Application Deep Dive:
Designing Cameras with Ansys Optical Simulation Tools

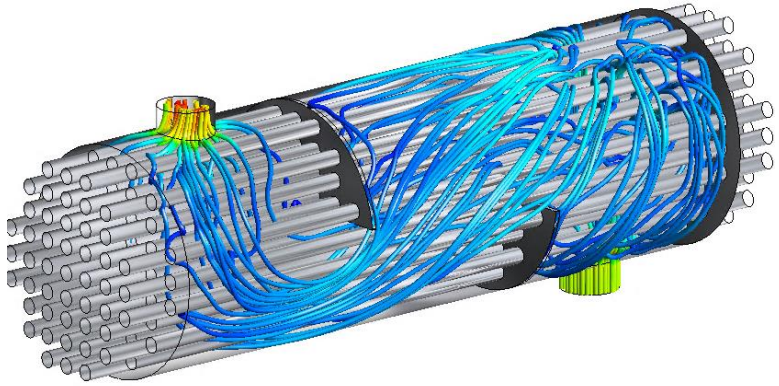
Ansys

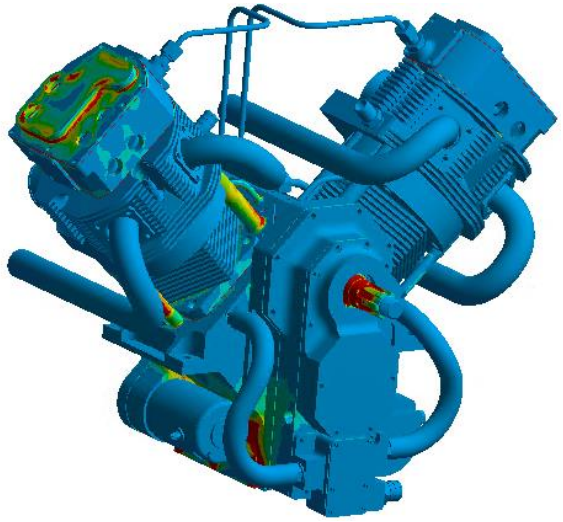
Agenda

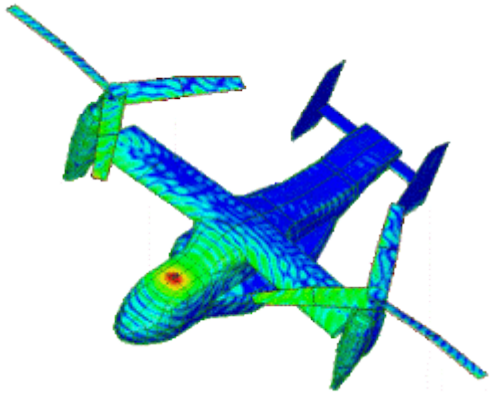
Introduction to DRD
Evaluating Cameras using Ansys
Questions

Mission Statement

DRD Technology helps engineering teams accelerate product development. With in-house expertise spanning the entire range of physics, we ensure customers succeed when using Ansys simulation tools for virtual prototyping and design verification.







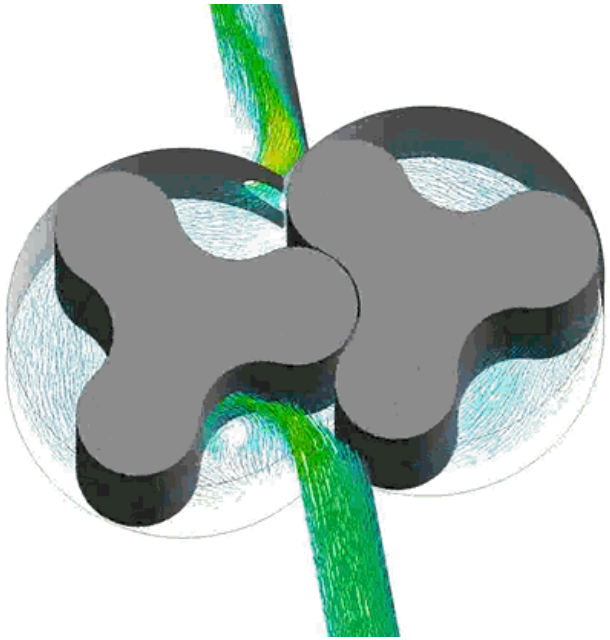
Ansys

CERTIFIED ELITE CHANNEL PARTNER

DRD History

Since 1980, DRD Technology has been focused on engineering simulation.

In 1984, DRD became an Ansys Channel Partner.



Lobe pump

I've been working with DRD for 29 years. Working with your team has been one of the more enjoyable parts of my career. You have always been ready to help in any way.

- Rick Kunc
Sr. Research & Development Engineer
SOLVAY
asking more from chemistry®

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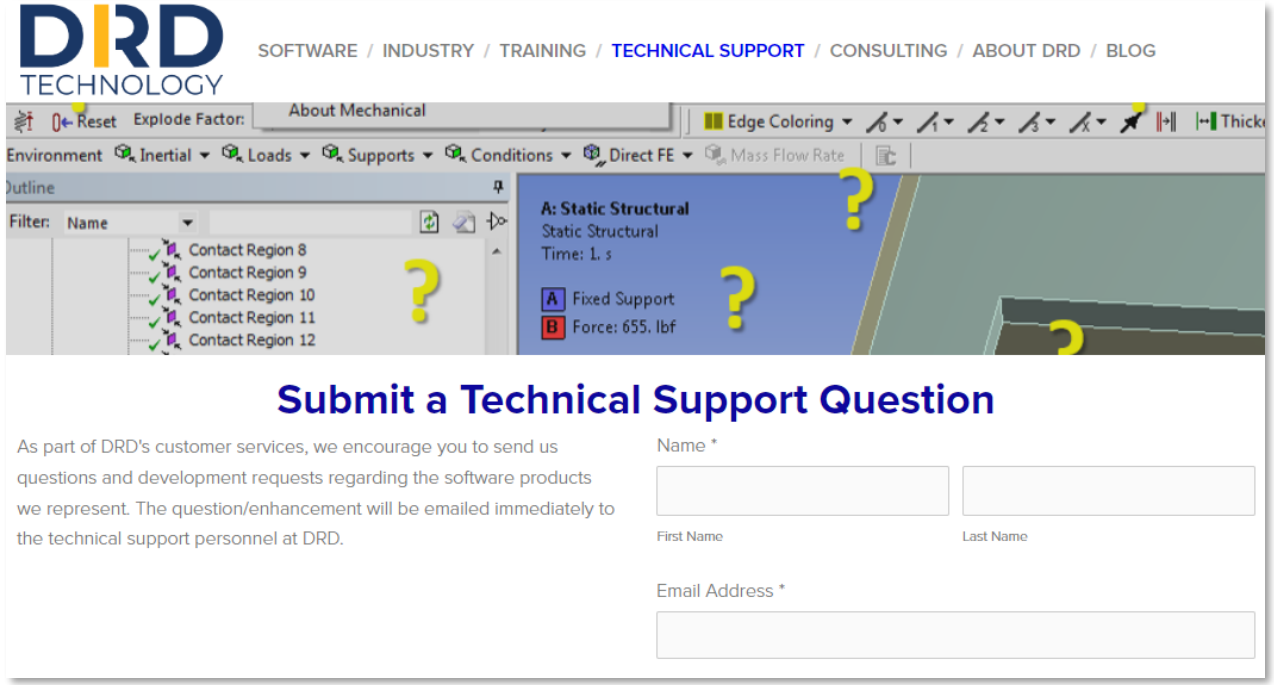
Technical Support Contact Coordinates

Support:
(918) 743-3013 x1
support@drd.com

Or through our website at
www.drd.com



For more than five years, I have worked closely with DRD Technology to execute tactical and strategic initiatives here at EaglePicher due to our unprecedented growth. We've been very happy with DRD and will continue to work with them as our business partner for using Ansys tools effectively and efficiently.

- Doug Austin
Director of Research and Development
EaglePicher™ Technologies, LLC

Ansys Software Training

Live, Virtual Courses from DRD

Structures

- Introduction to Ansys Mechanical (2 days)
- Ansys Composite Cure Simulation (1 day)
- Ansys Mechanical Nonlinear Structural Simulation (2 days)
- Ansys Mechanical Structural Dynamics (2 days)
- Ansys Mechanical Fracture Mechanics (1 day)
- Ansys Mechanical Thermal Simulation (1 day)
- Ansys Composite PrepPost (1 day)
- Ansys Topology Optimization and Metal Additive Manufacturing (1 day)
- Ansys Workbench LS-DYNA (2 days)
- Advanced Meshing for Ansys Mechanical (1 day)
- Introduction to SpaceClaim for Ansys Mechanical (1 day)
- Ansys Mechanical Fatigue Life Prediction (1/2 day)
- Ansys nCode Design Life (2 days)

System Modeling

- Introduction to Ansys Twin Builder for Mechanical Systems (1 day)

Fluids

- Introduction to Ansys CFX (2 days)
- Introduction to Ansys Fluent (2 days)
- Workbench Meshing for Ansys Fluent (1 day)
- Fault Tolerant Meshing for Underhood Thermal Modeling with Ansys CFD (1 day)
- Ansys Rocky (1 day)

Electronics

- Introduction to Ansys HFSS (2 days)
- Ansys HFSS Antenna Design (2 days)
- Ansys HFSS SBR+ Antenna Placement Design (1 day)
- Introduction to Ansys SIwave (1 day)
- Introduction to Ansys HFSS 3D Layout (2 days)
- Introduction to Ansys Maxwell (1 day)
- Ansys Maxwell Motor Modeling (1 day)
- Introduction to Ansys Icepak (2 days)

Ansys Expert Mail List

Request to be added by sending a note to support@drd.com

Ansys Expert Tech Corner

We hope that our website provides a great deal of valuable technical information, which is available to anyone who visits our website. The technical materials on this page, however, are intended only for DRD's customers, and are, therefore, password protected. We provide these materials to our customers as a benefit for doing business with DRD, and at our discretion we provide them to selected DRD friends and associates.

The topics on this page are intended for engineers who are interested in highly technical and detailed information on Ansys. These topics contain information, which is not readily available to Ansys users through standard documentation and training courses. For example, some topics provide information on Ansys capabilities that are under development or are not documented.

Previous Expert Topics

- 2022
- 2021
- 2020
- 2019
- 2018
- 2017
- 2016
- 2014 - 2015
- 2003 - 2013

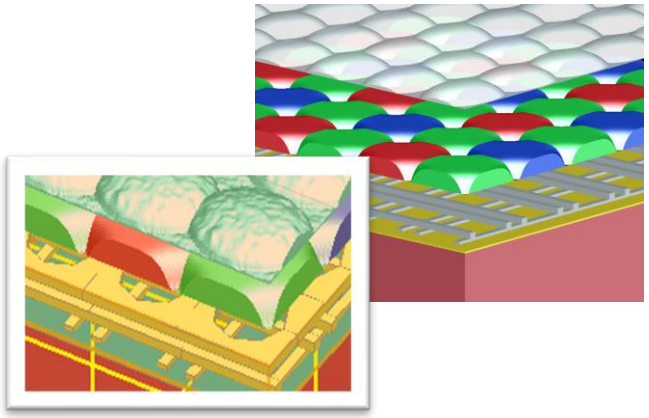
Fracture Mechanics Webinar: Gain Insight Into Structures with Cracks with Ansys Fracture Mechanics - (April 2023)

This webinar, conducted on April 28, 2023, provides a brief overview of fracture mechanics and Ansys capabilities in fracture analysis. DRD discusses safe-life vs. damage tolerant design, material data acquisition, and simulation of cracks in structures. Ansys fracture capabilities include both stationary, and static and fatigue crack growth options for engineers to analyze their systems.

For a recording and the presentation slides, download here. (A password is required if you have not obtained one already. Select Fracture Mechanics Webinar (April 2023) from the password topic list).

End-to-end coverage of Full Optics Portfolio is Significant

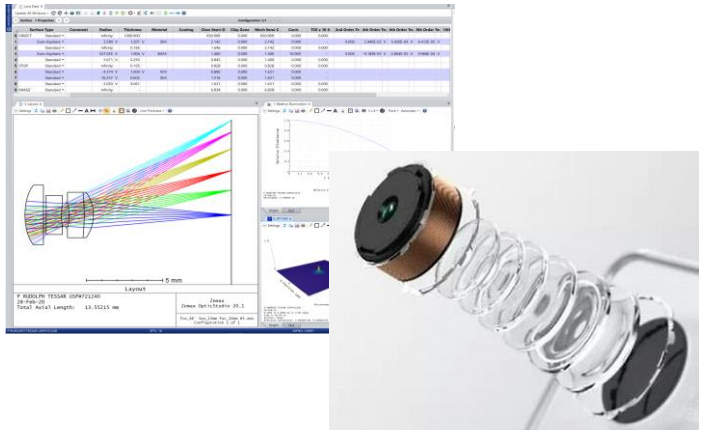
Ansys LUMERICAL



Photonic Component Modeling

Chip-Level (waveguides, sensors, microlenses)

Zemax An Ansys Company

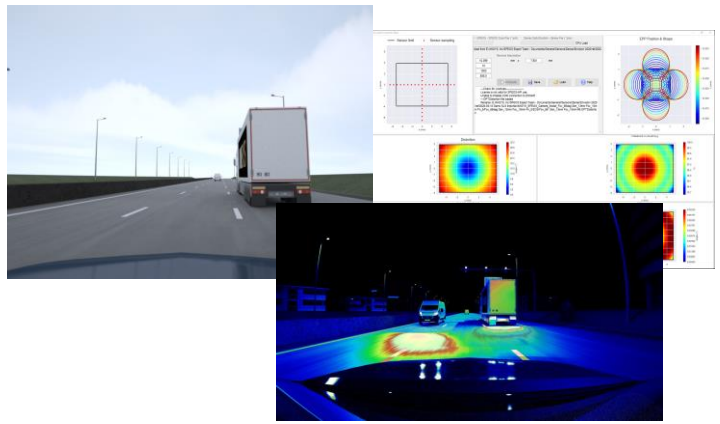


Optical Component Modeling

Lens stack optimization

Optical/Mechanical Tolerancing

Ansys SPEOS



System Level Modeling

3D Environment Integration

Lighting

Human Vision/Perception

From Nano → **To Macro** → **To System**

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Benefits of using full Ansys optical solution

1. Best in class optical tools through product development process
2. Single point of contact for simulation support
3. Seamless workflow and simplified data transfer from photonics design and optical design to in-context system
   - Direct integrations with Multiphysics software solutions, enabling robust system design

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Overview of Design Challenges & Workflow

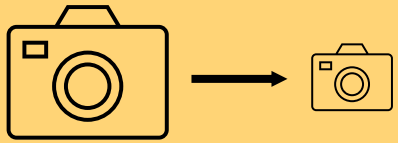
Camera Design for High Tech

Ansys

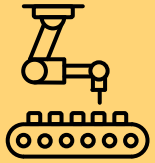
Design challenges for camera modules

Small form factor camera modules are pervasive in everyday life, from smartphones to drones to doorbells. These technologies all contain a host of high-tech optical systems and require robust imaging performance. However, to develop these solutions engineers must tackle an array of challenges, including:

- Increased demand for miniaturization

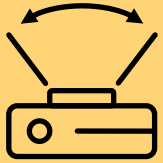


- High-volume, low-cost injection molded optics

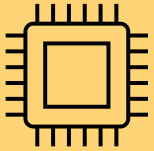


- Complex lens profiles and mounting arrangements

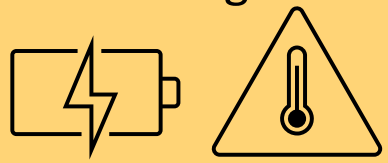
- Wide Field of View (FOV > 90 degrees)



- Integration with high-resolution sensors



- Internal and external heat management



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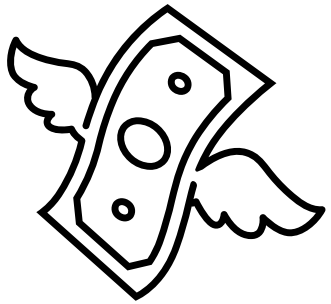
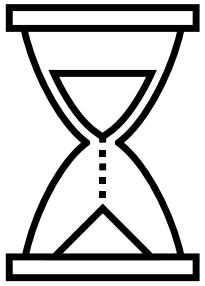
Design challenges for camera modules





<u>Design challenges tax engineering & development resources, increase cost, and delay time to market</u>.

- Increasingly complex optics and packaging constraints often cause data translation and communication issues between engineering teams
- Numerous iterations due to tradeoffs between high-performance imaging and wide FOVs
- Increased pixel density requires more sophisticated optical and electrical analysis
- Severe consequences if high-volume lens manufacturing runs fail
- Late-stage error identification in physical prototypes is tedious and time consuming to address
  - Stress- or heat-induced optical performance degradation
  - Assembly misalignments
  - Sensor integration errors

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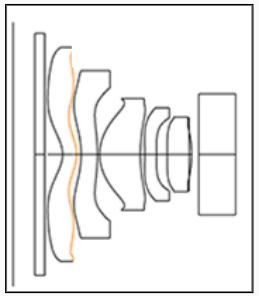
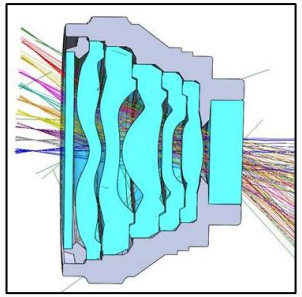
Workflow

Optical Development

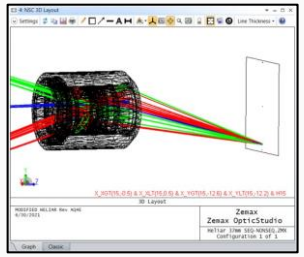
Lens Stack Optimization & Tolerancing



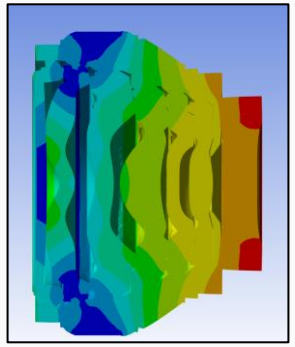
Optomechanical Packaging



Stray Light Analysis

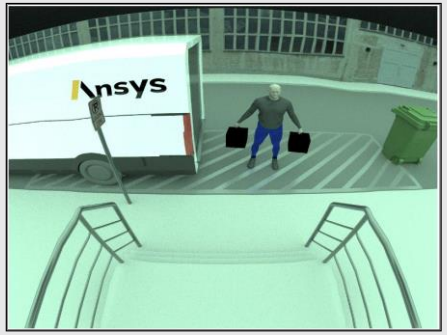


Structural & Thermal Analysis



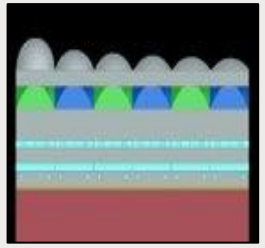
System Analysis

Environment Integration & Scene Visualization

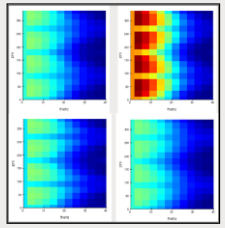


Imager Development

Microlens Array Optimization



Color Filter Optimization



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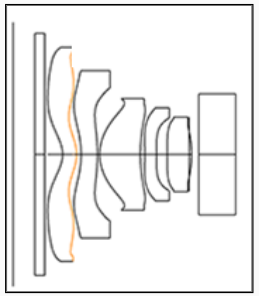
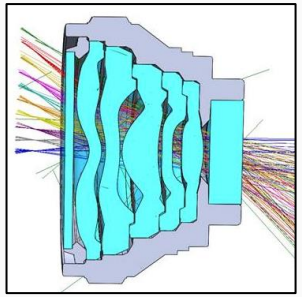
Workflow (with products)

Optical Development

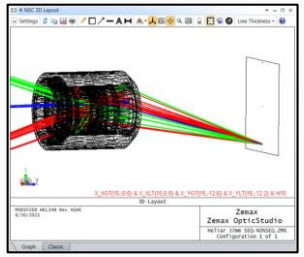
Lens Stack Optimization & Tolerancing



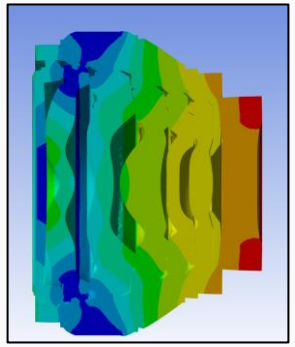
Optomechanical Packaging



Stray Light Analysis

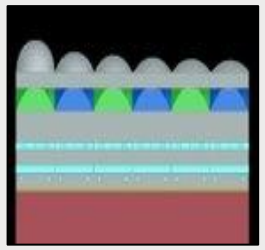


Structural & Thermal Analysis

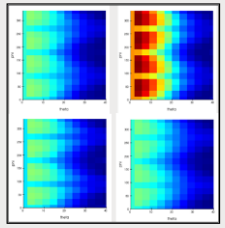


Imager Development

Microlens Array Optimization

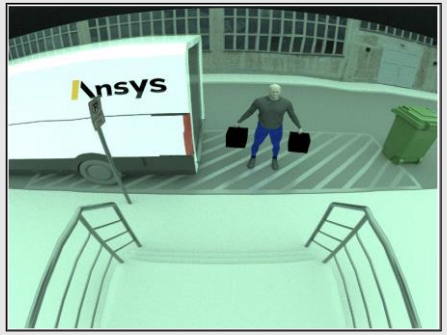


Color Filter Optimization



System Analysis

Environment Integration & Scene Visualization



Zemax

Speos

Lumerical

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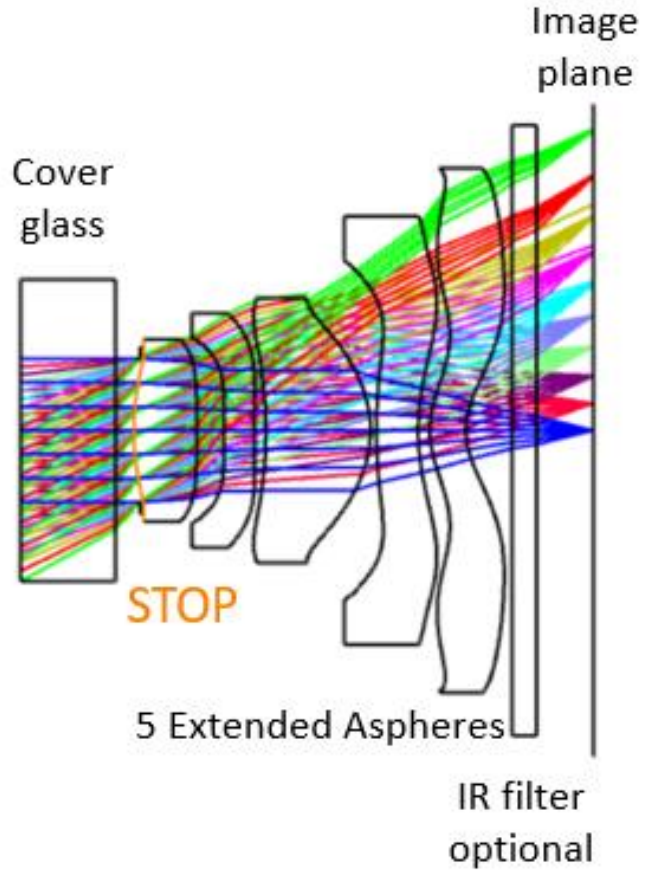
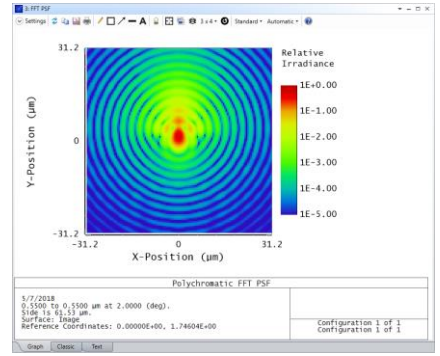
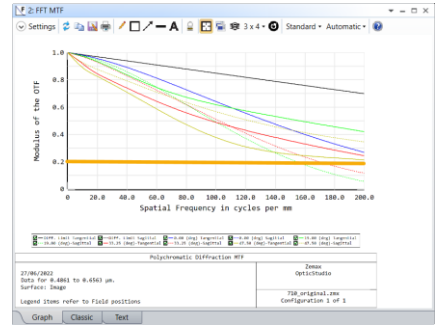
Optical Development Workflow

Lens Stack Optimization

- Design Templates for Starting Point Selection
- Select from glass & plastic lens materials
  - Built-in & custom defined
  - Industry standard analysis methods to track system performance
  - PSF, MTF, Wavefront Error, Relative Illumination
- Optimize for manufacturability
  - Control surface slope and system tolerances
- Automation via ZOS-API
  - Connections with Matlab, Python, Mathematica







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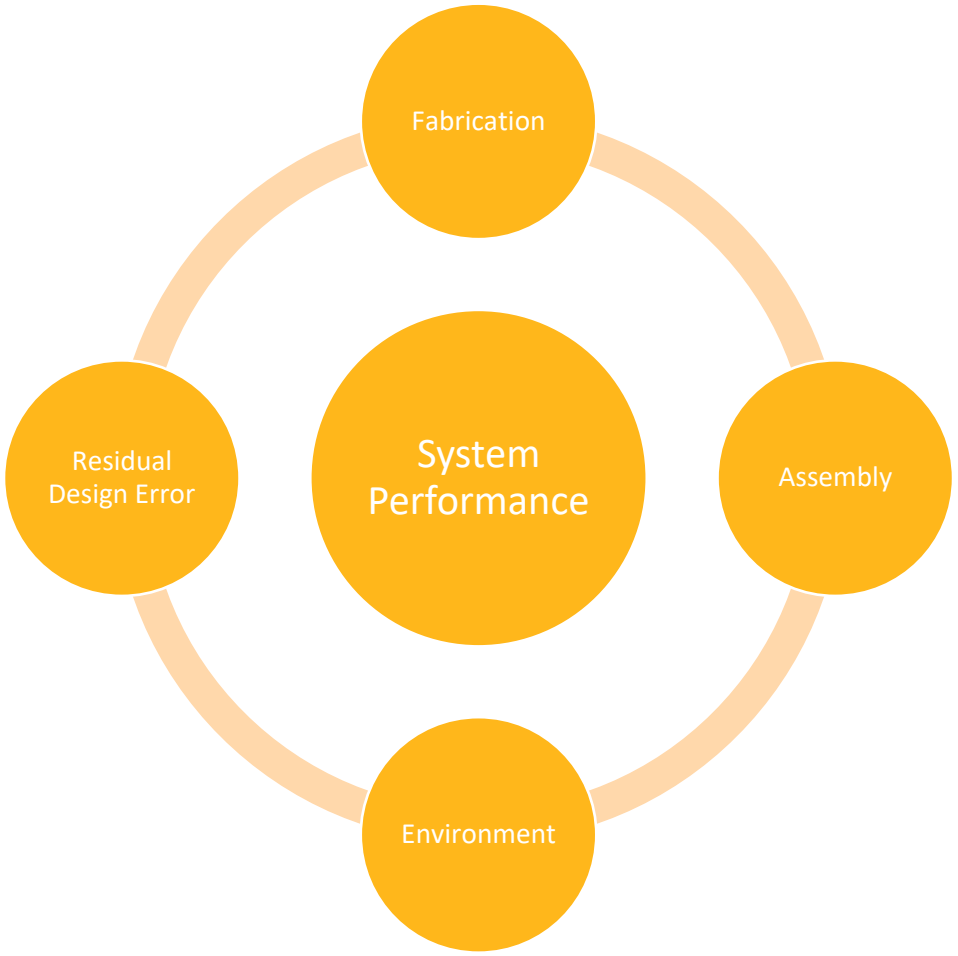
Lens Stack Tolerancing

- Introduce real-world manufacturing & assembly defects to determine optical performance degradation
- Evaluate the manufacturing tolerances to estimate the expected change in performance
  - Optical & Mechanical
- Types of available analyses:
  - Sensitivity & Inverse Sensitivity (Worst Offenders)
  - Monte Carlo (Manufacturing Yield)
- Flexible evaluation metrics, including…
  - Wavefront error
  - MTF
  - Boresight
  - User Defined



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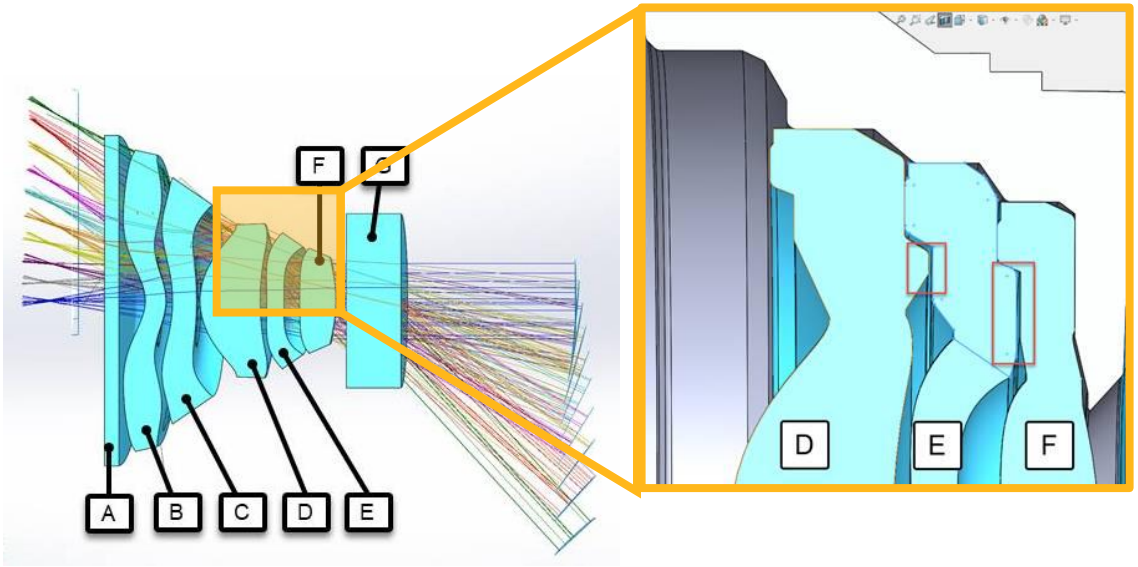
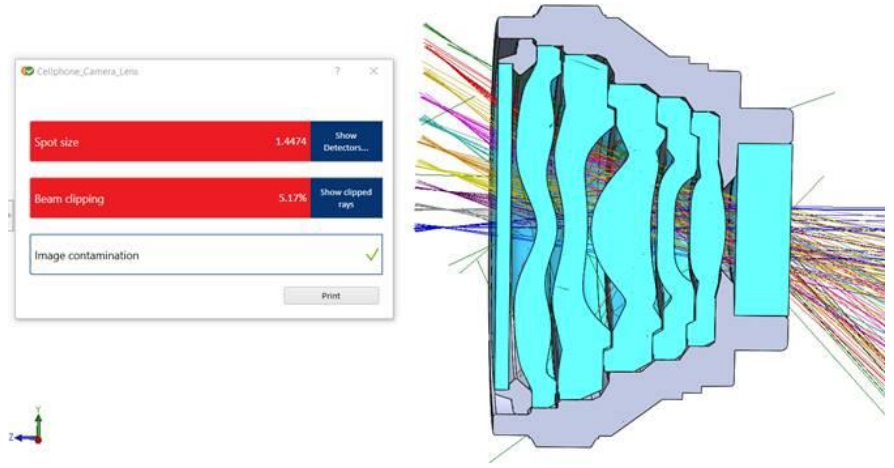
Optomechanical Design

- Seamlessly transition optical design specification to CAD environment, including:
  - Lens geometry
  - Material definitions
  - Light sources
  - Sensor positions
- Incorporate or design mounting structures
  - Mechanical housings
  - Complex lens edges
- Consider impact of both optical and mechanical components while evaluating optical performance metrics





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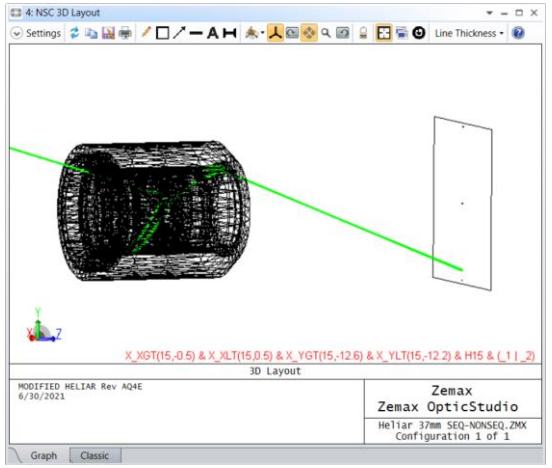
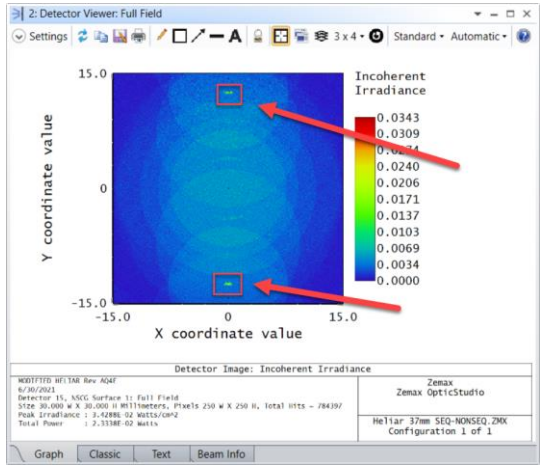
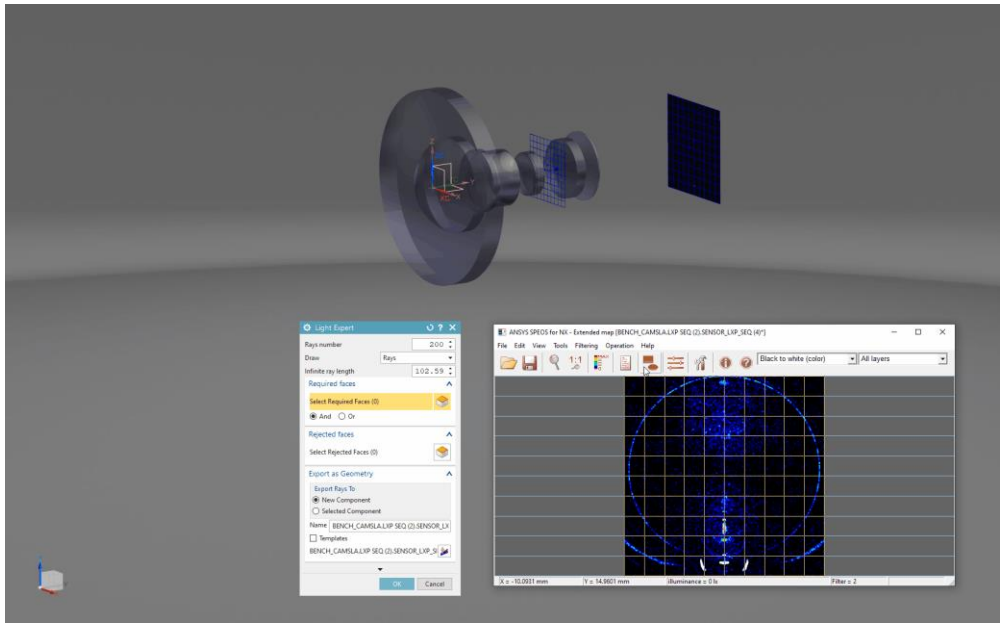
Stray Light Analysis

- Identify stray light paths while considering both optical and mechanical components.
  - Ghost Images
  - Ray sequences
  - Noise Paths
- Visualize specific ray paths with layout tools
- Analyze energy contribution of different paths/sequences
- Separate sequences with layers on sensors
- Quantify the image deterioration contributor







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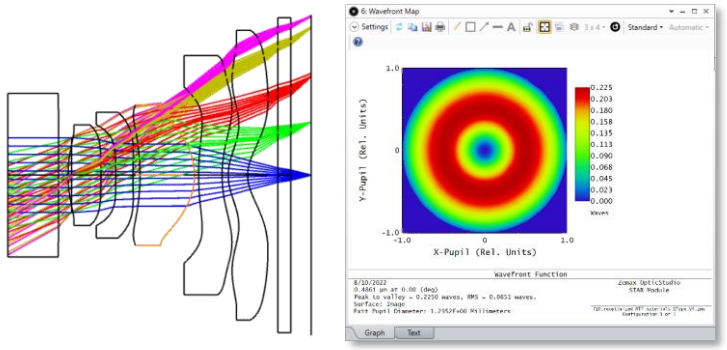
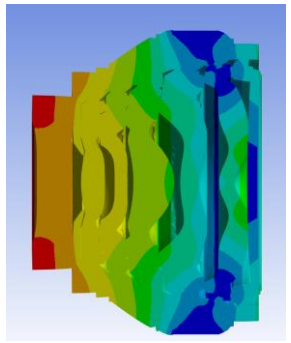
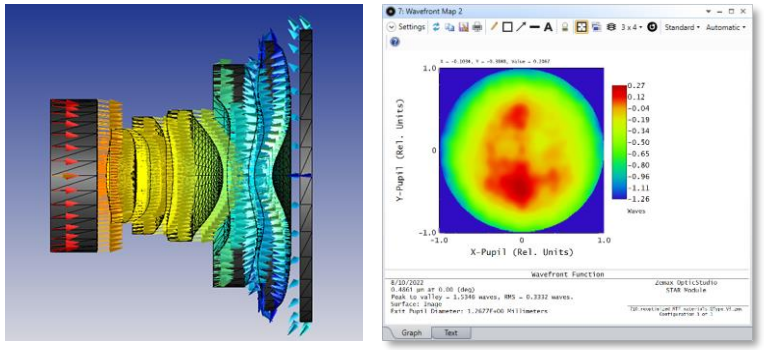
Structural Thermal Optical Performance

1. Perform nominal optical system design in OpticStudio
2. Send to CAD to incorporate optomechanical system design
3. Send to FEA to apply structural and thermal loads (surface deformation & thermal index variation)
4. Import deformed system to OpticStudio to analyze optical performance.







Optical Simulation (Nominal) → Thermal & Structural Analysis → Optical simulation (Degraded)

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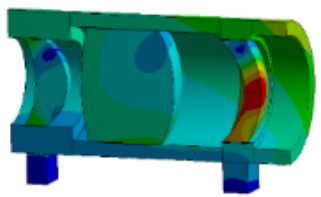
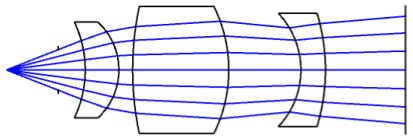
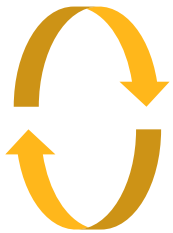
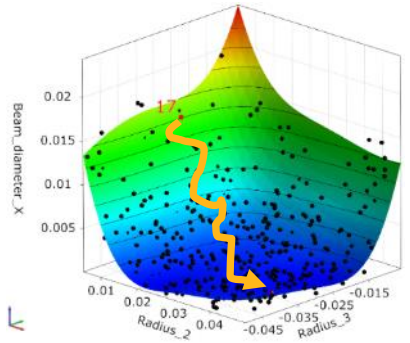
STOP Workflow Automation for design optimization

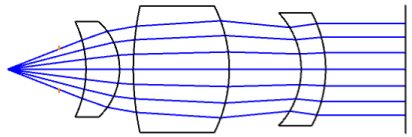
- **Workflow Automation**
  - Integration optical and mechanical simulation tools in Ansys optiSLang
  - Built complex workflows
- **Robust Design Optimization**
  - Sensitivity Analysis
  - Optimization
  - Robustness Analysis











Thermo-Mechanical Analysis

Optical Analysis

Initial Design

Design understanding with metamodeling and robust design optimization

Optimized Design

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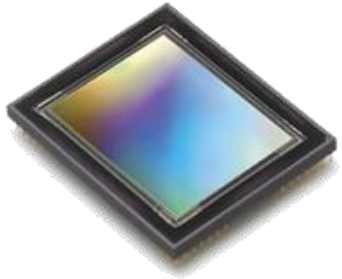
System Analysis Workflow

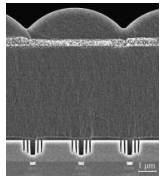
Workflow Overview: Full Scene Visualization

Scene
3D environment, moving objects, lighting & materials

Lens Stacks
Lenses shape, optical materials, mechanical packaging

Full Camera Simulation





Imager
Micro lenses array
Color filter array

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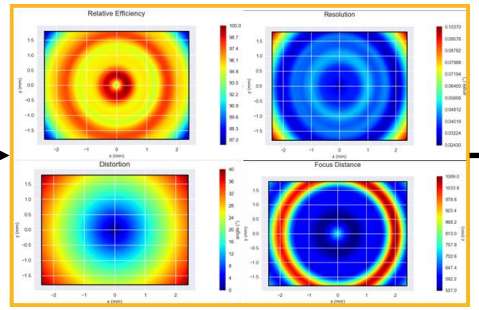
Export to Speos Lens System (SLS)

Optical Design in OpticStudio → Export to SLS →



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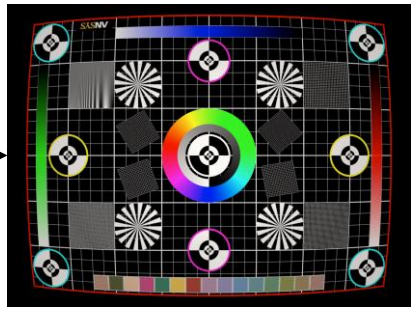
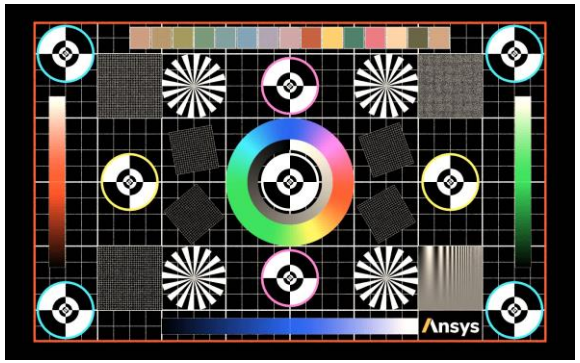
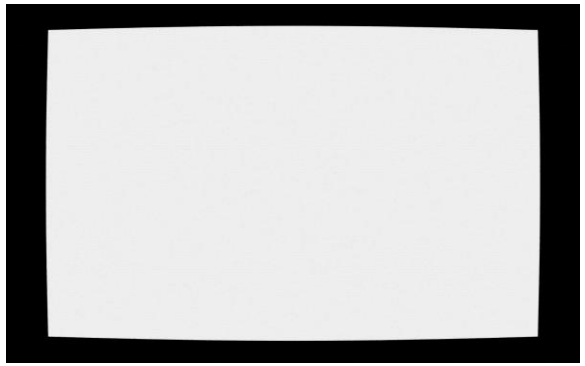


SPEOS Lens System:
Captures optical phenomena from lens design for simulation in 3D environment

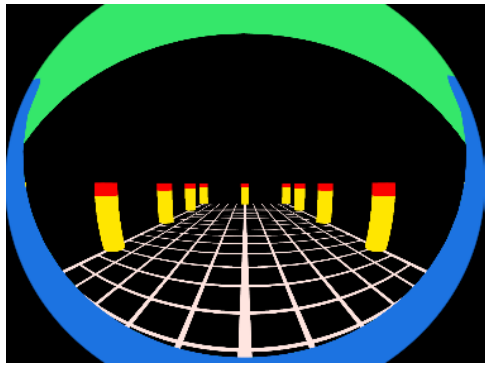
Distortion



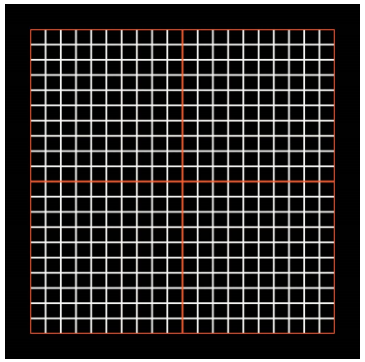
Vignetting



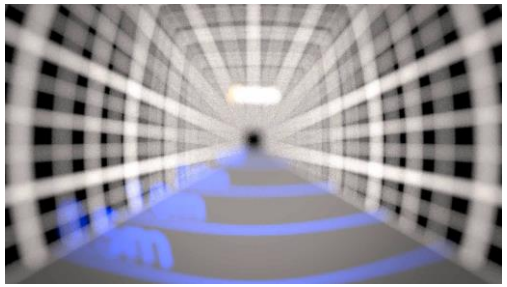
Entrance pupil position



Resolution



Focus



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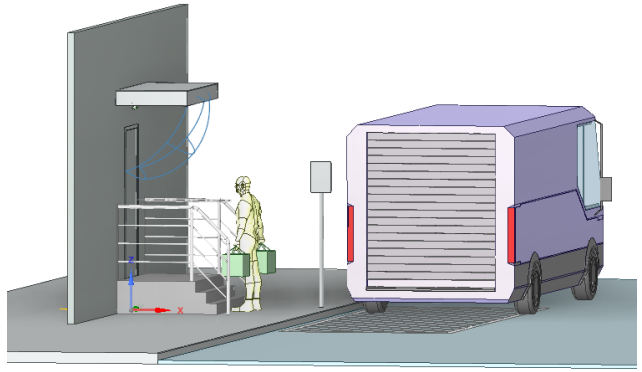
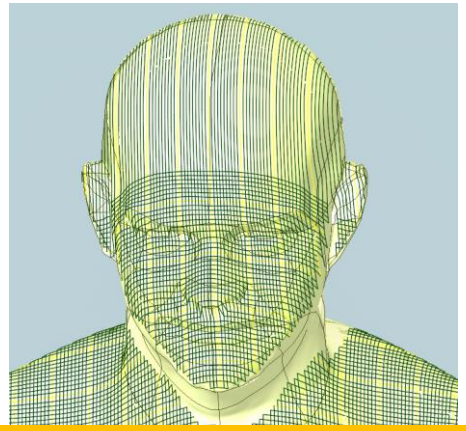
Environment Integration (Mechanical Packaging)

1. **Import CAD model**

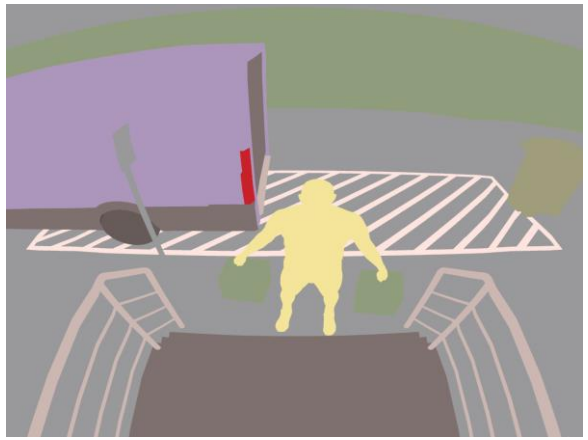


2. **Pixel grid projections**

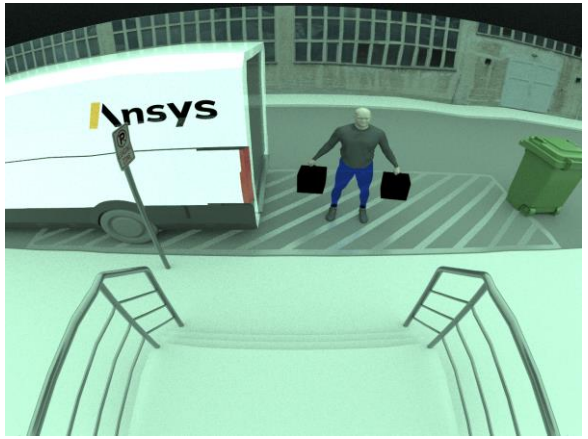


Green lines represent 1-pixel segments
Yellow lines represent 10-pixel segments

3. **Geometric and Photometric simulations**

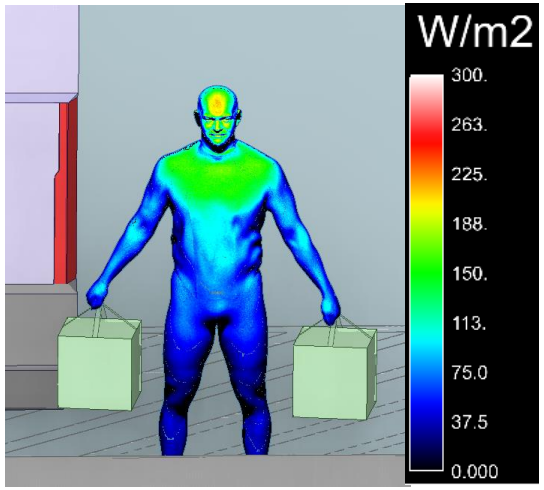


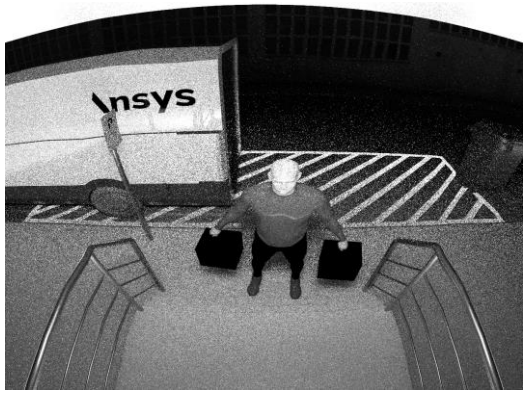
Geometric simulations Simulation time: < 1 minute



Photometric simulations Simulation time: 30min on 6 cores computer

4. **NIR emitter and camera simulation**





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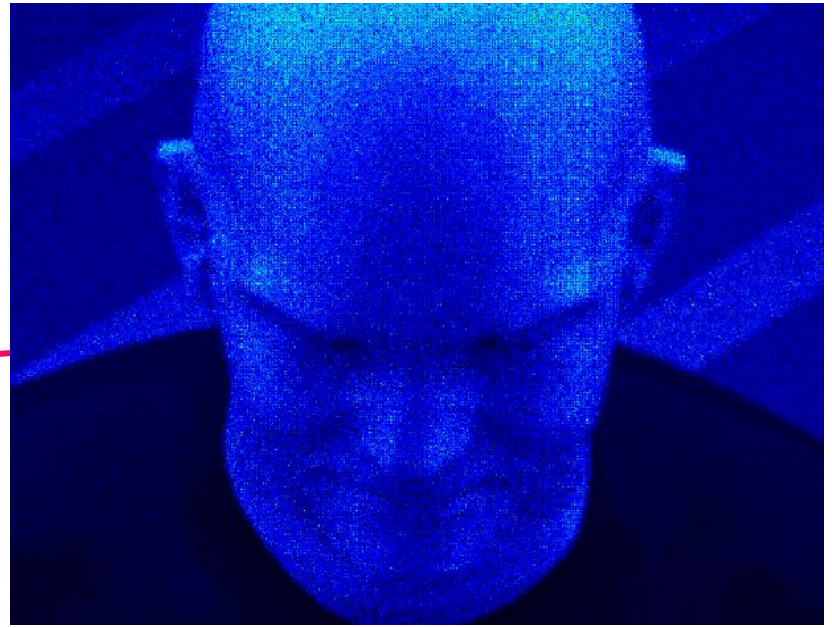
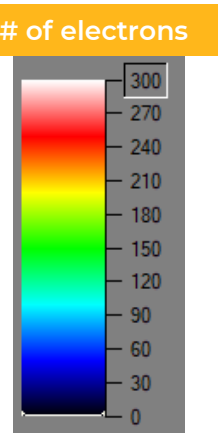
Electron map from 3D scene





Electrons/pixel – 20ms Integration Time, Full Well Capacity: 15,000 e-

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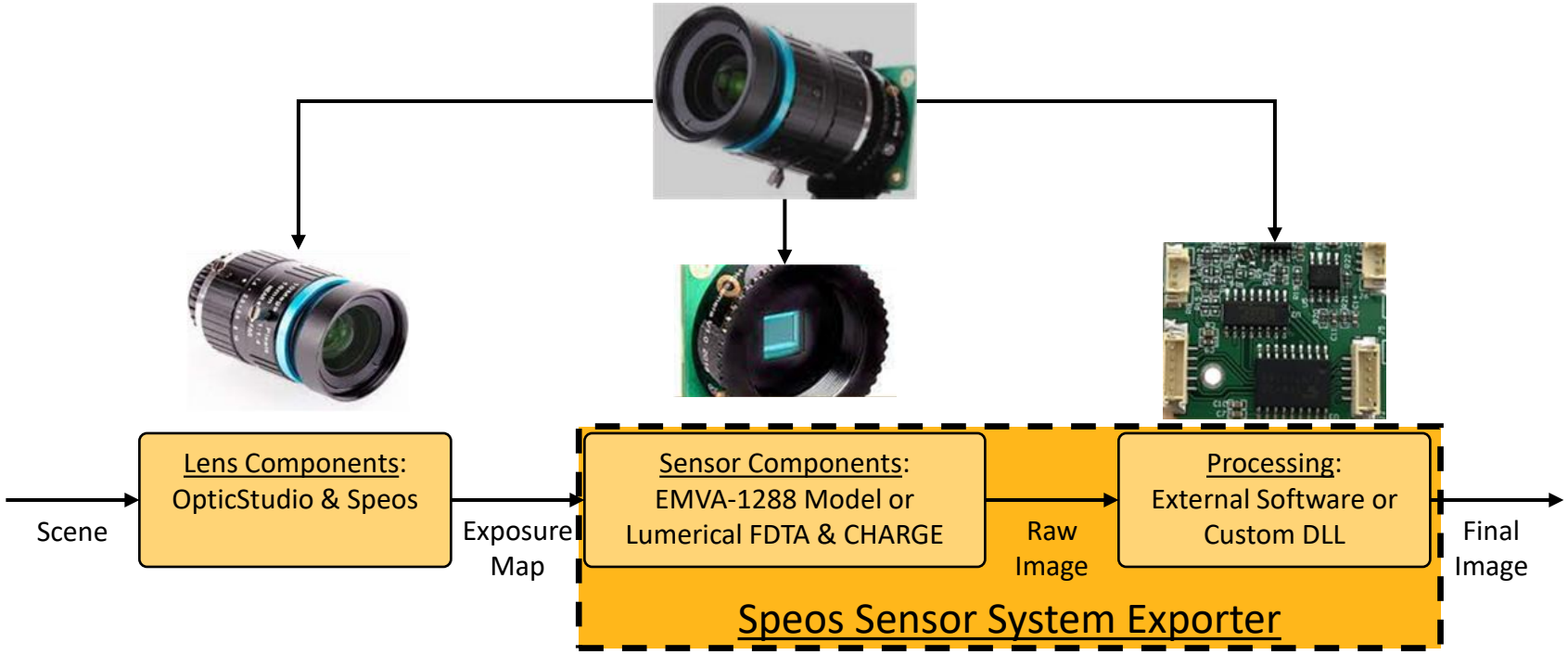
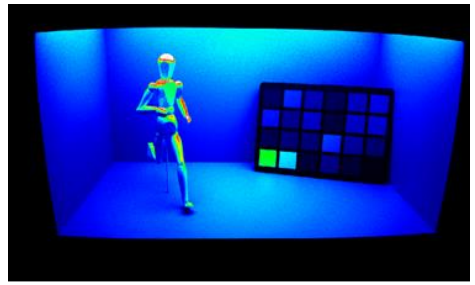
Image Processing

Speos Sensor System Exporter is a dedicated tool summoned at the end of a Speos simulation.

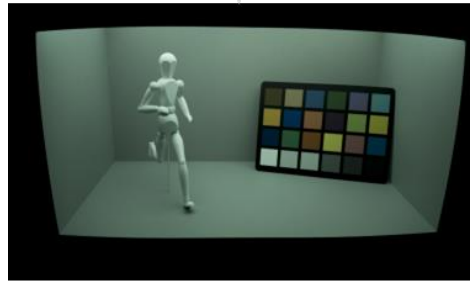
It converts photons into an image through the sensor and processing parts of the camera's acquisition chain.

Processing part can be linked to a third party from sensor suppliers.

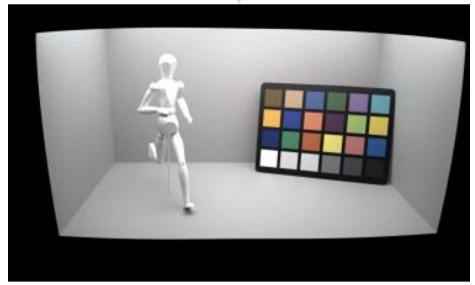




Exposure Map



Raw Image



Final Image

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Ansys