

Choosing the Right Illumination Design Software

Introduction

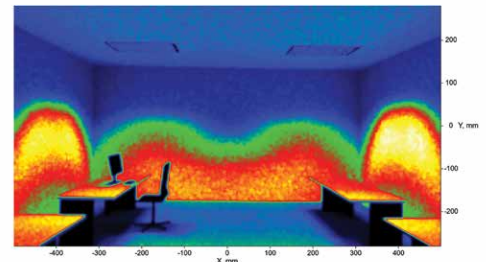
As a decision maker responsible for making the right choices for your company's bottom line, which optical design software should you choose? If the performance or cost of your illumination subsystem is critical to the success of your products, the answer is LightTools. LightTools will increase your engineering productivity, enable faster time to market, and provide your products the competitive edge they need. It accomplishes this through unique design and analysis techniques that support complex geometries and quickly provide accurate results.

Formerly an Optical Research Associates (ORA®) product, LightTools is a 3D optical engineering and design solution that supports virtual prototyping, simulation, optimization, and photorealistic renderings of illumination applications. ORA is now part of Synopsys, Inc. LightTools is developed and supported by a wide range of resources, including:

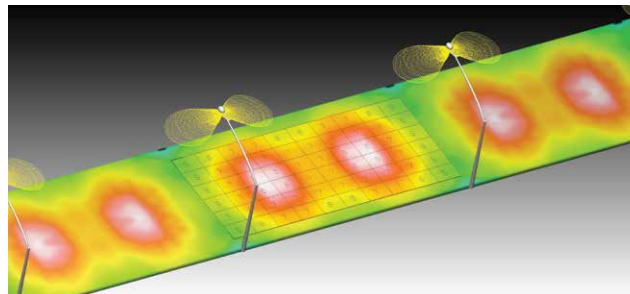
- The industry's largest software development staff devoted to commercial optical engineering software
- A customer support staff with over 50 person-years of engineering experience, who are dedicated to helping customers use our products successfully. This is their full-time job, not just an added responsibility



HUD street scene visualization in LightTools



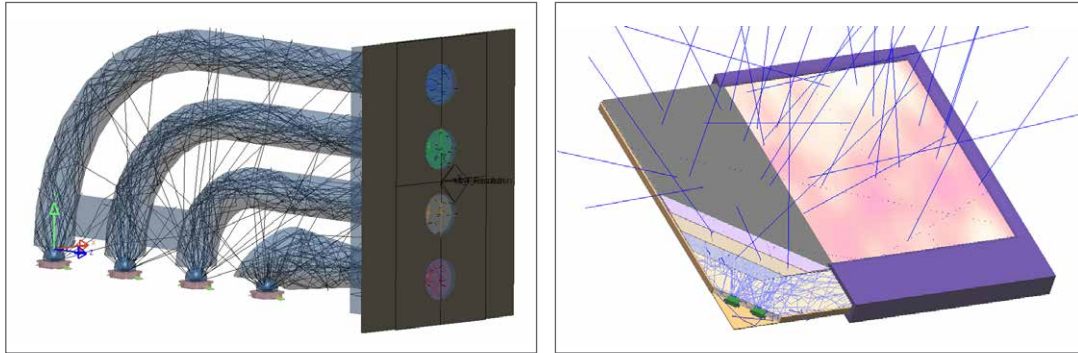
False color image of office interior illumination



Street level illuminance shown with LightTools Street Light Designer

- 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 thousand of test cases run daily on code under development
- Our in-house Engineering Services group validates each version of LightTools 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 this dedication to being the best can help your organization.



Design complex geometry in LightTools. Examples shown: Light pipe arrangement (left); Backlit display from cut-away (right)

Increase Your Engineering Productivity

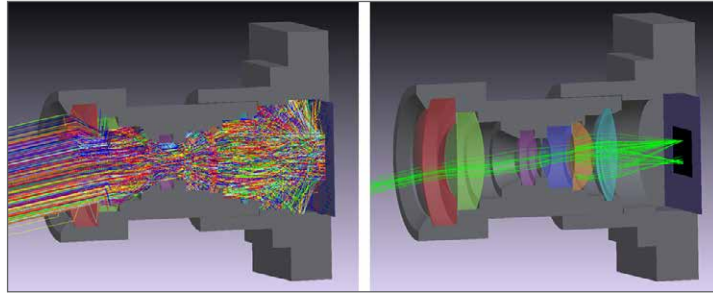
LightTools' advanced design and analysis capabilities, combined with its ease of use, make it the tool of choice for illumination engineers. The Windows-standard graphical user interface helps new users quickly access the power of LightTools' interactive 3D structure. You can cut and paste raw data, output graphs, and 3D geometry within LightTools, or into another application. LightTools has three types of navigation windows to help you understand exactly what is occurring within your model: the system navigator, the window navigator, and the preferences navigator, all of which provide easy access to important data. LightTools has also incorporated the latest technology in online, context-sensitive help. All of this makes LightTools one of the easiest illumination design software packages to learn and use.

In LightTools, creating or importing geometry is a straightforward operation, and its support of rapid design iterations and engineering change implementation offers substantive and unique productivity benefits. Design modifications are easily performed by LightTools because of the availability of Boolean and trimming operations, which retain the parametric information about how the geometry was created. Complex objects created using Boolean operations can be edited at any time. Surface and material properties are also maintained as you edit the model, allowing quick analysis of alternative design forms.

LightTools' Optimization Module allows you to quickly converge on the design that best meets your goals. Two different engines support the optimization of either Monte Carlo simulations or ray fans/grids, depending on the needs of your application. A point-and-shoot ray trace updates interactively as you change the model, and provides immediate feedback on the implication of each aspect of the design as it progresses or changes. This is an invaluable tool for gaining insight into the relationship between the geometry and the paths of light through the geometry.

The utilities provided with LightTools automate tedious or repetitive tasks, such as accessing LightTools' large libraries of sources, materials, lens catalogs, and surface treatments. There is a series of utilities that act as sub-routines for manipulating or accessing

geometry via the macro feature. High-level utilities for source, backlight, and reflector creation can often reduce the initial design time on a new illumination subsystem to minutes, instead of days or weeks.



Conduct comprehensive stray light analysis with Ray Path Analyzer and Receiver Filters

The COM interface in LightTools allows the integration of LightTools functions into other COM-enabled applications, such as Microsoft® Excel, MATLAB®, and Mathematica®. Data Exchange modules support the direct two-way transfer of data between LightTools and other CAD applications via the IGES, STEP, and SAT formats, in addition to the native CATIA transfer module. LightTools is designed to be a part of an integrated, multi-application engineering environment that improves communication between engineering disciplines, to the benefit of overall corporate productivity.

Rely on LightTools' Accuracy and Results

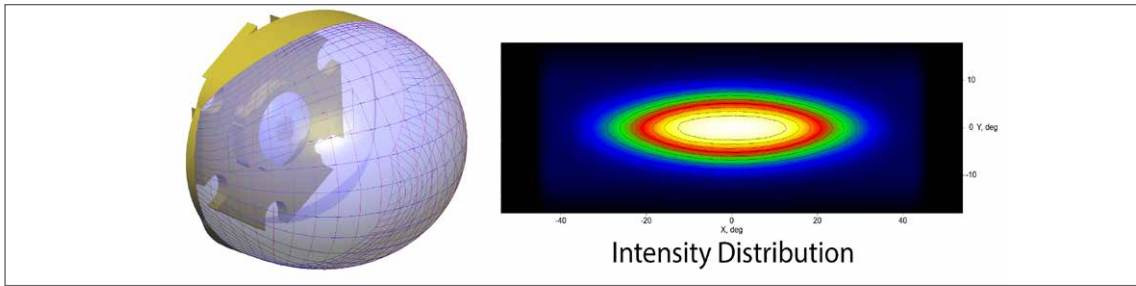
LightTools illumination design software is a 3D solid modeler with specialized optical features and "optical accuracy." When designing or machining a mechanical part, accuracy within 20 microns may be sufficient. However, when tracing the path of light rays through an optical system, specification of the surface shapes and intersections calculated at optical accuracy (a fraction of the wavelength of light) are necessary. Unlike some mechanical and optical CAD programs, surface shapes in LightTools are defined with parametric formulas (not tessellated approximations), which maintain the optical accuracy of surface shape, position, and intersection for all calculations. This optical accuracy ensures that the LightTools model performs as the real system will.

"Experimental results match LightTools well...we can use LightTools to test different illumination designs. The accurate results will save time and energy in prototyping," commented Feng Zhao of Lighting Research Center, Rensselaer Polytechnic Institute.

Some illumination design software products claim to offer faster ray tracing, but in LightTools, tracing millions of rays in a few minutes, not hours, is commonplace. Our development team has spent tens of person-years refining and optimizing complex proprietary ray tracing algorithms to allow LightTools to quickly and accurately trace rays for both native and imported geometries. This, coupled with illumination analysis that uses state-of-the-art Monte Carlo techniques, helps ensure accurate simulation of light effects for all systems all the time.

LightTools' illumination analysis is so advanced that it can tell you when enough rays have been traced to meet your design's accuracy requirements. You have control over the simulation to modify the receiver properties, such as the number of bins, and symmetry calculations to affect the simulation error estimate. Millions of rays can be traced during a Monte Carlo simulation for high-precision applications like microlithography systems. You can copy and paste data from the error estimate report to other applications for post processing or to incorporate into a report.

LightTools supports the bi-directional scattering distribution function (BSDF), which is known to be the most accurate simulation approach for scattering, and is the standard method for precision applications such as space-borne telescopes. LightTools also has parameter study utilities to determine an acceptable tolerance range for manufacturing, so that the as-built part meets product specifications. You can manipulate the ray trace to get more accurate, meaningful results, depending on the system configuration. For instance, LightTools supports probabilistic ray tracing at surface intersections, importance sampling on scattered surfaces, and user-defined source aiming regions.



Freeform LED lens designed using LightTools' unique Freeform Designer shown with intensity distribution

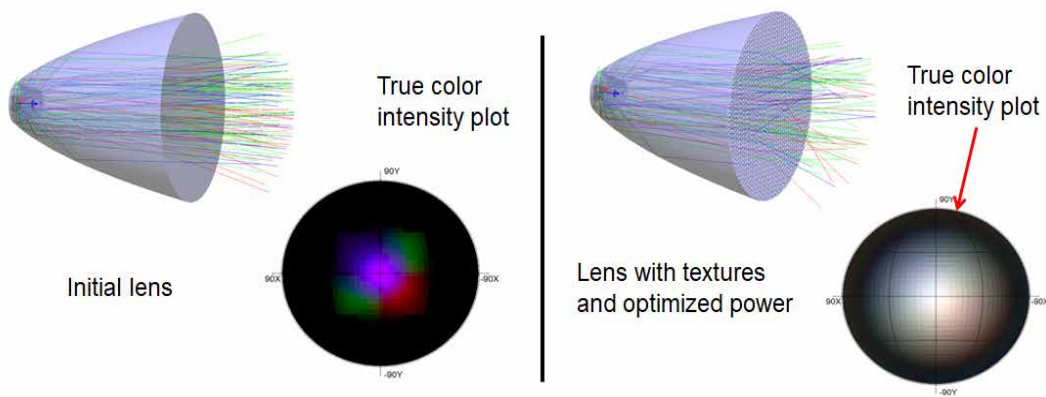
LightTools Readily Supports Complex Geometry

Illumination subsystem design challenges include not only engineering to get light through the system, but also modeling unusually shaped optical components or geometrically complex fixed portions of the system. LightTools, as a flexible 3D solid modeling design tool, addresses both of these issues.

LightTools' basic 3D solid primitives, including spheres, ellipses, toroids, blocks, cylinders (including cones), extrusions and rotationally swept polylines, can be parametrically edited and inserted at any size, in any location, and at any angle. Complex objects previously defined using Boolean operations can be edited at any time, even after they are complete. Each solid can be combined with any other solid (native or imported) using the Boolean operations, union, intersection, and subtraction. This allows the creation of complex, as-fabricated models, such as segmented reflectors and multifaceted light pipes. Note that the complex elements can be optical, mechanical, or structural components.

CAD geometry often defines existing structures of the optical system envelope. In addition to allowing you to import this geometry, LightTools' repair features automatically and interactively help you achieve more complete and accurate geometry sharing between CAD applications. Also, if your CAD modeling package is surface based instead of solid based, LightTools can automatically combine these imported surfaces into solid entities, providing increased flexibility when manipulating this geometry in LightTools.

Textures, both 2D (e.g., paint dots) and 3D (variously shaped bumps), can be applied to any planar surface with LightTools. This capability facilitates both the rapid creation of these complex surfaces and the efficient simulation of their impact on light propagation.



TIR lens with 3D texture optimized for color distribution

Uniquely Powerful Design And Analysis Capabilities

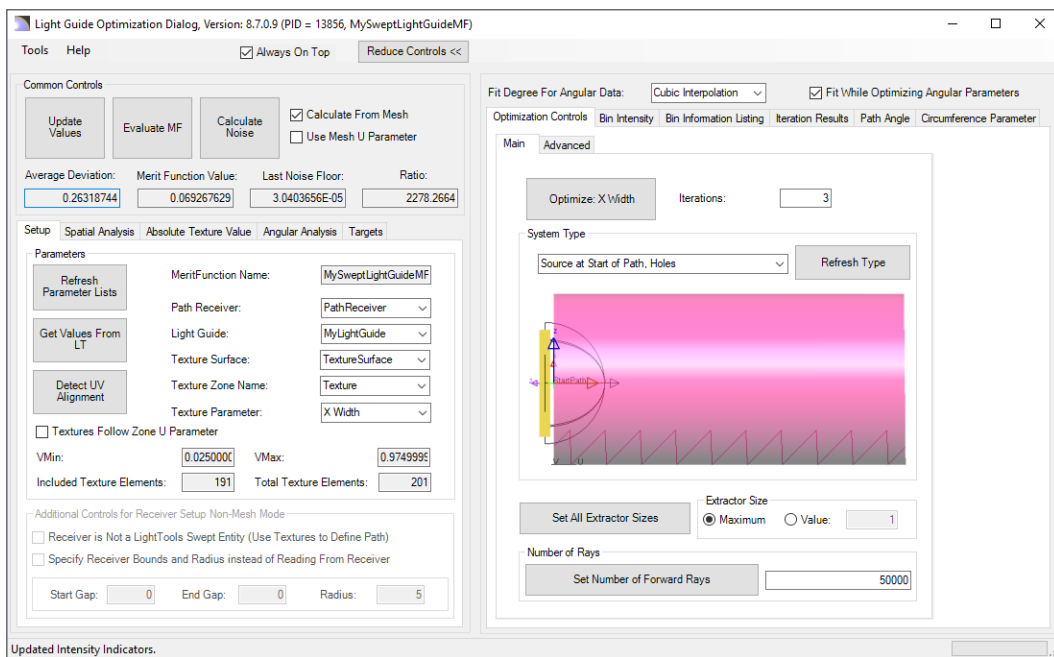
LightTools has many unique capabilities targeted toward the design of illumination optics. In fact, it can be characterized as the only illumination design program available today. Some of LightTools design capabilities include:

- Optimization for faster convergence of systems that meet specified design criteria
- Point-and-shoot interactive ray trace to give intuitive, real-time visual feedback of system performance during the design process
- Programming extensions using Visual Basic® and interaction with other applications via COM, which can streamline the design process and allow seamless integration of LightTools into your design and manufacturing processes

- Application-specific utilities, which can generate a wide variety of backlights, reflectors, and sources to reduce design time and enhance productivity
- Task-specific utilities for searching supplied libraries and applying utility-generated surface properties, spectral data, or angular distribution. Other utilities automate repetitive tasks, such as a parameter study for tolerancing designs before manufacturing
- Parametric editing of booleaned geometry for greater flexibility during the design process by allowing manipulation of geometries without having to start from scratch

Although software programs that analyze illumination power and distribution through optical subsystems are not unique, LightTools also has analytic capabilities not found in other products, including:

- Data plot filters that sort results based on a variety of different criteria without having to rerun the simulation
- Interactive re-binning of illuminance data, receiver size, and location, at any time during a simulation
- The ability to move the illuminance meter angle on the fly, to see what the fabricated system's performance will look like at any viewing angle, in real time
- Sobol (low discrepancy) random number generation, which provides faster convergence of simulation results
- True RGB color output
- A fully integrated plotting package that allows any data in any field to be plotted



LightTools Light Guide Designer for designing and optimizing complex light guides

LightTools Gives Your Product a Competitive Advantage

Whether you are designing projection optics or backlights, working to display information, or illuminate a specified area, LightTools has the capabilities and algorithms to help your design team develop and build the best optical systems and deliver them to your customers more quickly than your competition.

LightTools will help you design the best product for your needs, optimize it to increase system performance, and lower product costs. Competitive pressures require the best products, and business pressures require lower manufacturing costs. An investment in LightTools will repay itself many times over by helping you meet your product and business goals. It will also improve the productivity of your engineers, and give them a powerful tool to facilitate innovative engineering ideas.

If the performance or costs of illumination optics are critical to the success of your product, LightTools optical design and analysis software will help enable your success.

For More Information

At [synopsys.com/optical-solutions/lighttools.html](https://www.synopsys.com/optical-solutions/lighttools.html), you can find links to the LightTools brochure, white papers, a photorealistic rendering image gallery, and other useful information. Our Engineering Services organization has used LightTools extensively in many innovative illumination sub-systems designs. Over 50 articles, presentations, and publications authored by our engineers are listed on our website. Go to [synopsys.com/optical-solutions/learn/technical-papers.html](https://www.synopsys.com/optical-solutions/learn/technical-papers.html) to see the complete list. These articles cover a wide diversity of optical design and engineering applications, and are available at no charge, whether or not you are a LightTools user.

Other Publications of Interest

1. "Statistical Variation of Color Uniformity," Synopsys, Inc., 2018.
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3. "Mixed-Level Simulation of Opto-Electronic Devices," Bahl, Heller, Ayubi-Moak, C-Ng., Scarmozzino, Letay, and Schneider. Synopsys, Inc. NUSOD, 2016.
4. "Optical Simulations of Organic Light-Emitting Diodes," Bahl, Zhou. Synopsys Optical Solutions Group, 2014.
5. "Hollow Backlight Parametric Study," Magarill, Jenkins. Synopsys Optical Solutions Group, OSA Classical Optics, 2014.
6. "IODC 2014 Illumination Design Problem: The Cinderella Lamp," William J. Cassarly. Synopsys Optical Solutions Group, 2014.
7. "Daytime Running Light Design Approach," Thomas Davenport, Phd. Synopsys Optical Solutions Group, IFAL, 2013.
8. "Lightpipe Device for Delivery of Uniform Illumination...," Canavesi, Cassarly, Foster, and Rolland. The Institute of Optics, University of Rochester, 2011.
9. "Design of an Optimal LED Coupler," Anurag Gupta, PhD. Optical Research Associates, 2009.
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11. "Accurate Illumination System Predictions Using Measured Spatial Luminance Distributions," SPIE, Vol. 4775, 2002.
12. "Illumination Optimization: The Revolution Has Begun," IODC Conference, SPIE, Vol. 4832, 2002.
13. "LED Modeling: Pros and Cons of Common Methods," Photonics Tech Briefs, April 2002, NASA Tech Briefs, pp. 11a–2a.
14. "Analysis of Single Lens Arrays using Convolution," Optical Engineering, Vol. 40, No. 5, May 2001, pp. 805-813.
15. "Non-imaging Optics: Concentration and Illumination," OSA Handbook of Optics, Vol. 3, Chapter 2.
16. "Light Source Modeling," Short Course Presented at the SPIE Annual Meeting, 2001.
17. "High-uniformity Solar Concentrators for Photovoltaic Systems," SPIE, Vol. 4446, 2001.
18. Design of Non-imaging Illumination Systems," Short Course Presented at the SPIE Annual Meeting, 2001.
19. "Automated Design of a Uniform Distribution Using Faceted Reflectors," Optical Engineering, Vol. 39, No. 7, p. 1831.
20. "Modeling Anisotropic Scattering Surfaces in Illumination Software," SPIE, Vol. 4100, 2000.
21. "Design of Efficient Illumination Systems," Short Course Presented at the SPIE Annual Meeting, 1999.
22. "Fiber Optic Lighting: The Transition from Specialty Applications to Mainstream Lighting," Presented at SAE, International Congress and Exposition, March 1999, Paper No. 1999-01-0304.
23. "Full Field Mapping and Analysis of Veiling Glare Sources for Helmet-mounted Display Systems," SPIE, Vol. 3779, 1999.
24. "A Review of Source Technology and Modeling Techniques," Presented at SAE, International Congress and Exposition, 1999.

For more information, or if you would like a 30-day free-trial of LightTools, please contact Synopsys' Optical Solutions Group at (626) 795-9101, between 8:00 a.m.-5:00 p.m. PST, visit [synopsys.com/optical-solutions.html](https://www.synopsys.com/optical-solutions.html), or send an email to optics@synopsys.com.