

Innovate **Sustainable** **Mobility**

Accelerate Your Vehicle Development.

Optimum Performance of New CASE Technologies

TURN NEW BUSINESS MODELS AND DIGITAL TRANSFORMATION INTO PROVEN VALUE AND ROI

- Engineer high-performance batteries and lightweight designs that go the distance without sacrificing cost
- Experience, and validate on the production process early
- Sensing, connecting, and reporting for a safer driving experience
- Reach optimal passenger comfort and energy consumption



Get Sustainable Mobility Right the First Time

EARLY AND CONTINUOUS FOCUS ON VEHICLE PERFORMANCE WITH VIRTUAL PROTOTYPING AND HYBRID TWIN

- From vehicle engineering, manufacturing, and assembly operations to service process engineering & maintenance
- Define and deliver safe and reliable vehicles and production processes
- Achieve highest product quality and life-time performance reducing the reliance on physical prototypes

FIAT CHRYSLER

FORD

GESTAMP

HONDA

RENAULT NISSAN

VOLKSWAGEN

ZF AUTOMOTIVE

...

5 Main Automotive **Challenges**

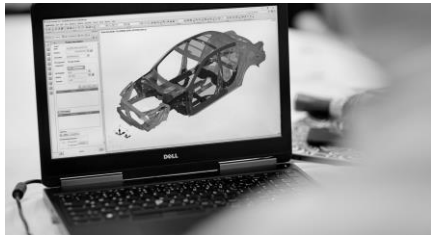
Secure Delivery & Lightweight Body & Chassis

Supporting **EV and Battery** market Challenges

Safe Driving Vehicle Operations & Autonomous

Towards **Efficient Product Assembly Line**

New **Passenger Experience**



1 **Multi Material**
Joining & Assembly

2 **Electrification**
& Battery

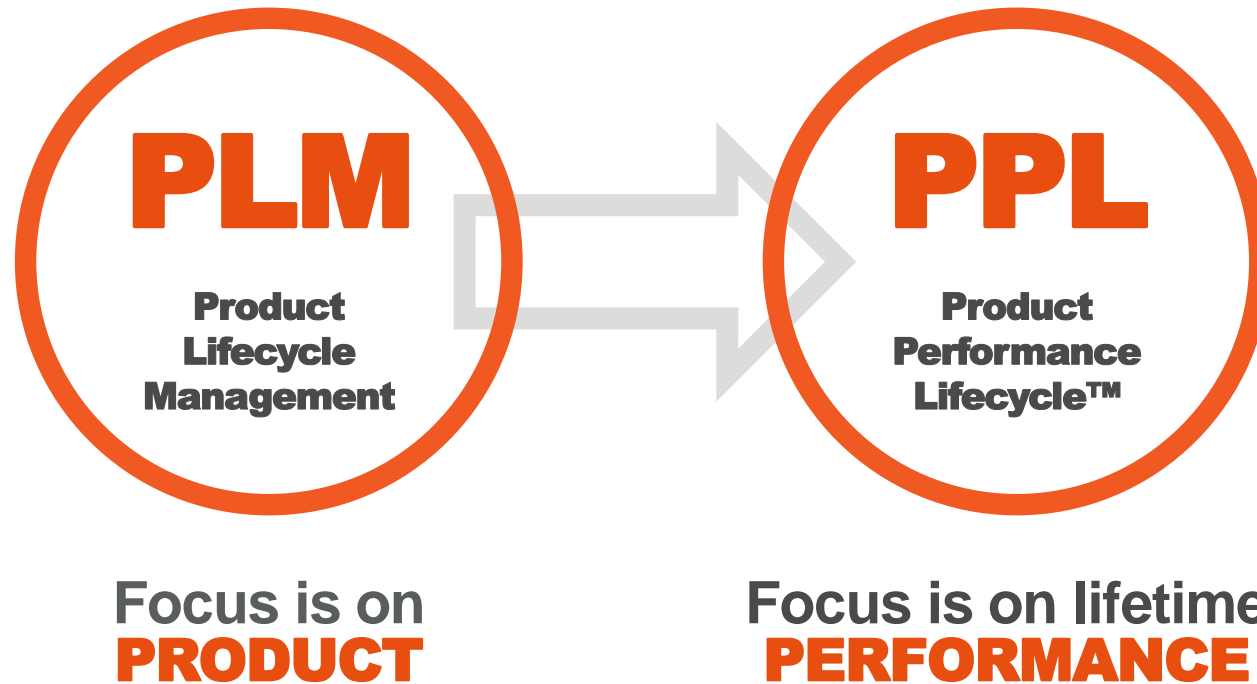
3 Smart **Safety**

4 Smart **Operator 4.0**

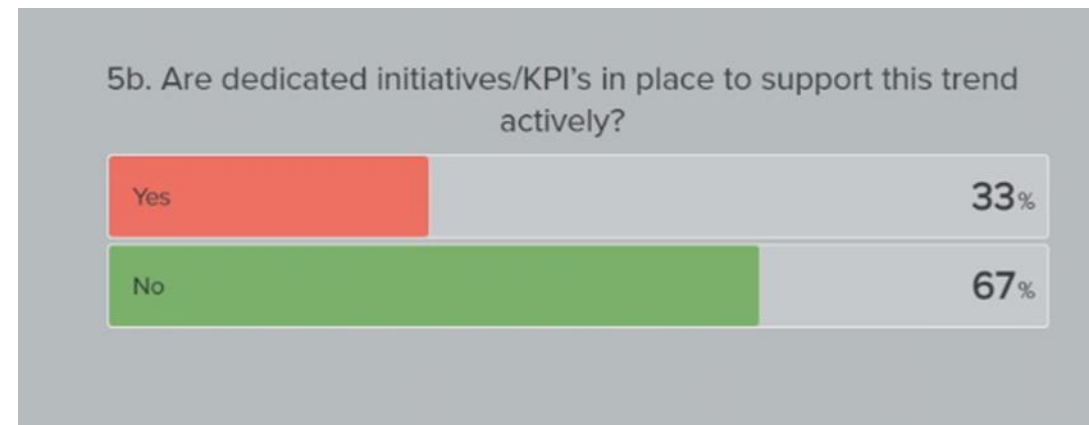
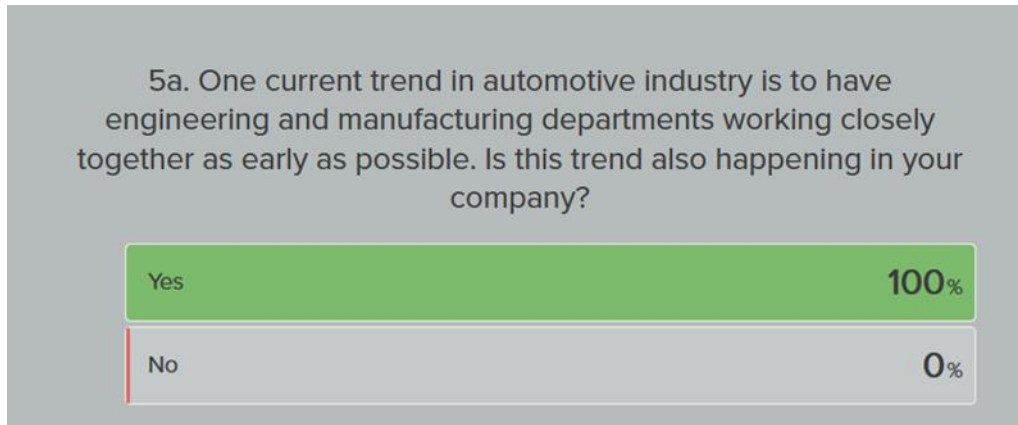
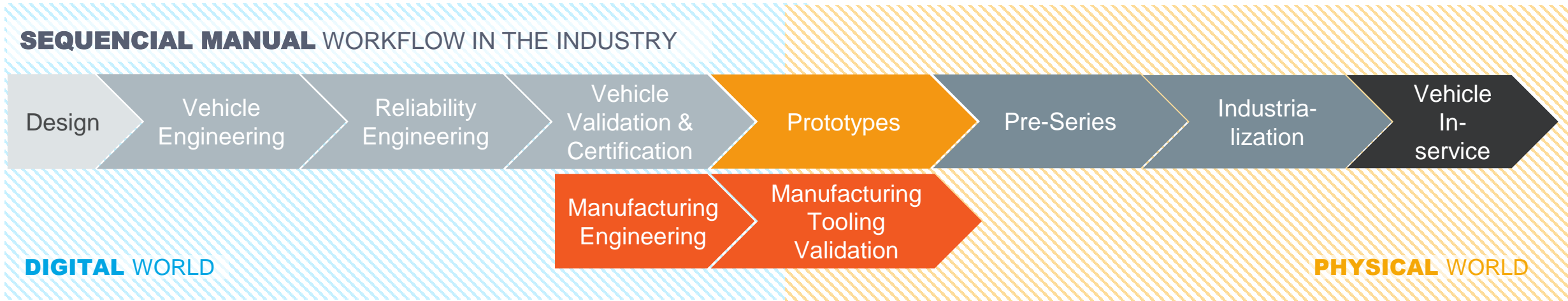
5 Smart **Cabin**

A Paradigm Shift

Towards Zero Downtime With Zero Physical Tests And Prototypes



Can You Currently Make the Right Decisions?



Non-representative ESI survey amongst decision-makers in the auto manufacturing space 3/21

Bridging Engineering and Manufacturing Worlds

SEQUENTIAL MANUAL WORKFLOW IN THE INDUSTRY

Design to Manufacturing

- Design right the 1st time
- Make decisions earlier and with higher confidence
- Reduce late manufacturing loops
- Minimize body & chassis manufacturing lead time

DIGITAL WORLD

Virtual Test With Virtual Prototypes

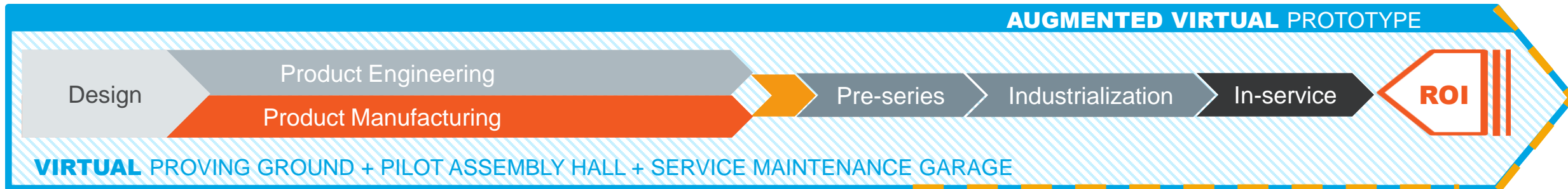
- Evolve towards zero physical prototypes to substantially decrease lead time and cost
- Overall reduced vehicle to market lead time while increased ROI

No Unexpected Downtime

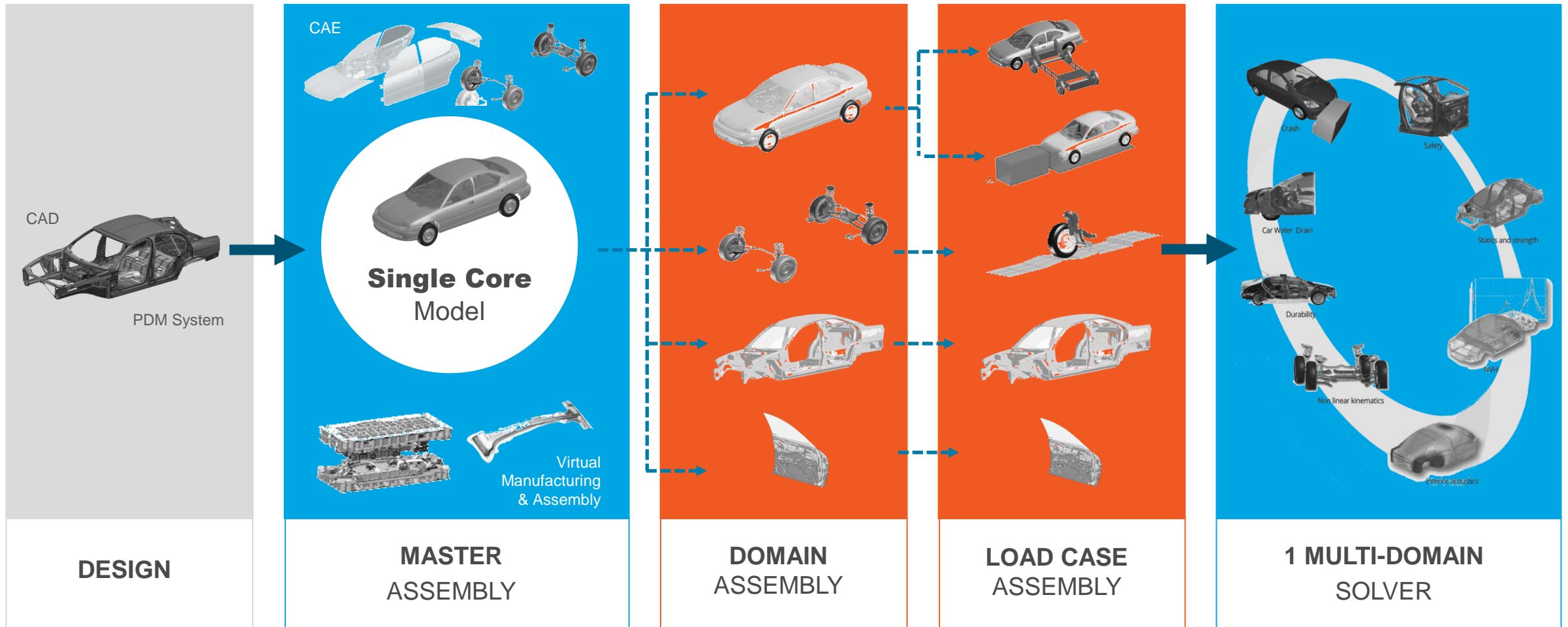
- Achieve maximum range without sacrificing comfort, safety, or cost

PHYSICAL WORLD

BLENDING VIRTUAL AND PHYSICAL –
THE **ART OF DECISION MAKING** @ESI

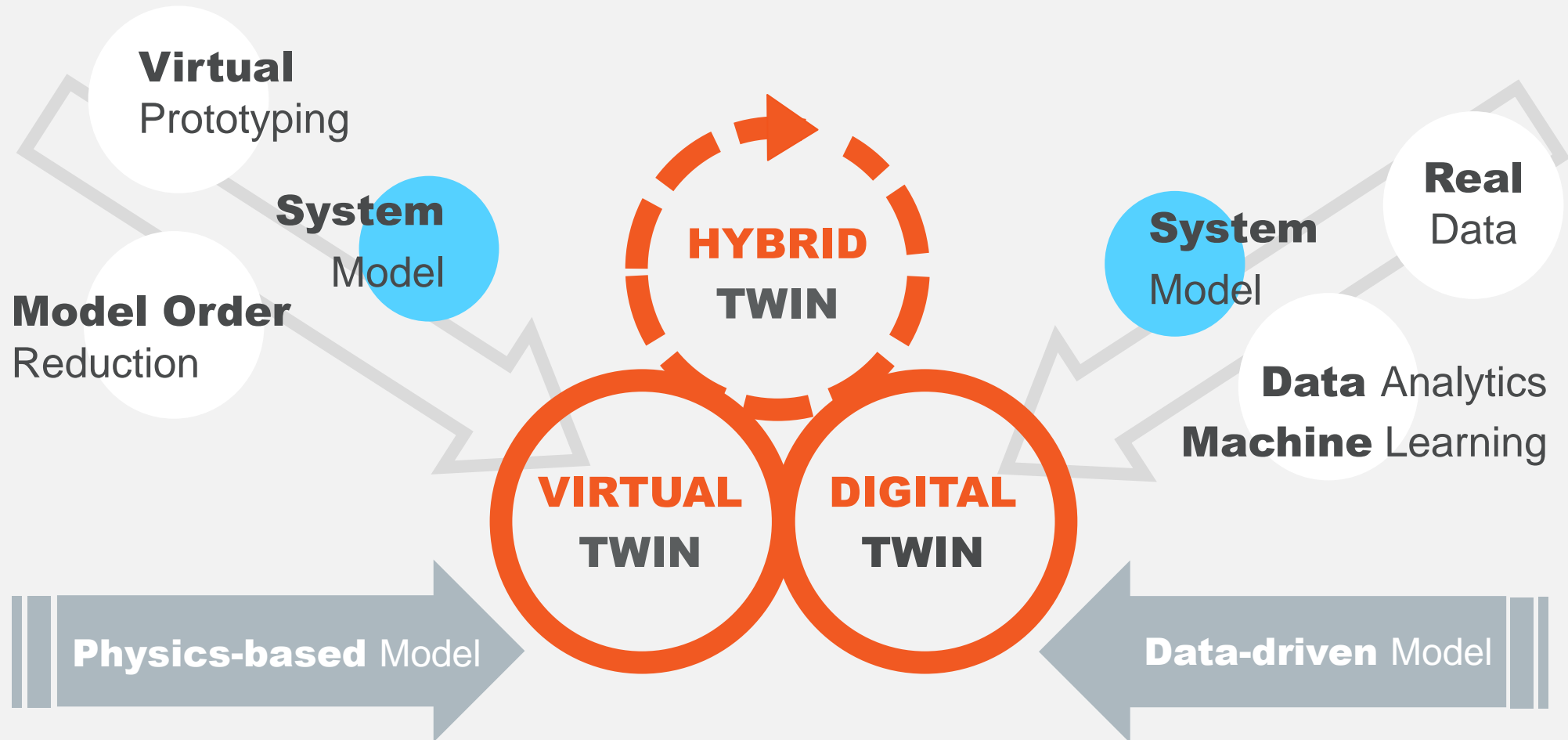


One Source of Truth for All Development Teams



Make the Right Decision at the Right Time for Your Asset

Make a Difference with the Hybrid Twin



Multi-Material Joining and Assembly of Chassis & Body

Topics

Product Design
Performance Engineering
Parts Manufacturing
Assembly Manufacturing

Spotlight on **Pain Points**

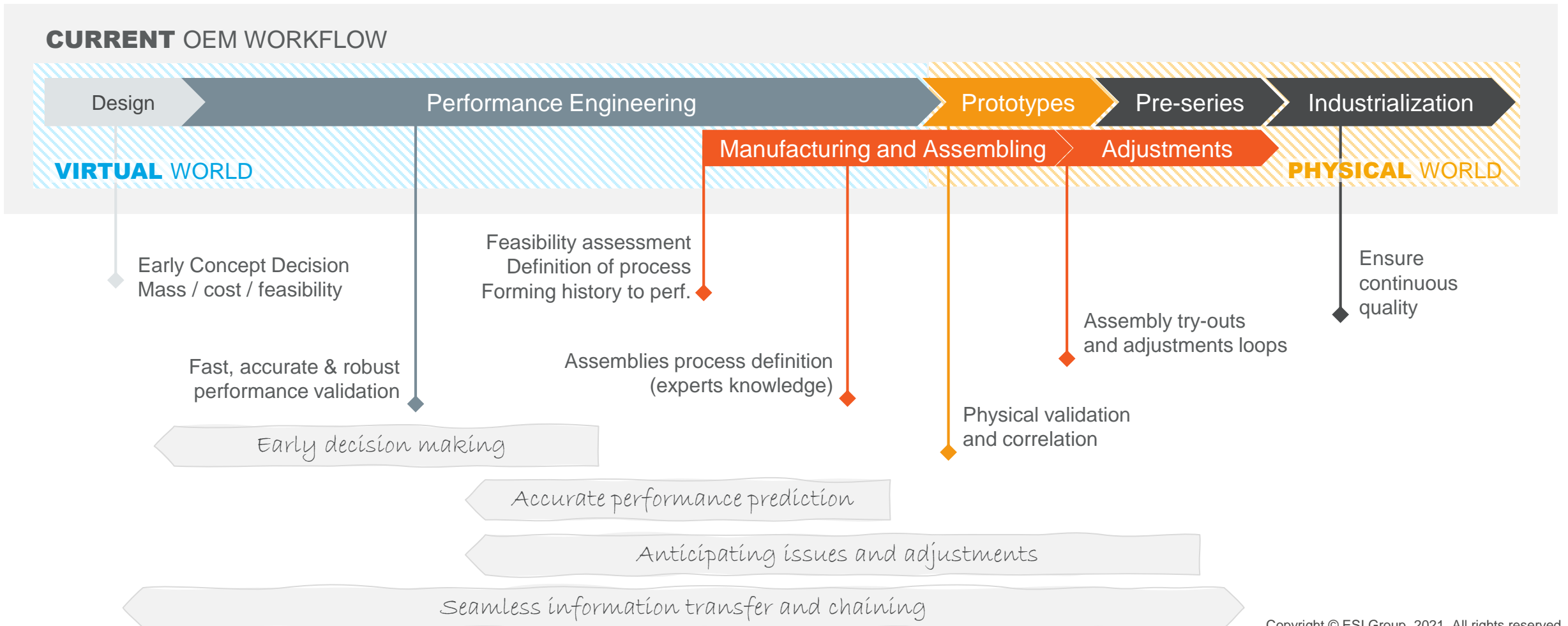
OEM'S AND TIER 1 SUPPLIERS MUST SOLVE THE MULTI-PROCESS AND MULTI-JOINING CHALLENGE

- Increasing demand for lightweight vehicles
 - linked to CO₂ emissions reduction
 - improvement of range for electrified vehicles
 - high demand for multi-material
- Multiplication of body variants increases complexity of manufacturing strategies
- Growing need to reduce physical prototyping cost in pre-production
- Ever rising quality standards

- Manufacturing & Assembly process digitalization as a key driver for answering those challenges



Adapt and Improve Workflows and Methodologies



Saving Potential in Conventional BiW Assembly

CURRENT OEM WORKFLOW



40,000,000 \$ per car program globally and annually: Total physical try-out cost for BiW assembly validation

10,000,000 \$ cost per program: Dimensional & perceived quality between body shop and trim / final assembly

3,000,000 \$ cost globally: Automotive geometrical & perceived quality

2,000,000 \$ cost per program: Body shop corrections & mitigations due to dimensional issues

2,000,000 \$ cost per program: Cost of Logistics and Human Resources

1,000,000 \$ cost per year: Cost of Physical prototypes for performances testing

100,000 \$ cost per resource: Full time employee added to the line for manual corrections

40,000 \$ cost per geo. fit issue: Analysis and correction of one sample geometrical fit issue at the line

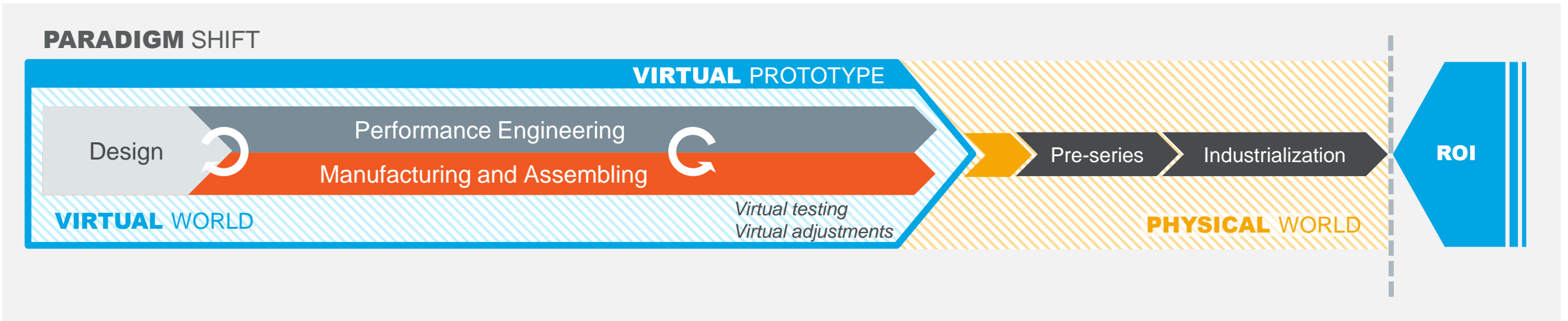
35,000 \$ cost per clamp: Two additional clamps added to an assembly fixture

+\$\$\$\$ 2-3 customer claims per year due to geometrical issues

+\$\$\$\$ Cost for dimensional & perceived quality issues reaching trim & final can be even higher than body shop costs



Digitalization Towards **End-to-end Virtual Prototyping**



MOVE TOWARDS ZERO
REDUCE RELIANCE ON PHYSICAL
PROTOTYPE FOR DECREASED
LEAD TIME AND COST

4 Key Domains For Body/Chassis Assemblies

1 Product Design

Definition of the new product design, architecture and **concept decision**

2 Performance Engineering

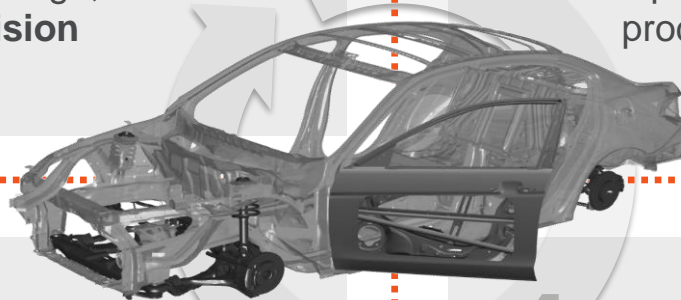
Optimization and **validation** of the product performances **as manufactured**

3 Parts Manufacturing

Definition and **accurate** validation of the single part manufacturing, **optimization** of the process parameters

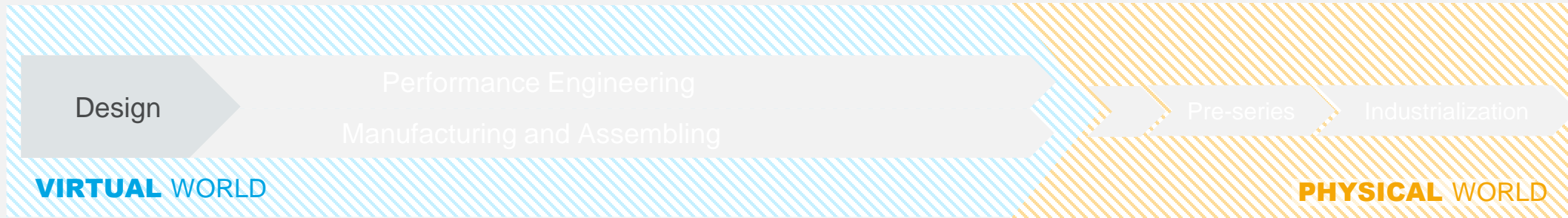
4 Assemblies Manufacturing

Evaluation of joining technology and **validation** of the **assembly dimensional quality** (tolerances and perceived quality criteria)



How ESI Chained Solutions **Shorten Time to Market I**

PARADIGM SHIFT



Product Design

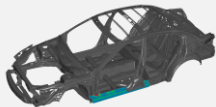
Ensure feasibility of new design

Doors and Closures

Body In White

Chassis

Estimate manufacturing feasibility as support for early decisions

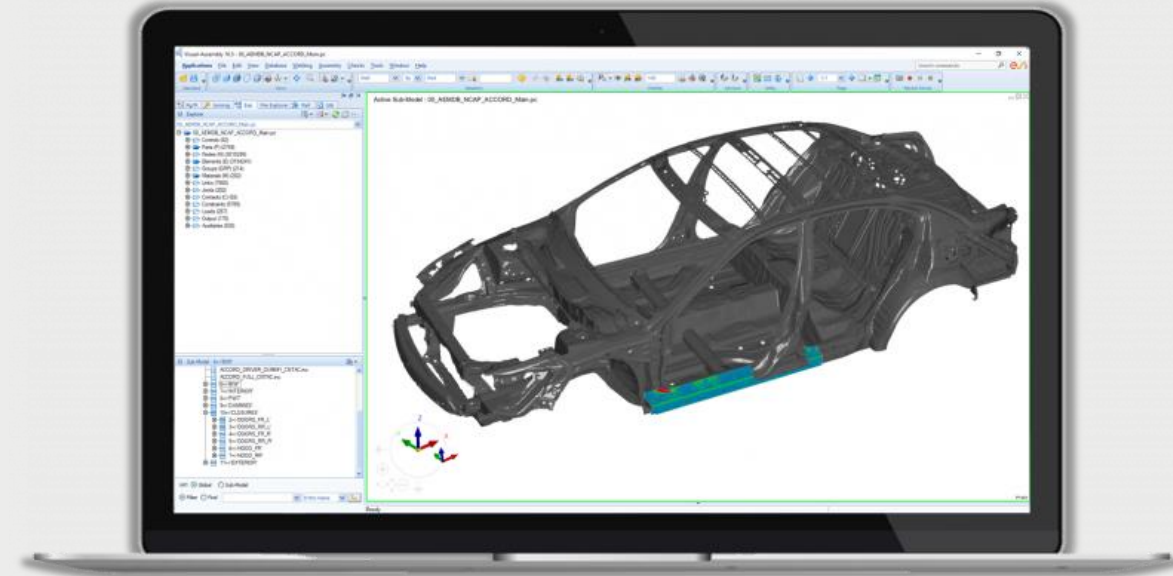


(Segment 1)

Early Manufacturing Feasibility Analysis

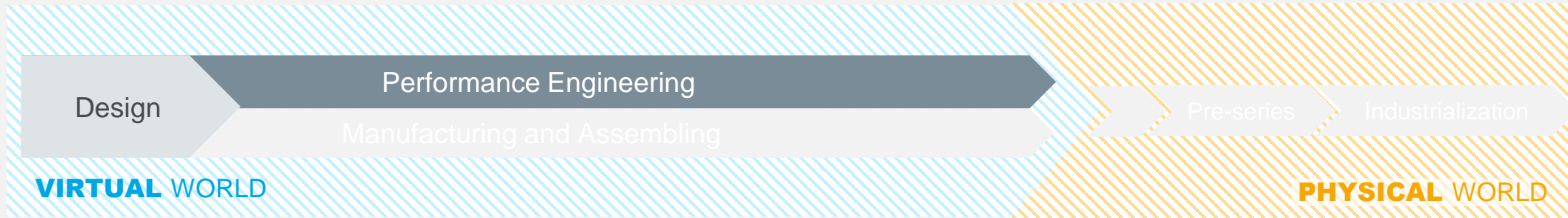
ESTIMATE MORE ACCURATELY THE FEASIBILITY OF A NEW DESIGN FOR EARLY DECISION MAKING

- Evaluate stamping operations without tooling definition
- Bring more accuracy to part cost estimations
- Anticipate critical manufacturing road blocker since the beginning of the project



How ESI Chained Solutions **Shorten Time to Market II**

PARADIGM SHIFT



Product Design

Performance Engineering

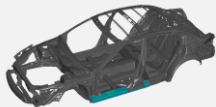
Ensure feasibility of new design

Doors and Closures

Body In White

Chassis

Estimate manufacturing feasibility as support for early decisions

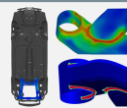


(Segment 1)

Predict Manufacturing & Joining process effects on **Crash performance**



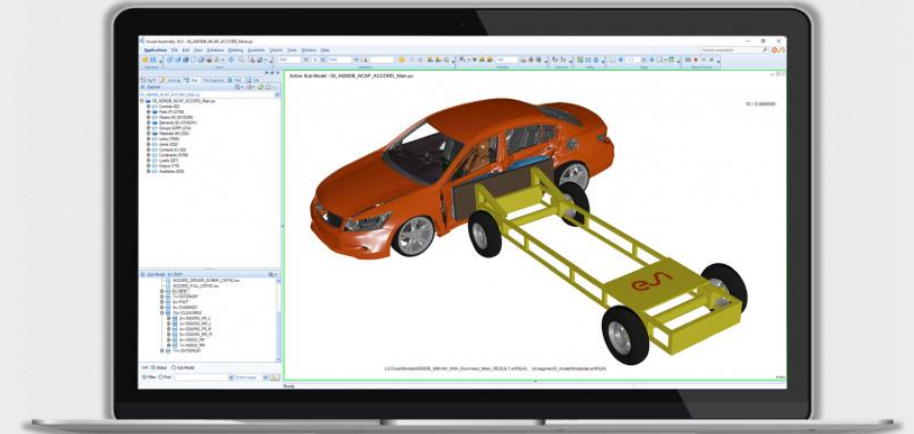
“...” on **Fatigue performance**



Validate BiW & Chassis Performance as Manufactured

MULTI DOMAIN, END-TO-END APPROACH BY CHAINING FORMING & WELDING EFFECTS TO PERFORMANCE EVALUATION

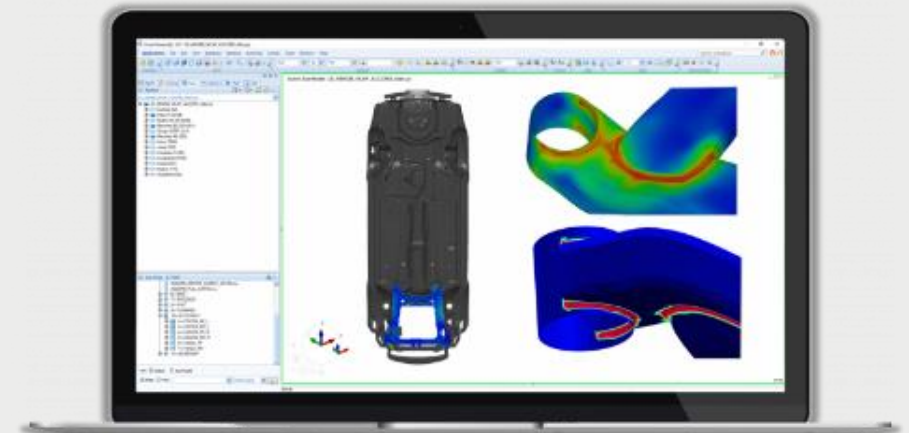
- More confidence in performance evaluation by mapping manufacturing effects
- Avoid unforeseen cracks in late-stage prototype crash test
- Ensure failure prevention in service life



STAMP

WELD

CRASH



STAMP

CLAMP

WELD

PAINT

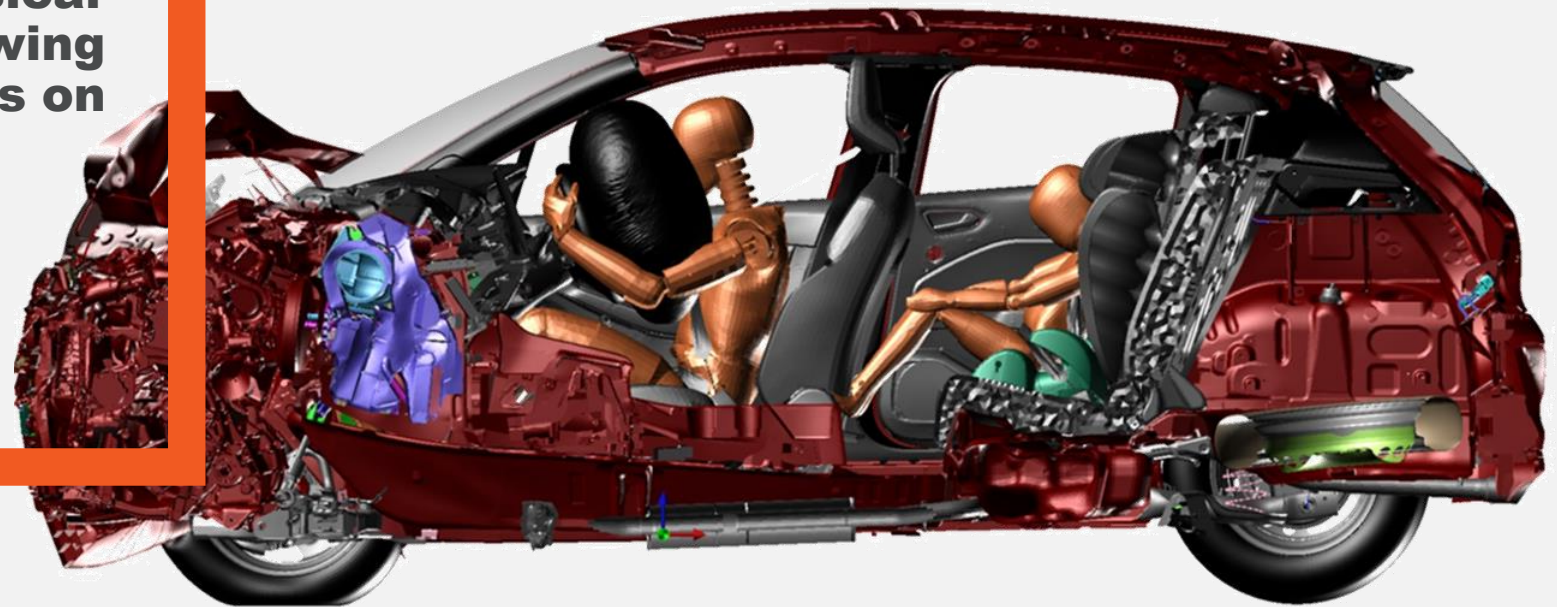
DURABILITY

“The consistent chaining of virtual manufacturing results and virtual performance for crash and safety as well as for NVH and durability is a definite technological breakthrough, ensuring the right levels of product performance for lightweight design.”

EISEI HIGUCHI HONDA R&D

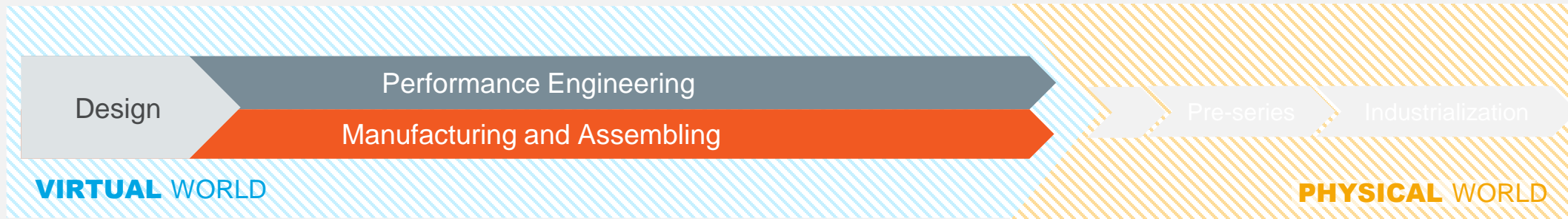
“Thanks to ESI [...] we succeeded in developing one of our new vehicles, achieving good physical tests right the first time, allowing us to earn the whole five stars on the Euro NCAP safety test, following its stricter protocol launched in 2018.”

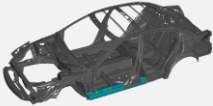

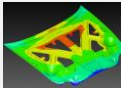
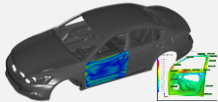
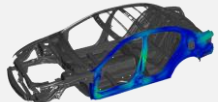

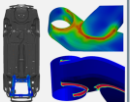
OLIVIER COLMARD RENAULT



How ESI Chained Solutions **Shorten Time to Market III**

PARADIGM SHIFT

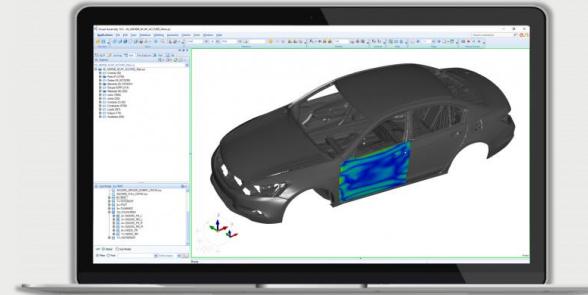


	Product Design	Performance Engineering	Manufacturing	Assembly
	Ensure feasibility of new design	Validate Performances as Manufactured	Accurate Manufacturing	Ensure Assembly Quality
Doors and Closures	Estimate manufacturing feasibility as support for early decisions 	Predict Manufacturing & Joining process effects on Crash performance 	Single part manufacturing 	Anticipate/control/ optimize Distortions & Perceived quality 
Body In White				Anticipate/control/ optimize Distortions on BIW assemblies 
Chassis				Anticipate/control/ optimize Distortions on Chassis assemblies 
		"..." on Fatigue performance 		

Closures, BiW and Chassis Dimensional Accuracy

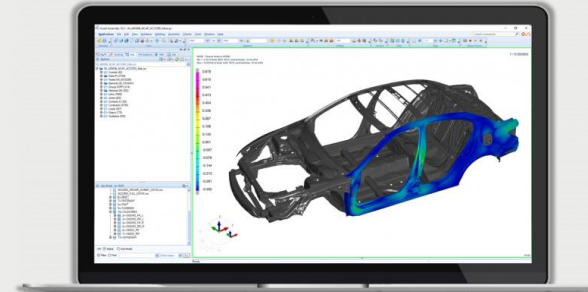
ENABLE VIRTUAL ASSEMBLY ALL ALONG THE DEVELOPMENT PROCESS

- Support assembly validation process in pre-production phase
- Reduce physical prototype testing and try outs
- Optimize the whole assembly validation process integrating virtual trials in earlier development phases
- Anticipate tooling/ fixtures definition and compensation decisions



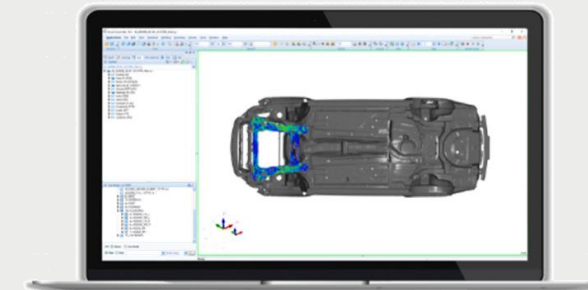
Doors and Closures

Plan Joining and hemming processes and check the perceived quality in the Virtual Light Room



Body in White

Predict distortions to optimize the assembly process definition and reduce physical try outs



Chassis

Predict thermal welding effects and control earlier the quality of the assemblies

CUSTOMER SUCCESS
Groupe PSA

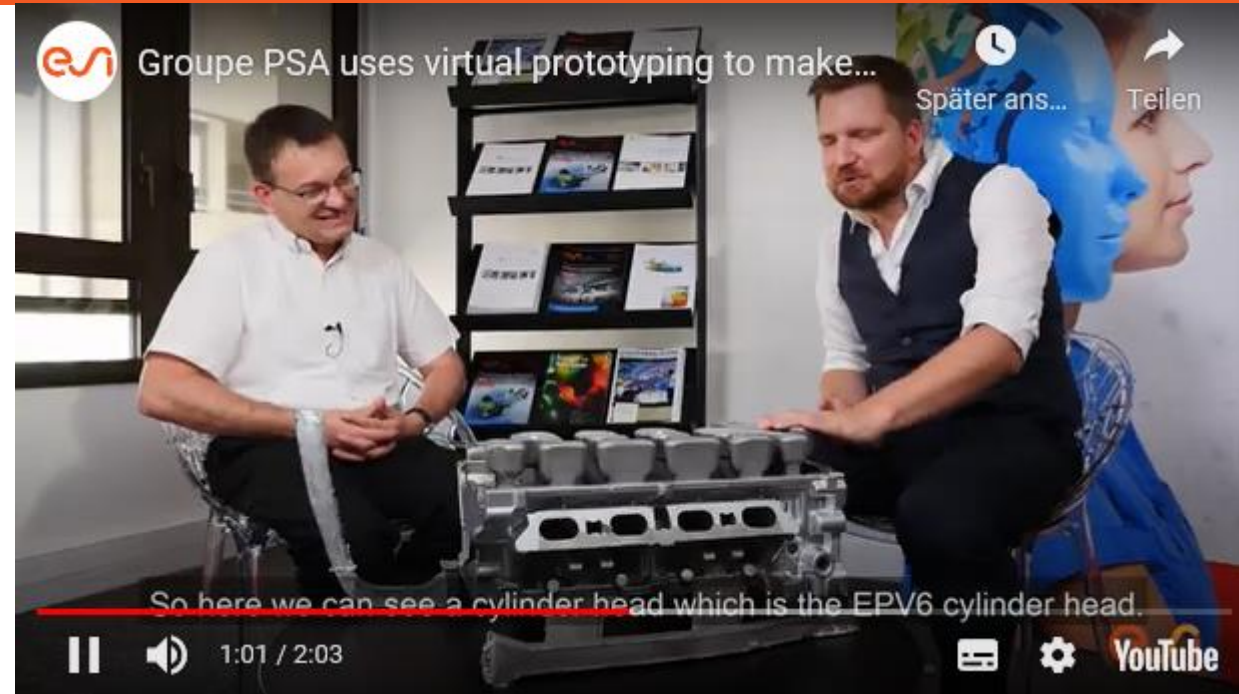
Groupe PSA uses virtual prototyping to make the right decisions in their casting process

Highlights

“There is no prototype phase in our development procedure anymore.”

Key Performance Indicator

robustness and reliability are key
engineers are solving 98% of process manufacturing issues without the help of any simulation expert or any real prototype





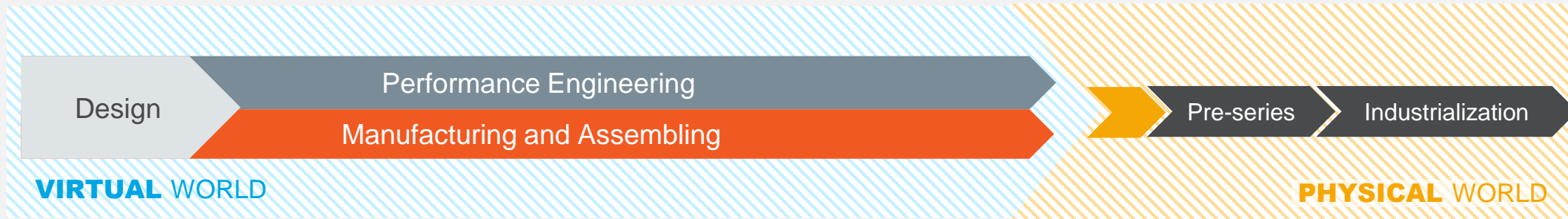
Nissan reduced engineering lead times for new lightweight material by as much as 50%.

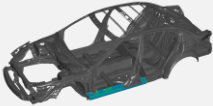

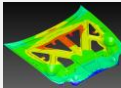
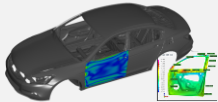
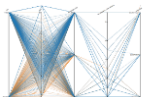
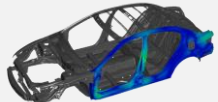
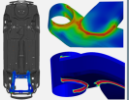
“We achieved very good results thanks to the accuracy of the simulation [and...] were able to [...] evaluate the die compensation, despite the complexity of such a case with three different thicknesses and two weld lines. “

EDUARDO SULATO & FÁBIO LICHTENTHÄLER **GESTAMP**

How ESI Chained Solutions Shorten Time to Market IV

PARADIGM SHIFT



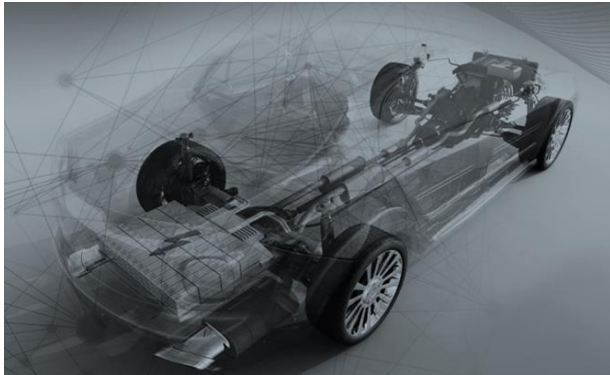
	Product Design	Performance Engineering	Manufacturing	Assembly	Indus. / In Service
	Ensure feasibility of new design	Validate Performances as Manufactured	Accurate Manufacturing	Ensure Assembly Quality	Improve Productivity
Doors and Closures	Estimate manufacturing feasibility as support for early decisions 	Predict Manufacturing & Joining process effects on Crash performance 	Single part manufacturing 	Anticipate/control/ optimize Distortions & Perceived quality 	Assembly Operation Performances Hybrid Twin of Assembly Line 
Body In White				Anticipate/control/ optimize Distortions on BIW assemblies 	
Chassis				"..." on Fatigue performance 	

Electrification & Battery

Topics

Go the Distance
Enjoy the Journey
Safety First
Green & Affordable

Build High-Performance Batteries That Go the Distance



Go the **Distance**



Enjoy the Journey



Put **Safety First**

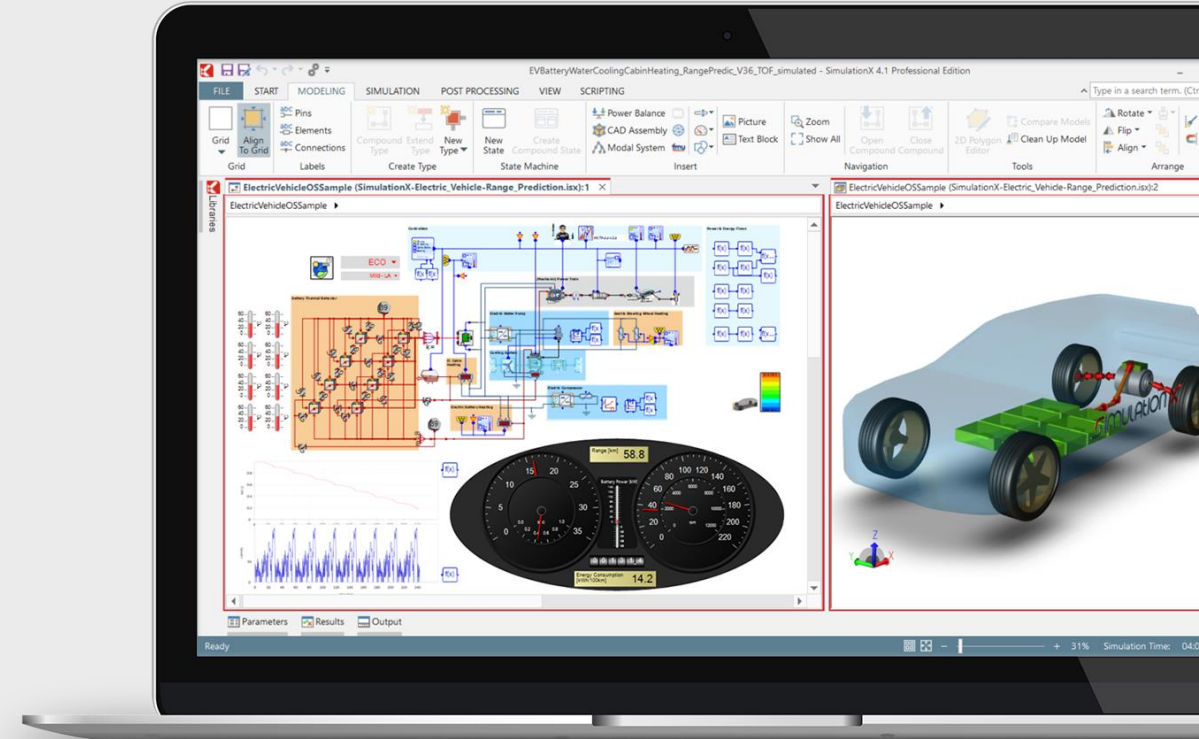


Make it **Green & Affordable**

Find the Optimal Electric Vehicle Setup

FIND THE OPTIMAL VEHICLE TOPOLOGY AND OPERATING STRATEGY IN LINE WITH RANGE REQUIREMENTS AND VEHICLE CHARACTER

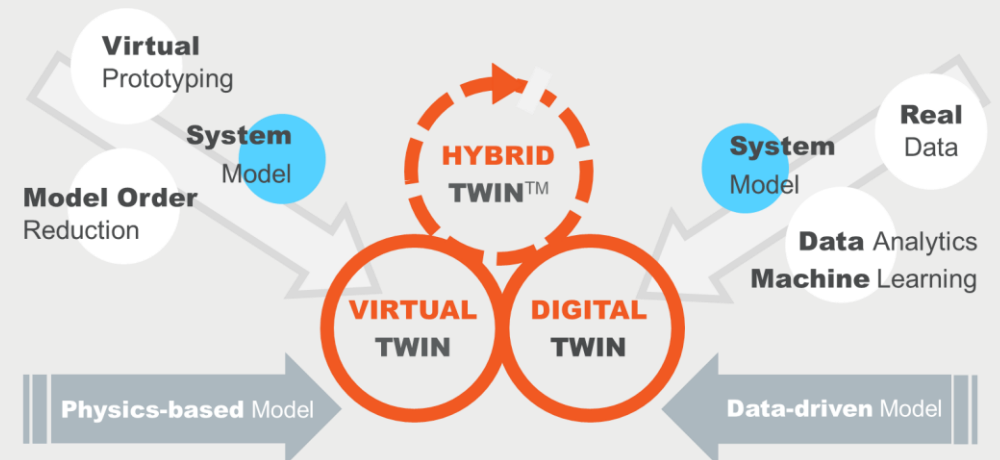
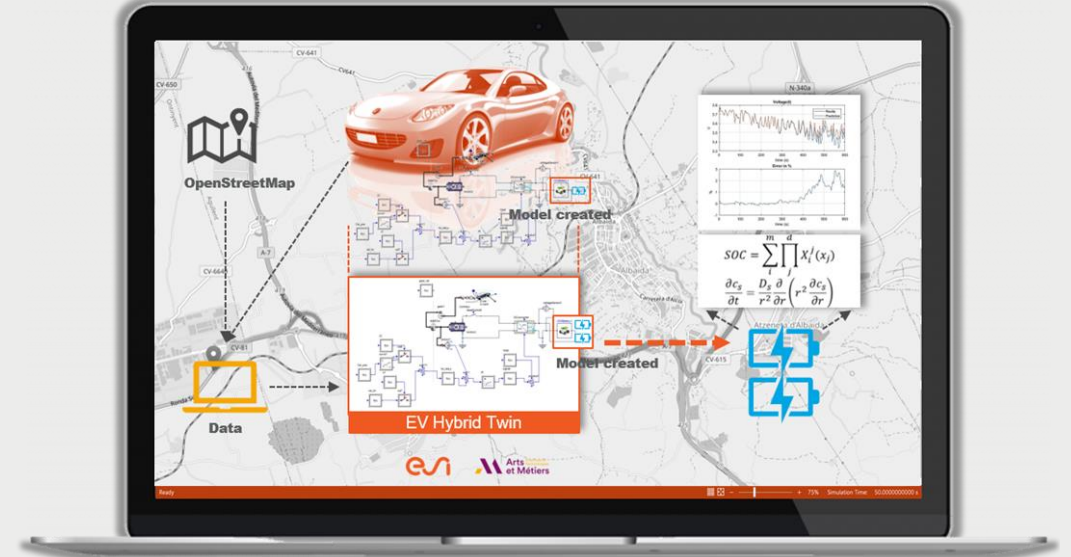
- Define vehicle system requirements for all components and subsystems
- Evaluate range under various route profiles and climate conditions
- Test and optimize different operation strategies and controller settings
- Find the optimal balance between all hardware and software configurations



Pre-Experience Vehicle Performance

FIND THE OPTIMAL BALANCE BETWEEN PASSENGER BEHAVIOR, ENVIRONMENT, AND VEHICLE PROPERTIES WITH HYBRID TWIN TECHNOLOGIES

- Vehicle health monitoring, diagnostics & prognostics
- Reduce failures & unplanned down time, maintenance and operations cost
- Explore energy storage & charging capabilities



CUSTOMER SUCCESS

AUDI

Maximizes the Driving Range and Acoustic Quality of the New e-tron

Highlights

Innovate aerodynamic features like enclosed air flow and virtual exterior mirrors to lower energy consumption

Virtual feature test before producing the first prototype

Key Performance Indicator

Reduce vehicle drag coefficient down to 0.27 - a top rating in the SUV segment

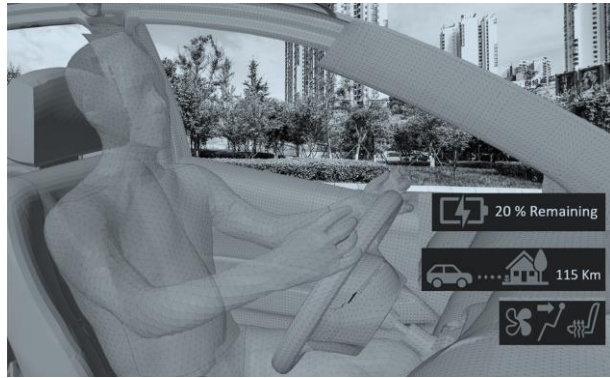
Deliver exceptional validation capabilities at the right time



Creating an Excellent **Passenger Experience**



Go the **Distance**



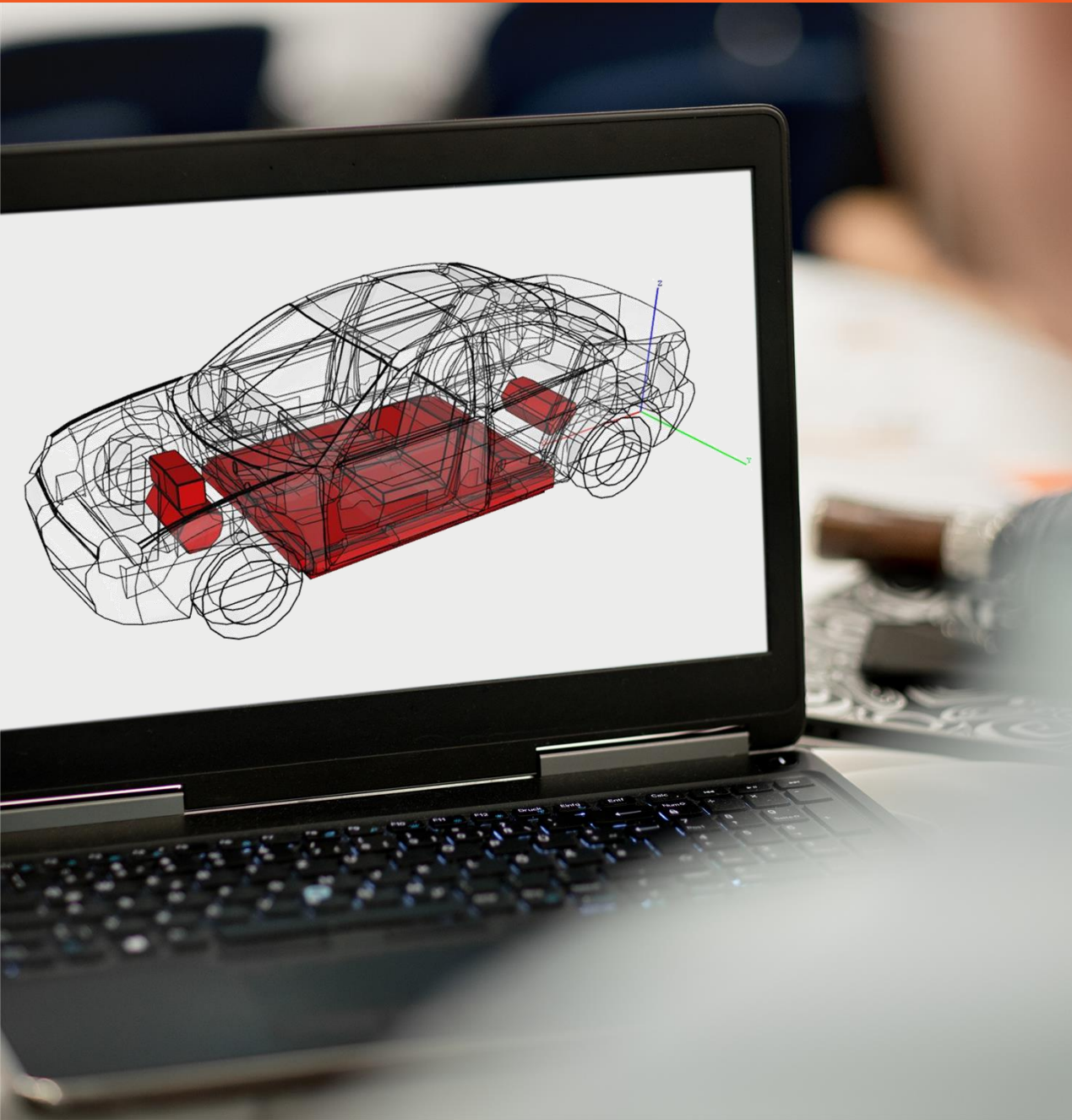
Enjoy the Journey



Put **Safety First**



Make it **Green & Affordable**

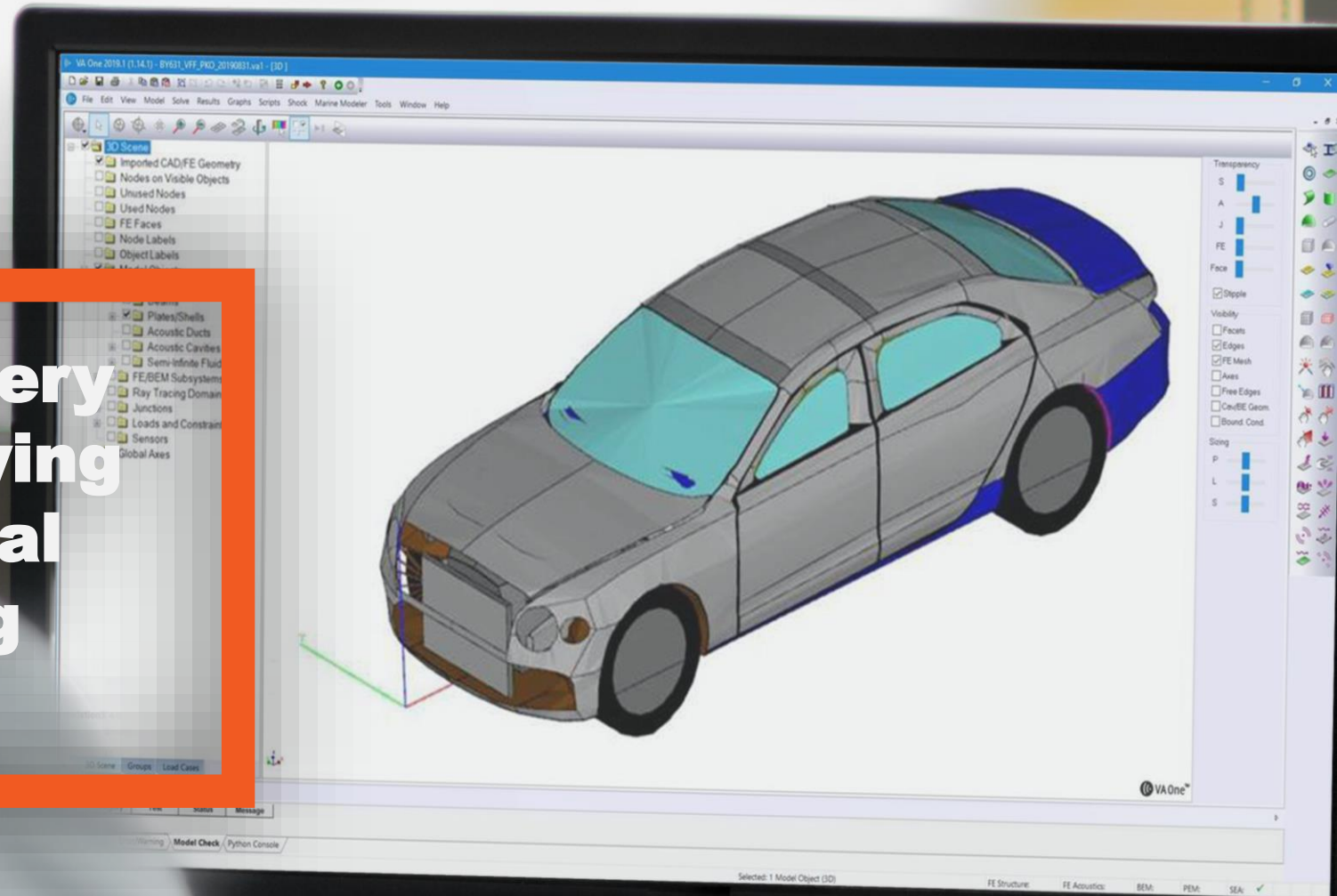


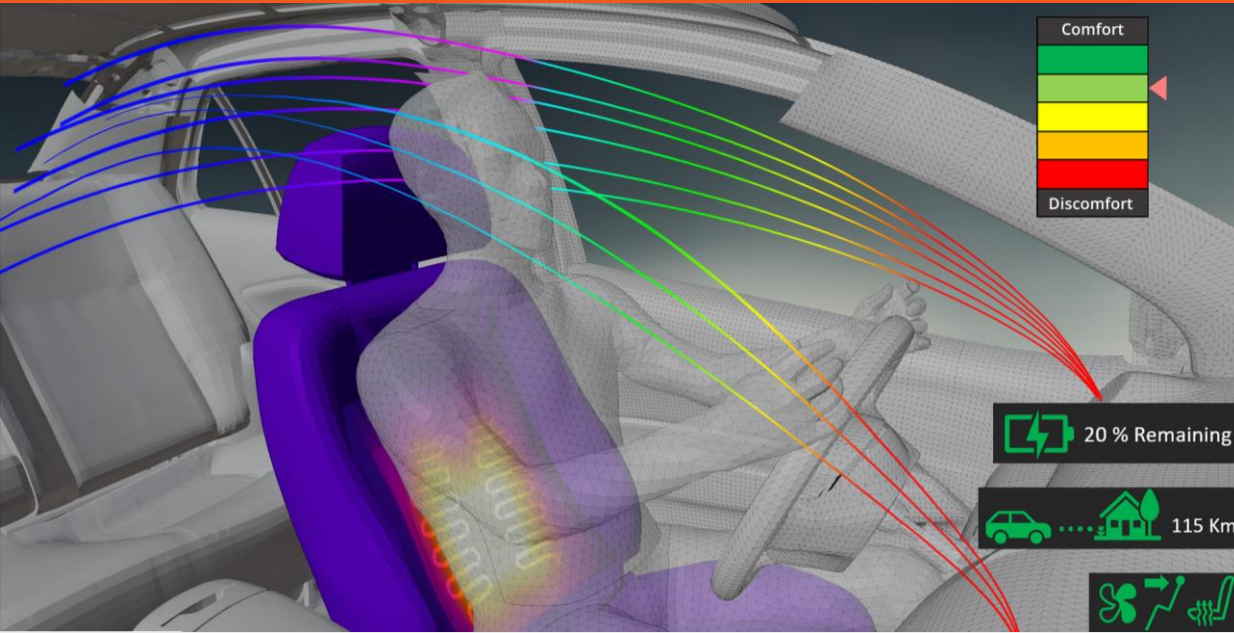
Remove Undesired **Interior Noises**

VIRTUALLY TEST AND OPTIMIZE ACOUSTIC EV PERFORMANCE TO CREATE EXCELLENT PASSENGER EXPERIENCE

- Maximize acoustic comfort level by solving new audible noise such as wind noise
 - Detect noise sources and path early in product development and optimize the design
- Create a truly enjoyable auditory experience with smooth voice-activated infotainment system interactions and individualized sound zones

Bentley optimized every component of the Flying Spur first in the virtual world before creating physical parts.

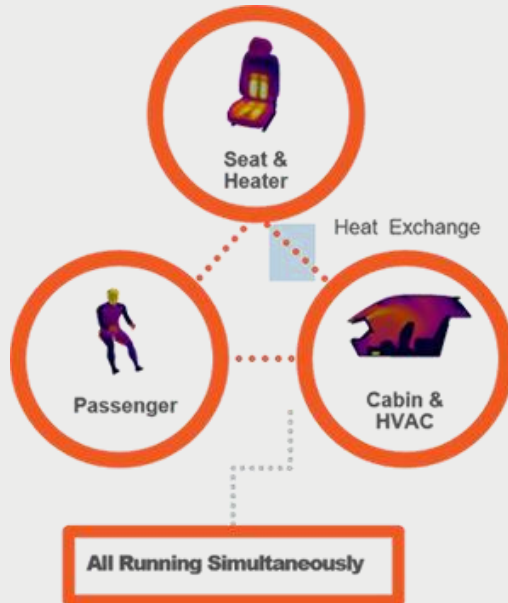




Ensure Efficient **Thermal Comfort**

ENSURE BOTH MAXIMUM COMFORT AND MAXIMUM RANGE

- Test different design variants and evaluate their impact on thermal comfort and on battery consumption
- Optimize HVAC, thermal and climate systems early in the development phases



Put Safety First and Make Vision Zero Come True



Go the **Distance**



Enjoy the Journey



Put **Safety First**

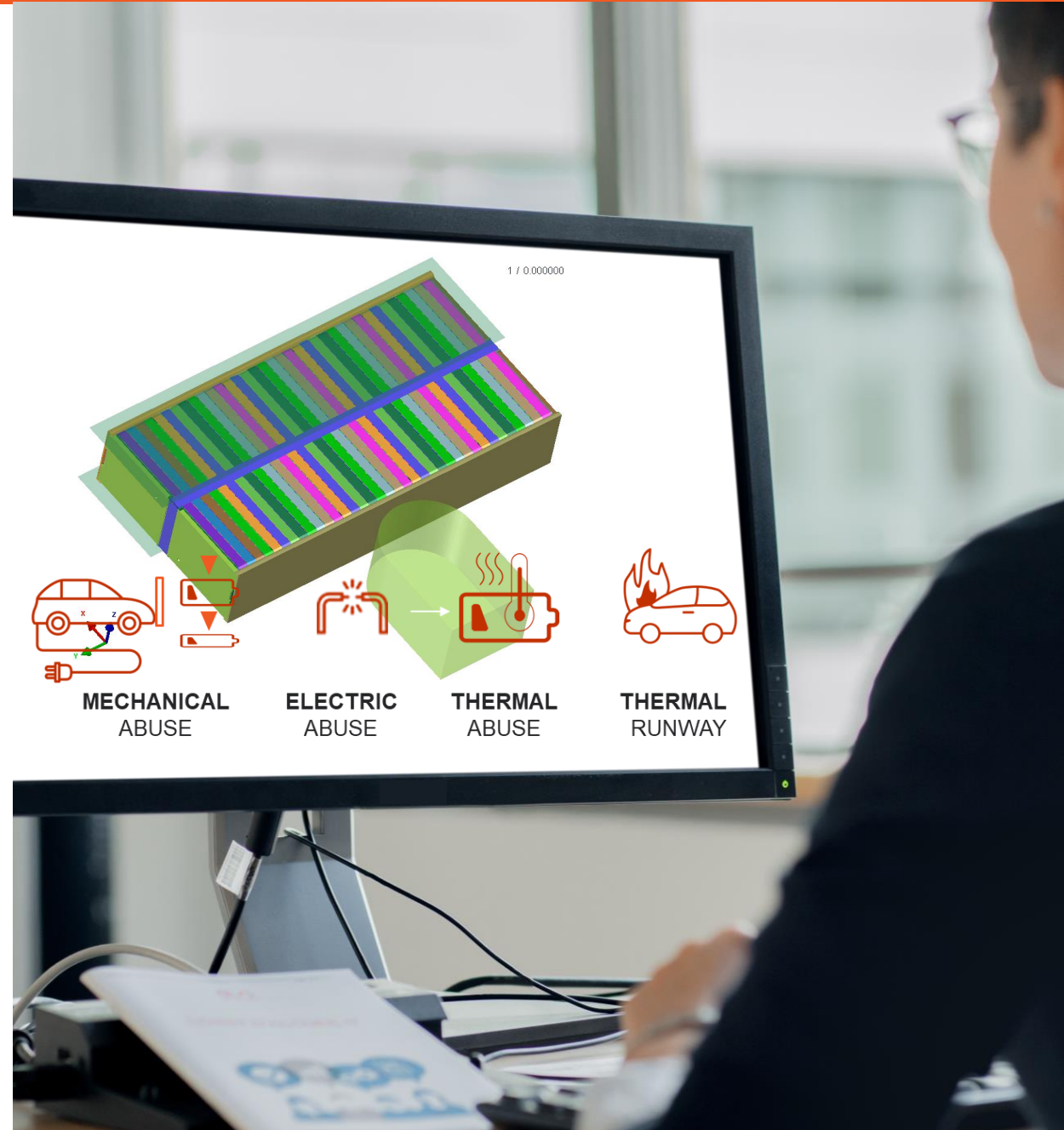


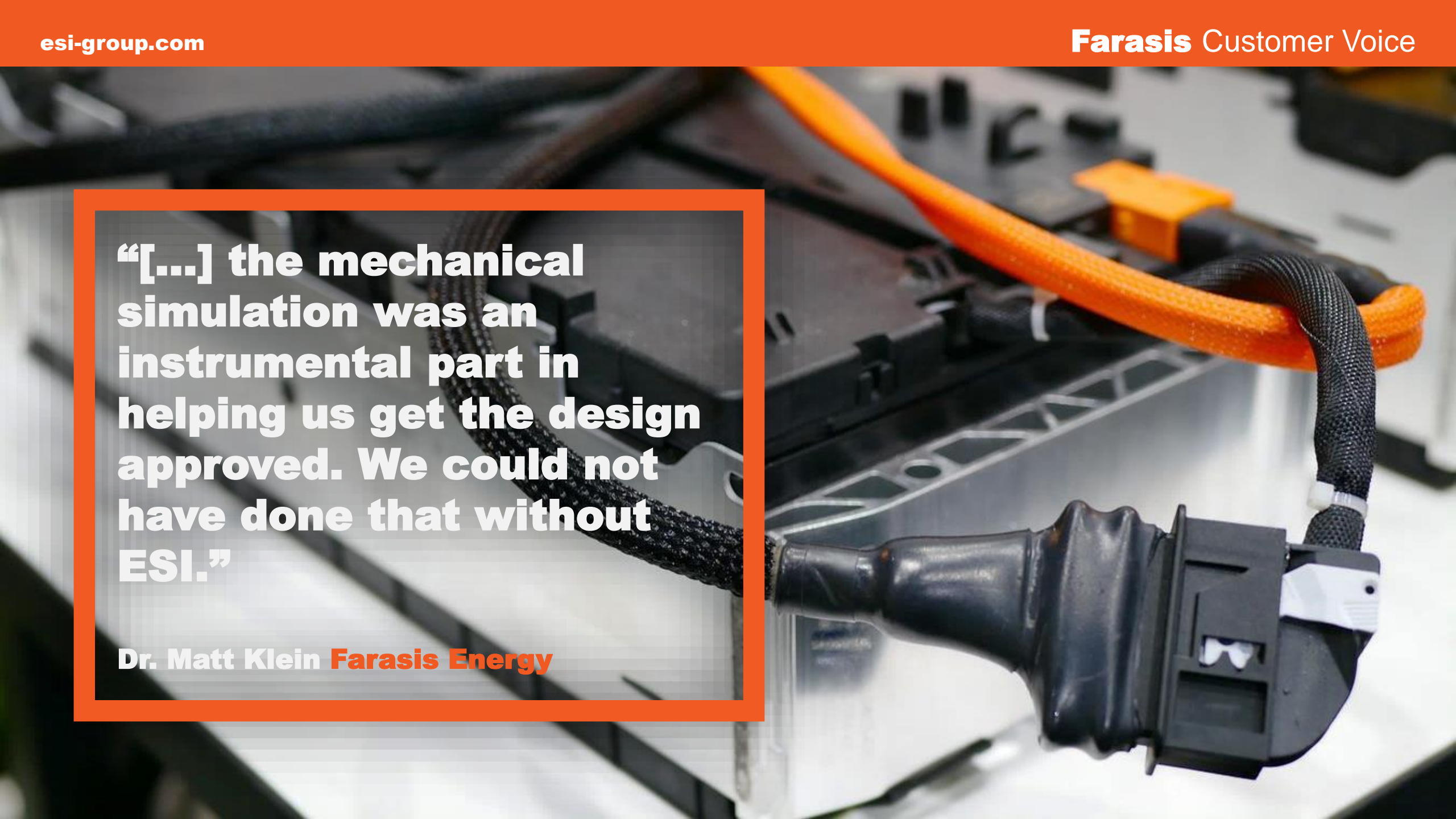
Make it **Green & Affordable**

KEEP UP WITH **BATTERY-SPECIFIC SAFETY NORMS**

DEVELOP POWERFUL BATTERY SYSTEMS THAT MEET SAFETY REGULATIONS

- Protect car occupants & pedestrians in case of emergency
 - Cell failure
 - Thermal runaway
 - Propagation
- Extend car lifespan ensuring safety and durability requirements are met





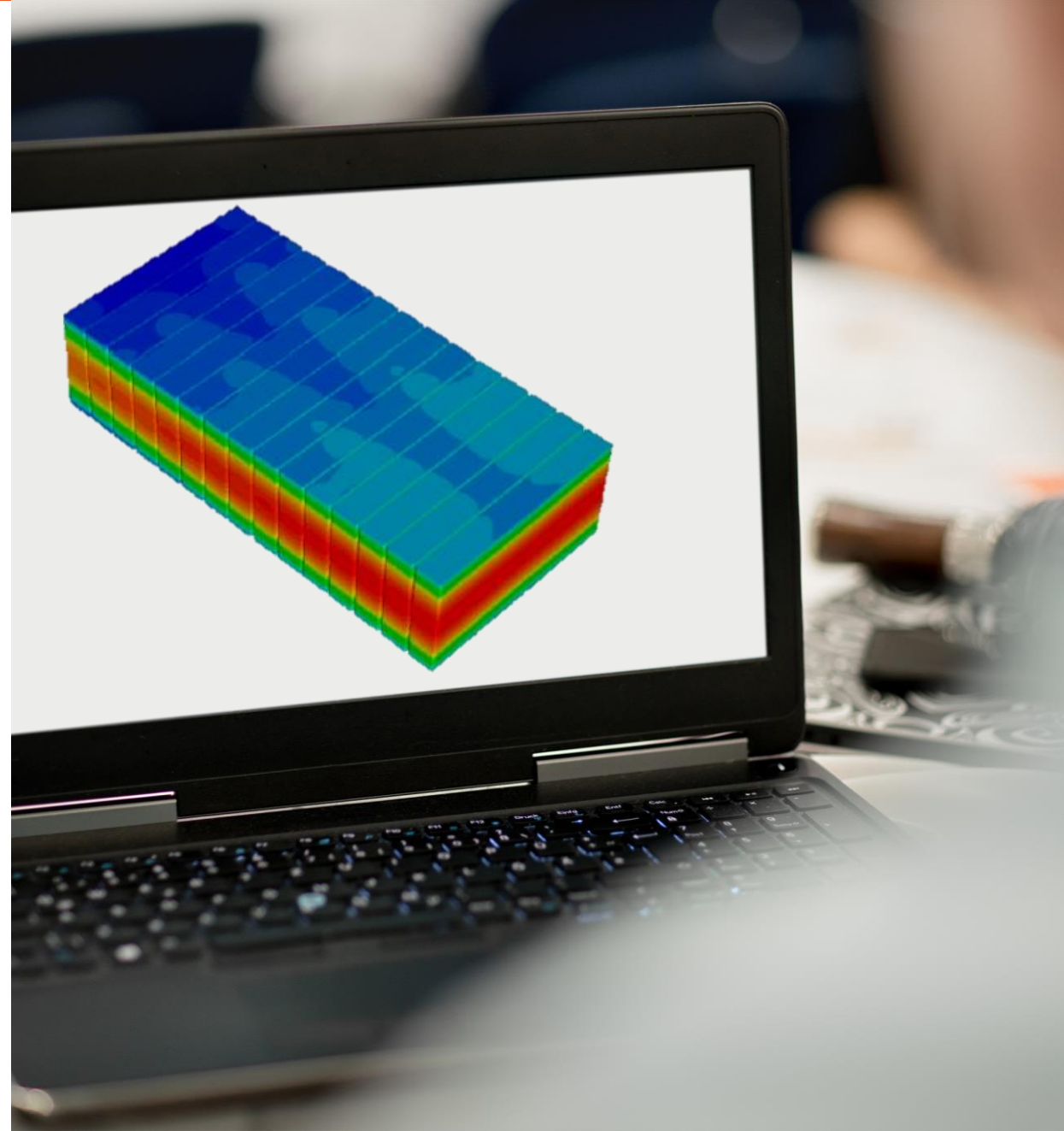
“[...] the mechanical simulation was an instrumental part in helping us get the design approved. We could not have done that without ESI.”

Dr. Matt Klein Farasis Energy

Effective Battery **Thermal Management**

FIND THE OPTIMUM THERMAL MANAGEMENT CONCEPT FOR THE BATTERY

- Understand battery heat generation
- Validate temperature distribution
- Run parameter studies to optimize battery cooling
 - Liquid cooling
 - Air cooling



RESEARCH STORY

upscale

Develop future advanced occupant protection systems covering main challenges of road safety with highly automated vehicles

Highlights

Upscaling product development simulation capabilities exploiting Artificial Intelligence for Electric Vehicles
Ensure batteries & full EV crash certification with accurate vehicle aero, thermal and crash modeling

Key Performance Indicator

Reduce development time by 20%
Increase vehicle performance



Make Noise Around Silence

FIND THE OPTIMUM SOUND MIX FOR ACOUSTIC VEHICLE ALERTING SYSTEM AND ENSURE ULTIMATE PEDESTRIAN SAFETY

- Ensure compliance with requirements on pedestrian safety and injury risk functions e.g. UN R138R1
- Proof virtually that EVs are safe for pedestrians when driving silently at low speed
 - Optimize warning devices
 - Explore the interaction of acoustic warning system with surroundings



Achieve Manufacturability, Dimensional Accuracy And Operational Excellence



Go the **Distance**



Enjoy the Journey



Put **Safety First**



Make it **Green & Affordable**

Human-Centric **Cell Design**

INTEGRATE AND BUILD YOUR NEXT ELECTRIC VEHICLE AS PLANNED BY KEEPING AN EYE ON INTERACTIONS BETWEEN HUMANS, PRODUCTS AND PROCESSES

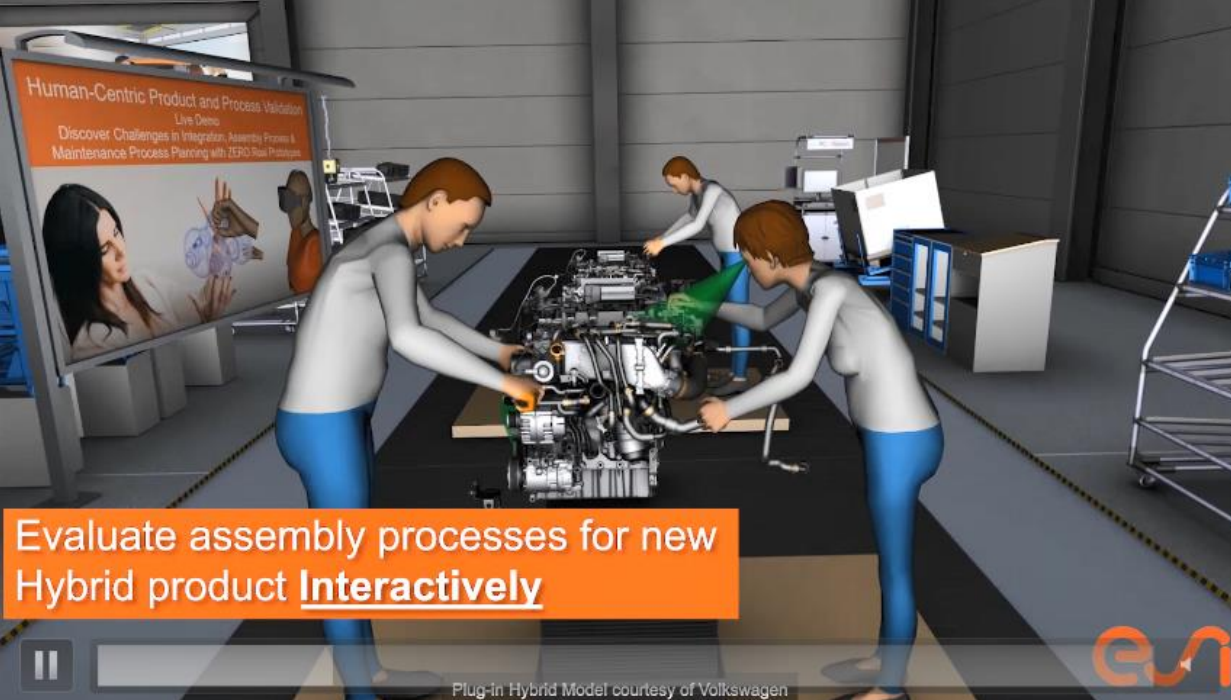
- Validate designs through eyes of operators
- Visualize concepts before they exist
- Deliver better safety and ergonomics for EV factory operations
- Increase ROI by getting electric vehicles and processes right the first time




Affordable Manufacturing of Sustainable Mobility

TOWARDS MASS ADOPTION OF NEW MOBILITY DEVICES WITH COST EFFECTIVE MANUFACTURING AND SUSTAINABLE PRODUCT VALIDATION

- Establish low impact manufacturing processes for die casting and moulding
- Define right composite process
- Get assembly distortion under control
- Ensure battery reuse for minimal environmental impact





BMW, Ford, Jaguar Land Rover, and Volkswagen count on ESI's Human Centric solution to predict the downstream impact of design decisions, validate ad-hoc design changes, and enable cross-functional teams to visualize cause and effect relationships.

Smart Safety

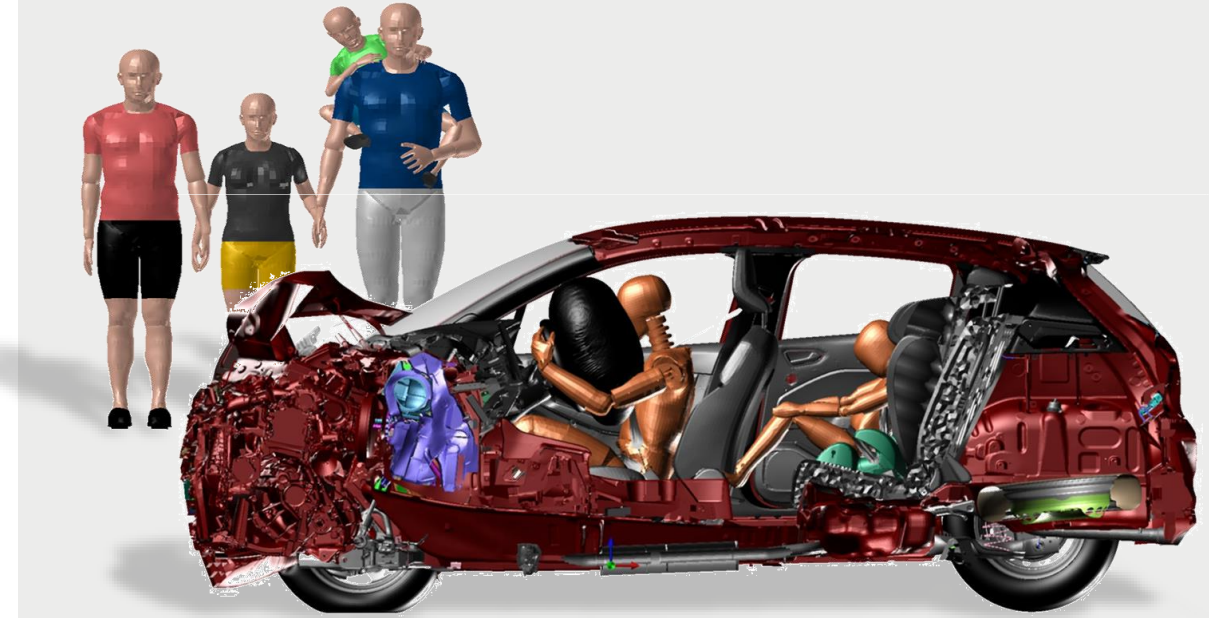
Topics

Passive Safety
Active Safety
ADAS

6 Facts Users Like Best About ESI's Auto Solutions

THE KEYS TO ACHIEVE SMART SAFETY

- Fastest crash simulation on the market
- Best-in-class airbag models to predict inflation kinematics/forces
- Unique single-core model approach for effective team-work
- ESI's unique expertise in material science with accurate modular material models



Maximum Passenger Protection

MAKE “VISION ZERO” COME TRUE:
ULTIMATE SAFETY WITH ADVANCED AIRBAGS

- Foster understanding of future accident scenarios in order to equip highly automated vehicles with new, advanced occupant protection systems



CUSTOMER SUCCESS

AUDI

Efficiently tackle simulation of Out of Position situations to pass regulations right the first time

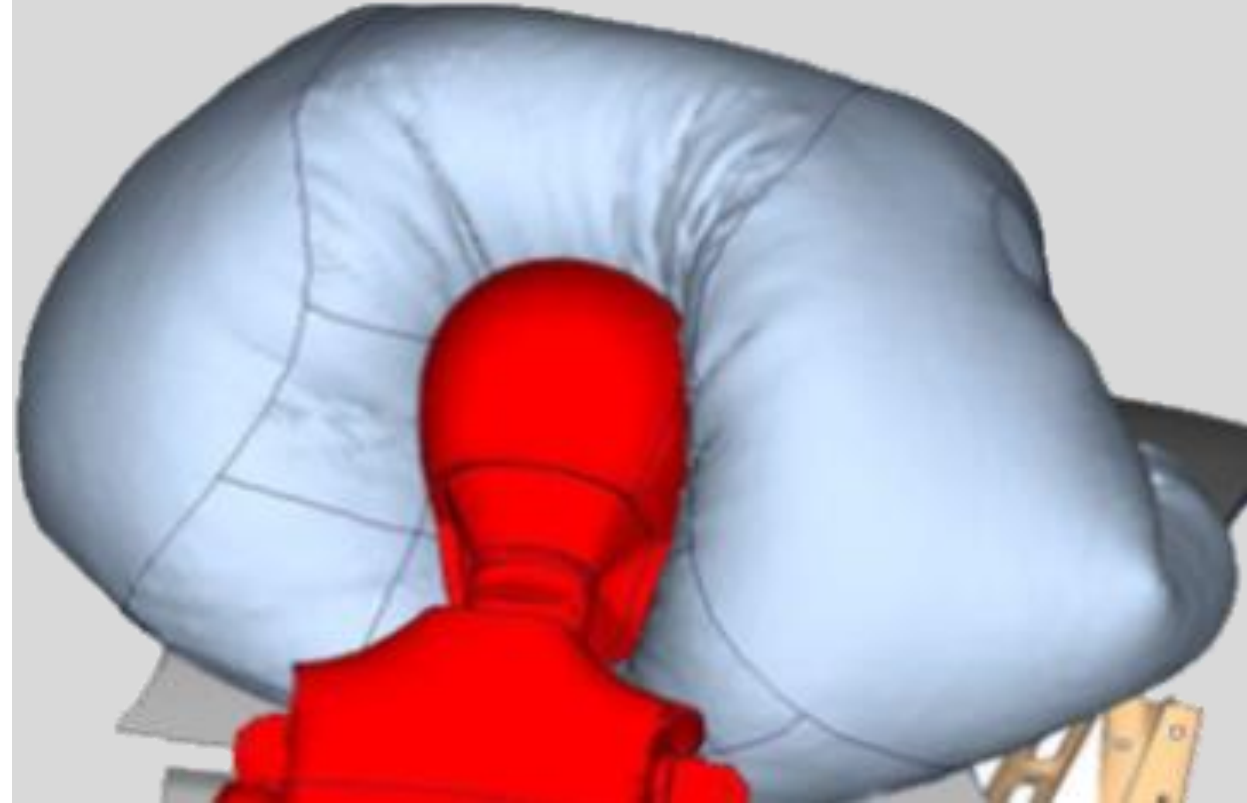
Highlights

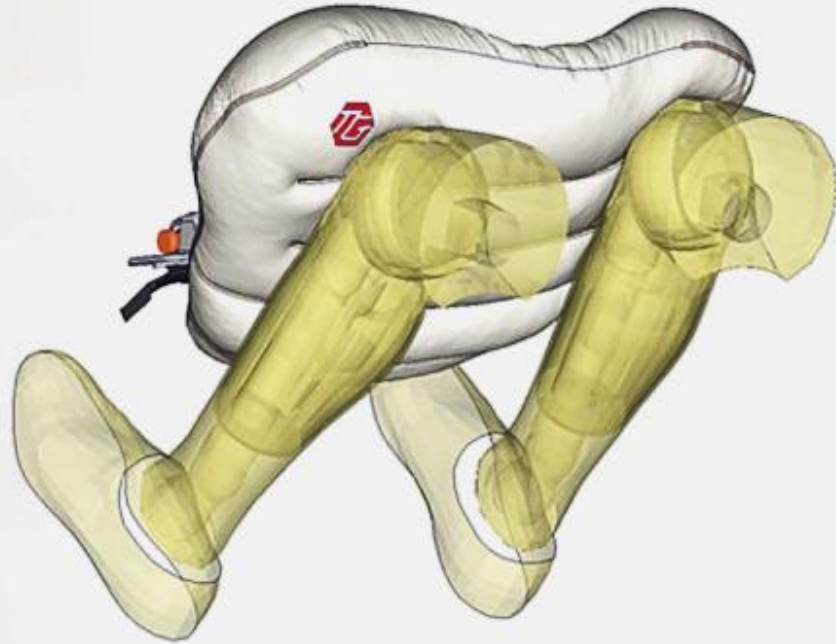
Joint collaboration on safety simulation in order to efficiently support the development of occupant safety standards

Optimize airbag folding patterns with reduced number of tests

Key Performance Indicator

Validate folding variations overnight instead of one week





CUSTOMER SUCCESS

Toyoda Gosei

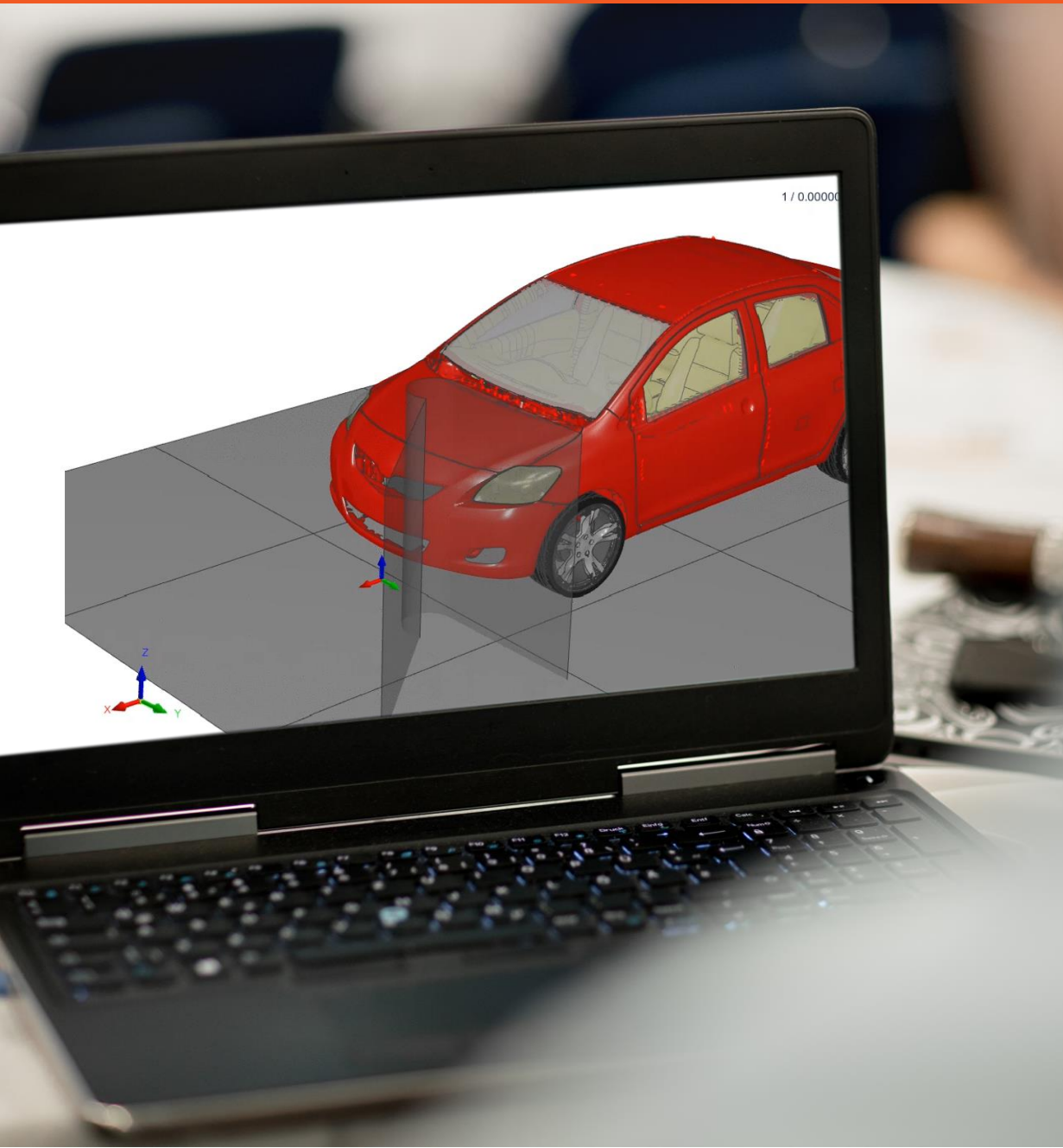
Cutting lead times in half with virtual prototyping

Highlights

Use ESI Virtual Performance Solution's airbag module for airbag folding and sewing

Key Performance Indicator

Accuracy and lead time for developing complex Knee Airbag (KnAB) have improved drastically



Highly Predictive, Accurate Virtual Testing

ACCURATE VIRTUAL PROOF OF WITHSTANDING COLLISIONS SHORTENS DESIGN CYCLES

- Virtually evaluate the most challenging car crash scenarios like small overlap test based on detailed models to understand the behavior of
 - suspension, powertrain, chassis
 - wheels with tire deflation & separation
 - fractured and joined materials

CUSTOMER SUCCESS

Gazelle Tech

Unleash Innovation for New Vehicle Technology
and Validate Business Models Early

Highlights

Validate the performance of innovative composite vehicle virtually even before the first real prototype is manufactured

Key Performance Indicator

1/2 of the typical weight

Reduced energy consumption by 40%

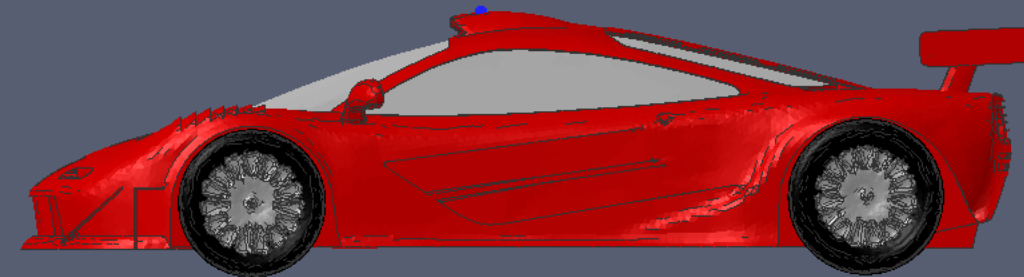
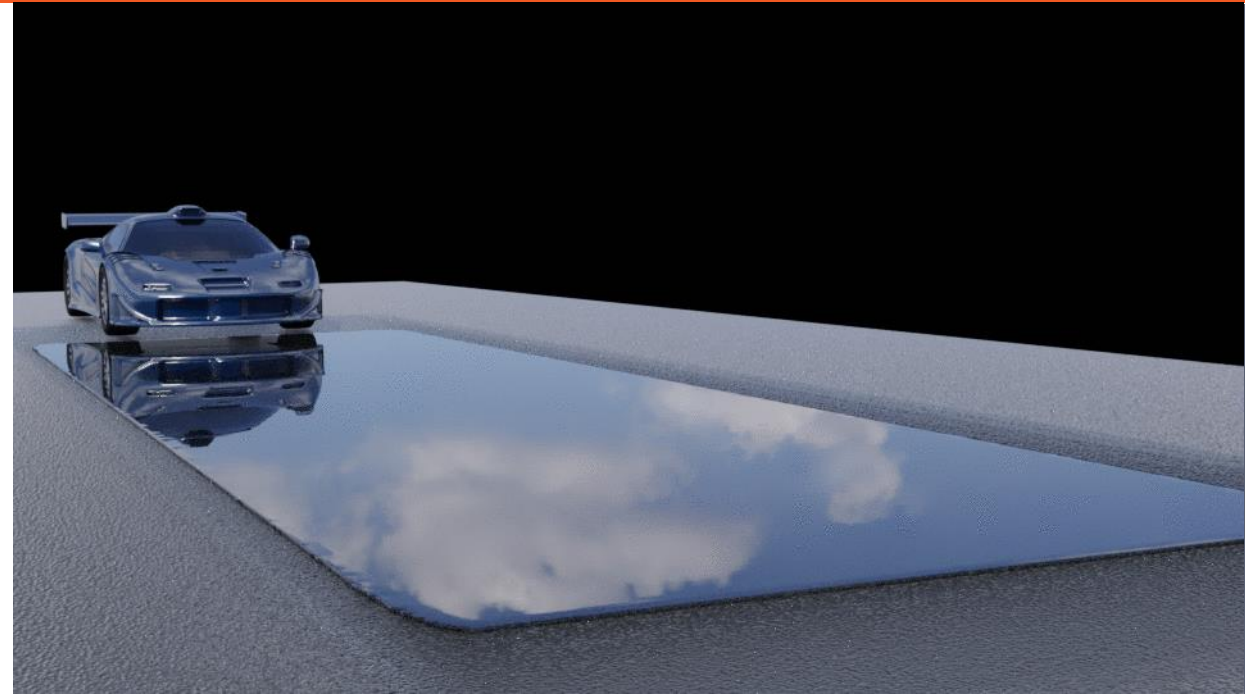
Reduce design iterations to 1 week instead of 5 months



Ensure **Drivability & Durability**

TIME TO GET REAL: ALL-NEW TECHNOLOGY REQUIRES ALL-NEW TESTING

- Simulation reigns supreme in reducing model preparation time by 50%
- Evaluate realistic situations and environments and accurately predict operating conditions





HONDA
The Power of Dreams

CUSTOMER SUCCESS

Honda Motor

Reduce Trial and Development Time Thanks to the Accuracy of Water Impact Simulation Testing

Highlights

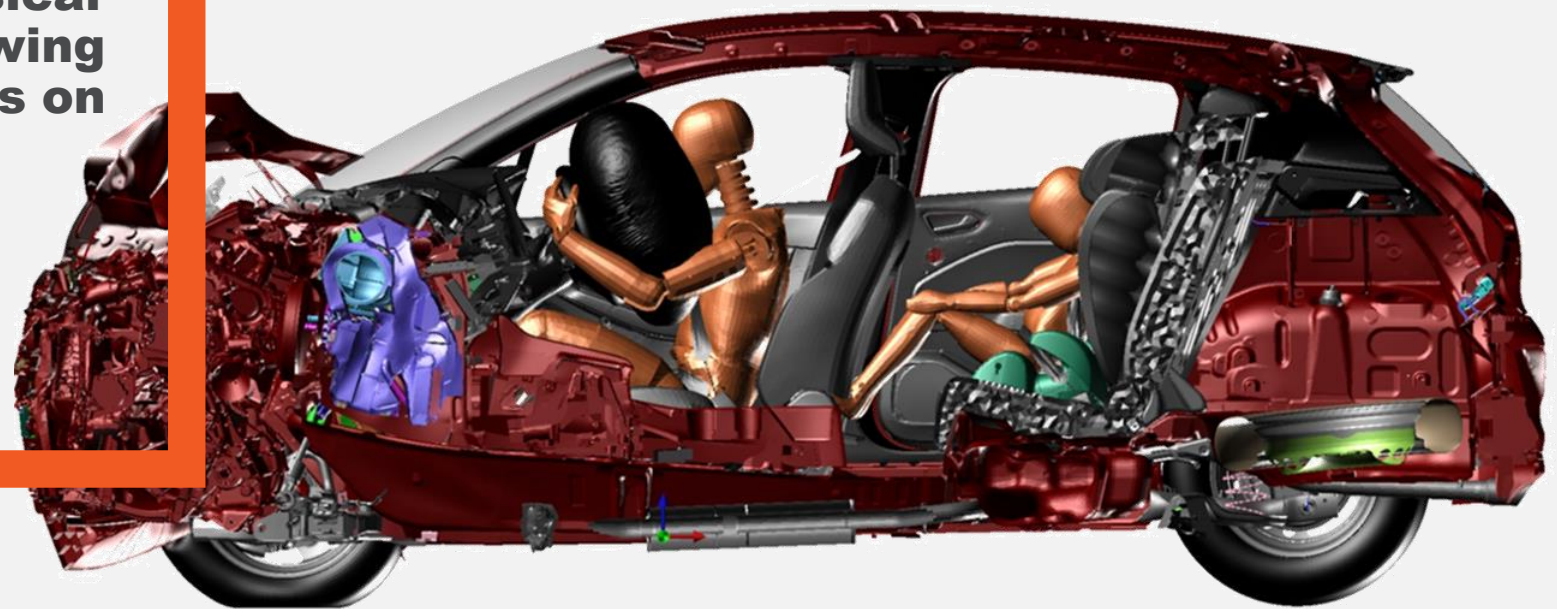
Using ESI's Virtual Performance Solution for water impact simulation

Key Performance Indicator

Ability to run unlimited tests that yielded important results on strength, durability, deformation, fluid flow and intrusion

“Thanks to ESI [...] we succeeded in developing one of our new vehicles, achieving good physical tests right the first time, allowing us to earn the whole five stars on the Euro NCAP safety test, following its stricter protocol launched in 2018.”

OLIVIER COLMARD RENAULT



Autonomous Driving Design for **Safe & Reliable Vehicles**

FOSTER THE UNDERSTANDING OF FUTURE ACCIDENT SCENARIOS

- Equip highly automated vehicles with new, advanced occupant protection systems
- Develop & virtually test radar, camera and LIDAR systems
- physics-based sensor models pave the road for pre-certification of highly automated vehicles



RESEARCH STORY

Oscar

Develop a novel, simulation-based approach to safeguard occupants

Highlights

Determine future accident scenarios

Develop advanced occupant protection principles

Assess new safety systems in future vehicles with human body models

Key Performance Indicator

Develop robust, efficient crash simulation tools for integrated assessment and overall impact demonstration with standardized virtual testing



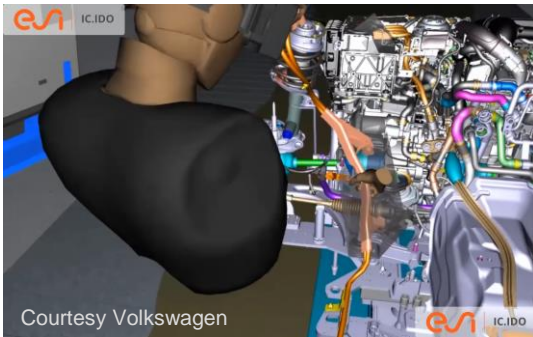
Evolve Towards Smart Operator 4.0

Topics

- Product integration validation
- Operator reachability
- Assembly process validation
- Service process validation

Human Centric **Product and Process Validation**

Product Integration,
Cabling & Wiring Layout,
Buildability & Serviceability
Validation



Operator Visibility,
Reachability & Accessibility



Human Centric **Assembly**
Process & Cell Validation



Human Centric **Service**
Process Validation



- Immersive virtual environment to evaluate interactions between people & resources in the processes
- True-to-life human interactions with products and resources in intended use or operation, including wiring & cabling
- Experiential discovery and validation of assembly & maintenance procedures
- First person VR experience with integrated real-time worker ergonomics assessment



Human-Centric **Product Integration Validation**

EXPERIENCE YOUR PRODUCT IN FULL SIZE AND COLLABORATE WITH STAKEHOLDERS CO-LOCATED OR REMOTE

- In early design stages through the eyes of the operators
- Discover, define, refine, and share product and process requirements
- Create synchronous or persistent experiences



Integrate and build your next vehicle 100% as planned and achieve solid ROI after 8 months. We did this with FCA.

Operator Reachability, Visibility, Accessibility

KEEP AN EYE ON WORKER ERGONOMICS AND TOOLING REQUIREMENTS

- Experience, validate and communicate the impact of production requirements & service procedures without construction of physical prototypes



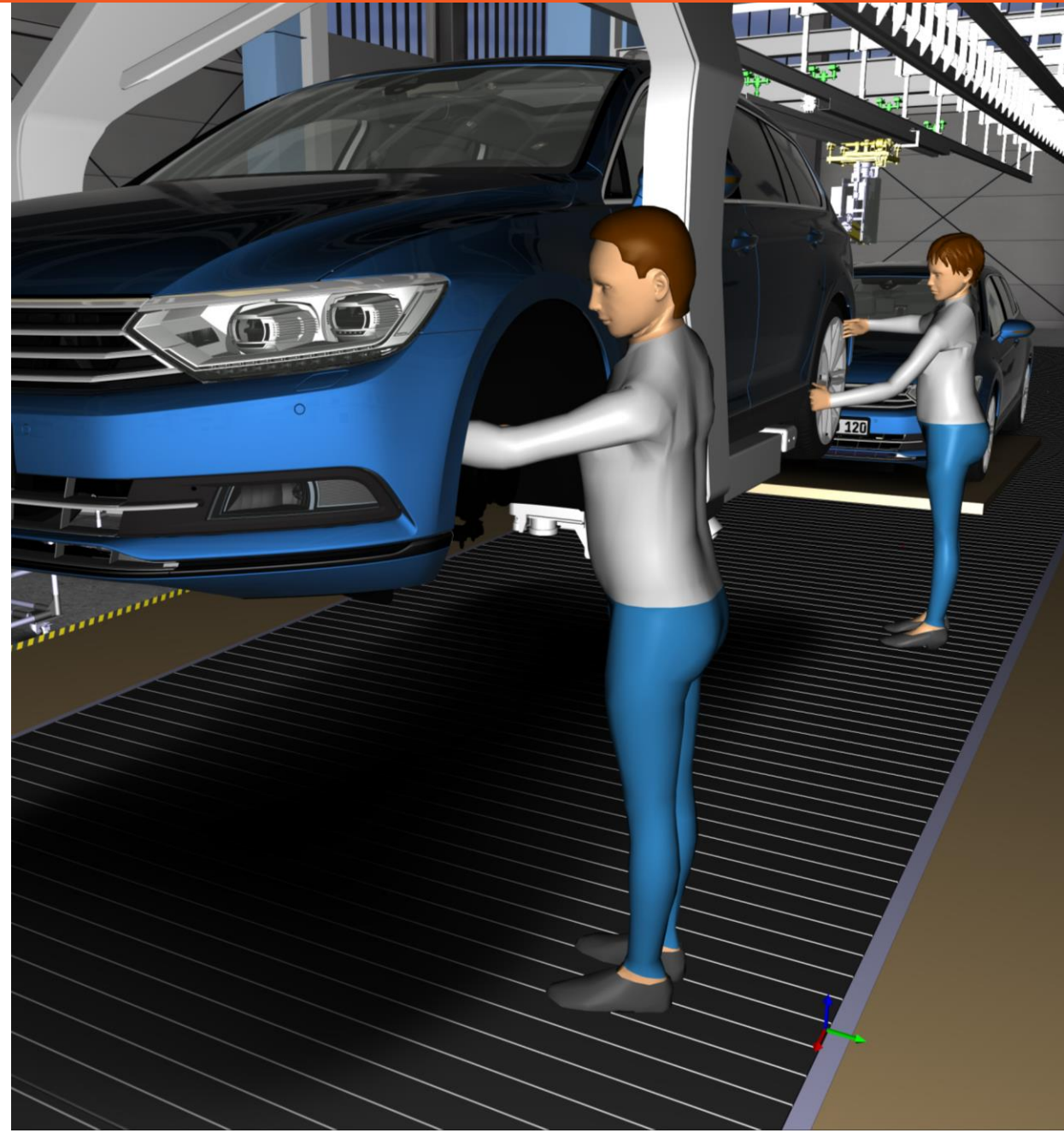
Working in an immersive virtual reality environment [...] enhances our understanding of complex manufacturing equipment and exposes potential issues, which can be corrected while still in the design stage.

BRAD PRICE NEXTEER AUTOMOTIVE

Human-Centric **Assembly Process Validation**

ENSURE SAFE AND PRODUCTIVE PRODUCT ASSEMBLY LINE OPERATIONS AND PRODUCTION ENVIRONMENTS

- Validate assembly processes & cell/line layout
- Identify safe procedures for human operators
- 1st person experiences validated for broad populations—3rd person digital human models



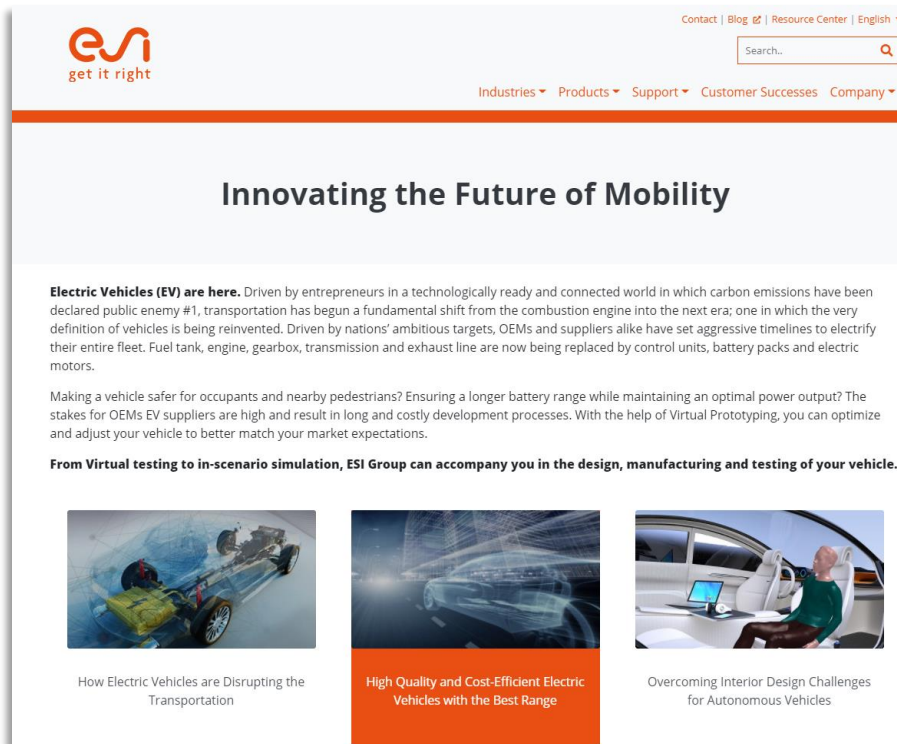


Human-Centric **Service Process Validation**

ENSURE SAFE AND PRODUCTIVE SERVICE OPERATIONS AND MAINTAIN ZERO DOWNTIME

- Validate service & maintenance procedures
- Conduct ergonomics assessments from first person perspective and validate across wide populations
- Collaborate in experiential serviceability and maintenance process reviews

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Innovating the Future of Mobility


Electric Vehicles (EV) are here. Driven by entrepreneurs in a technologically ready and connected world in which carbon emissions have been declared public enemy #1, transportation has begun a fundamental shift from the combustion engine into the next era; one in which the very definition of vehicles is being reinvented. Driven by nations' ambitious targets, OEMs and suppliers alike have set aggressive timelines to electrify their entire fleet. Fuel tank, engine, gearbox, transmission and exhaust line are now being replaced by control units, battery packs and electric motors.

Making a vehicle safer for occupants and nearby pedestrians? Ensuring a longer battery range while maintaining an optimal power output? The stakes for OEMs EV suppliers are high and result in long and costly development processes. With the help of Virtual Prototyping, you can optimize and adjust your vehicle to better match your market expectations.

From Virtual testing to in-scenario simulation, ESI Group can accompany you in the design, manufacturing and testing of your vehicle.



How Electric Vehicles are Disrupting the Transportation



High Quality and Cost-Efficient Electric Vehicles with the Best Range



Overcoming Interior Design Challenges for Autonomous Vehicles

Watch our on-demand webinars and get concrete, actionable insights from ESI's experts for Virtual Prototyping in the automotive industry

www.esi-group.com/innovating-the-future-of-mobility