

Choosing The Right Optical Design Software

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Author Introduction

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As a decision maker responsible for making the right choices for your company's bottom line, you understand that the return on any engineering tool investment is a crucial part of your business' growth and profitability. Why would you choose CODE V when there are potential solutions available with lower up-front costs? Because the return value from CODE V is far greater than the investment costs.

CODE V is the proven and trusted optical design tool of numerous companies, government agencies, research labs, and universities worldwide. When the quality of the optics is important to your business, CODE V can help you save time, money, and your company's reputation. CODE V reliably produces better optical designs in less time—designs that are often cheaper to fabricate than those produced with other software. That's why our customers continue to subscribe to CODE V year after year, despite the other choices available.

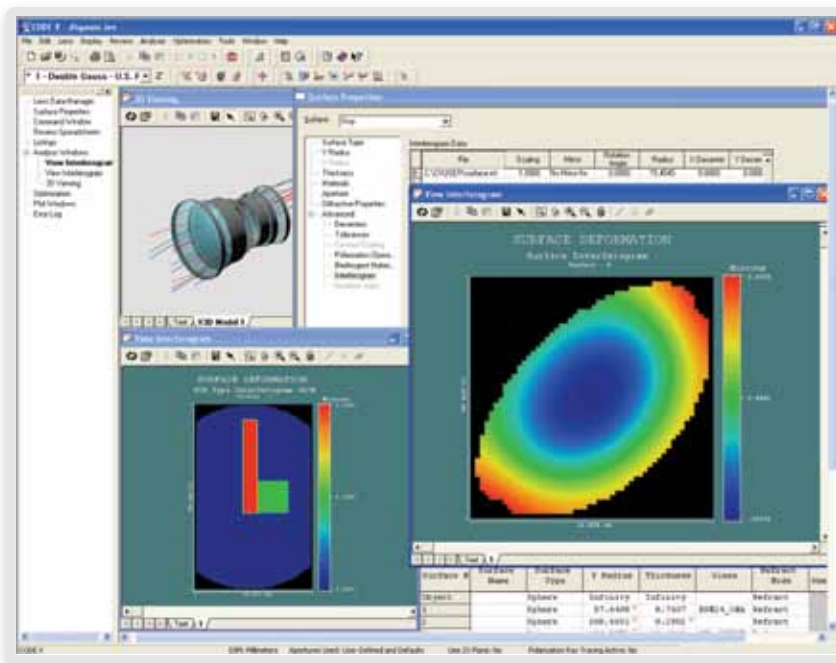


Figure 1: CODE V Graphical User Interface (GUI)

Feature list comparisons will not help you choose the right software for your company. The return on investment is completely dependent on the superiority of the algorithms and the implementation details, and depends little on the feature name. CODE V customers have done comparisons with competitive products that reveal the time-to-market and cost-to-manufacture savings that CODE V can provide. They see that the CODE V optimizer yields better, more manufacturable designs. They see that CODE V's fast wavefront differential tolerancing consistently predicts results that match measured performance, and can be computed in a fraction of the time compared to other tolerance approaches. They see that their engineers produce better designs, faster. Invest in CODE V and you will save your organization money. Following are more details regarding the benefits of CODE V software.

Formerly an Optical Research Associates (ORA[®]) product, CODE V is an optical engineering and design solution that supports the optimization, analysis, and tolerancing of image-forming optical systems and free-space photonic devices. ORA is now part of Synopsys. CODE V is developed and supported by a wide range of resources, including:

- ▶ The industry's largest software development staff devoted to commercial optical engineering software
- ▶ A customer support staff with over 50 person-years of engineering experience, who are dedicated to helping customers use our products successfully. This is their full-time job, not just an added responsibility
- ▶ Software development processes that have been formalized using state-of-the-art software configuration management methods to ensure an environment that produces innovative algorithms delivering high quality, reliable, and accurate results
- ▶ Staff of professional software testers. Our testing personnel construct and evaluate thousands of test cases run daily on code under development
- ▶ Our in-house Engineering Services group validates each version of CODE V on cutting-edge, real-world engineering applications
- ▶ Our staff includes three Fellows of the OSA and five 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

We are 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.

Produce Superior Designs Using CODE V's Optimization

Users have found that CODE V's optimization is unmatched in the variety of systems it can handle efficiently, its superior results, and the speed with which it delivers these results—often in a fraction of the time compared to competitive software—as demonstrated by customer benchmark studies.

Furthermore, CODE V's optimization delivers the design reliability and robustness required for the most demanding optical applications. That's why it is the primary optimization software used by the microlithographic industry to design optical systems that produce integrated circuits.

No other commercial package handles optimization constraints as well as CODE V. Competitive packages force users to include constraints as weighted aberrations, which results in time-consuming cycles of adjusting weights and re-optimizing to achieve the desired balance. 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.

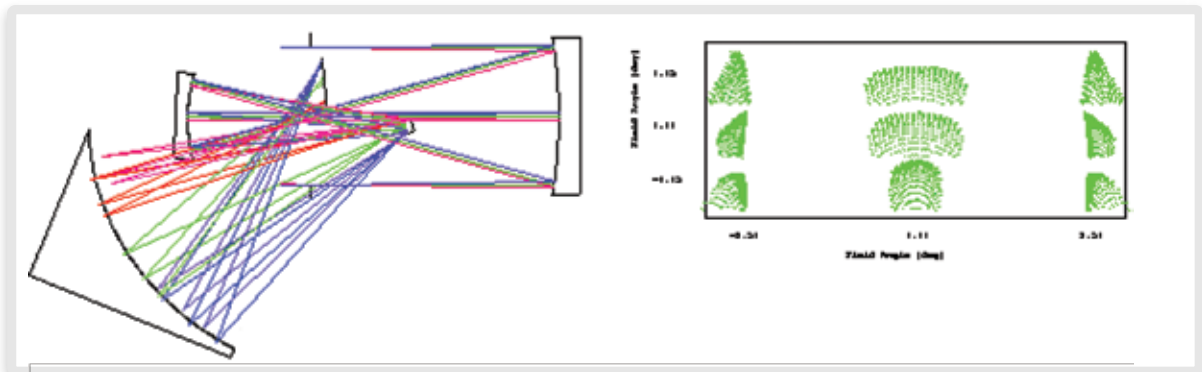


Figure 2a: 4-mirror off-axis system and full field spot diagram—before optimization

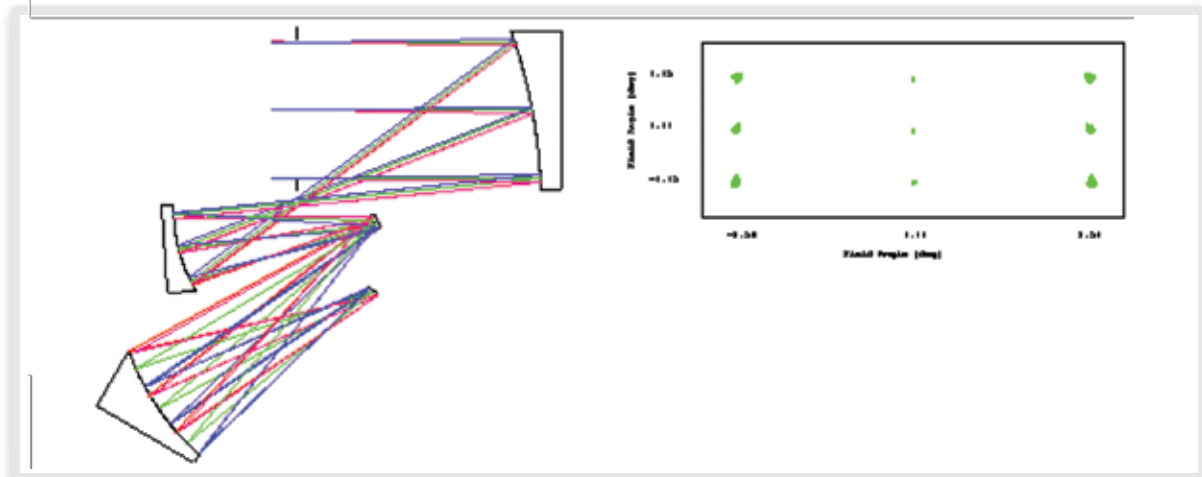


Figure 2b: 4-mirror off-axis system and full field spot diagram—after optimization

CODE V's global optimization feature, Global Synthesis[®], uses an algorithm invented at ORA, and has been verified time and time again by customers as the most capable in the market for generating unique design solutions for complex optical systems. In addition, the execution time for Global Synthesis scales approximately linearly with the number of variables 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 Services 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 MTF optimization algorithm is fast and very accurate, in contrast to competitive implementations that use a finite-differences algorithm.

CODE V Supports Your Manufacturing Process

Few designs end their life cycle on paper. They must be fabricated and meet performance specifications after assembly. 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.

CODE V's fast wavefront differential tolerancing feature is recognized in the industry as the most efficient tool for producing robust optical designs that will work when built. Its algorithm is just as accurate as Monte Carlo methods and can be hundreds of times faster than competitive algorithms¹. CODE V customers have reported situations where, when using other software, the measured performance of a system did not match the predicted as-built performance. The same tolerance analysis, when re-run in CODE V, agreed with the measured data.

The speed of CODE V's tolerancing enables it to be an integral part of the design process, rather than an end-of-the-design analysis. Very early in the design cycle, your engineers will be able to determine the design concepts that will deliver the best as-built performance, leading to efficient convergence on the optimal designs for your products.

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.²

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.

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.

As an example of CODE V's accuracy, NASA required the use of CODE V for the evaluation of all designs related to the corrective optics for the Hubble Space Telescope Servicing Mission. In fact, ORA's Engineering Services group 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.

As another example, CODE V includes a generalized beam propagation feature, Beam Synthesis Propagation™ (BSP), that was initiated in response to a NASA-funded project requiring accuracy levels that were previously unobtainable in any commercial software. BSP sets an industry standard for accuracy, efficiency, and ease of use. Its beamlet-based wave propagation algorithm is designed to deliver extremely accurate modeling of the effects of diffraction throughout almost any optical system. A major benefit of BSP is its groundbreaking Pre-Analysis feature, which automatically recommends appropriate inputs based on the resident lens system and delivers an accurate answer in the shortest amount of time.

CODE V is also recognized as the only real choice for accurate results if polarization has an effect on your image performance. CODE V's polarization ray tracing capabilities allow accurate calculations of system performance, including the input polarization state and system-induced polarization effects.

Additionally, 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.

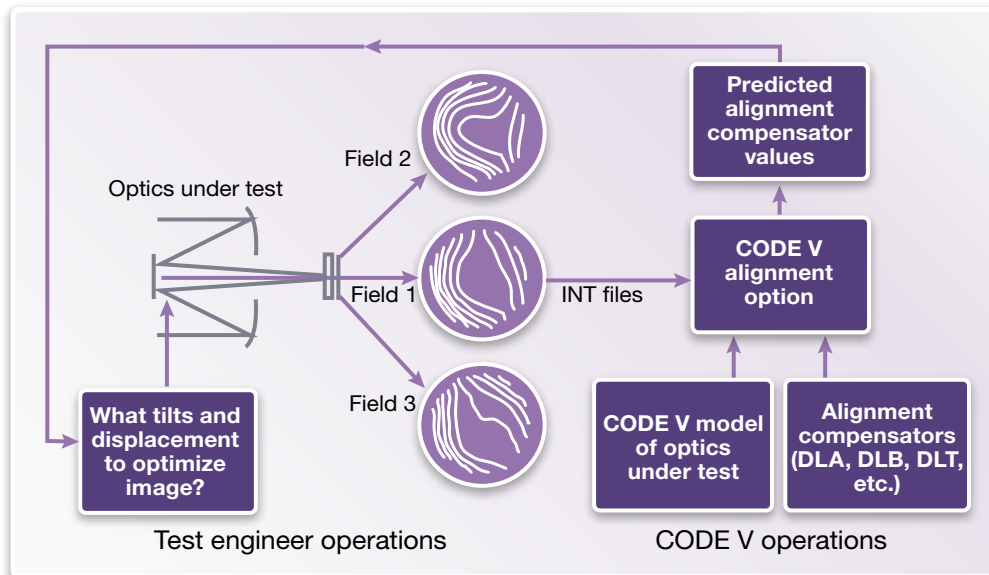


Figure 3: Schematic of the CODE V alignment optimization feature

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:

- ▶ From user comparison studies, optimization runs are many times faster (seconds compared to minutes) than competitive software and converge in fewer cycles. There are optimization convergence control features that can speed up convergence on extremely complex systems by an additional two to four times³
- ▶ Nearly all functionality can be run via a Windows standard graphical interface or command-line entry, allowing your engineers to use the program in the manner that is most efficient for them
- ▶ A fully functional macro capability is a very powerful tool to enable complex analyses to be run with an easy-to-use script
- ▶ There is also a COM Application Programming Interface (API), allowing users to create complex utilities and integrate CODE V with other COM-enabled tools

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. This service has proved invaluable to customers to quickly overcome obstacles.

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, build, and deliver the best optical systems.

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.

About Us

At <http://www.opticalres.com/cv>, you can find detailed product feature information, white papers, and the CODE V brochure. Our Engineering Services group has used CODE V extensively in the 4,800 optical engineering projects they have successfully completed over the past 45 years. Over 50 articles, presentations, and publications authored by our engineers are listed at <http://www.opticalres.com/engr/selectedpublications.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.

References

- ¹. ORA white paper, CODE V Tolerancing: A Key to Product Cost Reduction (2008).
- ². 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).
- ³. Advanced Topics in CODE V training notes, "Advanced Optimization Techniques" (2008).

For more information, or if you would like a 30-day free-trial of CODE V, please contact Synopsys' Optical Solutions Group at (626) 795-9101, between 8:00 a.m.-5:00 p.m. PST, visit www.opticalres.com, or send an e-mail to info@opticalres.com



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