations for 2030 production

- New applications and duty cycles drive new vehicle architectures
- Enabled by new steel materials and new fabrication technologies

Incremental Innovation strengthens the existing core concepts of the components while maintaining the traditional linkages between them (e.g. steel grade change)

Architectural Innovation is a more significant change to the existing design. It doesn’t change the underlying components significantly but makes a dramatic change to the ways they link together. (e.g.New load path or topology solution)



Modular Innovation improves the technology of a core component but doesn’t change the way the system links together. (e.g.new longit concept)

Radical Innovation is the most extreme of the four types and it involves changing both the technology of the subcomponents and the ways they link together

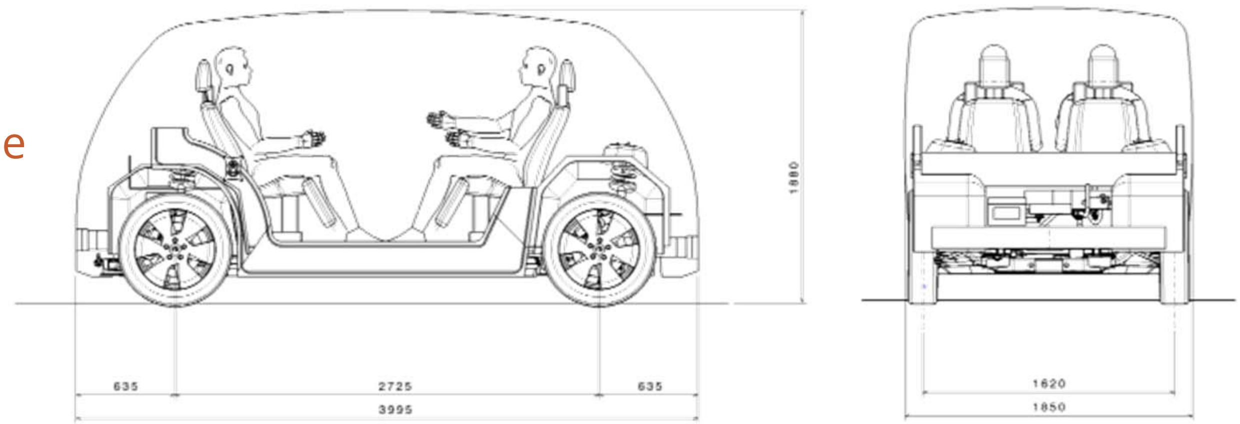
“Modular” + “Architectural” = “Radical”

Source: Rebecca M. Henderson and Kim B. Clark. “Architectural Innovation: The Reconfiguration of Existing Product Technologies and Failure of Established Firms.” Administrative Science Quarterly 35 (Mar 1990) 12

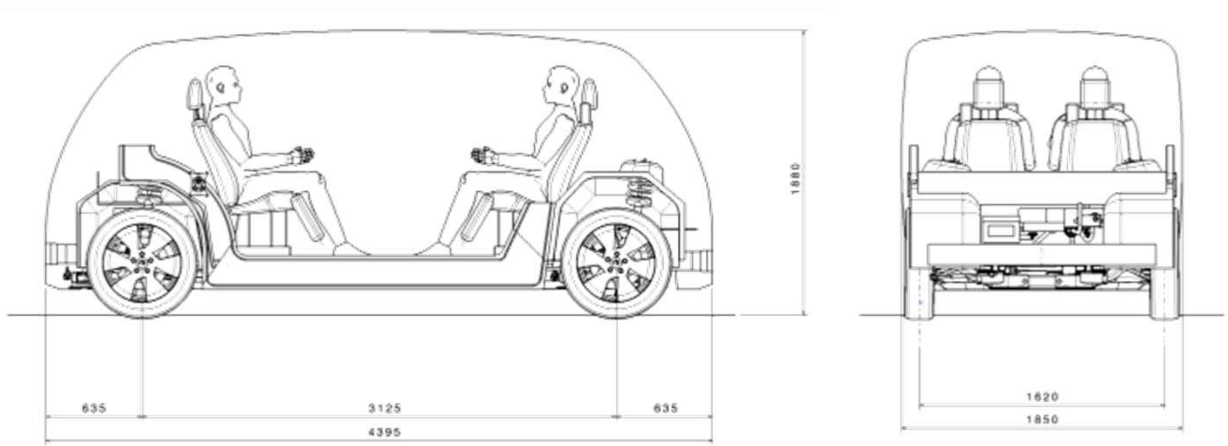
Source: https://medium.com/bsse-gets-social-media/high-end-products-can-t-be-disruptive-here-s-why-part-2-c51f49b030b7

Vehicle Technical Specification and Dimensions – Base Vehicle Geometry

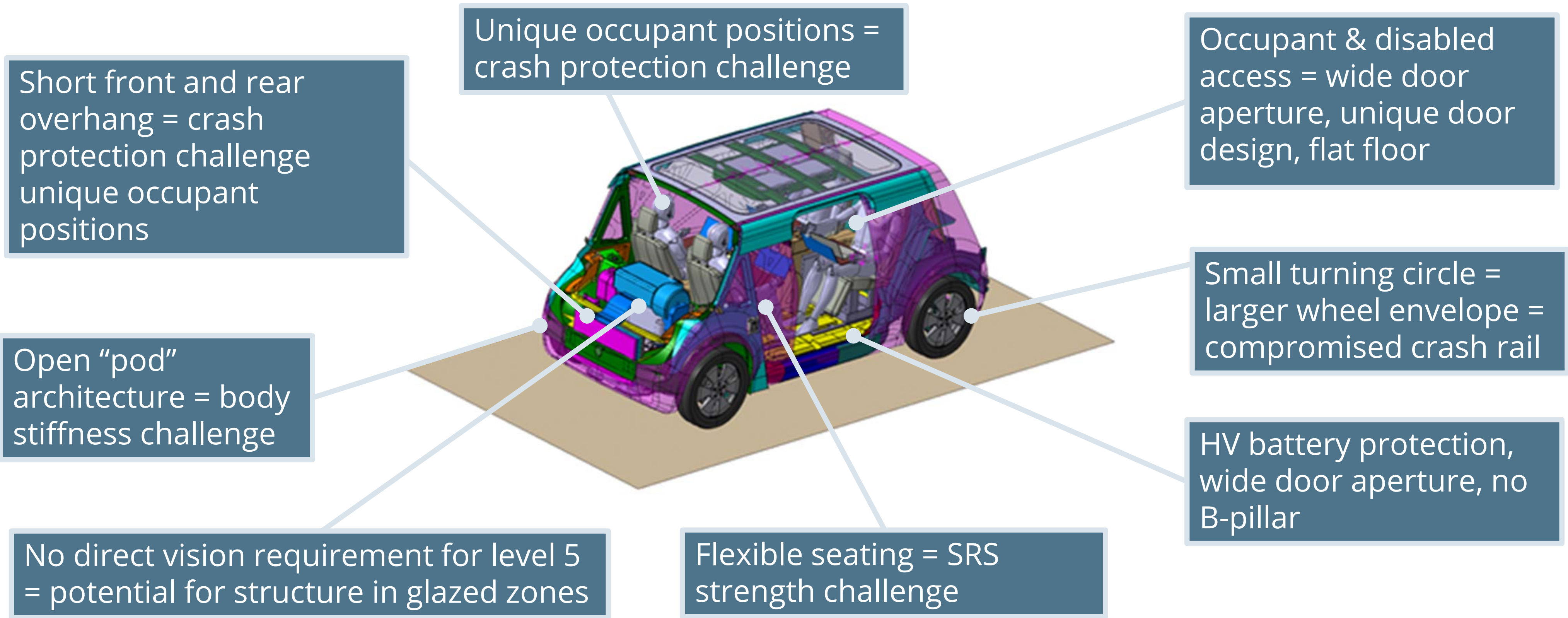
SEM1: Short Wheelbase
Urban Version



SEM2: Long Wheelbase
Extra Urban Version

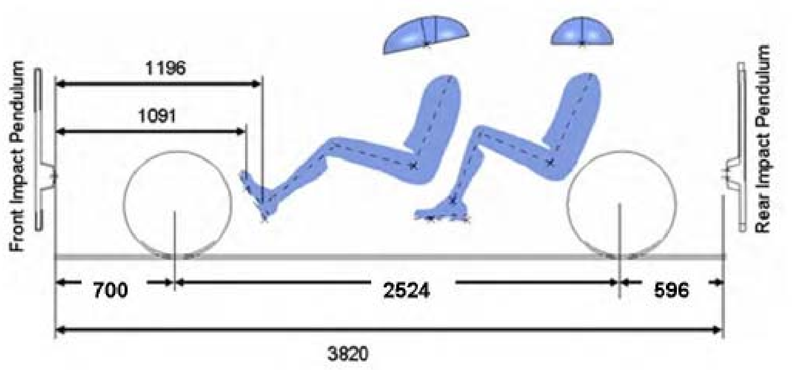


Challenges and opportunities of Level 5 autonomous MaaS battery electric vehicle

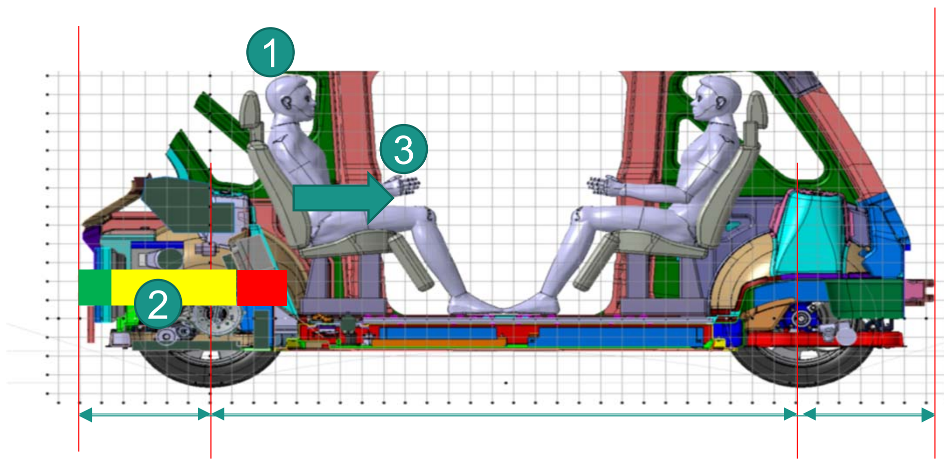


Crash and safety challenges with Level 5 autonomous vehicle (1)

FutureSteelVehicle

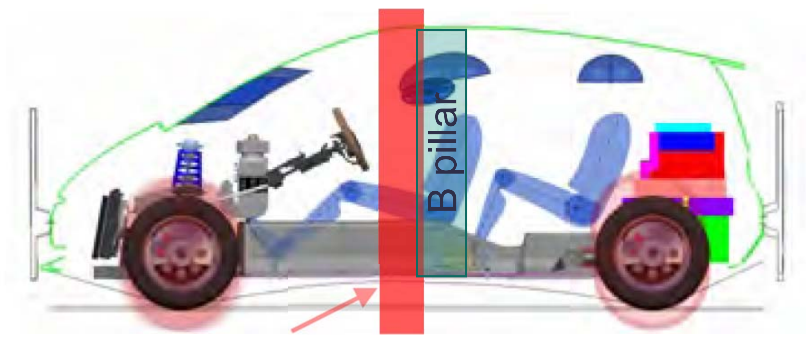


Steel E-Motive

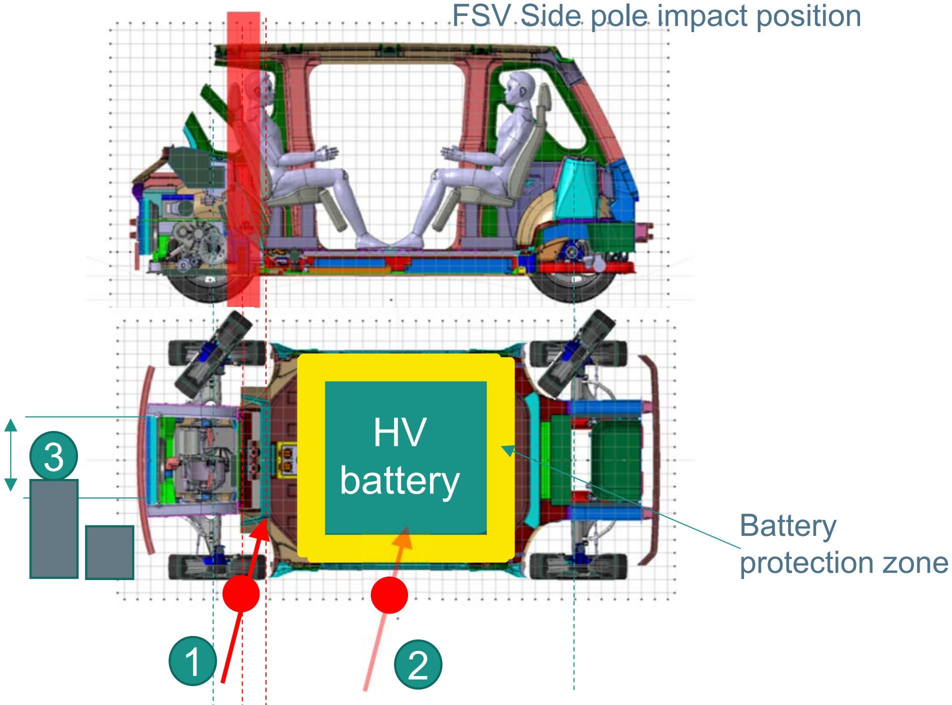


1. Level 5 autonomy enables potential for rear facing passenger. Occupant’s feet are away from front crush zone. Back and head are closer. Crash structure to be design accordingly. SRS challenges (not specifically covered in Steel E-Motive project)
2. Short front and rear overhang and crush distance - steel has good potential to address this. 3rd gen steels for crash rails under consideration
3. Wide door aperture for enhanced passenger ergonomics = no B-pillar, compromise to front crash loadpaths

Crash and safety challenges with Level 5 autonomous vehicle (2)

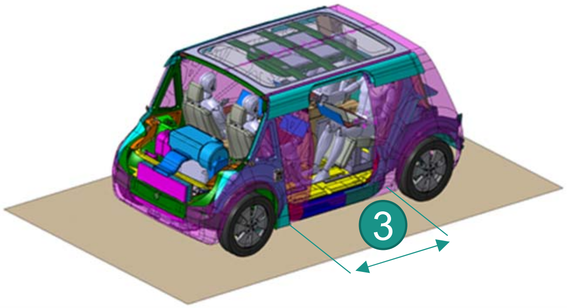


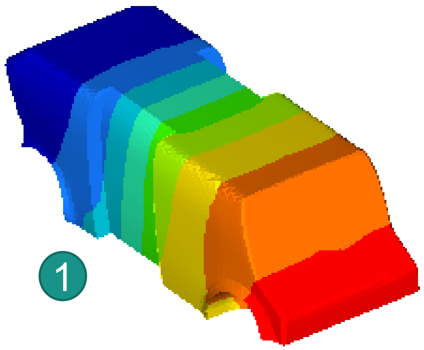
FSV Side pole impact position

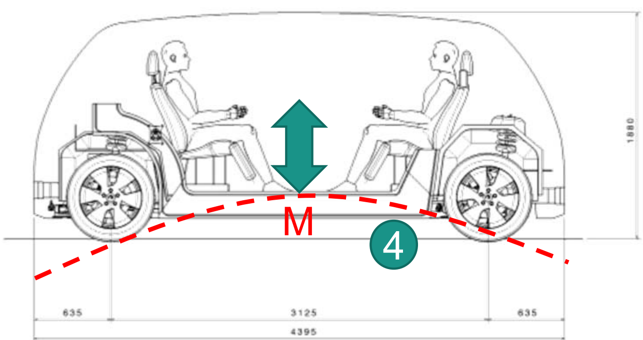


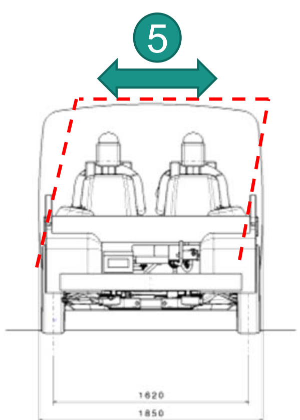
1. With rear facing front occupant, side pole impact point misses rocker. Additional structure required
2. High Voltage battery protection from front, side and rear impact
3. Competitive turning circle = f+r steer, large wheel envelope = narrower front and rear rail positions. This compromises offset (SORB) barrier pick-up

We have a number of NVH challenges to address in Steel E-Motive







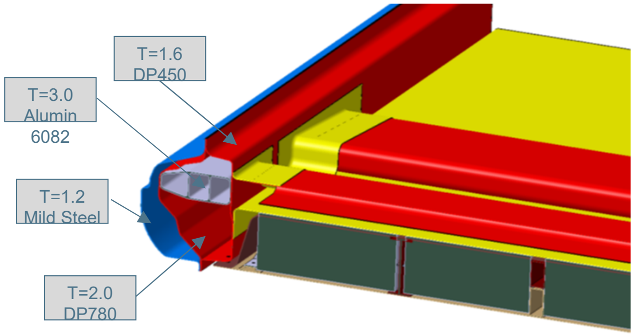


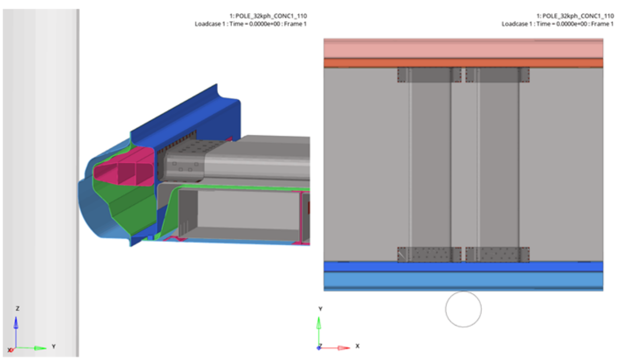
1. Large and unique occupant space = acoustic air cavity mode coupled with structure
2. Unique occupant position = unique NVH path-receiver element
3. Large door aperture. Compromise body structure stiffness
4. Heavy HV battery = floor panting mode risk
5. Lozenging modes with stiff floor and lightweight upper glass house

- Modal mapping approach / targets
- Inherent stiffness properties of steel
- Thorough NVH CAE simulation

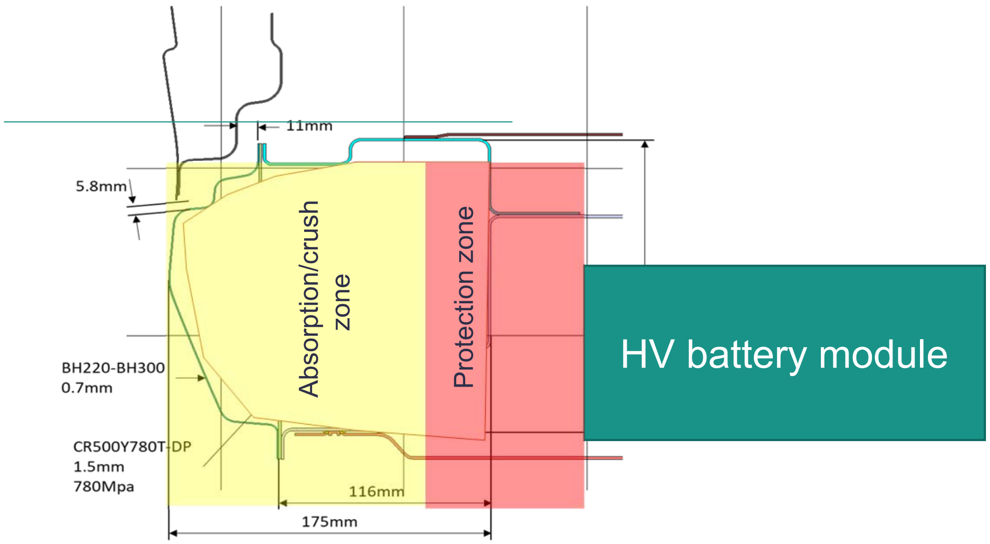
We are developing steel rocker crush and protection concepts with the objective to compete with extruded aluminium profiles

Side Pole benchmark/characterisation of extruded aluminium profile



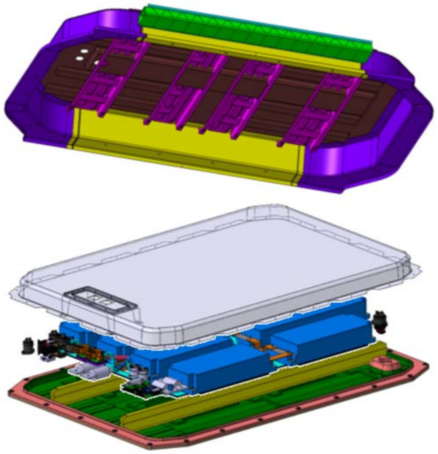


Development of Steel E-Motive rocker crush and protection components



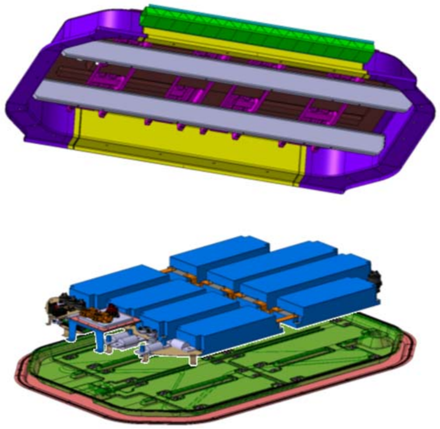
A number of HV battery enclosure concepts are being explored, targeting low mass, enhanced pack volume

“Conventional” Pack



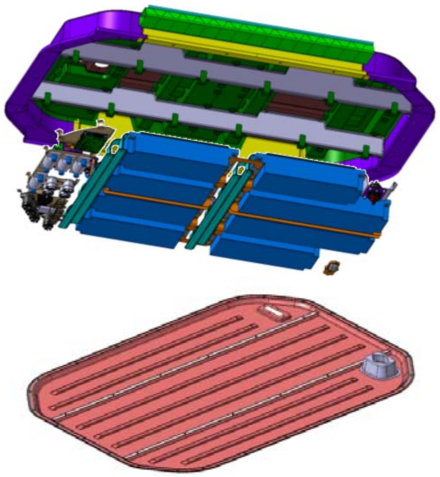
- current technology
- Sealed pack unit

“Coverless” Pack



- Modules attached to battery enclosure baseplate
- Pack attached and sealed to BIW Rockers and longitudinals
- Mass and cost saving

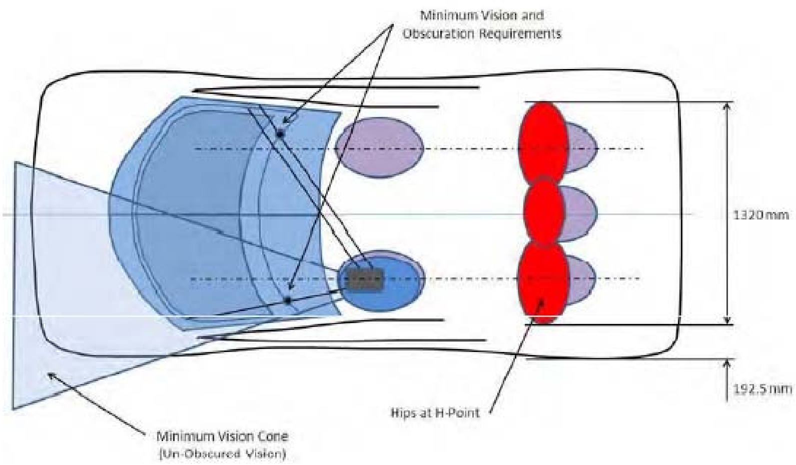
“Integrated” Pack (module to BIW)



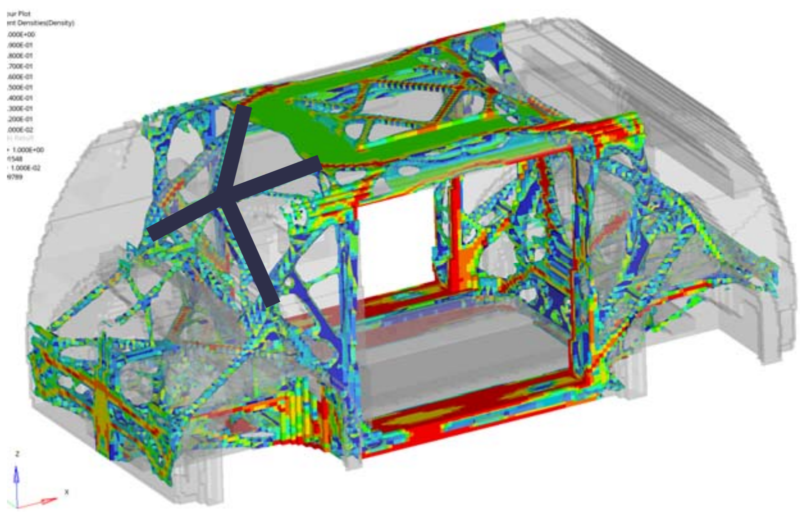
- Modules attached to BIW floor crossmembers
- Base plate attached to BIW Rockers and longitudinals providing sealing
- Good mass, cost and NVH benefits. Considerable sealing and assembly challenges being investigated

Level 5 autonomy removes the driver vision and obscuration requirements. We are investigating the potential to use this

Passenger car (Level 1 to 4) vision and obscuration requirements



We are exploring the options and benefits for placement of structural loadpaths in conventional glazed zones



Level 5 topology loadpath analysis

Steel E-Motive Summary

- Level 5 autonomous vehicles offer a number of advantages and enable design flexibilities but also introduce unique challenges that perfectly align with steel's capabilities.

- We are currently exploring these opportunities and challenges in the *concept* phase of Steel E-Motive programme.

- We are emphasizing passenger ingress/egress and optimal closures, integration of the battery into the crash structure and short front and rear overhangs.

STEEL E-MOTIVE

Shaping the future of sustainable mobility through steel innovation

- Program Completion: **December 2022**
- Continuous communications over the next two years

Subscribe for updates at **www.steelemotive.world**

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Thank you.

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