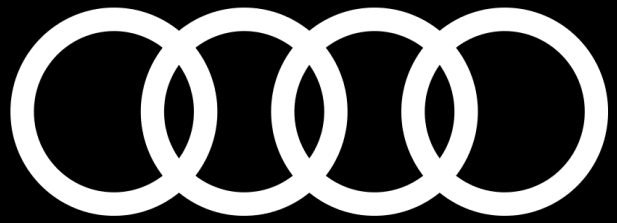
Archimedes App for coupled multi-windshield and Head-up display optimization

AUDI AG // ANSYS 2024 | Marcus Richter

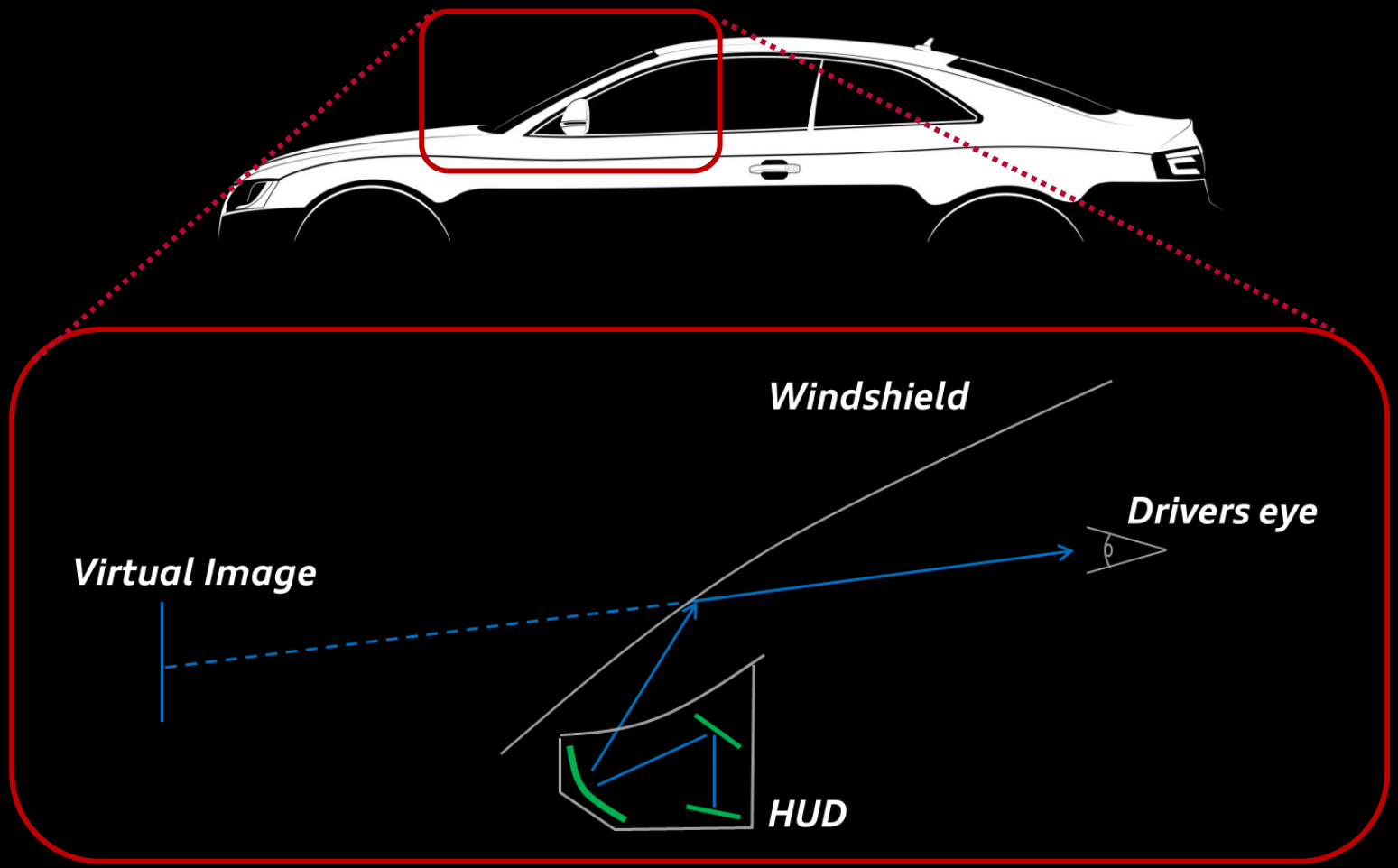


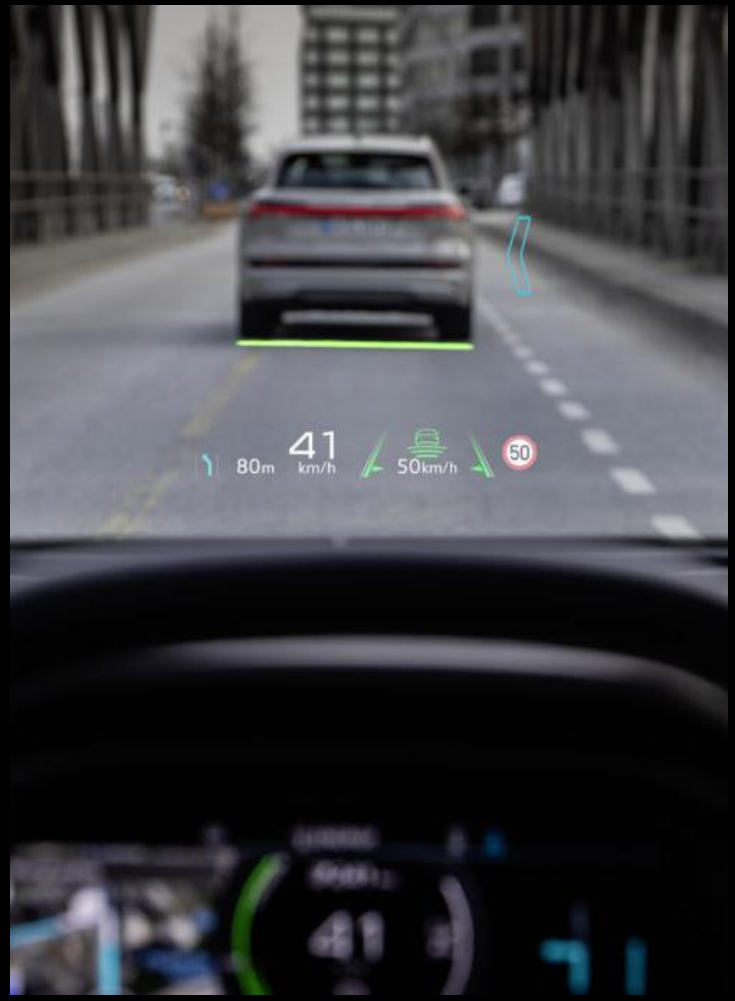
Project Introduction

Motivation / Challenges / Solution

HUD

What is a Head-Up display?





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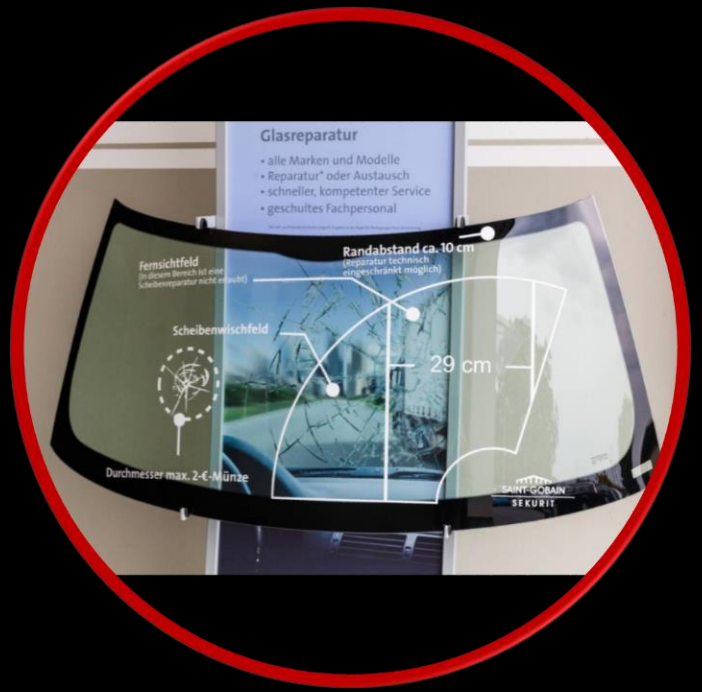
Motivation

1 platform - 5 derivatives



5 windshields – 10 Head-Up Display (HUD) systems

10 x Cost of Maintaining different parts

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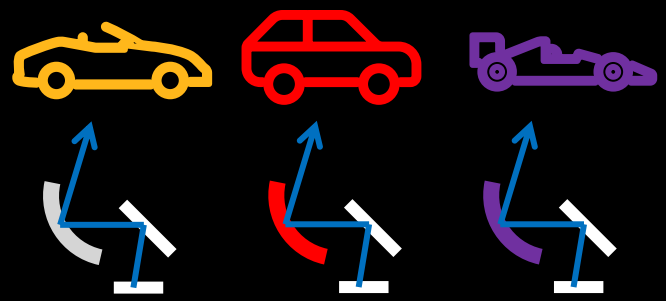
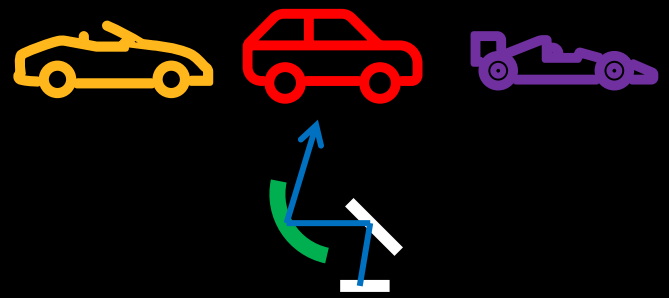
Summary potential gain Ansys solution

HUD development without Ansys solution



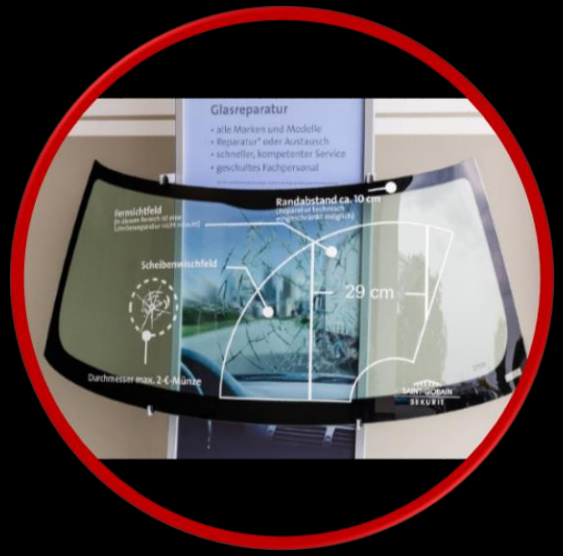
HUD development with Ansys solution



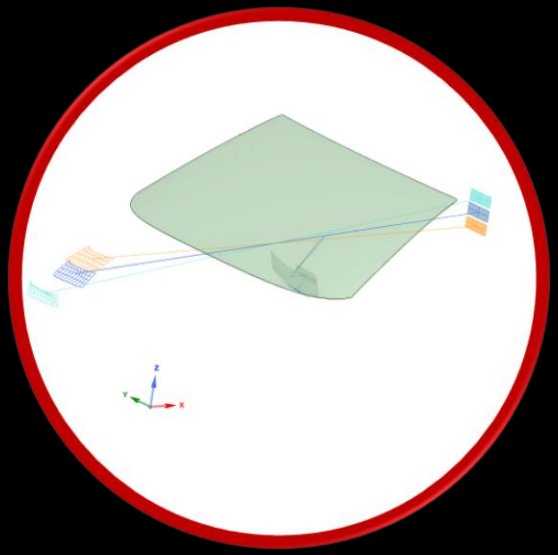
➔ Save up to 8 parts and their production & maintenance costs

Additional Benefit:
Secure space for HUD early in the design phase (48 Month to SoP)

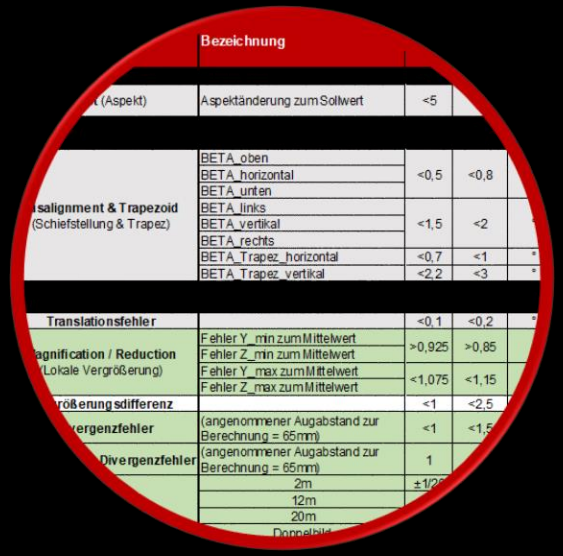
Main Challenges



Parametrization



Optical Simulation Model



Bezeichnung				
(Aspekt)	Aspektänderung zum Sollwert	<5		
salignment & Trapezoid (Schiefstellung & Trapez)	BETA_oben	<0,5	<0,8	
	BETA_horizontal			
	BETA_unten			
	BETA_links	<1,5	<2	
	BETA_vertikal			
	BETA_rechts			
	BETA_Trapez_horizontal	<0,7	<1	*
	BETA_Trapez_vertikal	<2,2	<3	*
Translationsfehler		<0,1	<0,2	*
agnification / Reduction (Lokale Vergrößerung)	Fehler Y_min zum Mittelwert	>0,925	>0,85	
	Fehler Z_min zum Mittelwert			
	Fehler Y_max zum Mittelwert	<1,075	<1,15	
	Fehler Z_max zum Mittelwert			
rößerungsdifferenz		<1	<2,5	
ergenzfehler	(angenommener Augabstand zur Berechnung = 65mm)	<1	<1,5	
Divergenzfehler	(angenommener Augabstand zur Berechnung = 65mm)	1		
	2m	±1/2		
	12m			
	20m			
	Doppelbild			

Optical requirements

Optimization Strategy

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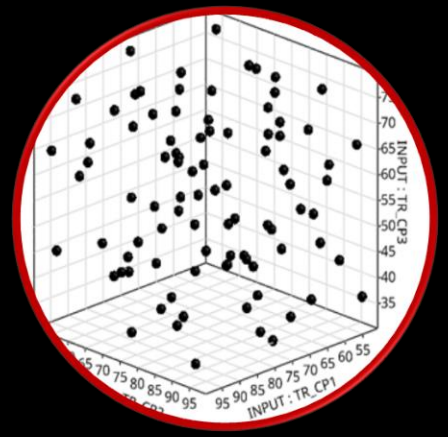
Optimization Strategy

Optimization Goal

- Co-optimize multi-windshields for one head-up display

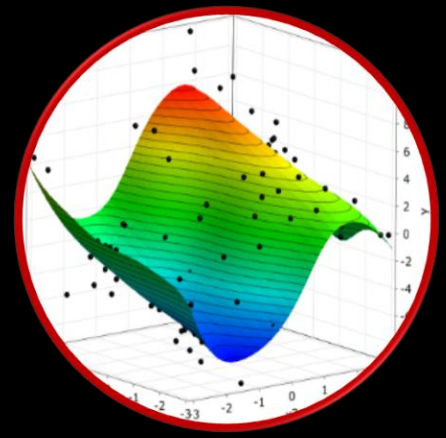
Solution

- Local shapes for geometry variation
- Workflow automation
- Sensitivity Study including prediction Model creation
- Multi-objective optimization based on prediction models, covering ~1000 metrics



/ Design of Experiments
Advanced Latin Hypercube Sampling

/ Optical Simulation
up to 500 geometry variations per windshield



/ AI/ML Metamodels based on simulations
56 scalar, 2 signal, 9 field prediction Models

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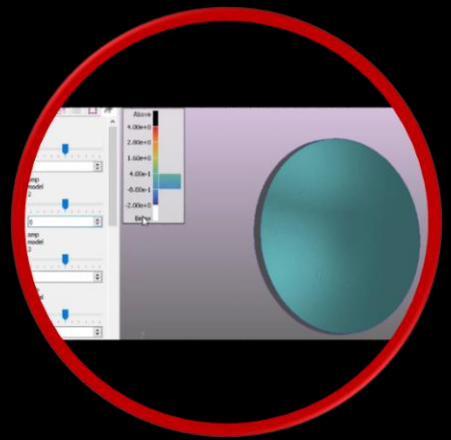
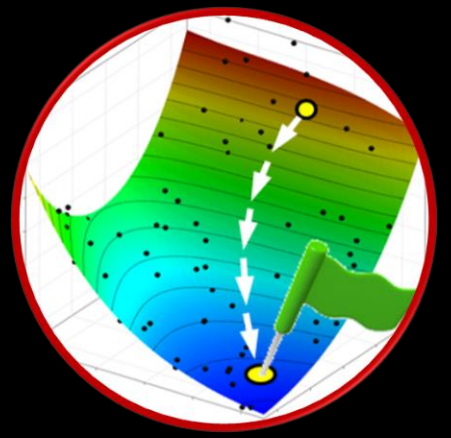


/ Surface parametrization
scatter shape technology



/ Fast Multi-objective Optimization
evaluation of 10k+ design

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Merit Function Definition – advanced optimization approach

Optimization Goal

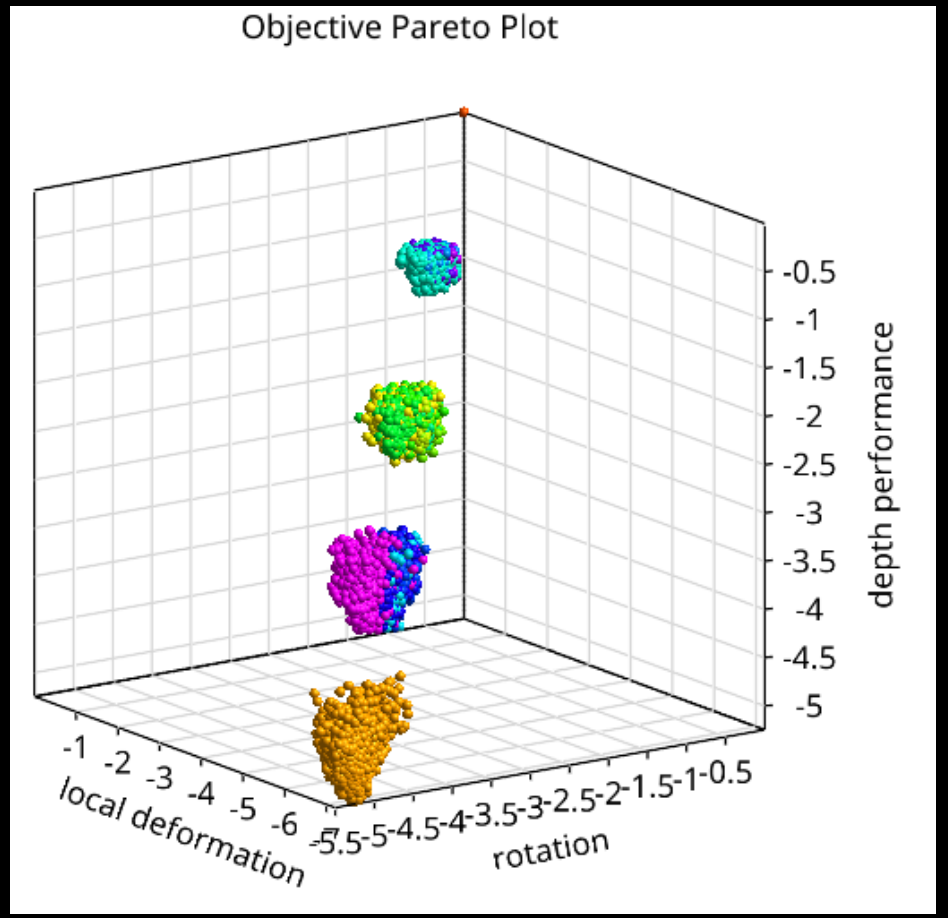
- Goal 1: find feasible design space where all criteria (customer regulations) over all windshields are fulfilled
- Goal 2: optimize criteria to increase all 3 optical performance groups (constraint subsets)
- Multi-Constraint Performance Optimization approach

Merit Function including:

- weighting of constraint subset
- weighting of performance values
- consideration of a Reward-Punishment system
- | Performance Optimization: get as far away as possible from the criteria limits and as close as possible to the ideal values

Benefit

- great visibility of windshield performance
- performance values are comparable
- Identification of fitting windshields



Multi-Constrained Performance Optimization
Level-based performance cloud plot

Solution: Archimedes App workflow

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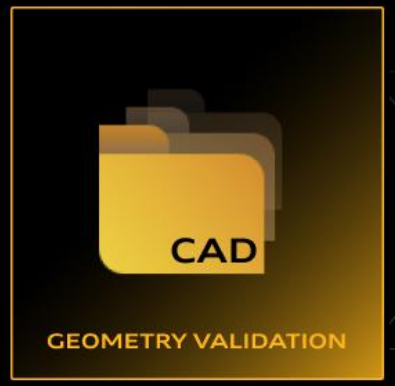
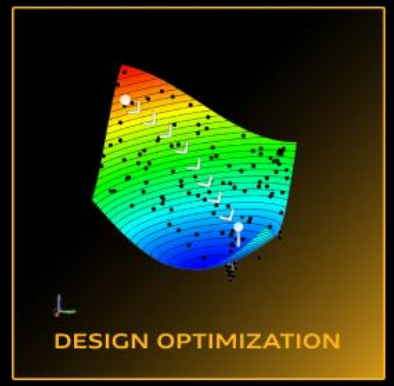
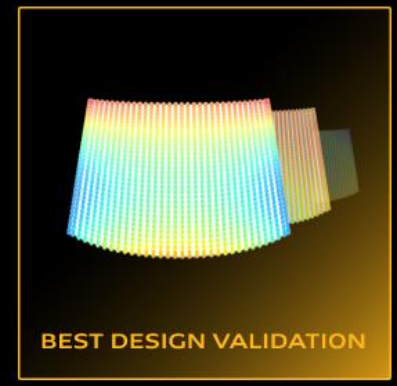
USER WORKFLOW







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Archimedes Application

Solution Application framework / Application Development / Application Demo

Solution Application Framework (SAF)

SAF is a high-level Python framework for the development of custom Ansys-driven solution applications, generally referred as **Ansys Solution Web Apps** or **Vertical Applications.**

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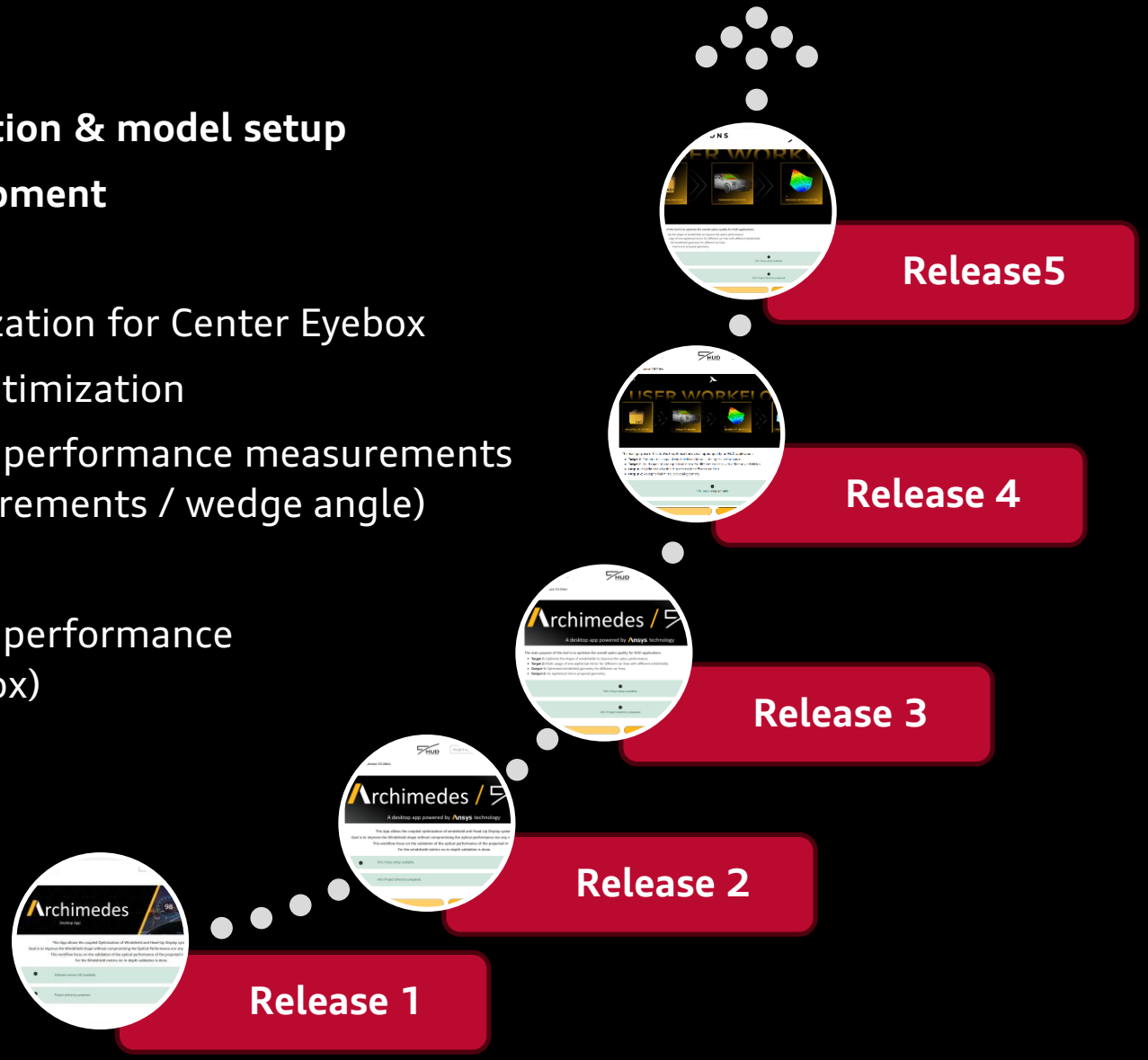
App development

App development to reduce complexity of optimization & model setup

Continues delivery with incremental feature development

- Release 1: 1 Windshield + constant HUD optimization for Center Eyebox
- Release 2: Multi Windshields + constant HUD optimization
- Release 3: implementation of additional optical performance measurements (ghost in transmission / wiper measurements / wedge angle)
- Release 4: Enable HUD optimization
- Release 5: implementation of additional optical performance measurements (Lower & Upper Eyebox)

With each Release: usability & readability improvement of the UI based on Audi and Ansys feedback



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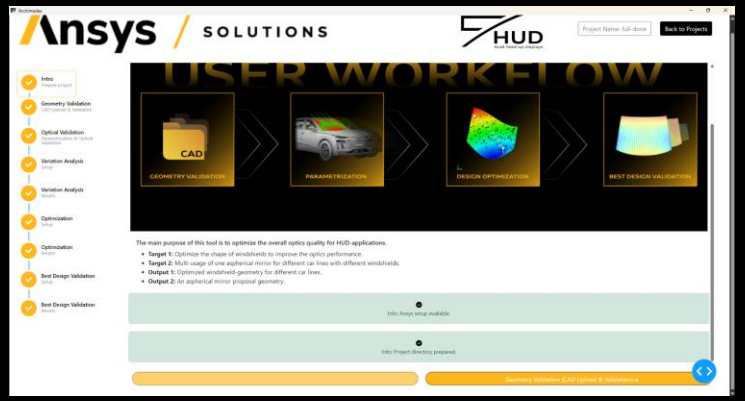
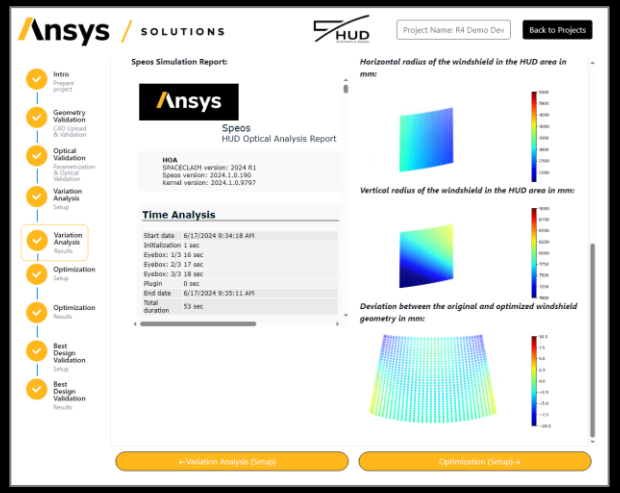
Archimedes App Overview



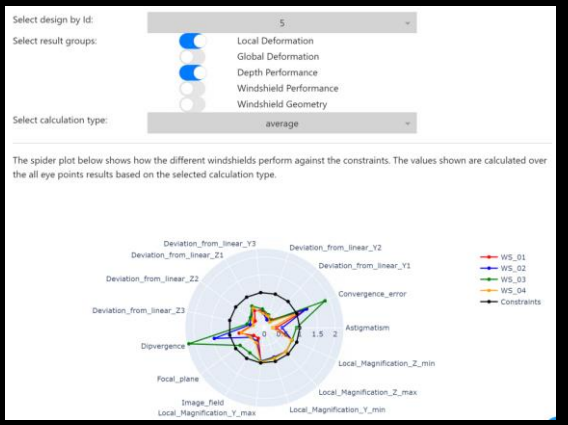
Start App

Upload data



Results: WSS curvature

Results: best designs and comparison



Results: design details

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Demo of Release 5

Comparison between current method and Archimedes

	Current manual method	Using Archimedes
Steps	1. create optical system 5x 2. create 5 x 10 windshields	1. Prepare windshield 5x 2. Upload data in app 3. Variation analysis 4. Optimization process 5. Best design validation 6. Check results/download data
Total Engineering time	More than 10 hours (expert user)	7 hours including intermediate checking (standard user)
Total Simulation time	5 x 0.5h	Up to 60h
Outcome	10 tested windshields 1 valid best design → working for 2 cars only	25000 evaluated windshields 20 valid best designs for each car **→ drastically improved design space exploration** **→ More reliable results** **→ High potential of cost saving**

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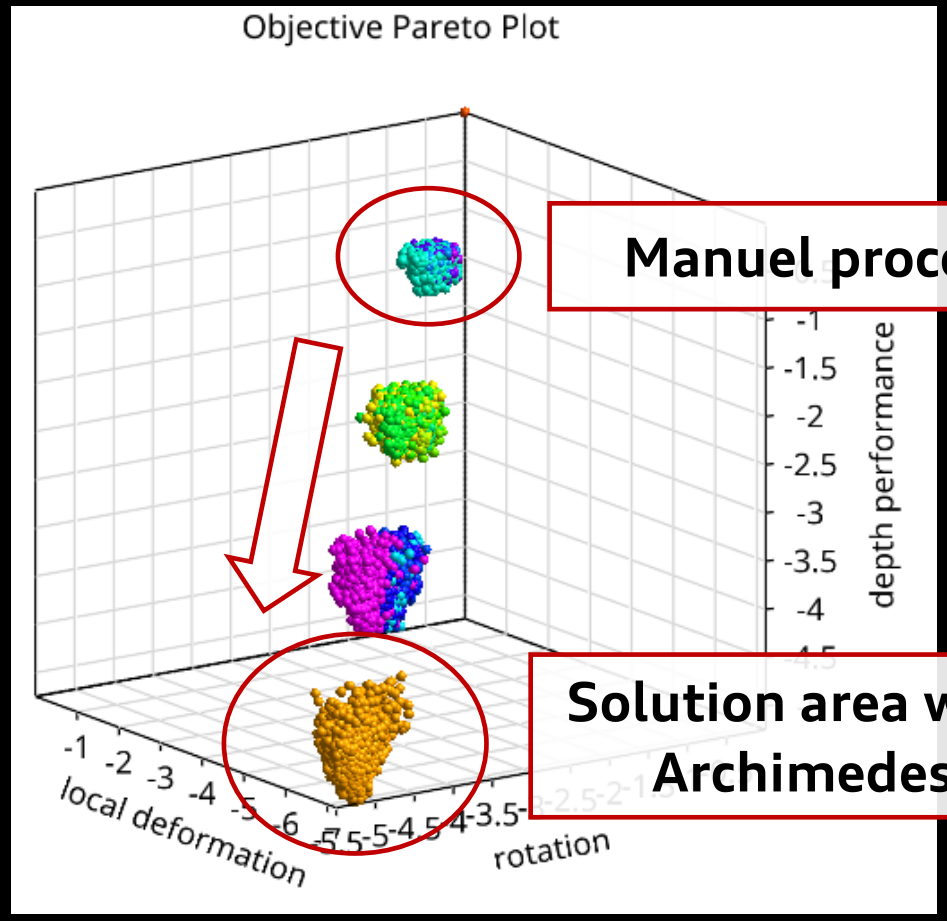
Comparison between current method and Archimedes next level of designing complex challenges



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Thank you to the full Project team Ansys&Audi

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Shravan Ghongade
Paul Fedrau
Madhumita Saravana Kumar
Simon Lutterer
Timofey Yugov
Christian Lenakakis

Marcus Richter
Philipp Nübling
Alexander Burghard
Vincent Kratzer
Zeljko Ladevic
Josef Ferstl
Christiane Bergmann

And many more!

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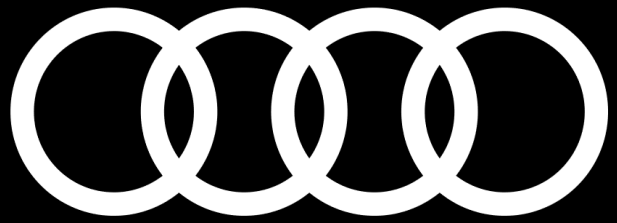

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Thank you!

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