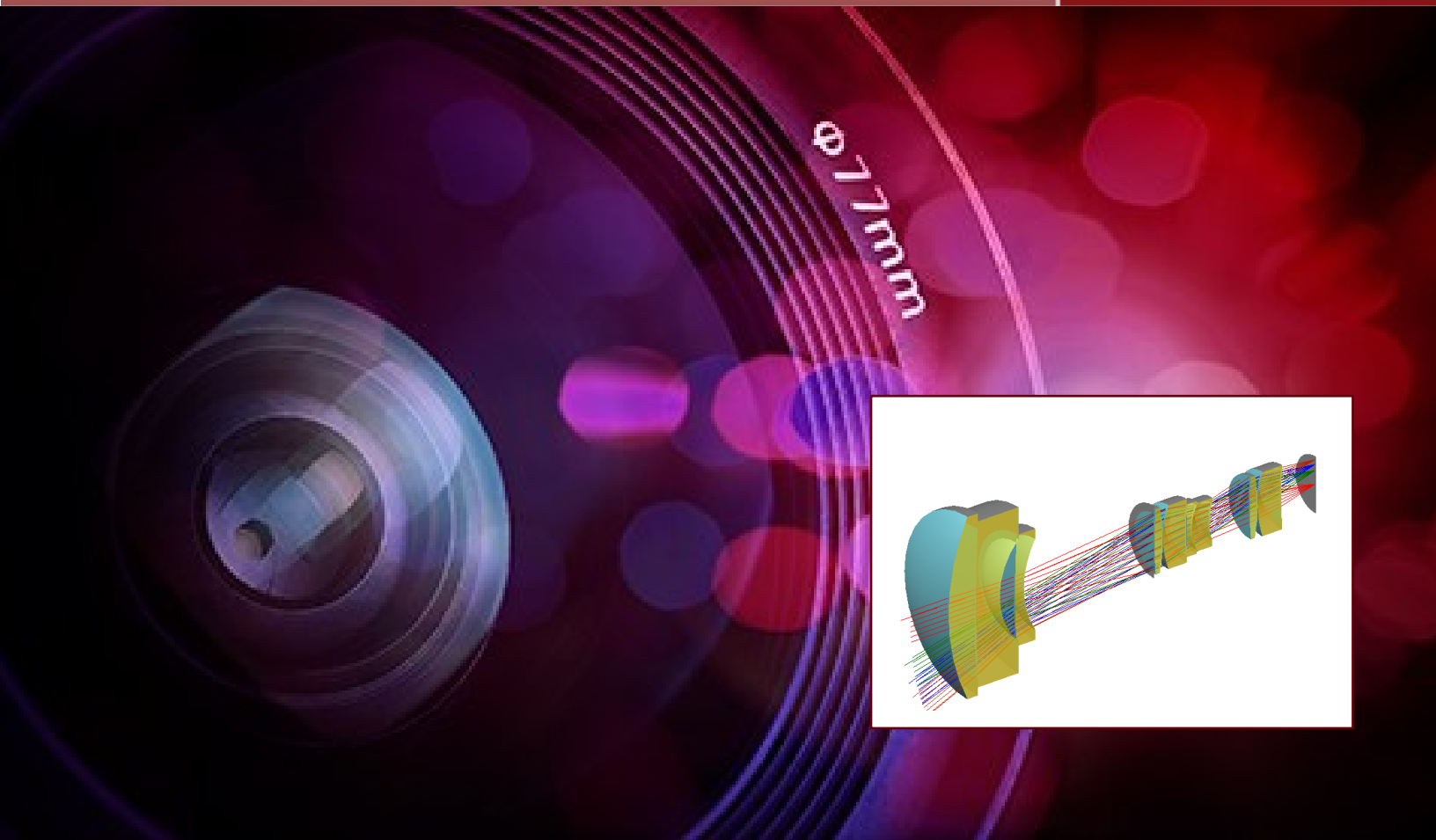




# CODE V Optical Design Software

Design, Optimize, and Fabricate Reliable Imaging Optics

# Overview

Modern imaging systems demand more from optical designs.

Optical engineers are expected to deliver high-performing, manufacturable designs faster — balancing image quality, packaging constraints, tolerances, and real-world operating conditions.

**CODE V** provides superior optical design tools for imaging optical design — from concept development through optimization, analysis, and fabrication support.

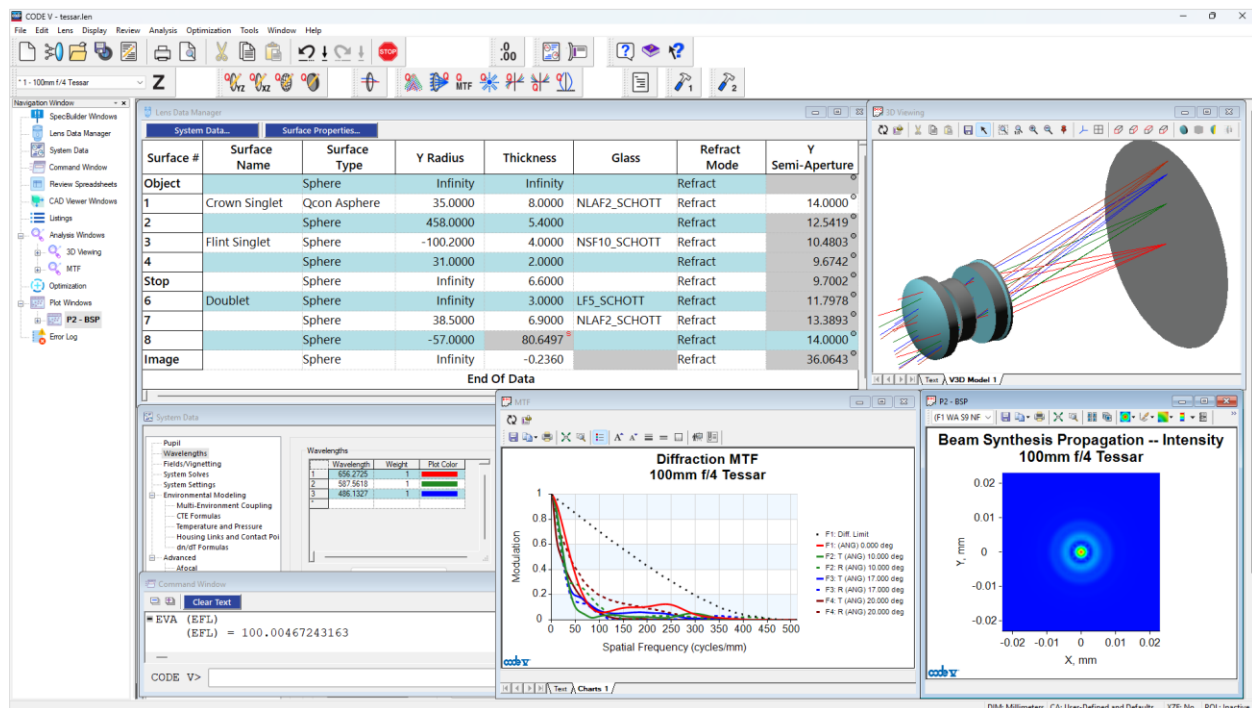


**Figure 1.** CODE V utilizes a standard Windows user interface with many navigation and usability features.

## Challenges in Modern Imaging Optical Design

Designing imaging optics today goes beyond creating a nominal lens.

Engineers must:

- Find a strong starting point quickly
- Navigate complex optimization spaces
- Predict real-world image performance
- Design across environmental conditions
- Ensure manufacturability and cost control

At the same time, optical systems are becoming more complex and are used across a wider range of applications — from consumer cameras and AR/VR to aerospace, medical imaging, and semiconductor lithography.

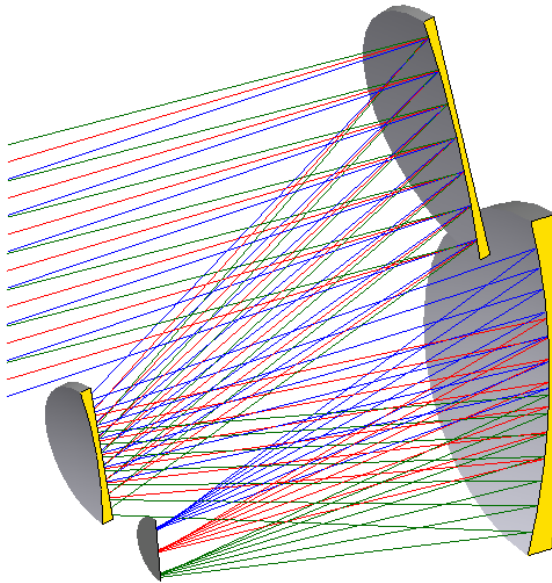


**Figure 2.** Freeform three-mirror anastigmat telescope

### Typical Design Bottlenecks

- Weeks lost finding initial layouts
- Optimization stuck in local minima
- Unpredictable tolerance sensitivity
- Late-stage redesign due to manufacturability issues

## What you Need from your Software

- Fast starting points for new designs
- Efficient optimization across constraints for complex systems
- Fast and accurate image-quality predictions
- Tolerancing tools that support manufacturability and cost control
- Flexibility across GUI, command, and programmable workflows
- Confidence that results will support real hardware decisions

## Build Better Designs with Confidence

**CODE V** is developed to design imaging optics. It enables you to:

- **Model** simple and complex imaging optics
- **Simulate** image quality with physical accuracy
- **Optimize** designs efficiently
- **Evaluate** manufacturability early

The result: better-performing designs with fewer late-stage surprises.



## Design for the As-Built System

The value of an optical design tool is not only in producing a good nominal design. It should also help teams understand performance sensitivity, manufacturability, and environmental effects early enough to avoid late-stage surprises.

### Why Teams Use CODE V

- Proven optimization methods
- Accurate metrics predictions
- Designed for production workflows
- Trusted in critical applications

## Find Better Design Solutions Faster

### Build a Strong Starting Point

#### Define Requirements with SpecBuilder

CODE V SpecBuilder™ guides designers through system requirements, constraints, and design specifications, creating a structured foundation for design exploration, optimization, and analysis.

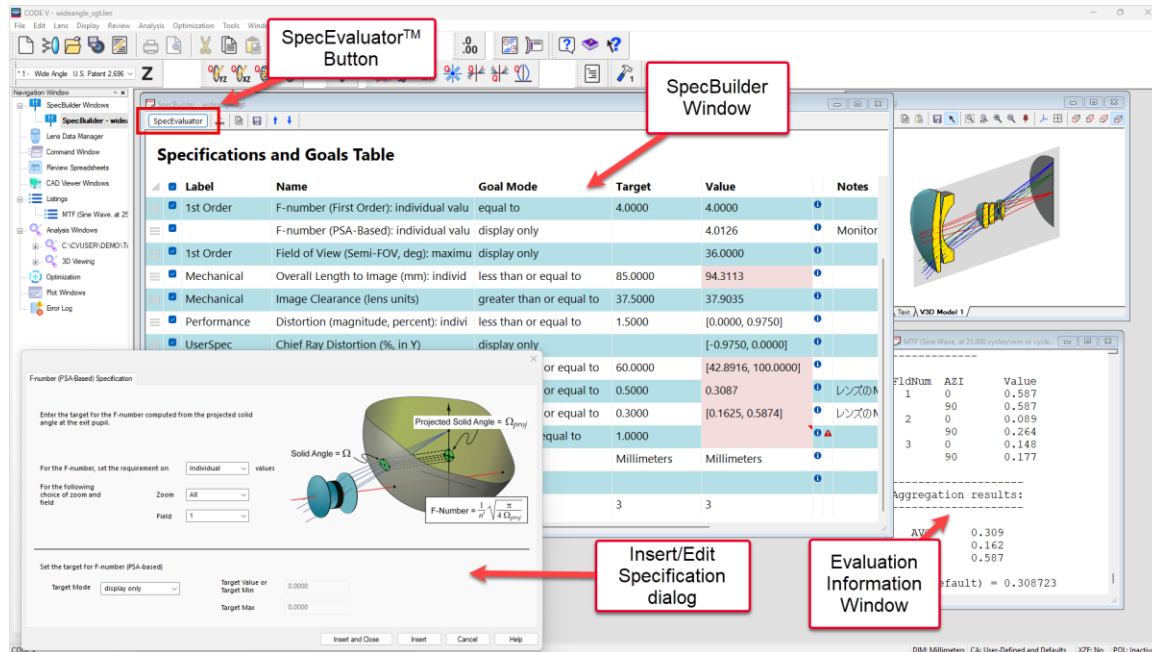


**Figure 3.** CODE V SpecBuilder™ guides users through the process of defining optical system requirements, constraints, and design specifications, helping engineers create well-structured starting points for optimization and analysis.

## AI-Assisted Design

A strong optical design starting point can reduce the time and effort needed to meet performance goals. AI Start Expert uses system requirements to generate tailored starting point lenses that closely match your goals with built-in smarts for sensitivity and lens shape. By accelerating the search for viable starting points, it gives designers more time to evaluate tradeoffs and improve performance instead of manually developing initial layouts.

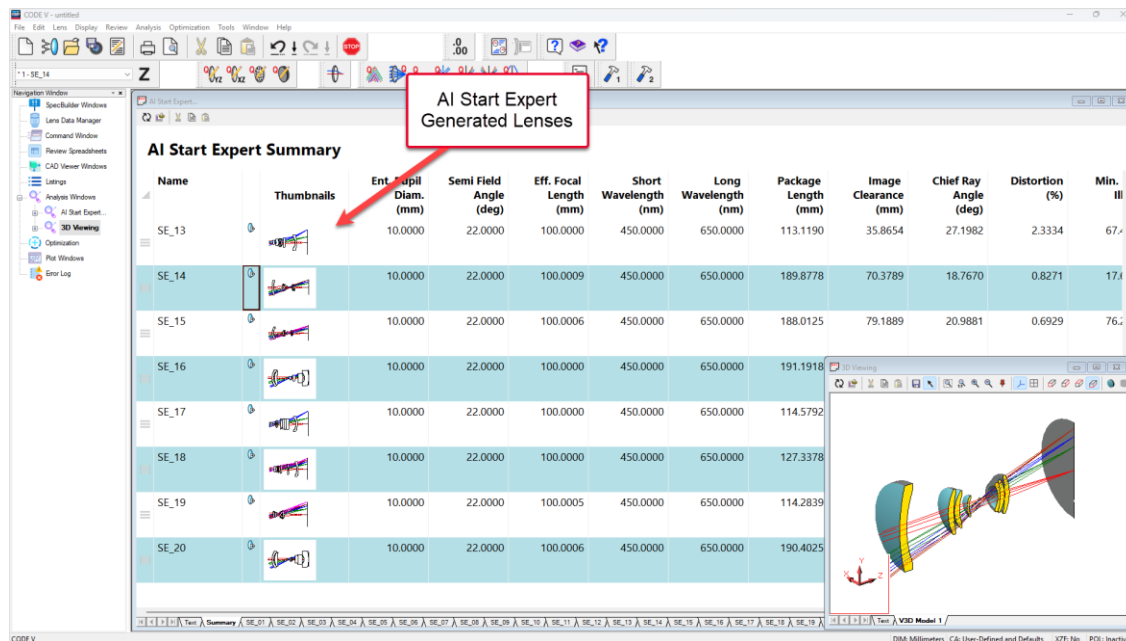


**Figure 4.** AI Start Expert helps engineers quickly identify promising optical designs that meet system requirements, accelerating concept development and optimization.

## Optimization

Optimization is central to imaging optical design. Explore design forms, refine performance, and navigate constrained solution spaces with tools built for serious optical design work. Whether you are balancing image quality, package size, glass choices, or asphere placement, CODE V helps you move from concept to credible design candidates faster.

CODE V provides:

- Local and global optimization methods
- Tools for exploring multiple design forms
- Constraint-driven optimization workflows
- Automated assistance for materials and aspheres

This allows engineers to converge on high-performance designs more efficiently.

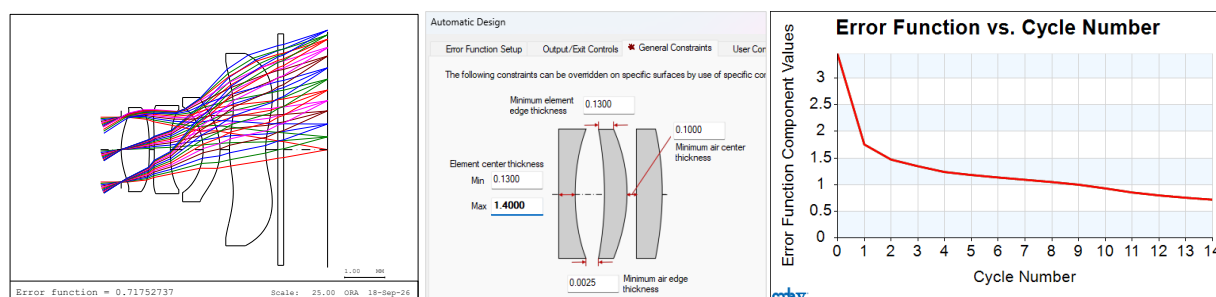


**Figure 5.** Optimize highly aspheric designs for performance and system constraints.

## Analysis

Design decisions depend on accurate analysis. Use a broad set of analysis options to evaluate image performance, diagnose aberrations, and investigate optical behavior with confidence. CODE V supports:

- Image quality evaluation (Spot Size, Ray and Wave Aberrations, MTF, PSF, Strehl Ratio, etc.)
- Diffraction and physical optics effects
- Polarization and coherence modeling
- Beam propagation analysis
- Tolerance Eigenmode Analysis

These capabilities help ensure that simulated performance reflects real-world behavior.

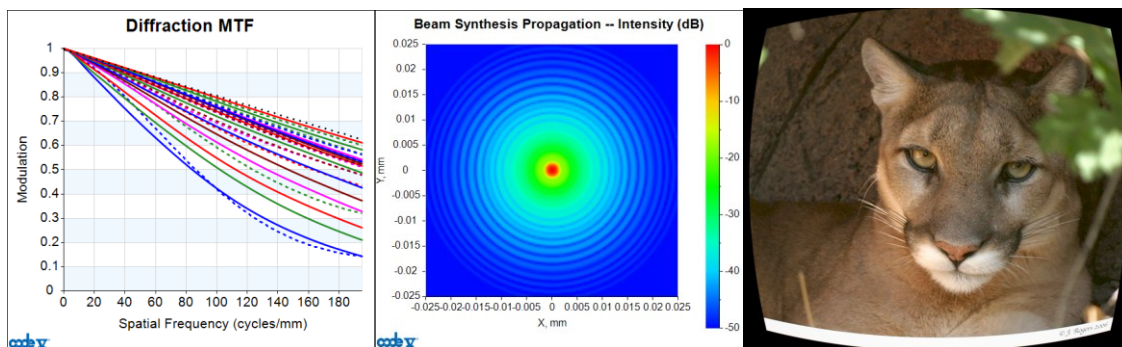


**Figure 6.** Analyze optical performance with Modulation Transfer Function (MTF), physical optics simulation using Beam Synthesis Propagation (BSP), and Image Simulation to evaluate image quality, diffraction effects, and real-world imaging behavior.

**Verified Simulations Mean Fewer Redesign Cycles.**

## Design for Manufacturability from the Start

### Tolerancing

Optical design doesn't end at nominal performance. CODE V helps you:

- Evaluate sensitivity to manufacturing variation
- Identify critical tolerances
- Define compensators and alignment strategies
- Balance performance with cost

| Tolerances and Compensators |                                                                       |                            |             |                               |        |                          |          |
|-----------------------------|-----------------------------------------------------------------------|----------------------------|-------------|-------------------------------|--------|--------------------------|----------|
| Commit                      |                                                                       | Fringe Wavelength 546.1000 |             | Insert Multiple Tolerances... |        | Delete All               |          |
|                             | Type                                                                  | Start Surface              | End Surface | Label                         | Value  | Freeze                   | X Offset |
| 1                           | DLF - Test Plat                                                       | 1                          | 1           |                               | 2.0000 | <input type="checkbox"/> | 0.0000   |
| 2                           | DLF - Test P                                                          | Stop                       | Stop        |                               | 2.0000 | <input type="checkbox"/> | 0.0000   |
| 3                           | BRL - Barrel (Gamma) Roll (radians)                                   |                            |             |                               |        |                          |          |
| 4                           | ROL - Group Roll of One Surface on Another (Cemented) 2D (lens units) |                            |             |                               |        |                          |          |
| 5                           | RLX - Group X-Roll of One Surface on Another (Cemented) (lens units)  |                            |             |                               |        |                          |          |
| 6                           | RLY - Group Y-Roll of One Surface on Another (Cemented) (lens units)  |                            |             |                               |        |                          |          |
| 7                           | STI - Group Shear Tilt 2D - Alpha & Beta (radians)                    |                            |             |                               |        |                          |          |
| 8                           | STX - Group Shear Beta Tilt (radians)                                 |                            |             |                               |        |                          |          |
| 9                           | STY - Group Shear Alpha Tilt (radians)                                |                            |             |                               |        |                          |          |
| 10                          | DOL - Group Overall Length Delta (lens units)                         |                            |             |                               |        |                          |          |

**Figure 7.** Insert multiple tolerances to generate default tolerances, or selected tolerances for a surface range.

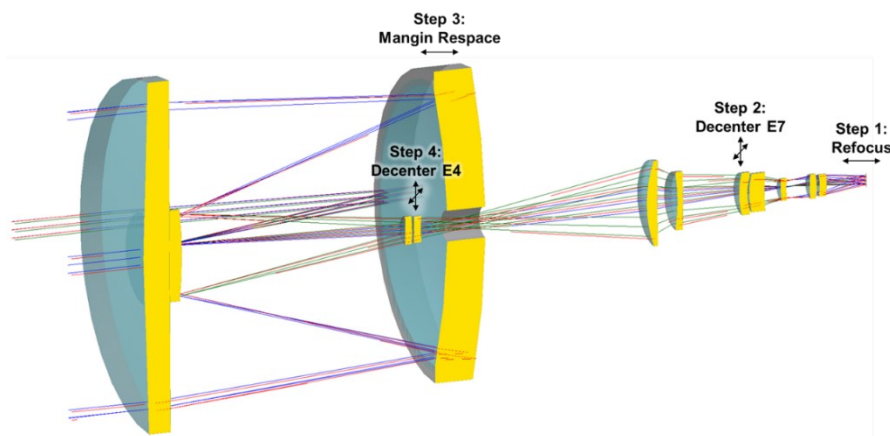


**Figure 8.** Perform multi-step alignment and evaluate as-built system performance using Monte Carlo tolerancing, tolerance sensitivity analysis, and real ray tracing.

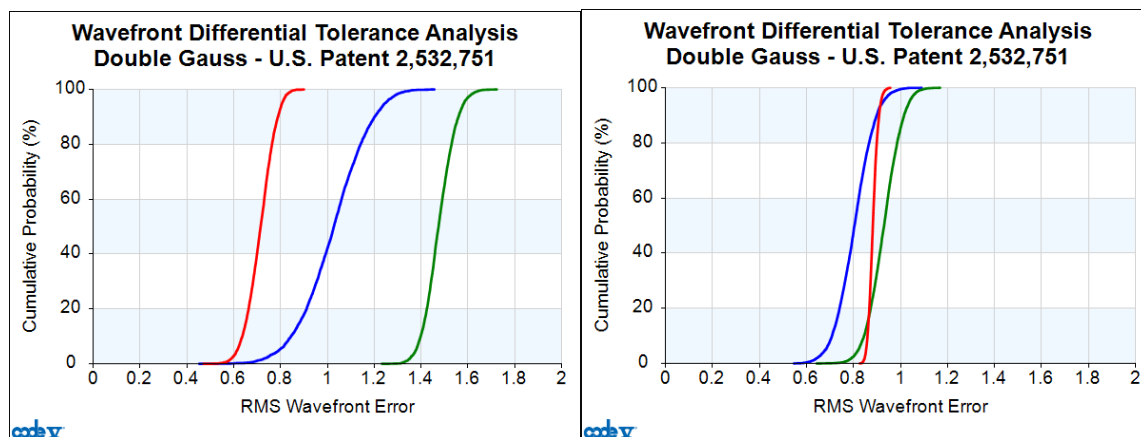


**Figure 9.** Evaluate as-built system performance and manufacturing robustness using cumulative probability analysis before and after optimization with the tolerance sensitivity error function.

## Real-World Conditions

Imaging systems rarely operate in only one ideal condition. CODE V allows you to optimize the optical design across the operational environment, solving the most difficult part of athermalized optical design in the design phase.

CODE V enables:

- Optimization and analysis across environmental conditions
- Design decisions that consider real usage conditions
- Early validation of performance robustness

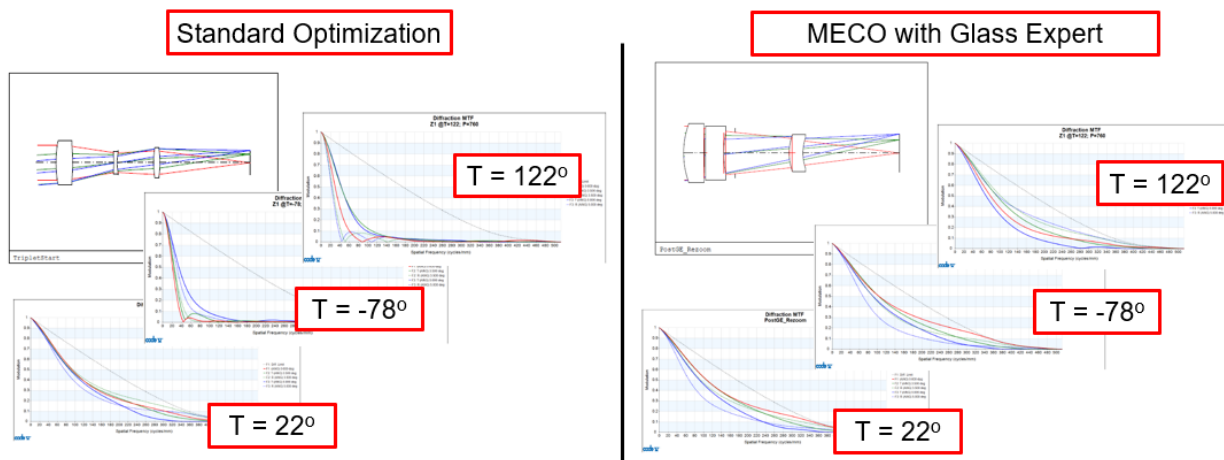


**Figure 10.** Multi-Environment Coupling (MECo) helps engineers design optical systems that maintain performance across changing environmental conditions. The higher MTF curves after athermalization with the combination of MECo and glass selection using Glass Expert demonstrates improved performance over an operating temperature range of 240 degrees C compared to a lens optimized with only the nominal temperature.

## Workflow Flexibility

Different designers work differently. Some rely on interactive workflows; others depend on command mode, macros, and agentic workflows. CODE V supports both. Its versatility unmatched due to its GUI mode, command mode, and native scripting language for agentic control as well as interoperability with other Keysight optical tools. The scripting mode of CODE V allows for graceful and powerful agentic AI control.

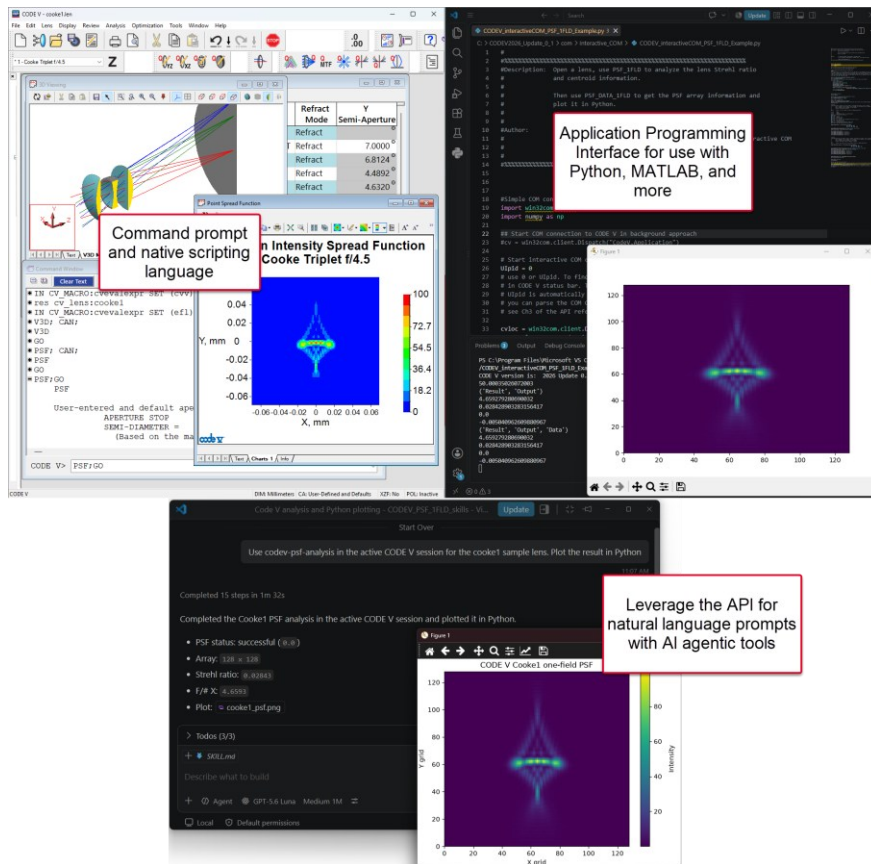


**Figure 11.** Automate and extend CODE V using commands, Macro-PLUS, and APIs with Python, MATLAB, and AI-driven workflows.

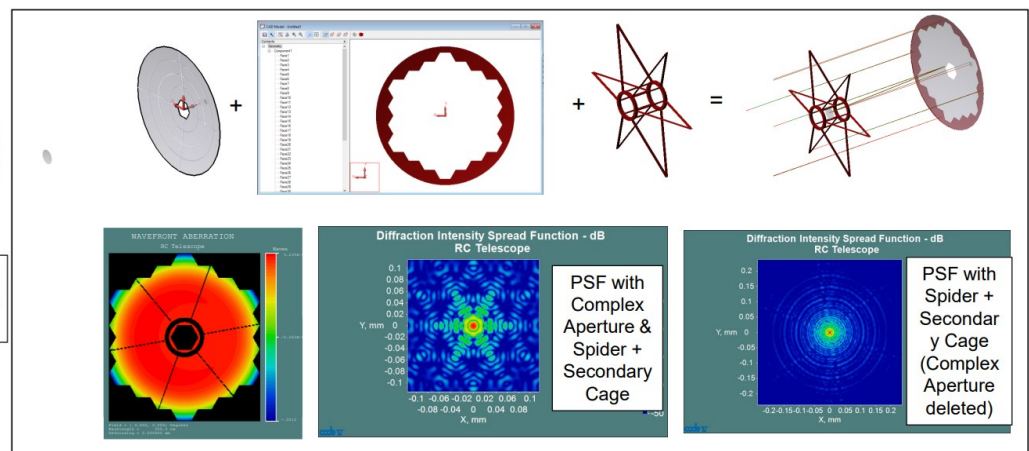


**Figure 12.** Evaluate the impact of mounting geometry on image performance in a Ritchey-Chrétien telescope, helping engineers predict and mitigate alignment- and structure-induced optical effects.

## Reduce Costly Surprises

- Detect design issues early
- Improve yield prediction confidence
- Eliminate redesign cycles

## Built for Real Engineering Workflows

### Integrated Optical Design Workflows

Modern optical systems often require more than lens design alone. CODE V works alongside other Keysight optical software to support end-to-end optical engineering workflows. Transfer imaging optics from CODE V into LightTools for illumination analysis, evaluate complete camera and sensor systems in ImSym, and connect to RSoft for photonic component and optical communications workflows. By leveraging interoperable Keysight tools, teams can reduce model recreation, maintain design continuity, and gain broader system-level insight throughout development.

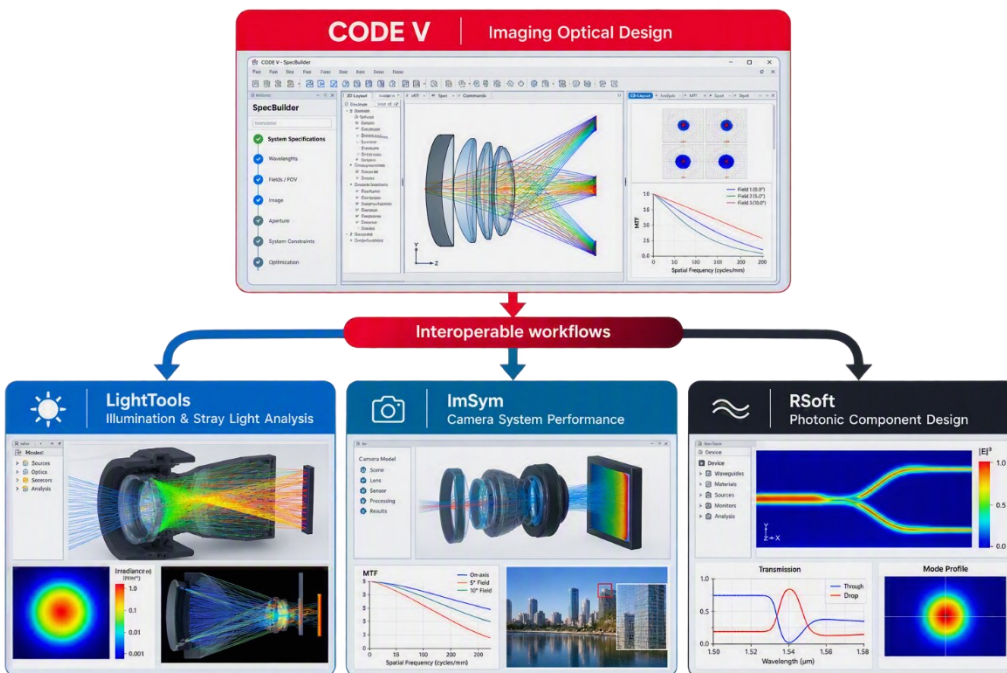


**Figure 13.** The Keysight optical software suite enables connected workflows across imaging optics, illumination, camera systems, and photonic design, helping engineers maintain model continuity and gain system-level insight throughout development.

## Expertise & Support

Choosing optical design software is also a decision about the expertise behind it. CODE V is supported by a team with deep optical engineering knowledge, training resources, and practical experience across imaging applications. That combination helps users adopt the software more effectively and apply it to real design problems.

## Applications

### Consumer Electronics

- **Mobile Devices:** Design and image simulation for multi-lens cell phone cameras, including zoom and wide-angle lenses.
- **Extended Reality (XR):** Development of augmented and virtual reality hardware where lightweight, high-resolution optics are essential.
- **Imaging Gear:** Optimization of DSLR & cinema lenses, and photographic systems.

### Aerospace & Defense

- **Space Exploration:** Design of high-performance telescopes (including segmented mirror systems), coronagraphs, and stellar interferometers.
- **Military Technology:** Infrared spectrometers, advanced surveillance systems, and optics optimized for visible and infrared bands (SWIR, MWIR, LWIR).
- **Aviation:** Development of Head-Up Displays (HUDs) and vision systems.

### Automotive

- **Autonomous Systems:** Design of sensors and navigation cameras for surround-view and 3D (stereo) imaging.
- **Advanced Lighting:** Optimization of headlamp optics and interior displays.

### Semiconductor & Manufacturing

- **Microlithography:** Design of complex lenses that image ultra-fine lines onto semiconductor wafers, which is critical for improving computer speeds.
- **Metrology:** Development of precision measuring instruments used in manufacturing.

### Medical & Healthcare

- **Medical Instrumentation:** Design of endoscopes, diagnostic imaging systems, and laser-based surgical equipment.
- **Biophotonics:** Optimization of free-space photonic devices and fiber couplers used in medical research.

## Research & Academia

- **Government Labs:** Advanced physics and optical research.
- **Scientific Research:** Development of complex interferometric telescopes and customized optical system modules.



**Figure 14.** CODE V is heavily utilized for compact, high-performance lenses required in modern personal devices. The software supports the development of high-precision diagnostic and surgical tools. Engineers use CODE V to develop the sophisticated visual sensing and lighting systems required in modern vehicles.

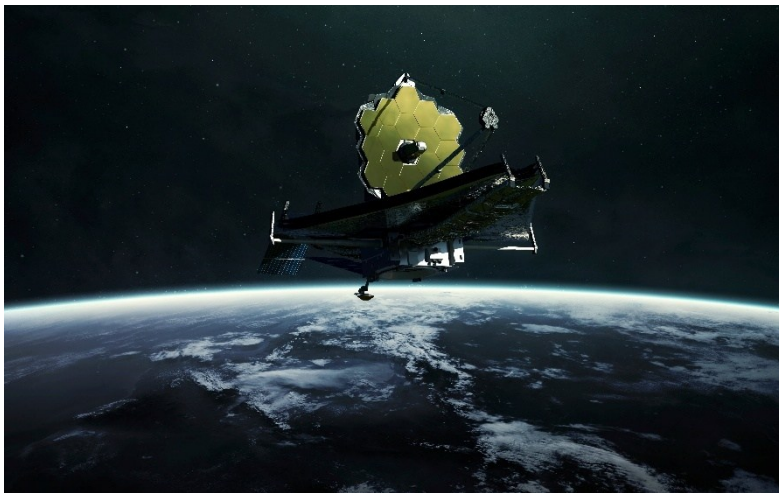


**Figure 15.** CODE V is often preferred for its mission-critical precision and the ability to handle extreme environmental modeling. From the James Webb Space Telescope to other groundbreaking aerospace programs, CODE V has helped engineers model, analyze, optimize, and verify complex optical systems where performance and reliability are paramount.

## See How CODE V Can Help your Team Design Better Imaging Optics — Faster.

### Design Better Imaging Optics with CODE V

Learn how CODE V can improve your optical design workflow—from concept to manufacturable systems.

- Visit the [CODE V optical design software page](#)
- [Request more information, trial, or quote](#)

For more information on CODE V and to request a demo, please visit the [Optical Design Solutions](#) page or contact us at [keysight.com/find/email-support](https://www.keysight.com/find/email-support).