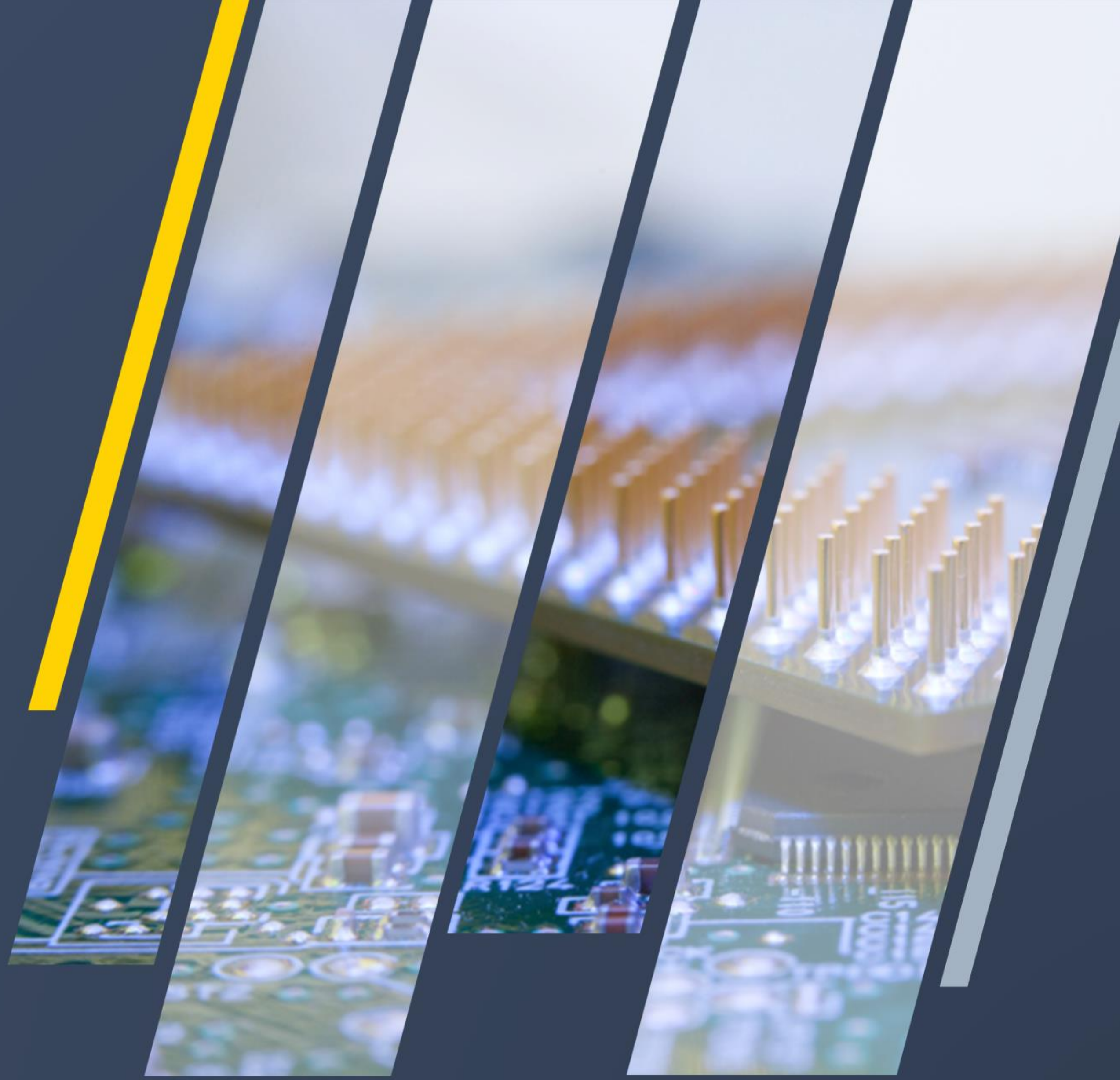
ANSYS SPEOS
Robust Optical Design through Multiphysics Simulation



Günther Hasna (Guenther.hasna@ansys.com)

Director Application Engineering

Europe, Mid-East and Africa

ANSYS OPTIS

History of OPTIS integration

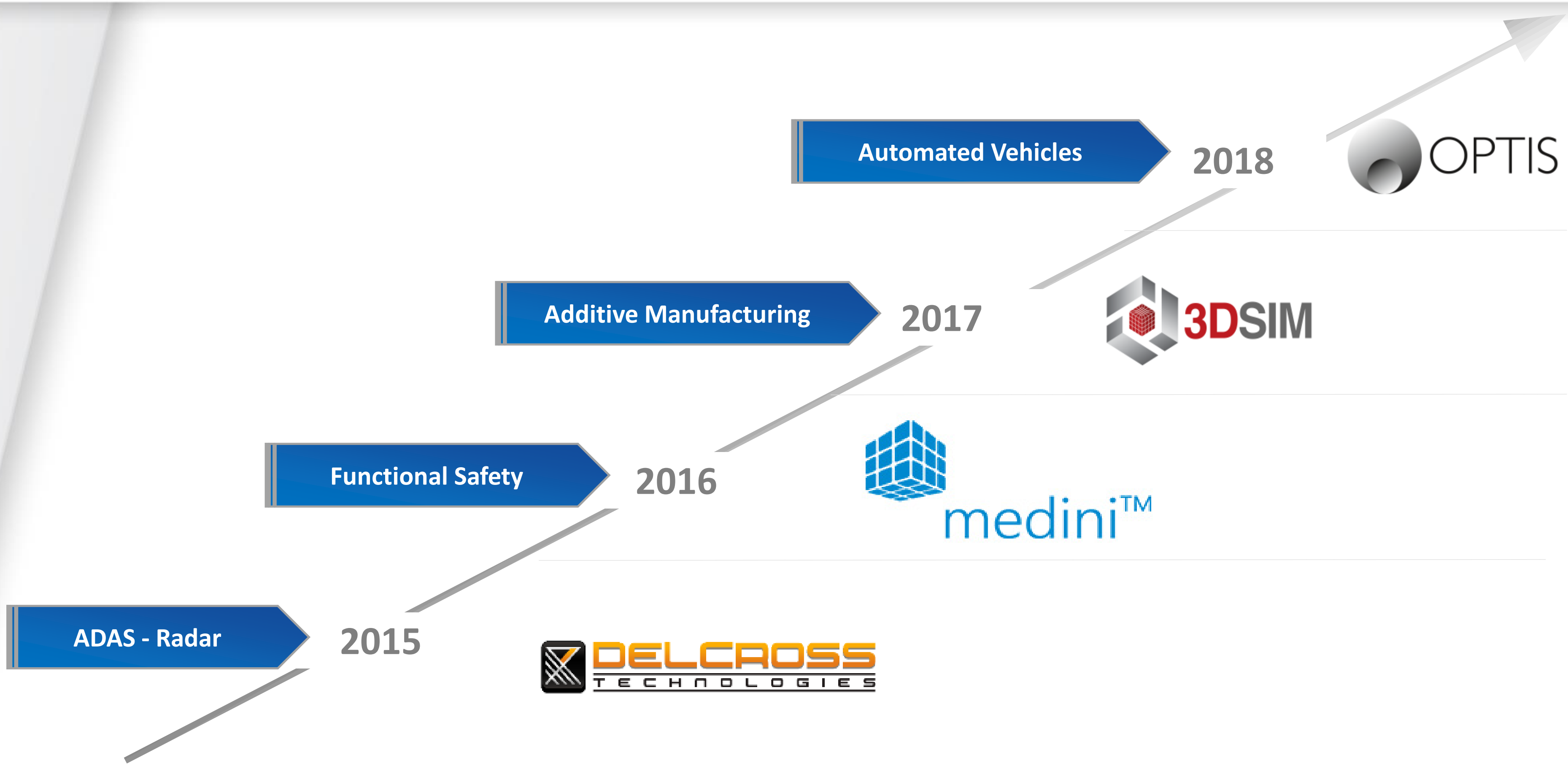
Strategic Investment

VISION

Focus on

solutions

Empower customers to deliver transformational products.



The ANSYS Journey

Twin Builder / VRX
(Simplorer)

Concept

Requirements

Architecture

Design

Implementation

Verification/Test

Integration

Manufacture

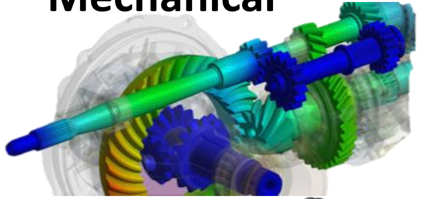
Operation/Maintenance

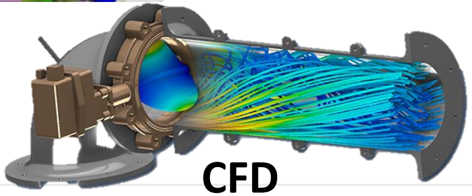
Safety critical embedded software

medini™ analyze

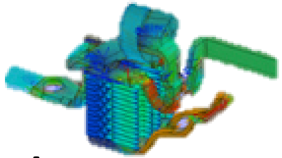
SCADE SUITE®

Mechanical





CFD



Electromagnetic

Optical

Multi-Domain System Simulation

- Variable model abstraction levels
- Thermal, electrical, optical, mechanical, simulation
- Support for FMI, Modelica,VHDL/AMS
- Multiple co-simulation

SAP®

ANSYS OPTIS Multiphysics

Use Cases Overview

ANSYS provides “Best-in-Class” Engineering Solutions

Structures

Fluids

Electromagnetics

Semiconductor Power

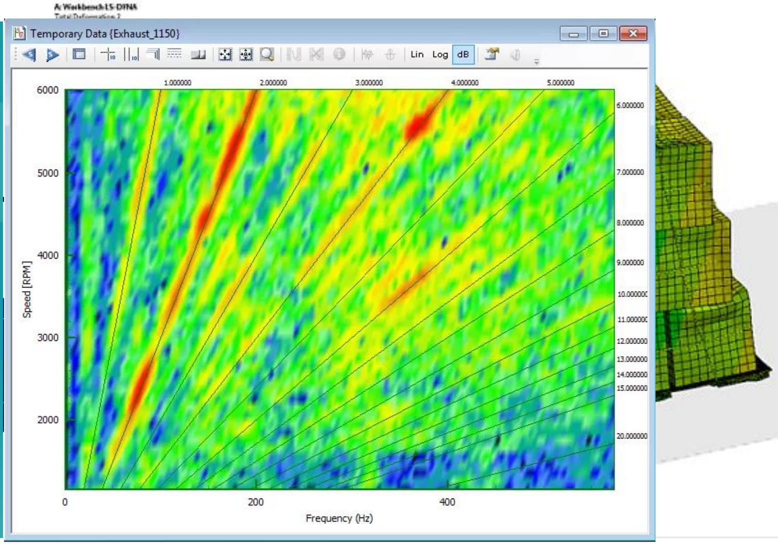
Mission-critical Embedded Software

Optical

Explicit Dynamics

Additive Manufacturing

Noise and vibration

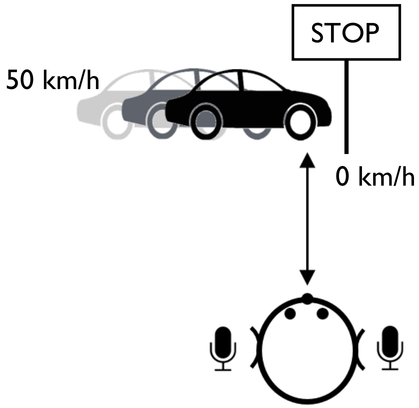


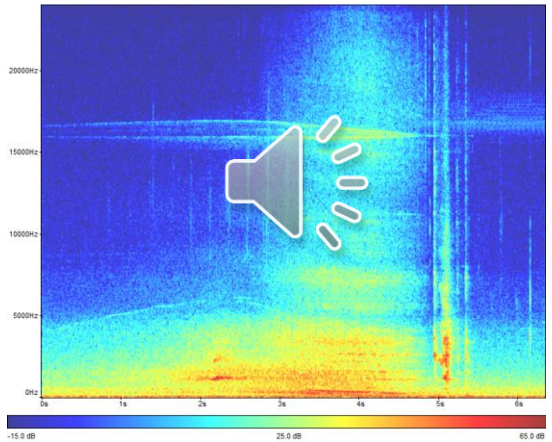
Fatigue & Lifetime

Rigid Body Dynamics

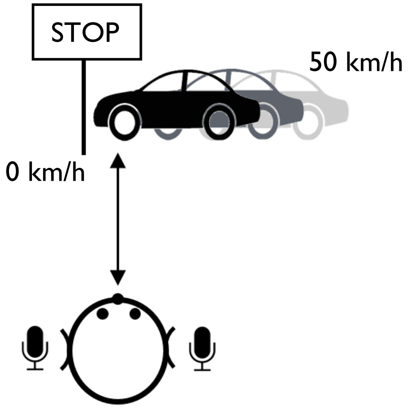
Exterior – stop and start recordings

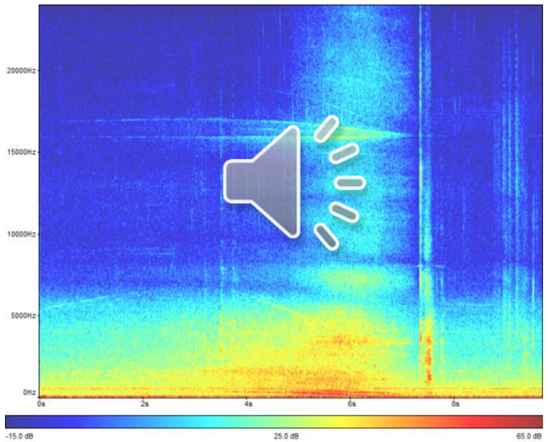
From left to stop in front



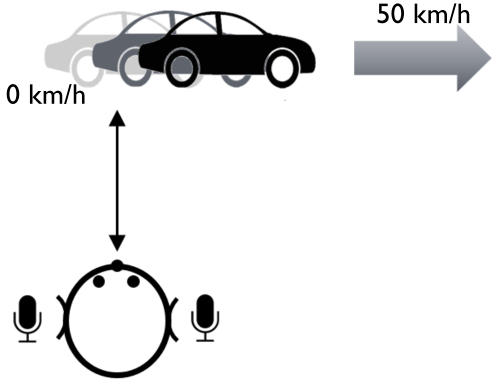


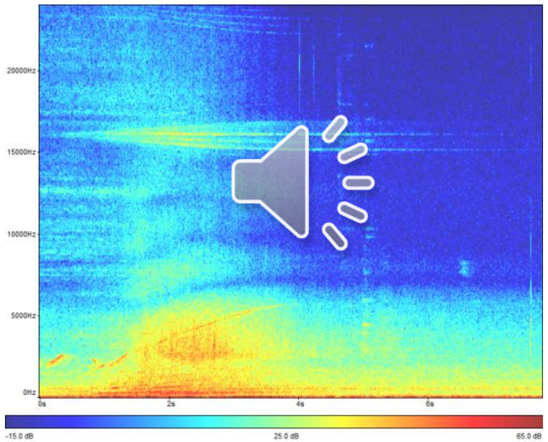
From right to stop in front





From 0 start to right





ANSYS provides “Best-in-Class” Engineering Solutions

Structures

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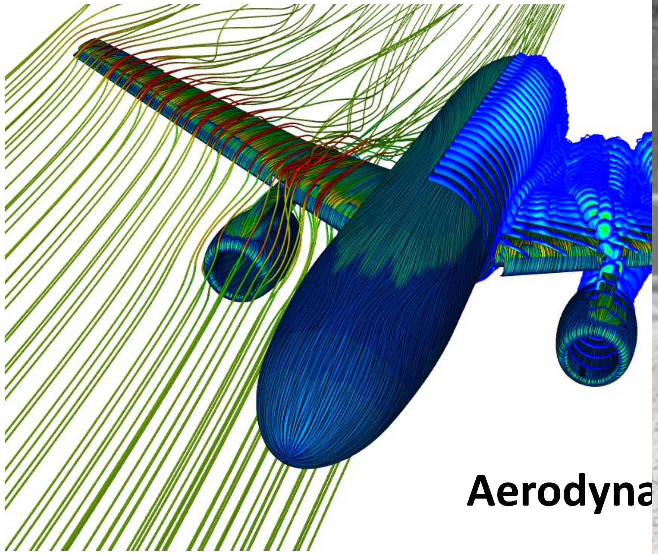
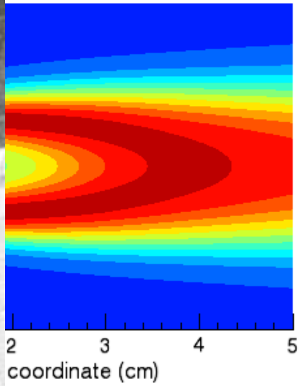
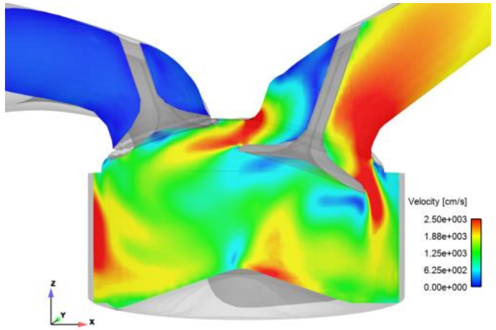
Optical



Aerodyna

nal Reactions





Multi-Phase

Injection Molding

ANSYS provides “Best-in-Class” Engineering Solutions

Structures

Fluids

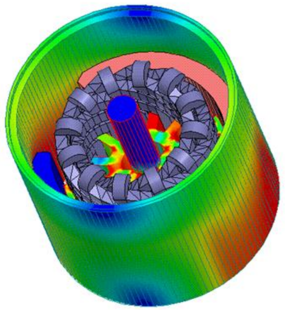
Electromagnetics

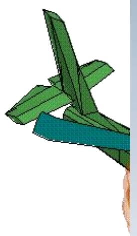
Semiconductor Power

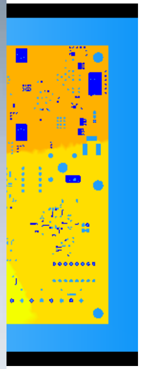
Mission-critical Embedded Software

Optical

Motors and Rotating Machi







Quasi-static EM Extraction

Signal Integrity

Electronics Cooling

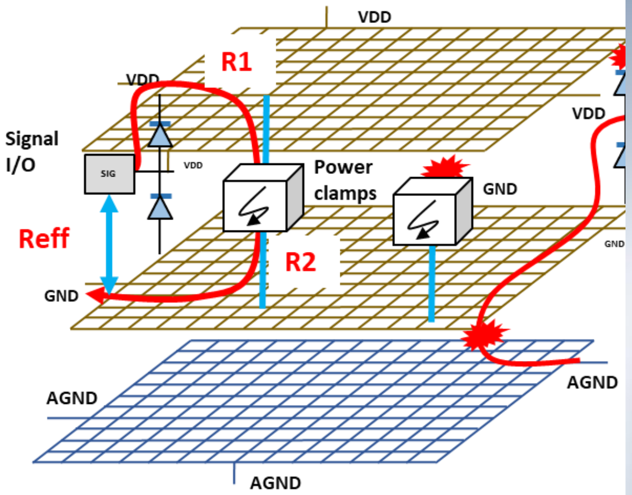
Antennas, Wireless Systems

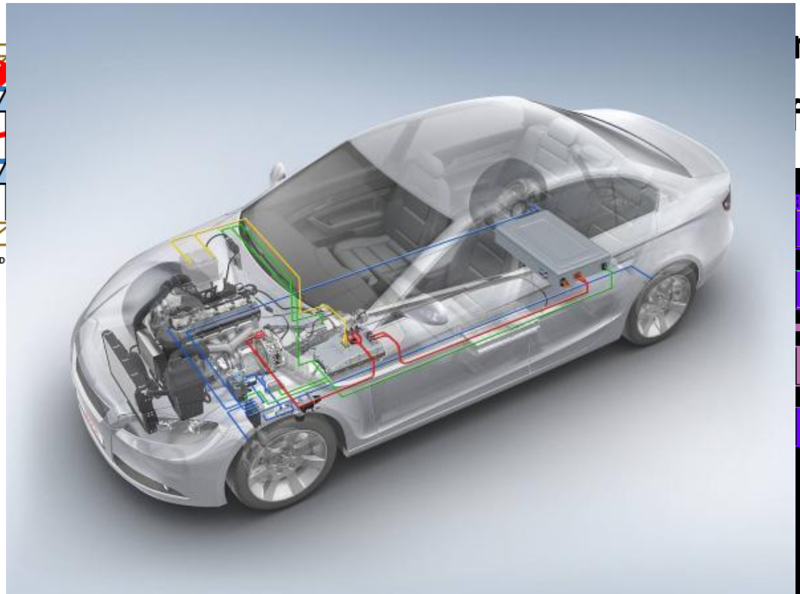
DC IR Drop

ANSYS provides "Best-in-Class" Engineering Solutions

- Structures
- Fluids
- Electromagnetics
- Semiconductor Power
- Mission-critical Embedded Software
- Optical

ESD Analysis





n

f Verification

..and validation

ANSYS provides “Best-in-Class” Engineering Solutions

Structures

Fluids

Electromagnetics

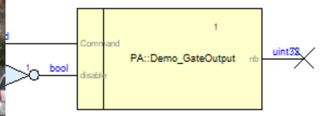
Semiconductor Power

Mission-critical Embedded Software

Optical

Model-Based System Validation

- Functional Hazard Assessment
- Hazard and Operability
- Failure Mode and Effects Anal
- Fault Tree Analysis
- Safety Plan
- Reliability Prediction



ARP 4754A
ARP 4761
IEC 61508
ISO 26262
SAE J1739
SN 29500
IEC 26380
IFDES, …

ANSYS provides “Best-in-Class” Engineering Solutions

Structures

Fluids

Electromagnetics

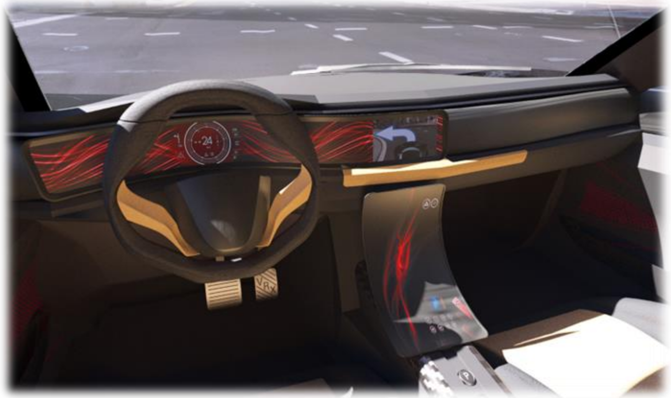
Semiconductor Power

Mission-critical Embedded Software

Optical

Optical System Design

- Heads-up display
- Interior Lighting
- Lidar
- Camera
- Virtual Reality
- Real-time Closed-Loop



Automotive Headlamp Design with ANSYS SPEOS

Introduction to Headlamp Design

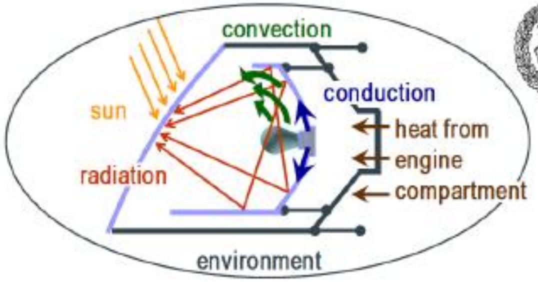
Background

- Headlamps are an important styling component for cars for brand recognition
- New technologies like LEDs provide new challenges to manufacturers
- Comprehensive lighting studies demand advanced modeling capabilities
  - Lighting components are great candidates for Multiphysics simulations

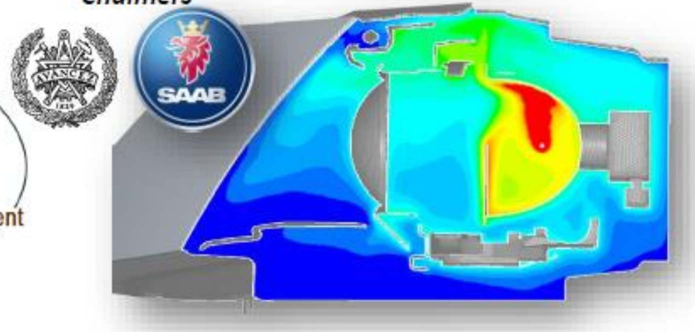
Headlamp Modeling Challenges

- High geometrical complexity, and many components
- For thermal management all heat transfer mechanisms need to be included
  - Convection, Conduction, Radiation – Monte Carlo
- Models are large and transient (e.g. adaptive curve light)
- Electronic components that may need to be investigated in detail
- Released heat impacts plastic components which may affect shape and lighting performance

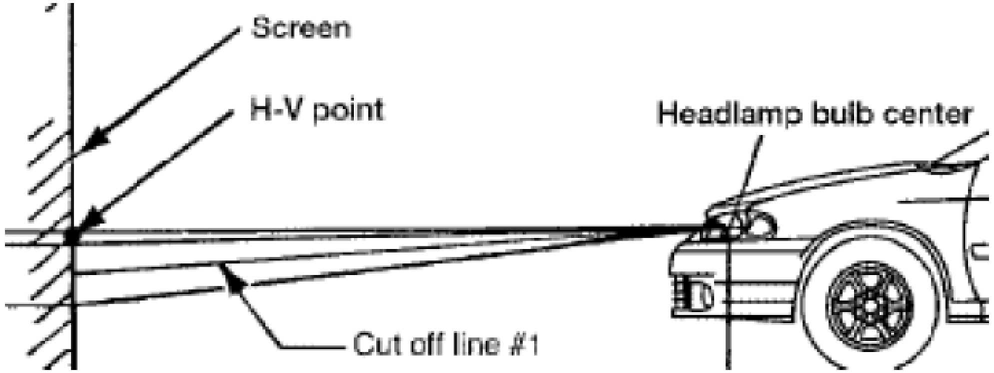
- **ANSYS Multi-Physics includes all modeling options needed to perform fast meaningful thermal management simulations for complete headlamps**

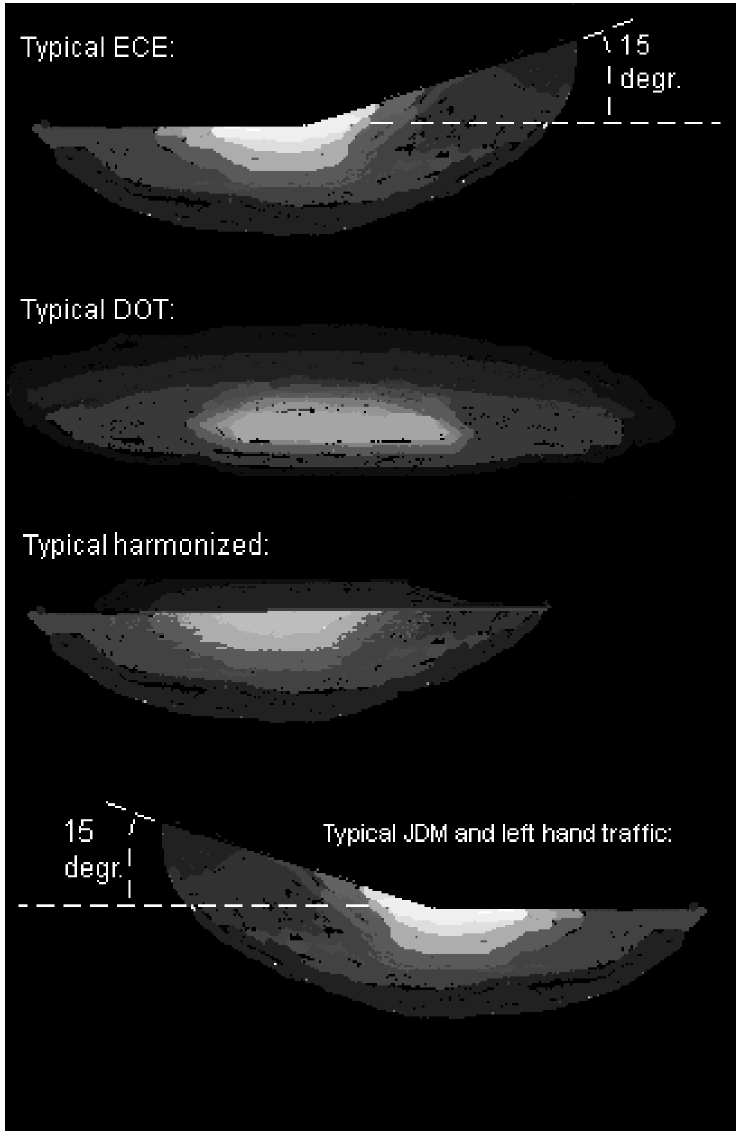


Courtesy of Saab, Chalmers

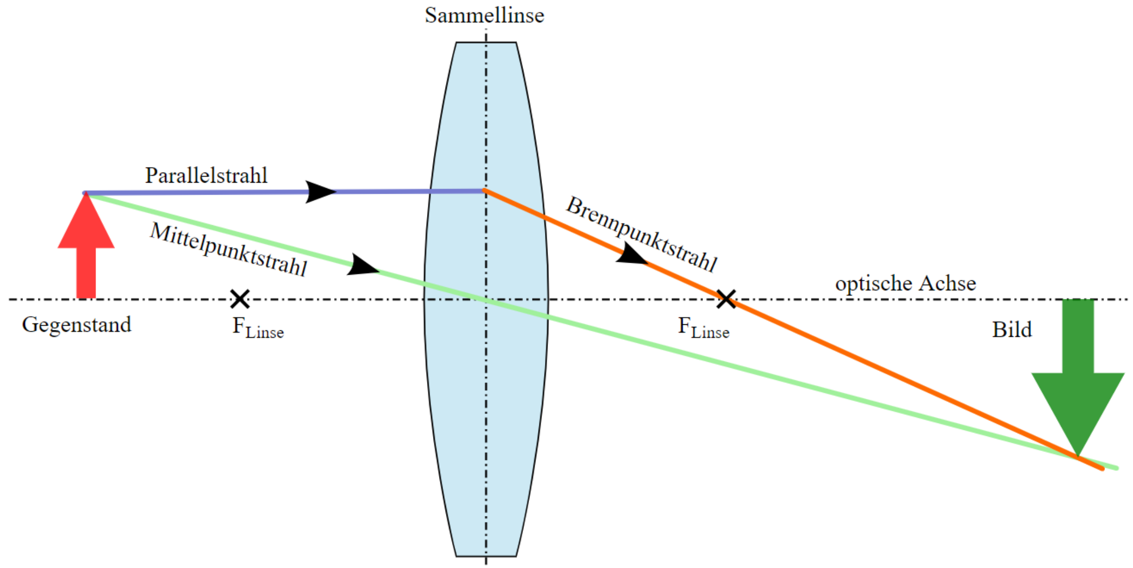


Automotive Headlamp Light Intensity Distribution





Optical Tolerances – Challenging for Lens Design



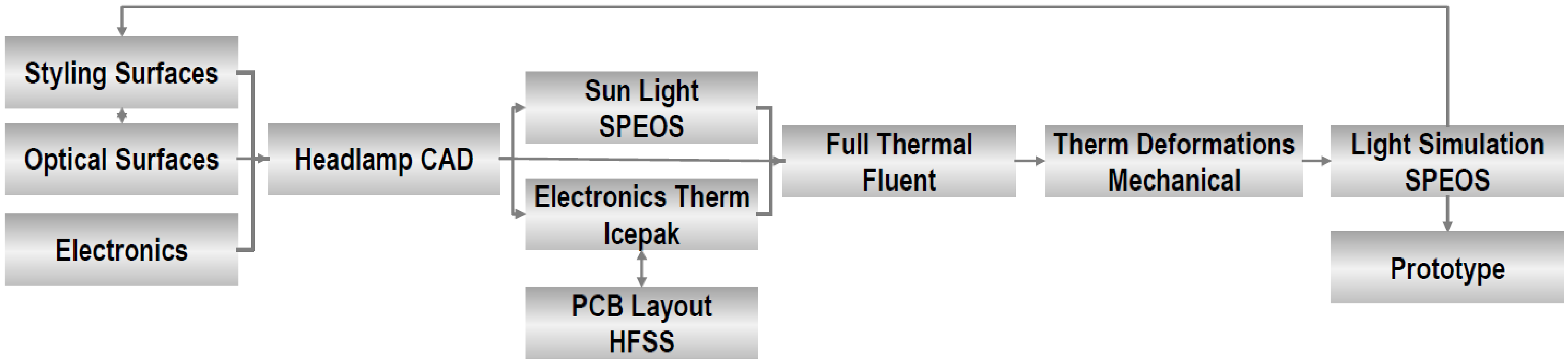
- Smaller Focal Length means higher cutoff angle tolerances
- LED housings have high tolerances, glaring oncoming traffic is downrating car safety (IIHS testing)
- The lens design needs to be exact (submicron scale)
- Surfaces need to be polished (tolerances in nanometer range)
- Lens material needs to have highest transparency
- …

Automotive Headlamp Multiphysics Use Cases

Ideas for robust design concepts

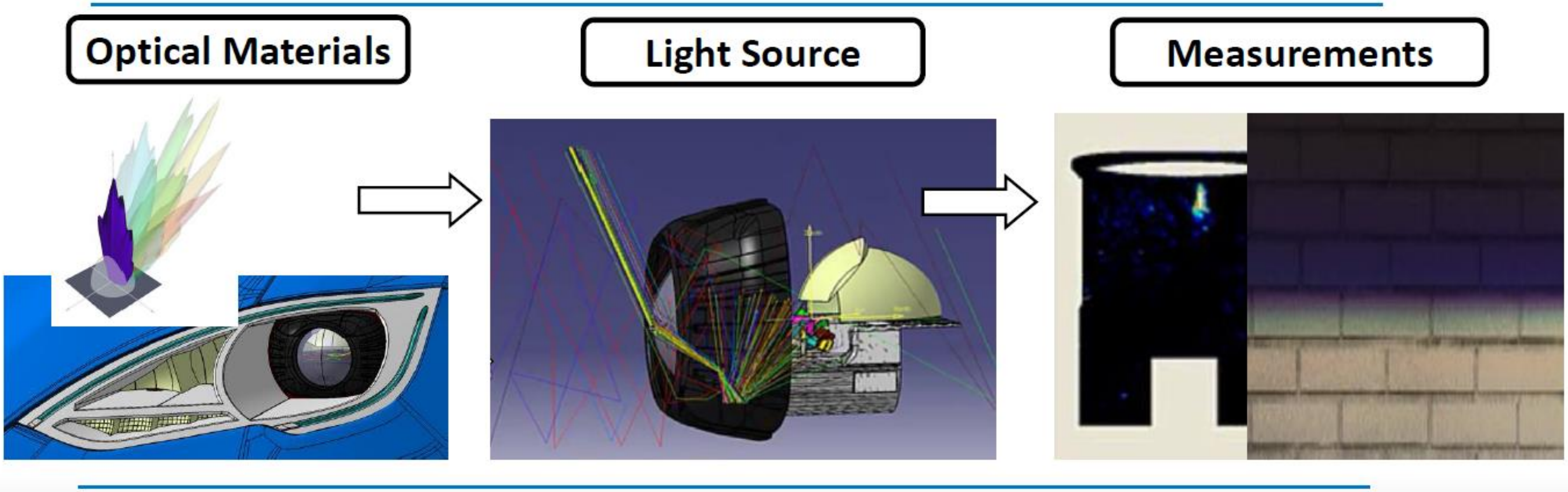
ANSYS Multi-Physics Overall Workflow

- ANSYS SPEOS will simulate the effect of sunlight on the headlamp and provide irradiation maps to Fluent
- ANSYS Icepak will model electronics components in detail and provide PCB Thermal conductivities to Fluent
- ANSYS Fluent will model the full headlamp assembly and provide thermal field to Mechanical.
- ANSYS Mechanical will verify the structural integrity and predict thermal deformations.
- ANSYS SPEOS will test the headlamp for optical performance after thermal deformation.



ANSYS SPEOS Workflow

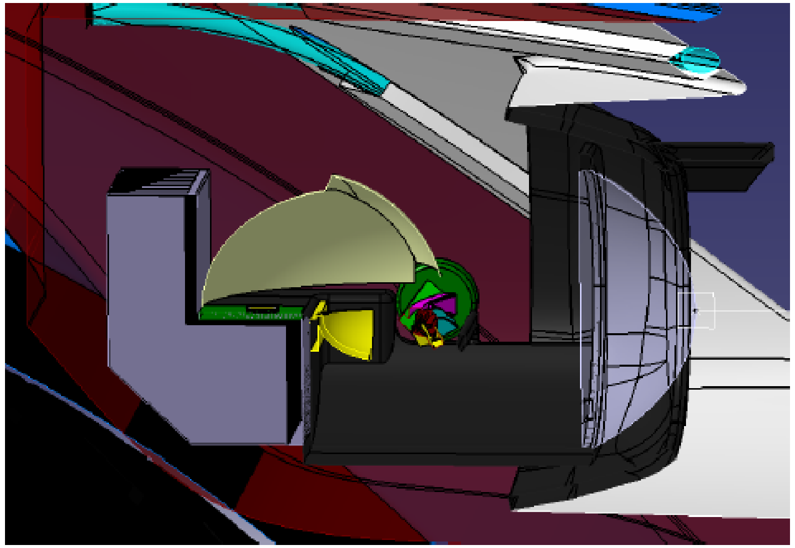
- Original geometry is provided as CAD files.
- Optical interactions for surfaces and solids defined via measured data
- Light sources correlated with real sources such as LEDs and natural light
- Measurements can be performed for sunburn or colorimetric separation



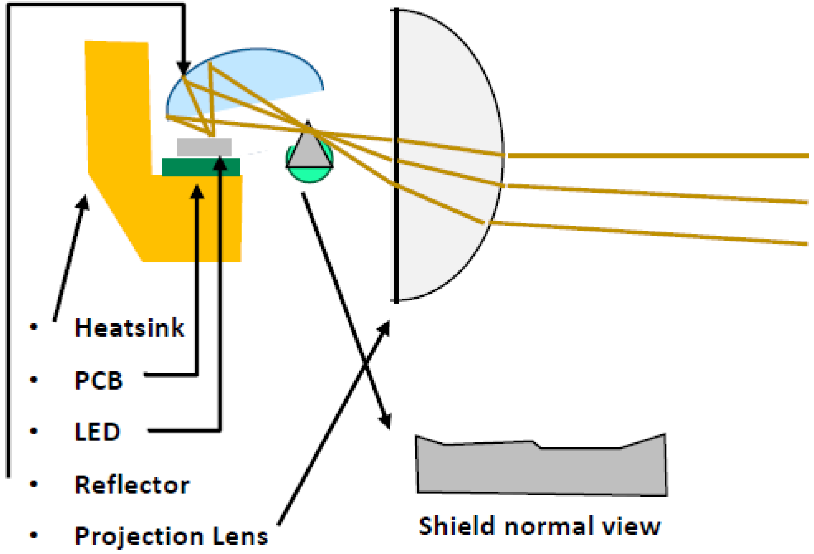
Projection Headlamp

Typical projection lamp system overview

- Light begins at the LED and in the diagram below,
  - Reflects across various points of the reflector
  - Is shaped by the shield (typically rotates, but in this case example would be for low beam with cutoff)
  - Passes through the projection lens and any outer lens



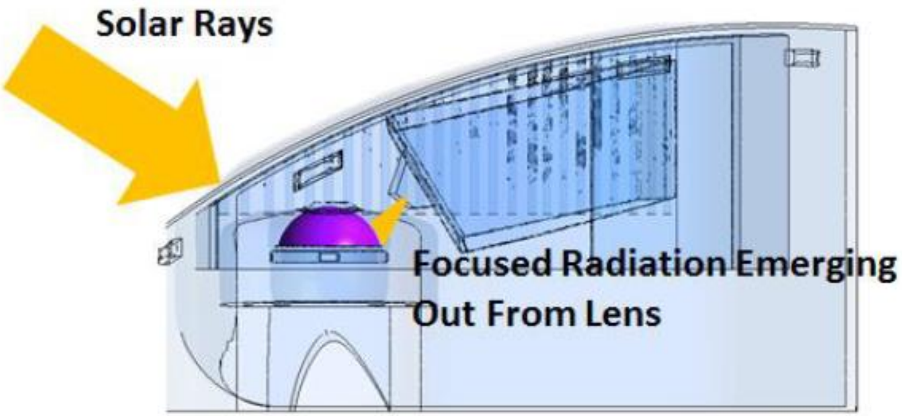
Example cross section of projection headlamp

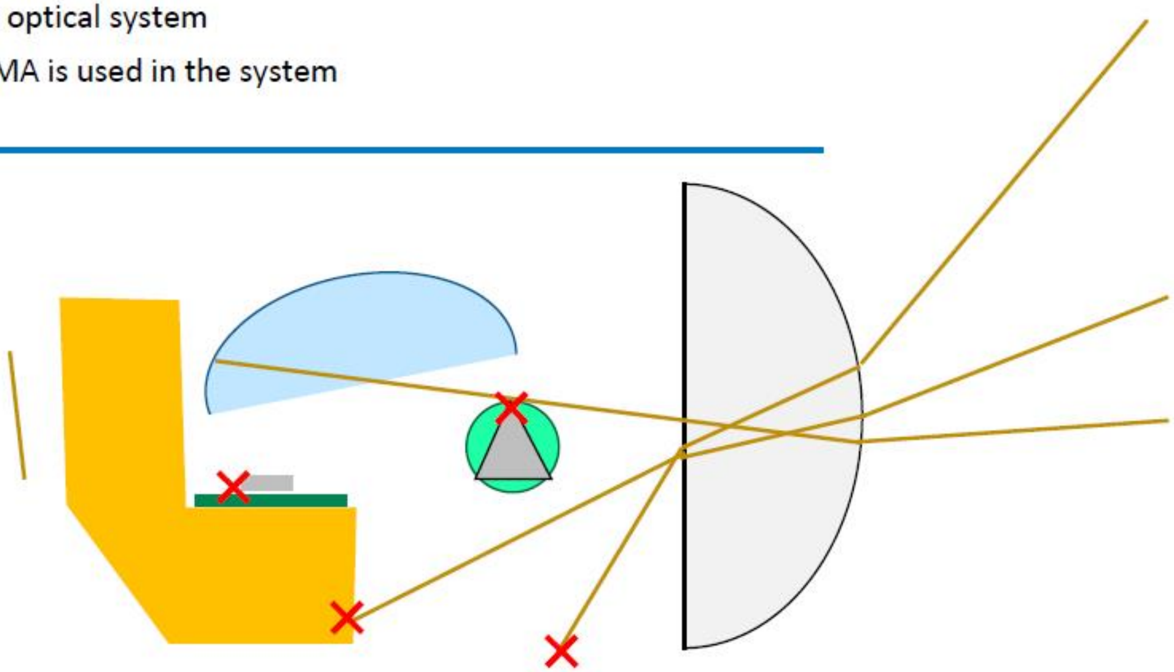


Sunlight Effects in a Headlamp

Sunburn – Sun Path Entry Concept

- Directional high energy light from direct sunlight enters the optical system
- With few protective features, this added energy can strain the current system
- May result in components changing on a level that would affect optical performance
  - Warping, affecting geometrical tolerances for a sensitive optical system
  - Colorimetric changes for plastic, such as yellowing if PMMA is used in the system

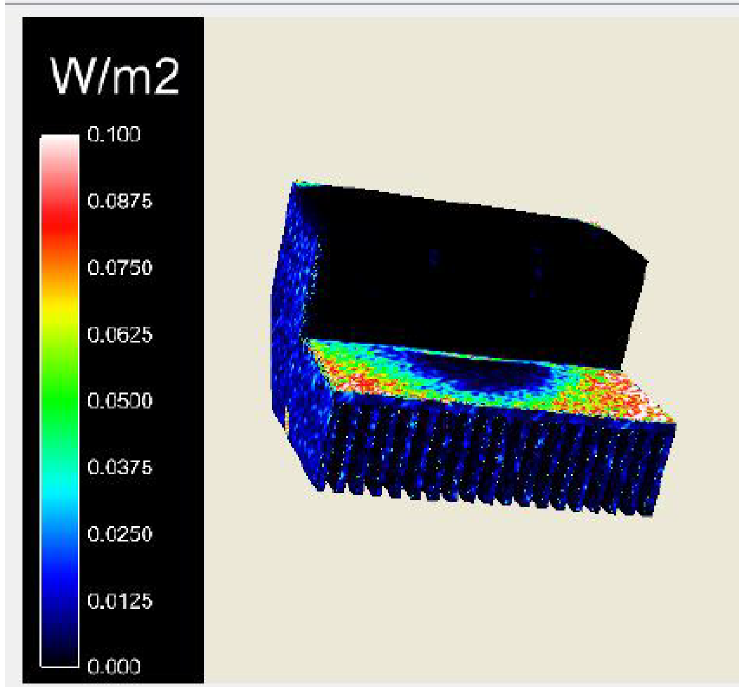




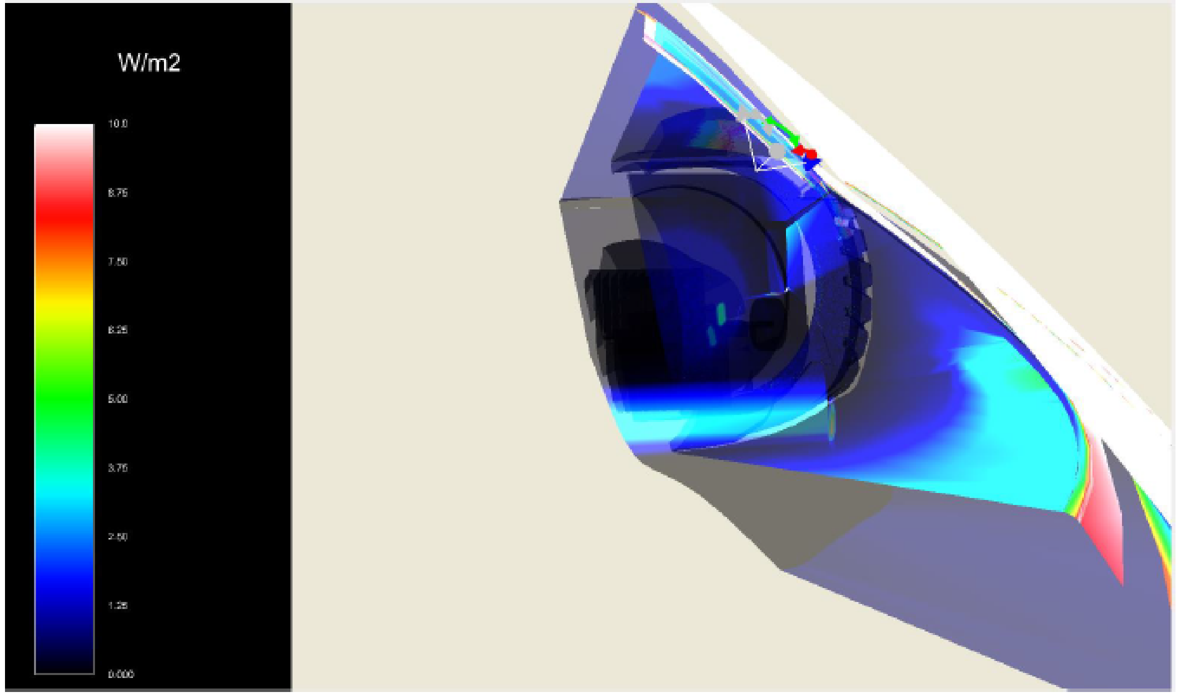
Pictured are potential external light paths that could damage the optical system with prolonged exposure

ANSYS SPEOS – Solar Load Analysis

- Solar light simulations have been conducted
- Irradiation maps for solar loads at different times of the day are created as input for the ANSYS Fluent simulation



Component level analysis radiometric quantities on heatsink

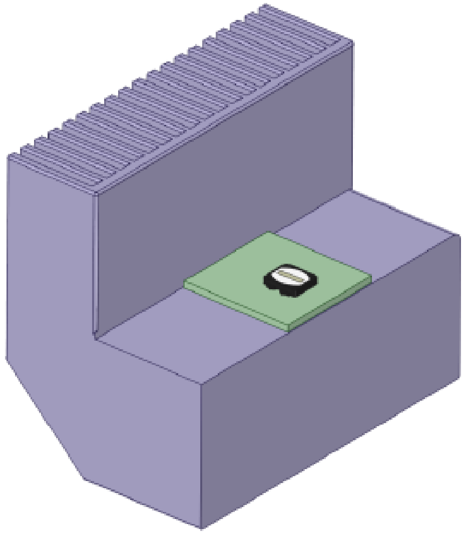


Cross section of radiometry of entire optical system

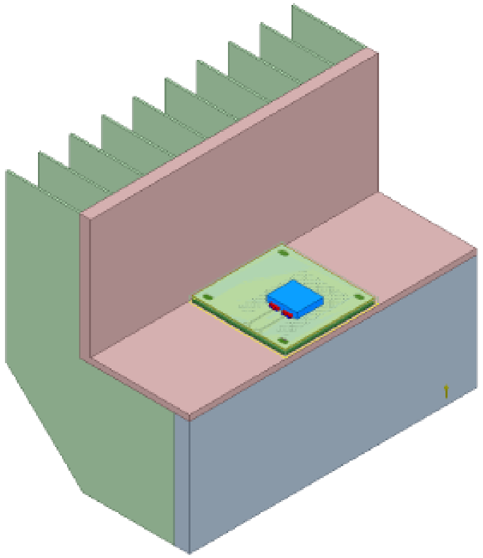
ANSYS Icepak Workflow

- CFD model was built using ANSYS Icepak in Electronics Desktop.
- A heatsink optimization was performed
- Three PCB layouts with thermal vias were created using ANSYS HFSS 3D Layout.

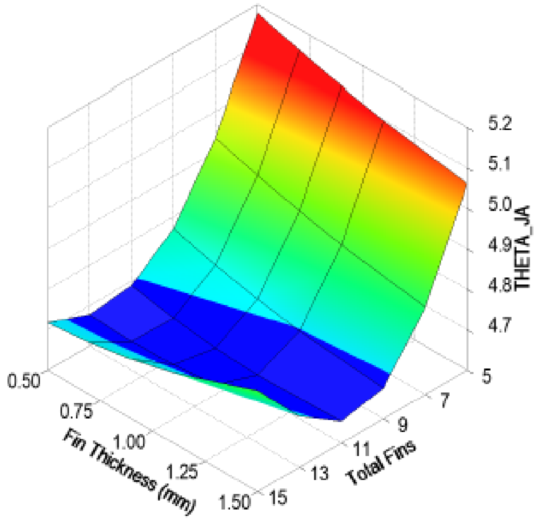
SpaceClaim



Icepak Model

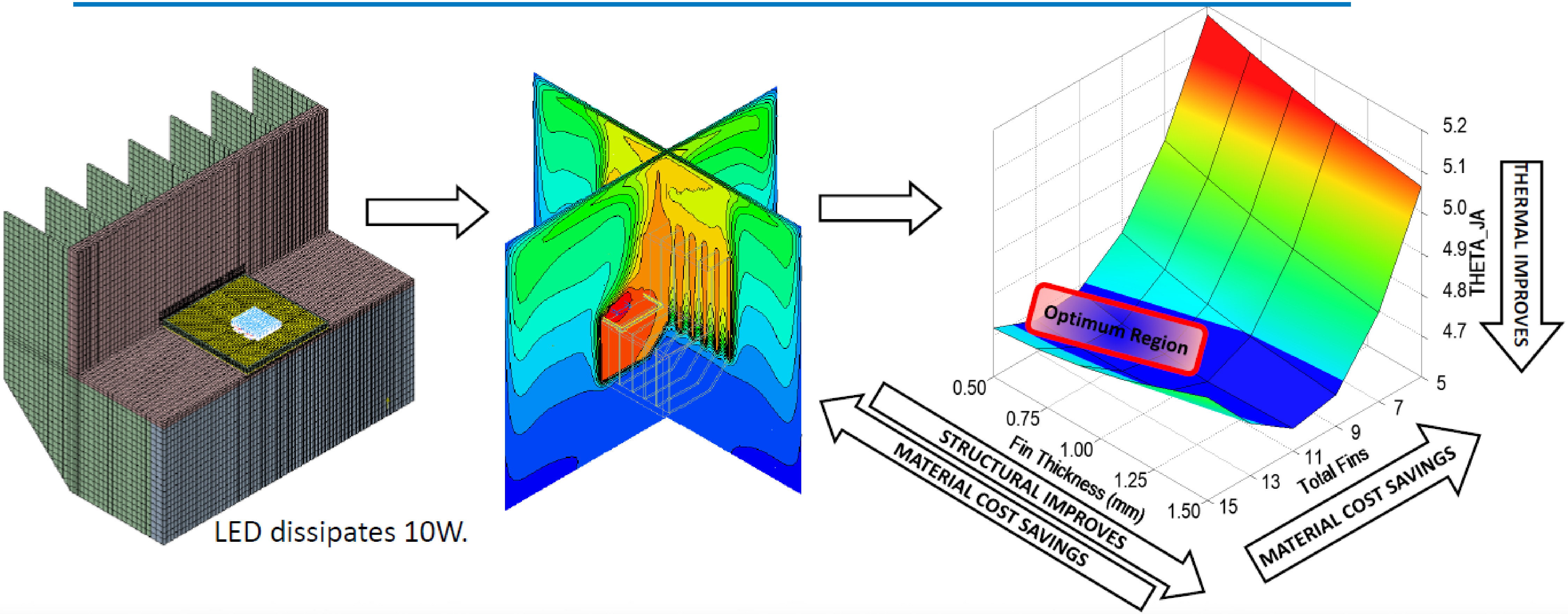


Response Surface



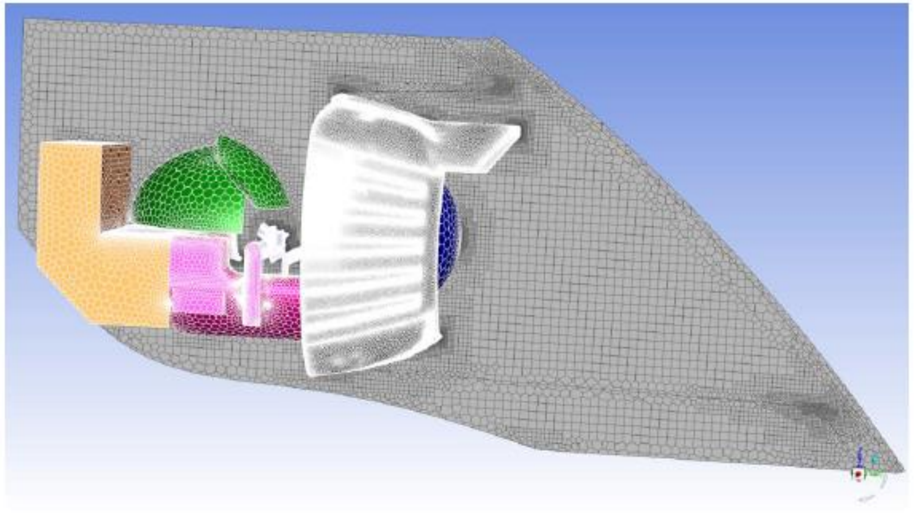
ANSYS Icepak Heatsink optimization

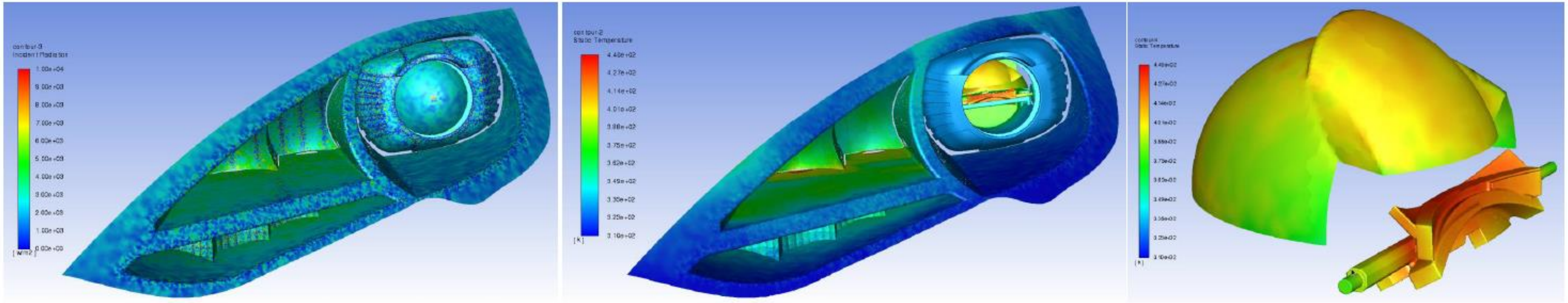
- The heatsink geometry was optimized using Optimetrics Analysis in ANSYS Electronics Desktop.
- The best balance of thermal, structural, and cost performance was chosen.



ANSYS Fluent Analysis

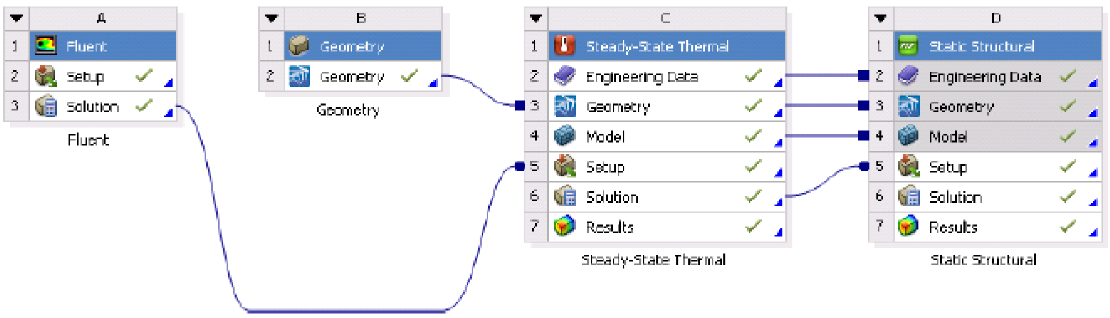
- Watertight CAD workflow in Fluent Meshing was used to create a Poly-Hexcore mesh for the Headlamp CAD with Baffles
- Irradiation Map from SPEOS for Solar Load and Orthotropic Conductivity Field from Icepak for PCB
- Conjugate Heat transfer Simulations were performed in conjunction with the Monte Carlo Radiation Model

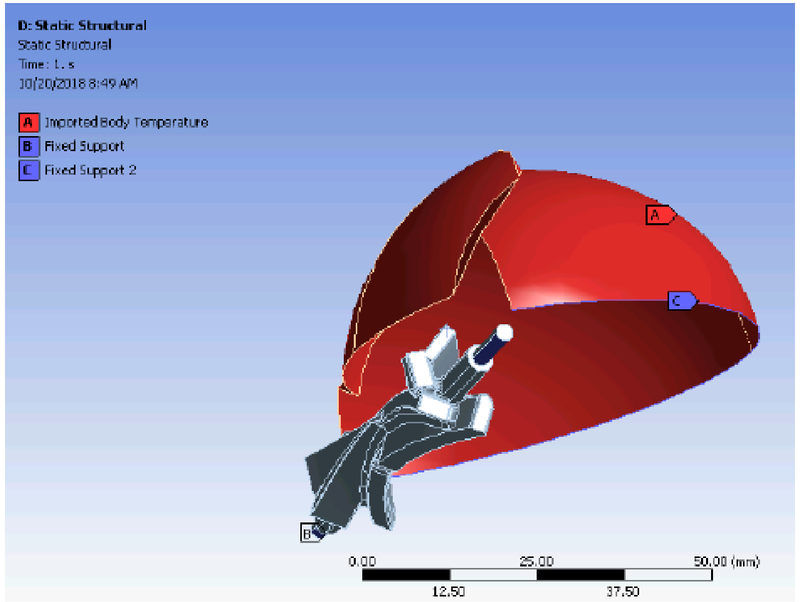


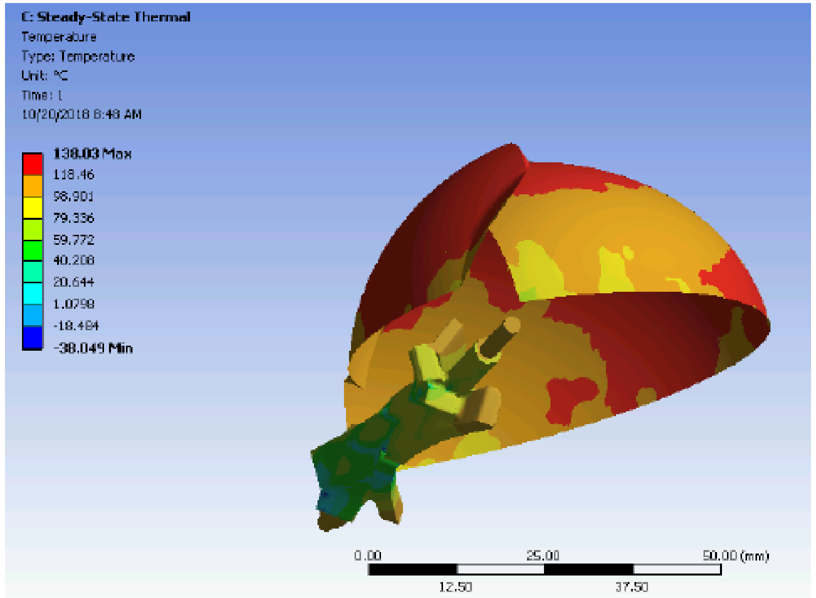


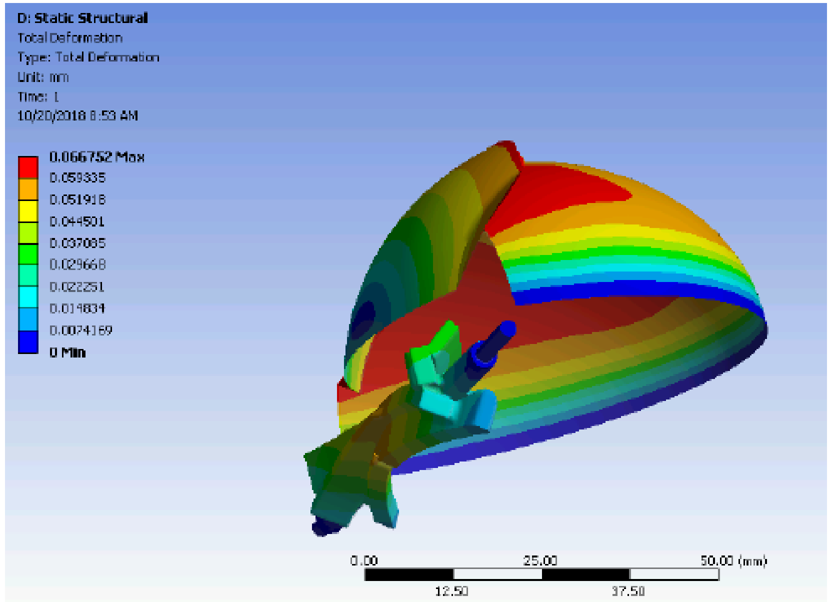
ANSYS Mechanical – Thermal Deformation

- Temperatures on the surface are mapped using WB
- Solved temperature field for steady state thermal analysis
- Performed static structural analysis using fixed support on the Reflector and Shield
- Deformation of the reflector and shield are exported as geometry in STL format





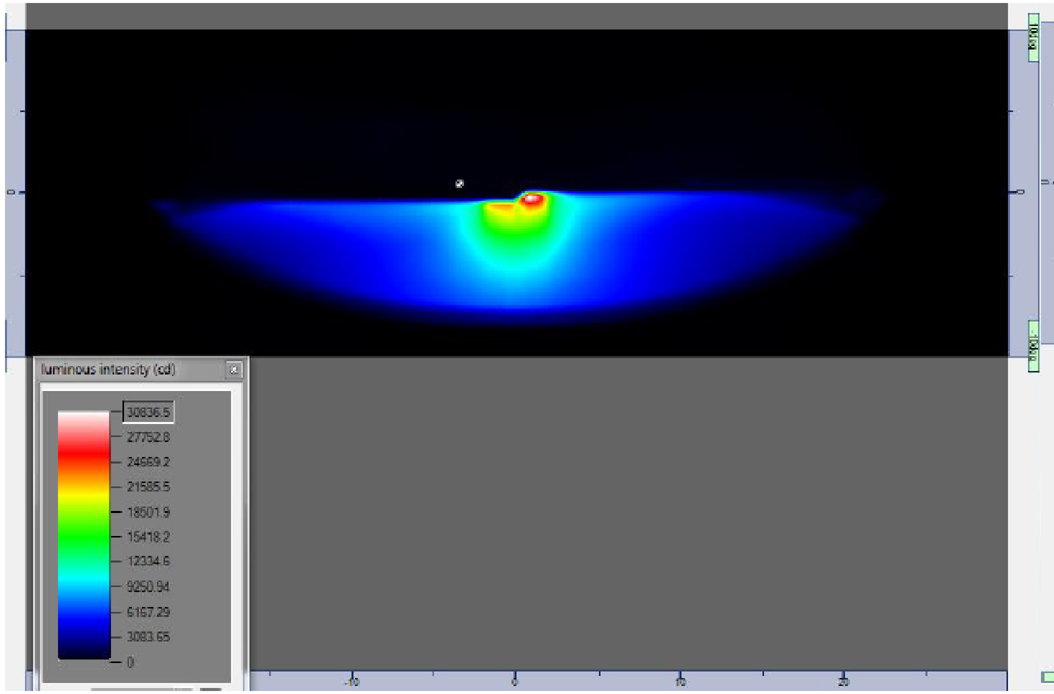




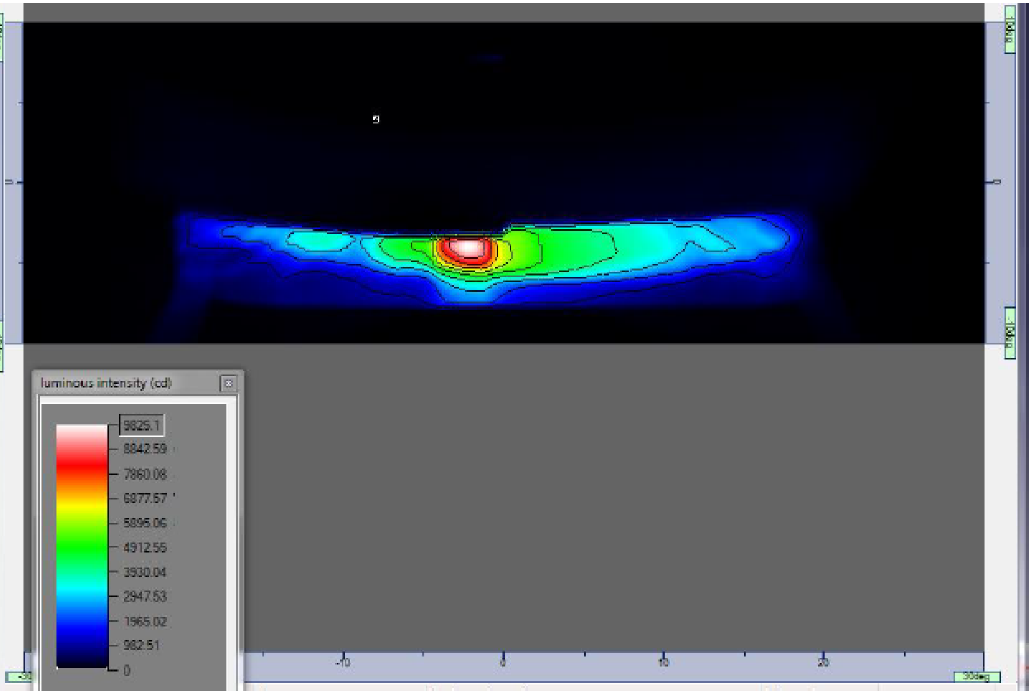
ANSYS SPEOS – Lighting Performance

- ANSYS SPEOS can compare the lighting performance of original and deformed/modified headlamp
  - Luminous Intensity can drastically change with deformed shield and reflector

Original



Deformed



ANSYS SPEOS – Lighting Performance

- ANSYS SPEOS can compare the lighting performance of original and deformed/modified headlamp
  - Luminous Intensity can drastically change with deformed shield and reflector
  - Deformations will affect pass/fail conditions of the headlamp per regulations

Original

S	Area	Measure	Value	Rule	Test	Target
	B50L	Average	231.857 cd	B50L_1 (passed)	>=	50 [50]
		Average	231.857 cd	B50L_2 (passed)	<=	350 [350]
	HV	Average	453.406 cd	HV_1 (passed)	>=	50 [50]
		Average	453.406 cd	HV_2 (passed)	<=	625 [625]
	BR	Average	291.317 cd	BR_1 (passed)	>=	50 [50]
		Average	291.317 cd	BR_2 (passed)	<=	1750 [1750]
	BRR	Minimum	295.959 cd	BRR_1 (passed)	>=	50 [50]
		Maximum	935.916 cd	BRR_2 (passed)	<=	3550 [3550]
	BLL	Minimum	102.037 cd	BLL_1 (passed)	>=	50 [50]
		Maximum	139.956 cd	BLL_2 (passed)	<=	625 [625]
	P	Average	144.234 cd	P (passed)	>=	63 [63]
	50R	Average	19003.5 cd			
	75R	Average	26019.2 cd	75R (passed)	>=	10100 [10100]
	50V	Average	20033.8 cd	50V (passed)	>=	5100 [5100]
	50L	Average	10376.2 cd	50L_1 (passed)	>=	3550 [3550]
		Average	10376.2 cd	50L_2 (passed)	<=	13200 [13200]
	25LL	Average	4307.02 cd	25LL (passed)	>=	1180 [1180]
	25RR	Average	4245.4 cd	25RR (passed)	>=	1180 [1180]
	Segment_20__below	Flux				
	Segment_10__below	Maximum	11507 cd	Segment_10__below (passed)	<=	12300 [12300]
	S50LL	Average	285.272 cd			
	S50RR	Average	177.443 cd			
	S50	Average	119.292 cd			
				S50_Sum=582.007	=	S50.Average+S50LL.Average+S50RR.Average
				S50_Lines (passed)	=	S50_Sum>=190
	S100LL	Average	248.44 cd	S100LL		
	S100RR	Average	244.612 cd			
	S100	Average	203.104 cd			
				S100_Sum=696.157	=	S100.Average+S100LL.Average+S100RR.Average
				S100_Lines (passed)	=	S100_Sum>=375
	Zone_3a_1	Maximum	285.978 cd	Zone_3a_1 (passed)	<=	625 [625]
	Zone_3a_2	Maximum	299.916 cd	Zone_3a_2 (passed)	<=	625 [625]
	Zone_3a_3	Maximum	295.588 cd	Zone_3a_3 (passed)	<=	625 [625]
	Zone_3a_4	Maximum	372.305 cd	Zone_3a_4 (passed)	<=	625 [625]
	Zone_3a_5	Maximum	309.901 cd	Zone_3a_5 (passed)	<=	625 [625]
	Imax	Maximum	30490 cd	Imax_1 (passed)	>=	16900 [16900]
		Maximum	30490 cd	Imax_2 (passed)	<=	44100 [44100]

Deformed

S	Area	Measure	Value	Rule	Test	Target
	B50L	Average	87.885 cd	B50L_1 (passed)	>=	50 [50]
		Average	87.885 cd	B50L_2 (passed)	<=	350 [350]
	HV	Average	111.967 cd	HV_1 (passed)	>=	50 [50]
		Average	111.967 cd	HV_2 (passed)	<=	625 [625]
	BR	Average	97.6668 cd	BR_1 (passed)	>=	50 [50]
		Average	97.6668 cd	BR_2 (passed)	<=	1750 [1750]
	BRR	Minimum	135.218 cd	BRR_1 (passed)	>=	50 [50]
		Maximum	225.679 cd	BRR_2 (passed)	<=	3550 [3550]
	BLL	Minimum	76.9394 cd	BLL_1 (passed)	>=	50 [50]
		Maximum	142.45 cd	BLL_2 (passed)	<=	625 [625]
	P	Average	59.9775 cd	P (failed)	>=	63 [63]
	50R	Average	142.075 cd			
	75R	Average	129.883 cd	75R (failed)	>=	10100 [10100]
	50V	Average	104.059 cd	50V (failed)	>=	5100 [5100]
	50L	Average	44.5126 cd	50L_1 (failed)	>=	3550 [3550]
		Average	44.5126 cd	50L_2 (passed)	<=	13200 [13200]
	25LL	Average	115.339 cd	25LL (failed)	>=	1180 [1180]
	25RR	Average	222.208 cd	25RR (failed)	>=	1180 [1180]
	Segment_20__below	Flux				
	Segment_10__below	Maximum	9805.84 cd	Segment_10__below (passed)	<=	12300 [12300]
	S50LL	Average	11.8970 cd			
	S50RR	Average	20.0625 cd			
	S50	Average	12.5656 cd			
				S50_Sum=44.5257	=	S50.Average+S50LL.Average+S50RR.Average
				S50_Lines (failed)	=	S50_Sum>=190
	S100LL	Average	70.9854 cd	S100LL		
	S100RR	Average	65.7287 cd			
	S100	Average	71.6500 cd			
				S100_Sum=208.374	=	S100.Average+S100LL.Average+S100RR.Average
				S100_Lines (failed)	=	S100_Sum>=375
	Zone_3a_1	Maximum	96.0082 cd	Zone_3a_1 (passed)	<=	625 [625]
	Zone_3a_2	Maximum	114.841 cd	Zone_3a_2 (passed)	<=	625 [625]
	Zone_3a_3	Maximum	84.0893 cd	Zone_3a_3 (passed)	<=	625 [625]
	Zone_3a_4	Maximum	113.581 cd	Zone_3a_4 (passed)	<=	625 [625]
	Zone_3a_5	Maximum	93.3251 cd	Zone_3a_5 (passed)	<=	625 [625]
	Imax	Maximum	163.037 cd	Imax_1 (failed)	>=	16900 [16900]
		Maximum	163.037 cd	Imax_2 (passed)	<=	44100 [44100]

Thank You for your Attendance – Q&A

Summary:

- Glaring of oncoming traffic is safety critical – ANSYS physics based simulations helps to optimize lighting systems
- In principle there is only one physics – every system is influenced by all physics, also lighting by thermal and mechanics
- ANSYS SPEOS is integrated in ANSYS workbench – Multiphysics Simulation are possible
- The use of optiSLang from Dynardo helps to reduce the simulation effort and to automate the robust design optimization