OPTICAL ENGINEERING SOFTWARE

LightTools®

DESIGN,

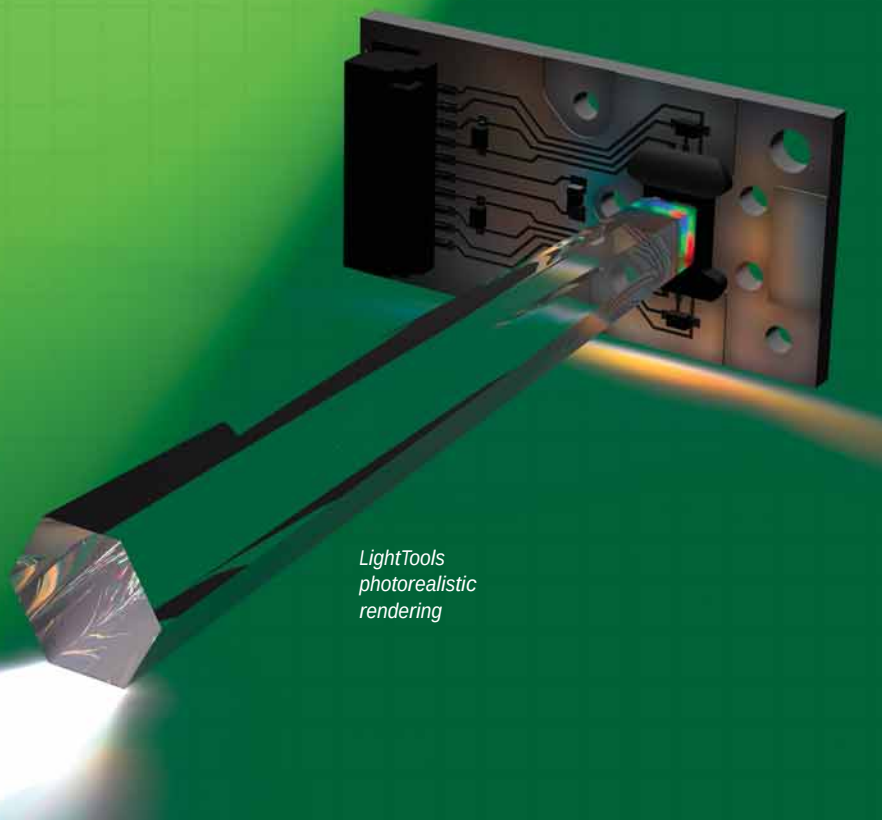
ANALYZE,

REFINE,

AND DELIVER

ILLUMINATION

OPTICS



LightTools photorealistic rendering

OPTICAL RESEARCH ASSOCIATES

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The Complete Design Solution for Illumination Applications

Design accurate, cost-effective illumination optics with *LightTools* software. Its unique design and analysis capabilities, combined with ease of use, support for rapid design iterations, and automatic system optimization, help to ensure the delivery of illumination designs according to specifications and schedule.

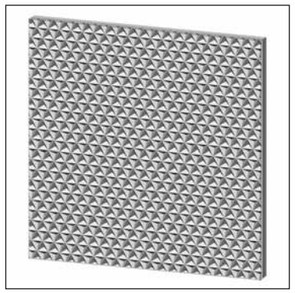
Key Design Features

- Interactive point-and-shoot ray tracing for quick evaluation of optical behavior
- Fully integrated illumination optimization that automatically improves model performance
- Modeling of real-world effects including polarization, scattering, surface reflection and refraction, and thin film coating and color filter performance
- Wide variety of surface optical properties, including colored and translucent plastics and glasses, glossy and matte surface finishes, and optical coatings and filters
- Specialized, robust features for modeling complex optical surfaces and elements
- Comprehensive source modeling, from compact fluorescent tubes to LEDs
- Receiver data filtering to pinpoint and solve illumination problems
- Support for measurement-based ray data sources, including Radiant Source™ Models
- Modeling of scattering effects using measured (BSDF) scattering data
- Libraries of models, sources, surface finishes, coatings, filters, and application-oriented utilities
- Interactive, smart user interface
- Customized solutions using Visual Basic® macros
- CAD software interoperability

UNIQUE MODELING AND DESIGN FEATURES

Smart system modeling with full optical accuracy and precision – Create designs easily with 3D solids that can be inserted into the model at any size, in any location, and at any orientation. Geometry is always editable using Boolean and trimming operations that retain the optical accuracy of surface shape, position, and intersection for all calculations, ensuring that the model performs as the real system will.

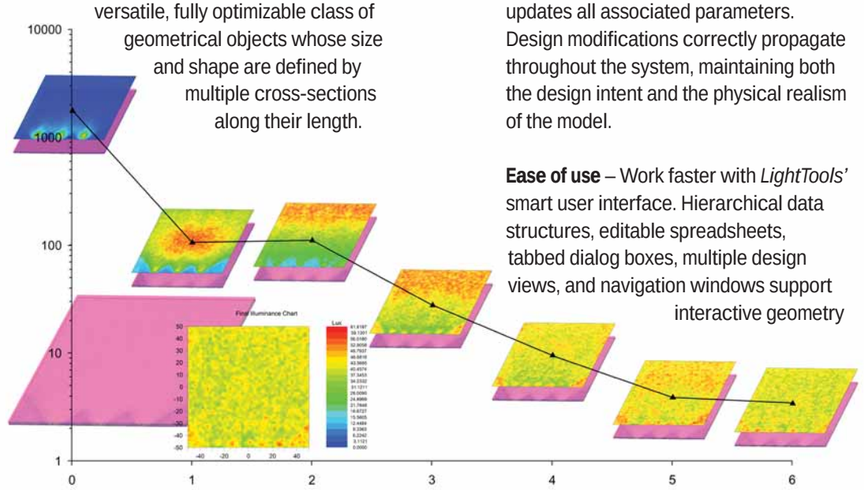
Rapid evaluation of optical behavior during design iterations – With point-and-shoot ray tracing, gain an instant understanding of the system's optical behavior by graphically starting and aiming rays from any point in the model. Rays are displayed visually and updated automatically as the model is changed, and they can be moved or rotated interactively to study the behavior of a model.



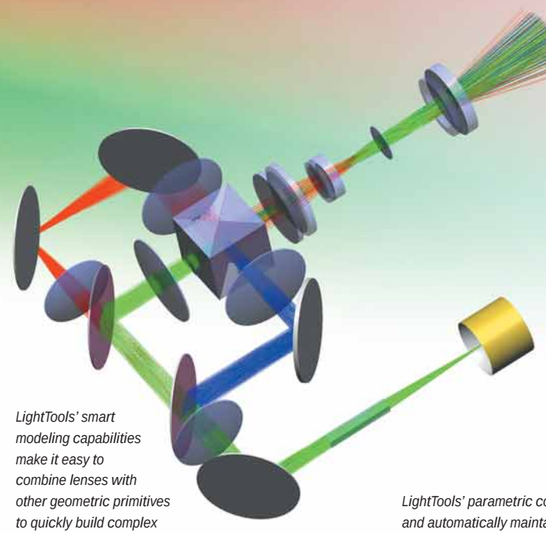
LightTools' user-defined 3D textures enable you to design arrays of complex shapes on a surface for backlights and microlens arrays.

Quick convergence on the design that best meets your goals – Improve system performance automatically with *LightTools'* fully integrated illumination optimization, which combines design and analysis features with optimization algorithms especially selected to solve illumination problems. For example, you can optimize a system to match a target illumination distribution while simultaneously maximizing total power, maximize light intensity projected in a given direction, or maximize flux on a receiver.

Robust modeling of complex surfaces – *LightTools* offers many capabilities for modeling complex optical surfaces. For example, skinned solids are a highly versatile, fully optimizable class of geometrical objects whose size and shape are defined by multiple cross-sections along their length.



LightTools' fully integrated illumination optimization capability greatly improved the illuminance uniformity of this edge-lit LED backlight system in six iterations, with minimal user input.

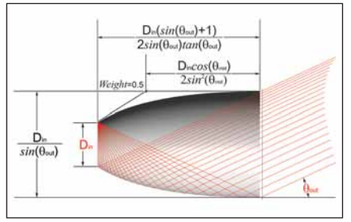


LightTools' smart modeling capabilities make it easy to combine lenses with other geometric primitives to quickly build complex illumination systems. Point-and-shoot ray tracing provides instant feedback on system alignment.

Textures – 2D, 3D, and user defined – can be applied to any planar surface, and include built-in flexibility to vary the shape, size, and spacing of texture elements.

Efficient model parameter management – Use parametric controls to establish links among optical system parameters so that changing one parameter automatically updates all associated parameters. Design modifications correctly propagate throughout the system, maintaining both the design intent and the physical realism of the model.

Ease of use – Work faster with *LightTools'* smart user interface. Hierarchical data structures, editable spreadsheets, tabbed dialog boxes, multiple design views, and navigation windows support interactive geometry creation and modification. Windows® functions like point-and-click, copy-and-paste, and moving and resizing windows are instantly familiar.

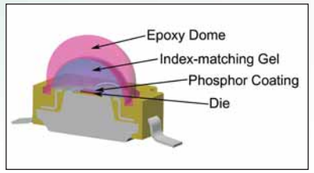


LightTools' parametric controls link system properties and automatically maintain design integrity. This compound parabolic collector was completely specified with only two parametric controls: the input diameter and output collection angle.

PRODUCTIVITY ENHANCEMENT TOOLS

Reduced design time with libraries, example models, and utilities – Focus on designing, facilitated by *LightTools'* robust set of libraries, including sources, materials, lenses, and surface treatments. Wizard-like utilities help you create, analyze, and modify designs. Jump start your design with pre-built systems. Example models demonstrate key *LightTools* features, including modeling sources and defining surface properties, receivers, geometry, and materials.

LightTools can easily handle complex LED packaging design requirements. You can immerse elements in one another, in multiple levels—ideal for modeling the embedded phosphor and epoxy covering in an encapsulated LED.



Custom solutions to automate tasks and leverage other tools – The *LightTools* COM interface provides unlimited design flexibility. Automate repetitive design tasks using Visual Basic® macros, and let the computer do the work for you. Or, incorporate *LightTools* functions into other COM-enabled applications such as Microsoft Excel® or MATLAB® to achieve an integrated, multi-application engineering environment.

INTEROPERABILITY TOOLS

Seamless information sharing with CAD programs – The SolidWorks® Link Module (SLM) enables you to link SolidWorks 3D opto-mechanical models to *LightTools*, where you can assign optical properties and use the Optimization Module to optimize your design. SLM provides full parametric interoperability, so that all changes made to the model in *LightTools* are automatically updated in SolidWorks. In addition, *LightTools* supports the import or export of models using product-specific and industry-standard CAD formats.

LED taillamp linked from SolidWorks.

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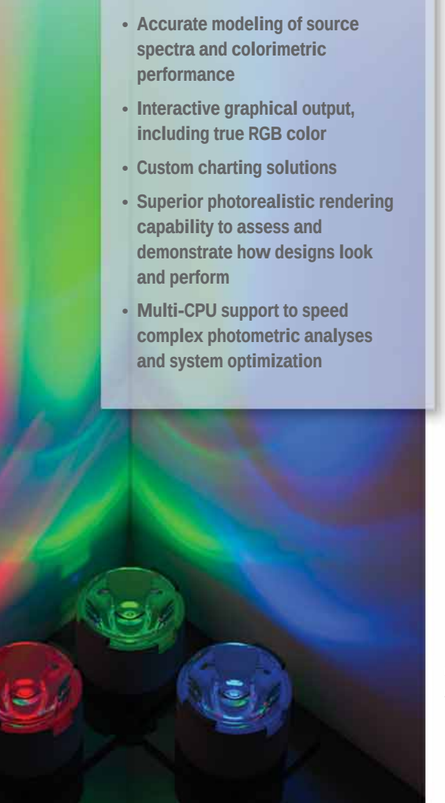
Analysis Tools that Verify and Ensure Design Performance

With *LightTools'* virtual prototyping capabilities, you can quickly analyze your system and perform tradeoff studies. Explore design alternatives, study light behavior, and improve product quality by identifying and fixing potential problem areas early in the product development process.

Analysis Feature Highlights

- Full suite of simulation tools
- Fast and robust forward and backward Monte Carlo ray trace capabilities
- Sobol sampling, the most sophisticated and accurate method for random ray generation
- Simulation of real-world surface and material effects
- Accelerated ray tracing option that increases ray trace speed by 4x to 60x or more
- Accurate modeling of source spectra and colorimetric performance
- Interactive graphical output, including true RGB color
- Custom charting solutions
- Superior photorealistic rendering capability to assess and demonstrate how designs look and perform
- Multi-CPU support to speed complex photometric analyses and system optimization



LightTools' photorealistic renderings can accurately model the color and dynamic range of LED systems.

COMPREHENSIVE ILLUMINATION ANALYSIS FEATURES

LightTools calculates all the photometric and radiometric quantities needed to perform a complete illumination analysis. You can define any number of receivers on real or virtual surfaces in the model to collect ray trace results for illumination analysis. Illuminance, luminance, luminous intensity (near and far field), and encircled energy (angular or spatial) can be calculated at any receiver. Key features include:

LightTools accurately models all light effects, including material properties such as dispersion as shown in this photorealistic rendering.

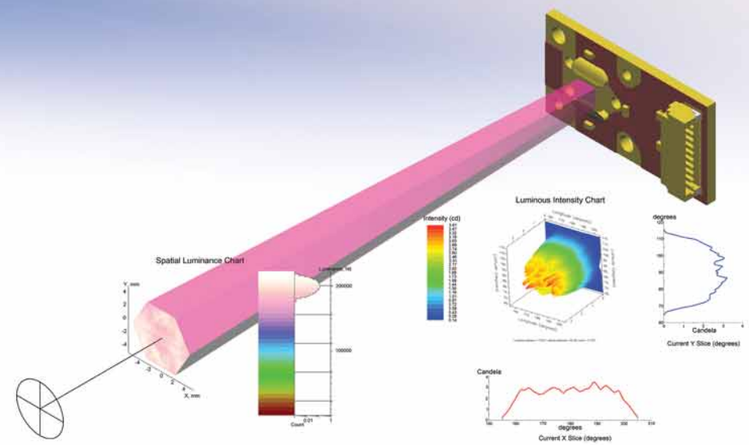
Angular and spatial luminance analysis – *LightTools* provides simulated angular and spatial luminance meters that you can attach to surface receivers to analyze and display luminance. Move the luminance meter angle to see what the fabricated system's performance will look like at any viewing angle, in real time.

Accurate predictions of colorimetric performance – Obtain calculations of CIE coordinates (1931 x-y or 1976 u'-v') for receivers as well as the Correlated Color Temperature (CCT) as a function of position or angle. Visualize true color appearance of an illuminated surface using the RGB plotting capability.

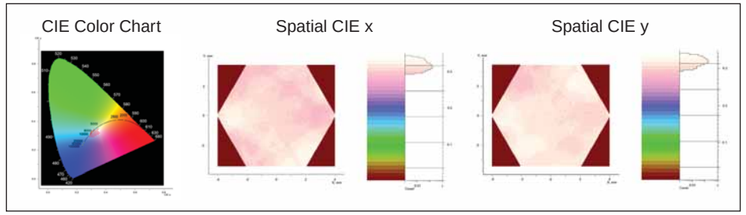
Simulation of real-world conditions – Include surface effects such as polarization, scattering, reflection and refraction (with Fresnel losses), and the performance of thin film coatings. Include material effects such as dispersion, volumetric absorption, volume scattering, and color filtering.

Flexible, efficient Monte Carlo ray tracing – Perform an accurate illumination analysis anywhere in the system with rapid and robust Monte Carlo simulations. Select either forward or backward ray tracing to enhance simulation speed and accuracy. Filter data according to a variety of criteria to improve your understanding of the results. Graphically display the paths of traced rays. Maximize the efficiency of ray tracing and illumination calculations by defining aim regions for sources and surface scatterers to limit traced rays to important areas of the model.

Accelerated ray tracing – Select ray tracing shortcuts to speed up simulations. With accelerated ray tracing, control the level of accuracy on selected surfaces to increase ray trace speed by 4x to 60x or more. Turn on probabilistic ray splitting to enable *LightTools* to intelligently choose which rays to trace and to ignore ray paths that carry little power.



LightTools' full suite of analysis tools includes intensity, luminance, and illuminance charts.

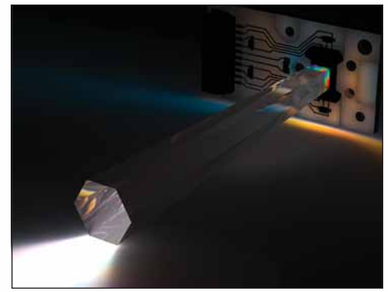


Colorimetric analysis output showing the distribution of color with respect to an object and within the chromaticity diagram. These can be used to verify color uniformity and the system white point.

Visual design evaluation and communication – Use the fully featured, high-speed photorealistic rendering tool to assess and demonstrate how your illumination optics look and perform. Apply surface finishes from an extensive built-in library and set backgrounds to enhance the realism. Include lit appearance to show the luminance effects of light sources contained in the model.

Interactive graphical output – Display the output of illumination calculations as line or raster plots, scatter plots, contour plots, 3D surface plots, and many more formats. Or, use powerful macro capabilities to develop custom charting solutions for easy visualization of complex data sets.

Faster solutions with increased computer power – Use *LightTools'* multi-CPU support to speed up complex analysis and optimization processes. *LightTools* makes full use of hardware configurations involving multiple CPUs, or single CPUs with hyperthreading or multiple core architecture.



You can use LightTools' photorealistic renderings to demonstrate the appearance of your optical system during design evaluations and product presentations.

Exceptional Software Support

When you use *LightTools*, you can expect to receive the most comprehensive software support in the industry to ensure that you are productive throughout your illumination design projects.

- Expert technical support staff comprised of degreed optical engineering professionals
- Dedicated customer Web site includes FAQs, macros, example models, tips, and more
- Comprehensive documentation
- Onsite and offsite software training
- Regular program updates with customer-requested enhancements

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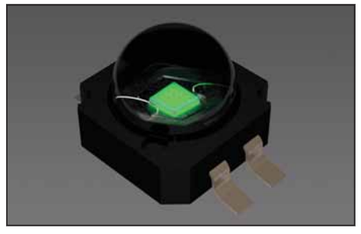
Specialized Features for Illumination Applications

Across a broad range of illumination applications, *LightTools* helps you get high-performance, cost-effective systems to market faster. Its complete design and analysis features, combined with groundbreaking illumination optimization capabilities, allow you to achieve design solutions unachievable with any other software.

Here is a sampling of the program's applications and related key features.

LEDs, including LED dies, LED arrays, and LED packaging

- LED utility to quickly build a complete model.
- Library of pre-defined LEDs.
- Multiple immersion for modeling the embedded phosphor and epoxy covering in an encapsulated LED.
- Fully optimizable skinned solids for creating efficient LED couplers.
- User-defined materials to model phosphor-based white LEDs.



Software should evolve with its industry. As new light sources and optical technology becomes available, LightTools continues to provide the geometric and optical tools necessary to utilize these concepts and speed the adoption of new technology outside of R&D. This photo-realistic rendering of a lit LED shows a level of source model detail that can be easily achieved in LightTools.

Backlit displays

- 2D and 3D textures, including multiple appliqués, dot patterns, fine groove structures, or bump structures for solids and surfaces.
- User-defined 3D texture shapes and patterns for designing and analyzing arrays of complex surface reliefs.
- Backlight utility that automates system setup and facilitates rapid design studies.
- Backlight Pattern Optimization utility that designs and optimizes backlight extraction patterns.

LightTools can be used to design and analyze a wide variety of consumer products, from LCD and keypad backlights on cellphones to household lighting fixtures.

Digital and overhead projectors

- Library of pre-defined LCD, DMD, and LCoS projector models.
- Light source definition using existing ray data sources, including Radiant Source Models.
- Built-in colorimetry analysis features to evaluate color quality and simulate display appearance.
- Skinned solids to create complex mixing-rod shapes with minimal effort, and optimization capabilities that automatically refine the design form.
- Backward ray tracing for rapid, high-accuracy spatial luminance calculations.

Lighting/luminaires

- Photorealistic renderings to visualize both how a luminare is lit and how it lights a room.
- Reflector construction and automatic pattern-generation tools.
- User-defined 3D textures that efficiently model a variety of complex components, from pillow optics to light diffusers for fluorescent troffers.
- True-color RGB output.
- Utility to read and convert IES-formatted angular intensity data files into *LightTools* angular apodization files.

Lightpipes

- Interactive construction, parametric editing, and automatic optimization of complex shapes.
- 2D and 3D texture capabilities, where each solid or surface can have multiple appliqués, dot patterns, fine groove structures, or bump structures.
- Probabilistic ray splitting, Fresnel loss, and mixed scatter to improve speed and accuracy of light pipe simulations.

LightTools has the ability to model myriad complex optical interactions, including polarization, Fresnel surface loss and back-scatter, dichroic coatings, and spatial light modulators such as LCOS. These capabilities are all useful for the design and analysis of digital projector optics.

- Volume scattering inside a material to simulate the diffusing characteristics of appliqués.

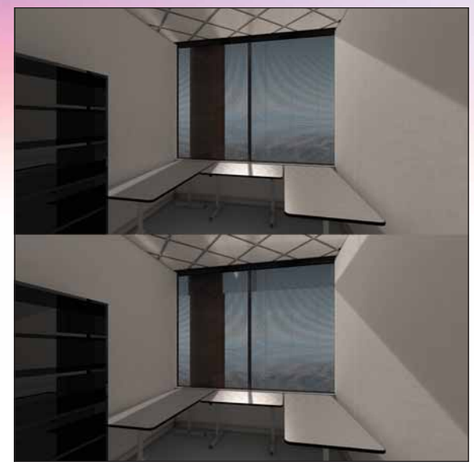
Stray light simulation

- Ray path analysis that visually identifies stray light issues and summarizes energy flux and total power. Color coding highlights light paths of interest.
- Point-and-shoot rays that illustrate potential ray path problems.
- Receiver data filtering for multiple analyses from a single simulation.
- Importance sampling using aim areas for efficient analysis of stray light in systems.
- Ghost image analyzer utility.

Vehicle interior lighting and displays

- Library of pre-defined LED and filament sources.
- CAD import and export to leverage existing data.

LightTools optimization empowers illumination designers to explore new design spaces and incorporate emerging technologies. For instance, this headlamp includes filament sources for the high beam and turn signal while using five separate optics for an LED low beam.



LightTools is useful for modeling the effect of solar radiation for daylighting and architectural applications. This pair of photorealistic renderings shows the effect of adding a brightness-enhancing film to the south-facing window of an office.

- Photorealistic renderings of an optical system's lit appearance to assess how the human eye reacts to an illuminated system.
- Virtual luminance meters that can be graphically positioned at any location in the model space to measure spatial and/or angular luminance and evaluate display visibility and quality.

Vehicle exterior lighting

- Macro control of spline, sweep, and patch surfaces.
- SAE Test Point Analyzer utility that analyzes receiver data against most SAE standards, displays results, and sets up type A and B photometers.
- Far-field and surface receivers that collect light rays and successfully predict the luminous intensity output of lighting components.
- Accelerated Ray Tracing option to speed ray tracing of imported CAD geometry.

Solar collection and daylighting

- Skinned solids for classical and custom solar collection optics.
- Solar utilities for modeling of solar collection systems.
- 3D textures to model brightness-enhancing optics.
- Fluorescence to enhance light capture in solar concentrators.
- Photorealistic renderings to show the effect of daylighting enhancements.

Medical devices

- Full suite of volumetric optical effects, including scatter, phosphorescence, and absorption.
- Ability to apply Henyey-Greenstein models to a material for tissue modeling.
- Extensible BSDF surface scattering capabilities.

Machine vision and laser scanning components

- GRIN material modeling and a full complement of geometric laser propagation capabilities.
- Accurate geometric modeling of both illumination and detection optics across the electro-magnetic spectrum.
- Photorealistic renderings to evaluate illuminator and detection optics from the detector's point of view.

Aerospace and defense/spaceborne systems

- Stray light and off-axis rejection analysis, including aim areas and importance sampling.
- Blackbody source spectrum.
- CAD import for optical mounts and assemblies.

Configure *LightTools* to Meet Your Needs

LightTools has multiple modules that can be licensed in various configurations to meet your specific application needs. The Core Module is a prerequisite for all other modules, which include the Illumination Module, Optimization Module, Advanced Physics Module, SolidWorks Link Module, Data Exchange Modules, and Imaging Path Module. These modules work together seamlessly to provide a complete design and analysis solution for illumination systems.

Core Module

The *LightTools* Core Module provides graphical 3D solid modeling functionality and interactive optical ray tracing for creating and visualizing optical and opto-mechanical systems, including the capability to specify properties for materials and optical surfaces.

Productivity-enhancing features include an intuitive user interface, libraries of task- and application-specific utilities and example systems, programming extensions for automating workflow, and photorealistic renderings of mechanical models.

All other *LightTools* modules are fully integrated with the Core Module.

Illumination Module

The Illumination Module enables designers to simulate and analyze light as it traverses the optical and mechanical components that make up a model. You can specify multiple sources and receivers and quickly trace rays through the system using state-of-the-art Monte Carlo techniques, which provides accurate predictions of intensity, luminance, and illuminance throughout the model. Powerful illumination analysis capabilities, such as photorealistic renderings that show the luminance effects of light sources in the model, simulate real-world conditions and reduce the need for physical prototypes.

Optimization Module

The Optimization Module automatically improves the performance of virtually any type of illumination system and gives designers tremendous flexibility to choose from hundreds of system parameters to designate as variables, constraints, and performance criteria in order to achieve the desired system performance. Full integration with the *LightTools* 3D solid modeling environment ensures that the Optimization Module delivers practical, realistic solutions in a fraction of the time it would take to accomplish manually.

Advanced Physics Module

The Advanced Physics Module extends *LightTools'* optical modeling capabilities for cutting-edge applications. Designers can take advantage of programming extensions to develop custom optical parts and advanced illumination subsystems, such as proprietary polarization components, scatterers, coatings, and other specialty optical materials, including gradient index (GRIN) materials used in copiers, scanners, and fiber optic telecommunication systems. The results can be packaged into a portable format and exchanged with your project team, customers, suppliers, and subcontractors. Capabilities for creating and assigning phosphor materials are also included in this module.

SolidWorks Link Module

The SolidWorks Link Module enables you to link SolidWorks 3D opto-mechanical models to *LightTools*, where you can assign optical properties and use the Optimization Module to optimize your design. This module provides complete parametric interoperability between *LightTools* models and SolidWorks.

Data Exchange Modules

The Data Exchange Modules provide import and export capabilities for industry-standard CAD file formats, including separate translation modules for IGES, STEP, SAT, CATIA® V4 and V5, and Parasolid® Supporting features for the Data Exchange Modules include the ability to group and simplify imported geometry and perform geometry repairs to maintain CAD model integrity and improve ray trace speed.

Imaging Path Module

The Imaging Path Module allows you to define an imaging path based on sequential optical surfaces and perform lens analyses. The Imaging Path capability can be used directly in *LightTools* or in conjunction with CODE V.

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About Optical Research Associates

For more than four decades, Optical Research Associates (ORA®) has pursued its vision—to accelerate the development and adoption of innovative optical technology throughout the world. ORA was founded in 1963 as a leading-edge optical design services provider. Since then, we have built upon our early successes to become the largest optical design software provider with the world's leading packages: CODE V® and LightTools.® We are also the largest independent optical engineering services organization. Working with our distribution partners, we now have customers in more than 25 countries.

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