

Choosing the Right Optical Design Software

As a decision maker responsible for making the right choices for your company's bottom-line, which optical design software should you choose? If the performance of the optics is critical to the success of your product, the answer is CODE V®. CODE V will improve your design team's productivity, facilitate designing and building it "right" the first time, enable faster time to market, and provide your products the competitive edge they need.

CODE V software is developed by Optical Research Associates (ORA®), an organization that has been supporting customer success for over 40 years:

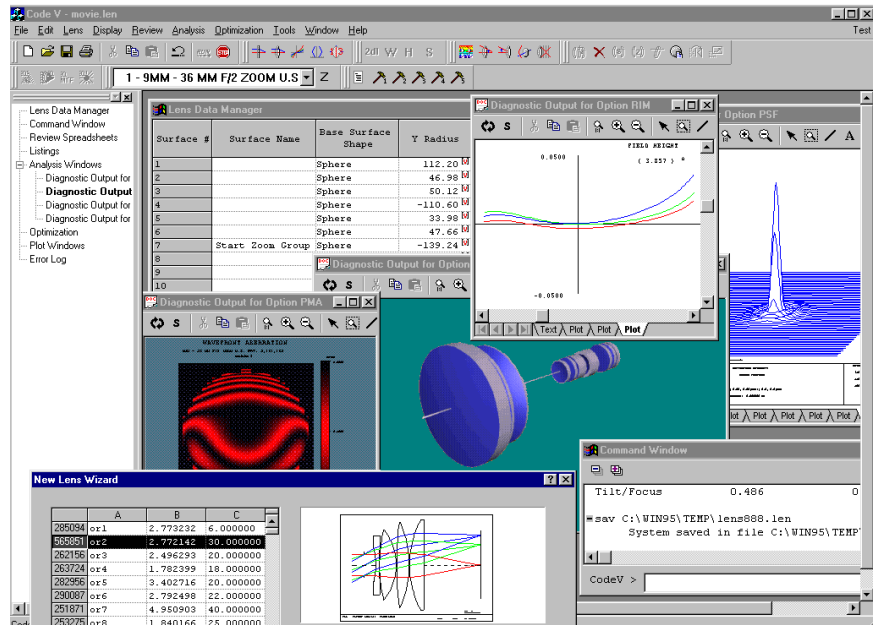
- ORA has the largest software development staff in the world devoted to commercial optical engineering software.
- ORA software development processes have been formalized using state-of-the-art software configuration management methods to ensure an environment that produces innovative routines delivering high quality, reliable, and accurate results.
- ORA's Customer Support staff has over 50 person-years of engineering experience and is dedicated to the task of helping customers use our products successfully. This is their full time job, not just an added responsibility.
- ORA has a staff of professional software testers. Our testing personnel construct and evaluate thousand of test cases run daily on code under development.
- ORA's in-house Engineering Services group validates each version of CODE V on cutting-edge, real-world engineering applications.
- ORA's staff includes three Fellows of the OSA and four Fellows of the SPIE. ORA Engineers have published over 300 articles and are listed as inventor or co-inventor on nearly 100 patents related to optical systems.

ORA is organized to produce the best optical engineering software products available. Here are some

of the ways that this dedication to being the best can help your organization.

Increase the productivity of your design team

CODE V is designed to help optical engineers throughout the entire concept-to-fabrication design cycle. The Windows-standard graphical user interface helps new users access CODE V's power quickly. CODE V also supports command-line entry, an easy-to-learn macro capability, and a COM Application Programming Interface (API). All this enables your engineers to use the program in the manner that is most efficient for them, and allows CODE V to be integrated with your other engineering software tools that support COM.



CODE V Graphical User Interface (GUI)

CODE V has capabilities to allow your engineers to model and analyze extremely complex systems. CODE V supports several varieties of user-programmable routines (e.g., a user-programmed surface shape, user programmed surface properties, etc.) to allow ultimate

flexibility in system modeling. Diffractive properties can be applied to any base surface shape for modeling gratings, kinoforms, binary optics, etc. CODE V supports astigmatic sources, polarization devices, uniaxial crystal birefringence materials, stress birefringence modeling, through focus analysis, true afocal modeling (ideal for designing visual systems), and much more.

CODE V includes several unique and fast algorithms that are either not found, or are not as well implemented, in other software. CODE V's global optimization uses an algorithm invented at ORA, and the only algorithm commercially available proven to generate useful results on complex optical systems, including zoom lenses. Your engineers can use this feature to generate starting designs, or to confirm that the final design candidate is indeed the best one.

CODE V's MTF optimization algorithm is fast and very accurate, in contrast to competitive implementations that use a finite-differences algorithm. CODE V's glass optimization is unsurpassed, especially when working outside of the visible spectral band.

CODE V's main tolerancing feature uses a wavefront differential algorithm that enables tolerancing to be part of the design process, rather than an end-of-the-design analysis. The algorithm can be order of magnitudes faster than competitive algorithms, depending on the complexity of the system. This capability allows your engineers to determine the design concepts that will deliver the best as-built performance, and this determination can be done very early in the design cycle. This leads to efficient convergence on the best designs for your products.

Rely on CODE V's accuracy and results

Errors in the design process can lead to missed schedules and extra costs, as unwanted redesigns are performed. It is critical for your optical modeling software to exceed the accuracy specifications that your own products must meet. CODE V utilizes the most accurate algorithms available and has the quality assurance processes in place to maintain this accuracy.

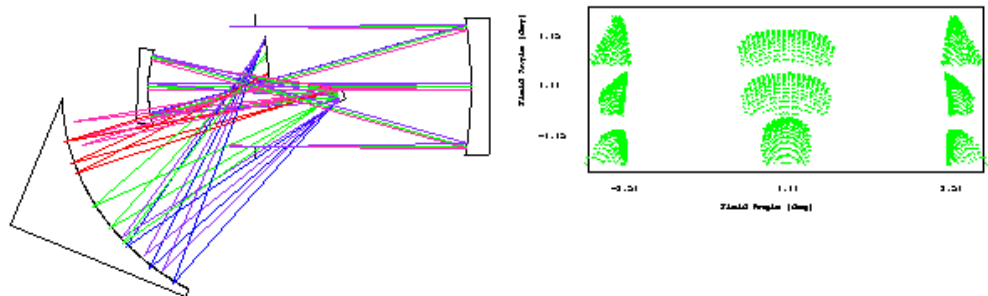
In recognition of CODE V's accuracy, NASA required that CODE V be used to evaluate all designs related to

the corrective optics for the Hubble Space Telescope Servicing Mission. In fact, ORA's Engineering Services developed the designs for the test optics for the WFPC2 camera and COSTAR corrective optics. The successful design of these test optics required the computation of individual Zernike coefficients to a minimum accuracy of 0.01 wave in a system model that included off-axis anamorphic aspherics (i.e., for COSTAR). The ultimate success of the servicing mission is clear in the stunning images now being returned by the HST.

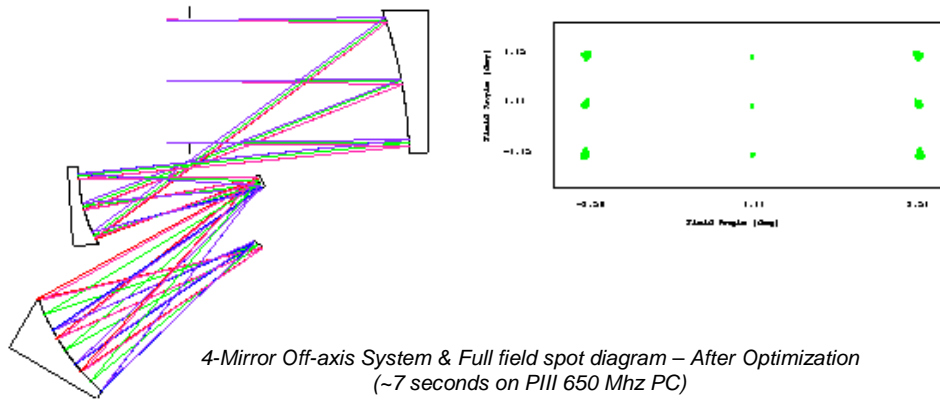
CODE V includes a generalized beam propagation feature that will accurately compute the effects of diffraction throughout the entire optical system. CODE V's partial coherence analysis feature allows the user to accurately predict aerial image structure assuming an object that is illuminated with light ranging from incoherent to fully coherent. CODE V's polarization ray tracing capabilities allow accurate calculations of system performance including the effects of input polarization, and system-induced polarization effects.

CODE V optimization consistently yields the best results among all optical design software. For example, microlithography systems (i.e., optical systems used to produce integrated circuits) represent one of the most demanding applications for optical design software. CODE V is the primary optimization software used by the microlithographic industry.

CODE V's default constraint handling for optimization uses a superior implementation of Lagrange Multipliers, which allows the performance merit function to converge in a least constrained mode, while still meeting all packaging constraints.



4-Mirror Off-axis System & Full field spot diagram – Before Optimization



CODE V is known for providing intelligent, engineering-based defaults for its analysis and optimization features. In addition, if CODE V detects that a system may be violating some assumption of the analysis algorithm, it issues warnings. This means that your engineers can proceed with confidence, and often without extra setup work sometimes required in other software, to achieve useful and accurate results from CODE V.

CODE V supports your manufacturing process

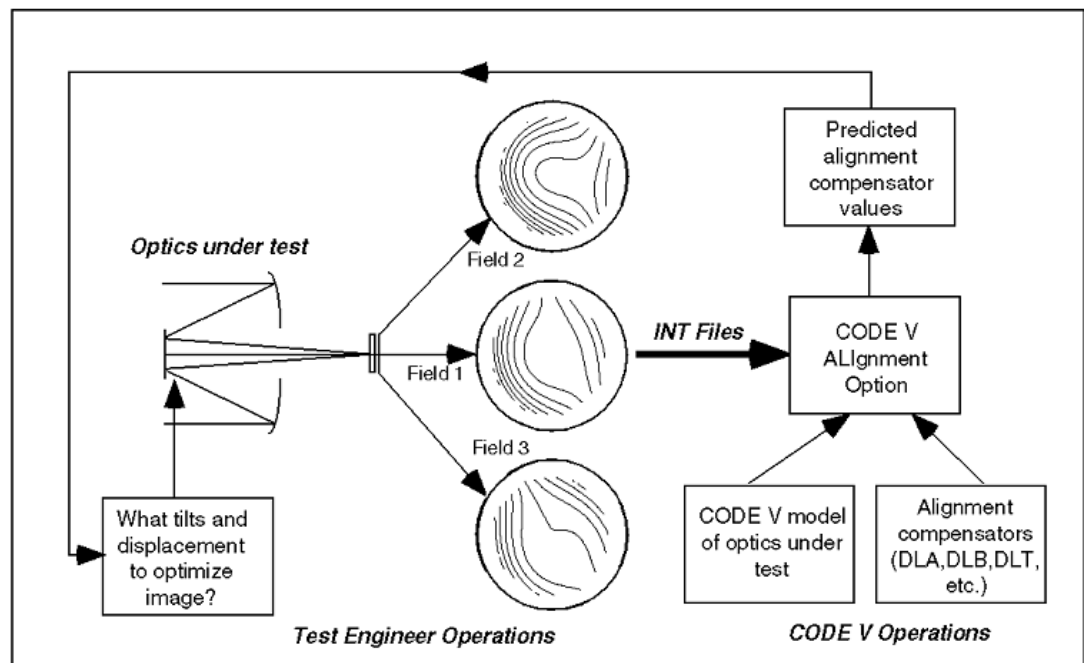
CODE V is intended for the optical engineering of “product-critical” optics. Delivering the best performing as-built optical design with minimized recurring and non-recurring costs is one of CODE V’s greatest strengths, and many of its features are directed to this end.

As mentioned previously, CODE V’s fast and accurate wavefront differential tolerancing allow as-built considerations to be evaluated very early in the design process. The result is a system with superior performance that will cost less to fabricate due to looser tolerances and optimally selected tolerance compensation adjustments.

CODE V’s unique alignment optimization feature can be used to automatically determine the appropriate

hardware adjustments to realign your optics based on measured interferograms for your system. This feature has saved many organizations countless hours of alignment time.¹

In addition, CODE V includes features to automatically fit your lens radii to test plates, accurately model glass index variations based on melt fit data, automatically compute CAM positions for zoom lenses, and create lens drawings following the ISO10110 or Chinese National formats.



CODE V enables faster time to market

CODE V’s flexible user interface, faster algorithms, intelligent defaults, and features to support the manufacturing process all result in developing and

assembling the best design, faster. Some examples worth noting:

- CODE V's ability to define fictitious glass dispersion properties appropriately for the spectral band of interest saves time, and leads to higher performance, when substituting real glasses for the optimized glasses.
- The execution time for CODE V's global optimization algorithm, Global Synthesis[®], scales approximately linearly with the number of variable and constraints, compared to the approximately exponential scaling of simulated annealing and genetic algorithms found in some competitive implementations. In one recent example from ORA's Engineering group, an overnight Global Synthesis run generated 66 unique configurations for an eight-element relay system, two of which were selected for further development.
- CODE V's wavefront differential tolerancing algorithm can be shown to be 70x to 1800x faster for a 6-element objective lens compared to tolerancing algorithms based on finite differences or Monte Carlo. CODE V's method yields accurate information about individual tolerance sensitivities (like finite differences) and accurate predictions of overall performance (like Monte Carlo).²
- CODE V's optimization convergence control features can speed up convergence on extremely complex systems by two to four times.³

In addition, ORA's technical support staff is available five days a week, 10 hours a day to help your engineers should they have a question that requires some outside insight.

CODE V gives your product a competitive advantage

Whether your application is micro-optics or large space-borne instruments working at wavelengths ranging from the extreme UV through the far infrared, CODE V has the capabilities and algorithms to help your design team develop and build the best optical systems, and deliver them.

Remember that software functionality cannot be determined simply by comparing the "feature lists" among competitive products. All algorithms are not created equal. Consider also that the cost of leasing CODE V is a fraction of your annual investment in your optical engineers. Equip your design team with

CODE V, and they will be able to develop the best optical systems possible.

If the optics are critical to the success of your product, CODE V optical design and analysis software helps enable your success.

Notes

1. K. Sugisaki, et al., "Assembly and alignment of three aspherical mirror optics for extreme ultraviolet projection lithography," *Proc. SPIE*, Vol. 3997, pp. 751 – 758 (2000).
2. ORA white paper, *CODE V Tolerancing: A Key to Product Cost Reduction* (2002).
3. *Advanced Topics in CODE V* training notes, "Advanced Optimization Techniques" (2003).

Want to know more?

Optical Research Associates has more information available for you to better understand the benefits of using CODE V. At http://www.opticalres.com/service_f.html you can find application notes, white papers, copies of our email newsletter *CODE V Tips*, and other useful material and documentation. Our Engineering Services organization used CODE V extensively in the 4200 optical engineering projects that they have successfully completed over the past 35 years. Over 50 articles, presentations, and publications authored by ORA engineers are listed at http://www.opticalres.com/engr/selected%20publications_f.html. These articles cover a wide diversity of optical design and engineering applications, and are available for no charge, whether or not you are a CODE V customer.

Do you still have questions? Are you interested in trying CODE V at no charge for 30 days? For any reason, please don't hesitate to contact us in the U.S. by telephone at (626) 795-9101, or by email at info@opticalres.com.

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