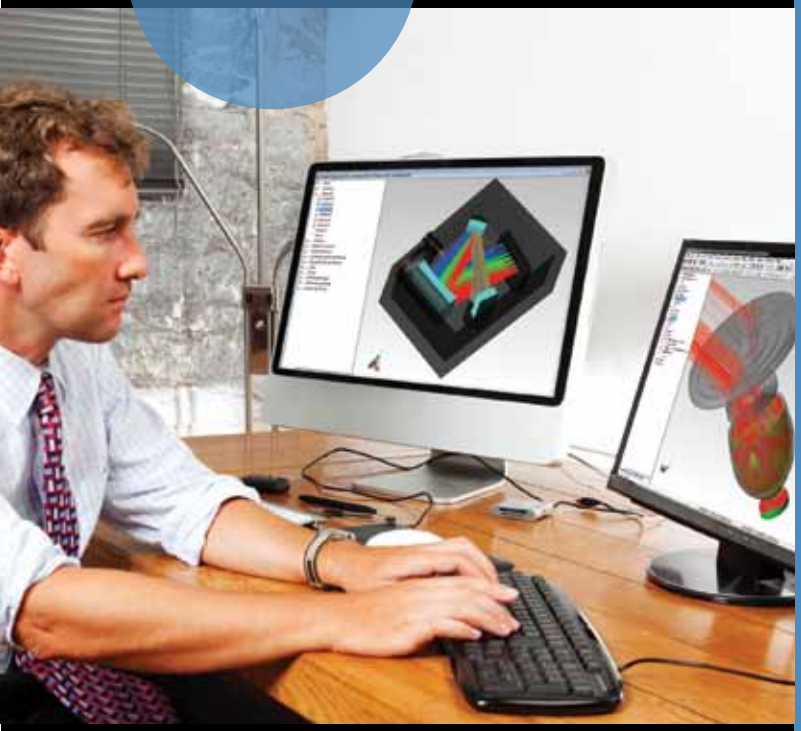
SUPERIOR *OPTO-MECHANICAL* **SOFTWARE**

TracePro

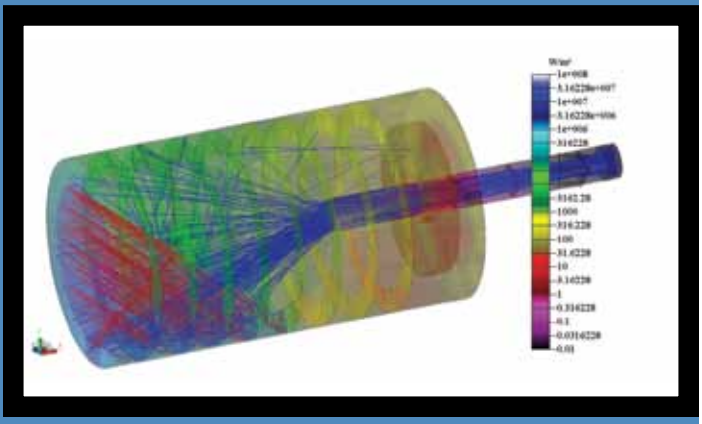
Illumination Design, Analysis, and Optimization Software



TracePro® is award-winning opto-mechanical software used for design, analysis, and optimization of optical and illumination systems. With its intuitive CAD interface and powerful features like interactive optimizers, TracePro offers users a sophisticated and powerful optical design environment combined with a short learning curve to accelerate product time-to-market.

LAMBDA RESEARCH CORPORATION

TracePro streamlines the prototype to manufacturing process for optical and illumination systems with a familiar CAD interface, 2D and 3D optimization, and seamless interoperability with popular CAD software, such as SolidWorks®.



Visualization of Cassegrain Telescope

Solid Modeling

TracePro models are created by importing lens design or CAD files, as well as by directly creating the solid geometry within TracePro. Models can be modified by using move, rotate, scale, sweep, and revolve object and surface operations via the user-friendly, 3D CAD interface. Primitive solids, such as tubes, blocks, cones, and spheres; and optical elements, including lens elements, reflectors, and Fresnel lenses, can also be inserted. TracePro utilities allow interactive sketching to quickly enter 2D and 3D profiles; and then extrude, revolve, and combine these surfaces to create sophisticated geometry, like lightpipes, reflectors, and free-form optics. Visualization options include: photorealistic rendering, solid rendering, silhouette, wireframe, and hidden line views. Users also have the ability to pan, rotate, zoom, and perform other standard geometry manipulation techniques. TracePro's multiple document, multiple view architecture allows you to have several views of the same model open at the same time, and several models open at the same time. Copying and pasting objects from one model to another requires just a couple of keystrokes or menu picks.

Optical Properties

A wide range of material and surface properties can be applied to objects and surfaces in the model. Optical properties that can be specified include:

- Material properties – index of refraction, absorption coefficient, and birefringence
- Aperture diffraction
- Surface properties – reflectance and transmittance coefficients, surface absorption, surface scatter
- Bulk scatter
- Fluorescence
- Gradient index
- Mueller Matrix for polarization modeling
- Surface source
- Temperature distribution
- Thin film stacks for modeling multilayer optical coatings, including anti-reflection coatings, bandpass filters, and cutoff filters

Surfaces with random or periodic arrays of repeated structures can be created using TracePro's RepTile™ feature.

Properties can be defined with customized parameters or applied from TracePro's catalog of commonly used, commercially-available materials and coatings. You can also add your own properties to the database to streamline the modeling process.

Polarization is modeled seamlessly, using the Mueller calculus, with Mueller Matrices applied to objects and rays defined by Stokes vectors.

Performance and Accuracy

TracePro's ray tracing engine is fast and accurate, providing complete control of threshold parameters to achieve simulation results quickly with no compromise in accuracy. Analysis Mode ray tracing, unique to TracePro, is a very powerful capability that creates an interactive environment to analyze every surface and object both visually and quantitatively to gauge the feasibility of a design.

Ray tracing features include:

- Ray Splitting
- Exact Ray Tracing – no missed intersections or "leaky" rays
- Analysis Mode ray tracing for interactive viewing of any analysis result on any surface or object after the ray trace is completed
- Simulation Mode ray tracing for tracing very large numbers of rays with little or no memory consumption
- Multiple Exit Surfaces (Simulation Mode)
- Voxelization of Object Space for fast ray tracing using uniform or octree voxels
- Aperture Diffraction
- Stratified Importance Sampling
- Reverse ray tracing for designs in which sampling is improved by this method

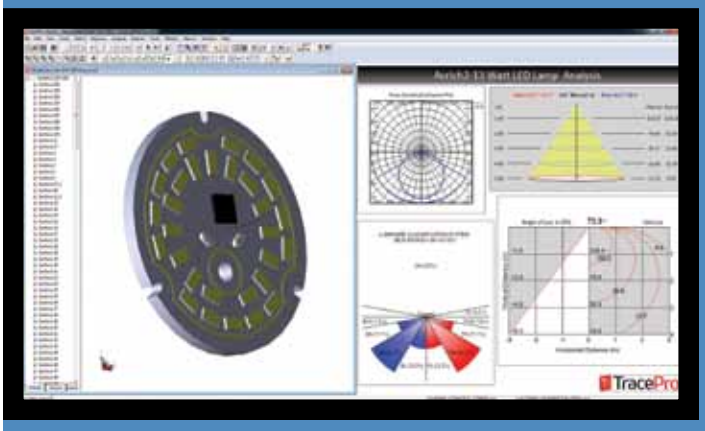
Light Sources

TracePro simulates the distribution of luminous intensity, irradiance/illuminance, and flux throughout a model or at selected surfaces by tracing rays using the Monte Carlo method. Light sources are modeled by emitting rays. Additionally, TracePro's Surface Source Property Utility enables graphed surface source properties to be imported directly from a manufacturer's datasheet.

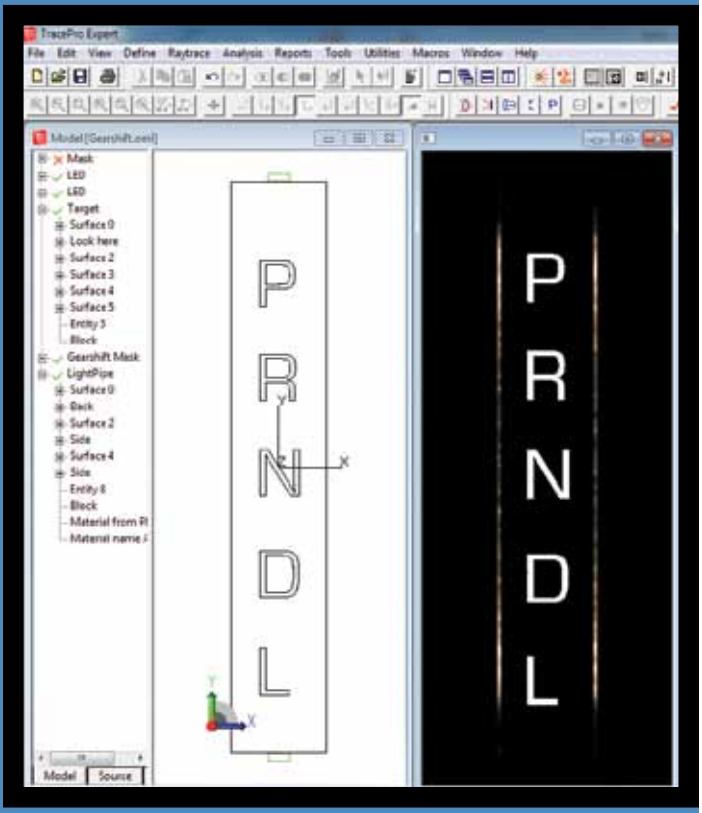
Ray sets are defined using any combination of three methods:

- **Grid** – specify spatial and angular beam profile, wavelengths, and dimensions along with beam orientation, polarization state, and degree of polarization.
- **Surface** – specify angular distribution and emission spectrum from one or more surfaces of any solid object using luminous flux or irradiance/illuminance. Surfaces can also be defined as blackbody or graybody radiators. Any combination of surfaces can be defined as sources.
- **Ray File** – predefined ray tables consisting of XYZ starting points and direction vectors, polarization states, wavelength data, and the initial flux value or Stokes vector for each ray. Ray files are typically created from source measurements or theoretical calculation.

TracePro's RepTile (Repetitive Tile) is an on-the-fly surface creation utility that defines and creates repetitive microstructures on any planar surface. RepTile is a convenient, easy-to-use function that reduces the time it takes to build and modify a structure, as well as ray trace millions of surface entities for lighting and display backlight analysis.



Acrich2-13W LED Array Report



Photorealistic Rendering: Gearshift Lever

Photorealistic Rendering: Lighting Louver

Analysis

TracePro provides a comprehensive set of tools to view and analyze results of the ray trace, including:

- Irradiance/Illuminance Maps show irradiance or illuminance, CIE, and true color maps of light incident on, absorbed by, or exiting a selected surface. Multiple options are available to control pixelization, profiles, relief plotting, linear and logarithmic output, gradient, color maps, and smoothing operations; as well as the capability to export results to a text file or a bitmap file.
- Luminance/Radiance Maps can be displayed as true color based on the wavelengths traced. Luminance Maps can be used to make very accurate photorealistic renderings using the optical properties and sources applied to the model.
- 3D Irradiance Plots map irradiance, CIE, and true color plots of the incident, absorbed, or exiting flux onto the selected surfaces or objects in the system view. This mapping is achieved by layering the light map of the displayed flux or color output on top of the 3D CAD geometry. Multiple options are available for contour plotting, transparency, ambient lighting, linear and logarithmic output, gradient shading, color maps, and smoothing.
- Candela Plots show luminous or radiant intensity in candela or watts/steradian. There are four types of candela plots: Polar Candela, Iso-Candela, Rectangular Candela, and Iso-Candela.
- Polarization Maps chart the polarization ellipse for the incident flux onto the selected surface. Color levels and ellipses graphically display the degree of polarization and ellipticity at points on the surface.
- Incident Ray Tables provide tabular output of rays incident on a selected surface.
- Ray History Tables give a complete history of every ray incident on a selected surface.
- Path Sorting Tables give a sortable table of ray paths incident on a selected surface, with interactive viewing of rays and irradiance maps of paths you select.
- Optical Path Length (OPL) or Time-of-Flight plots present flux absorbed or incident on a selected surface versus OPL for specialized analyses.
- Volume Flux Maps allow visualization of the flux absorbed, incident, lost, or emitted throughout a rectangular volume.

Map and plot output can be further controlled with Ray Sorting. For example, analysis results can be filtered to show only the rays intersecting a surface, rays of a certain wavelength, interaction type, or flux range.

2D & 3D Optimization

TracePro offers 2D symmetric and 3D non-symmetric optimizers that enable quick specification of a starting design and interactive control- and segment-point specification. The optimizers have built-in interactive ray tracing tools to quickly diagnose the feasibility of a design, pulling on a control- or segment-point automatically updates any ray trace. TracePro's optimization process rapidly determines the feasibility of the design, while also allowing results to be continuously monitored and used for subsequent refinement of the model. Complex non-symmetric designs are supported with the 3D optimizer, which is perfect for designing unusually shaped complex lightpipes and LED lenses.

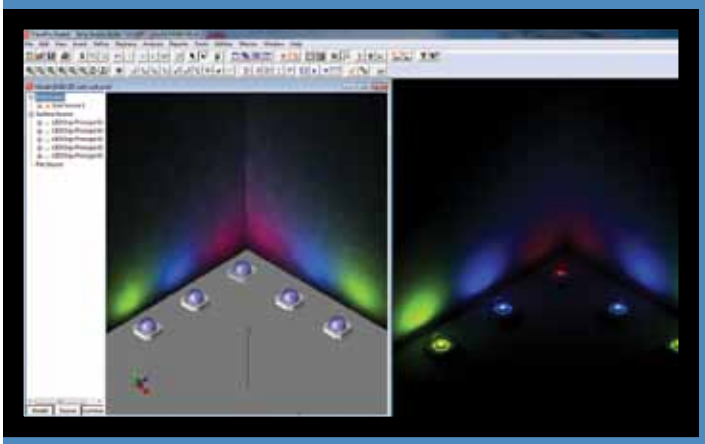
Texture Optimization

TracePro offers the Texture Optimizer, which allows you to optimize the distribution of scattering dots on a backlight. First define a target irradiance distribution, then define a starting point distribution of dots. The optimizer will adjust the density of the dots to achieve your target distributions.

Visualization & Rendering

TracePro has several surface and ray display options that help identify problem areas and visualize energy propagation through any optical or illumination system. Large and readable irradiance/illuminance and candela plots with linear or log scales, several color palettes, profiles, and 3D viewing options enable understanding of the flux or irradiance on any surface.

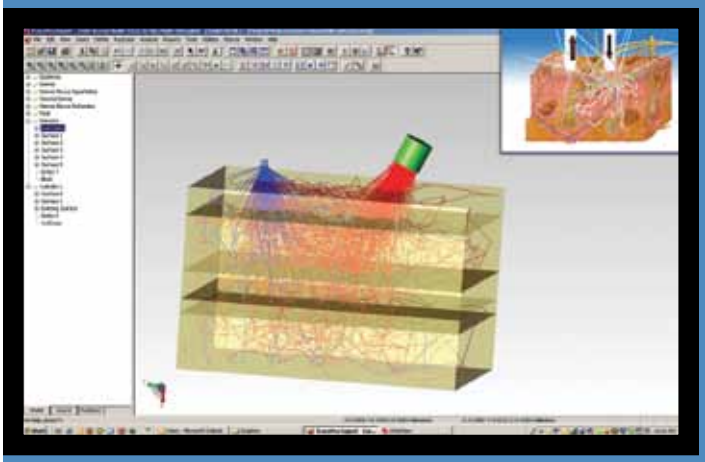
TracePro's Photorealistic Rendering feature uses source and optical properties of the model and real ray tracing and photon mapping algorithms to enable you to visualize your design's lit appearance from any position.



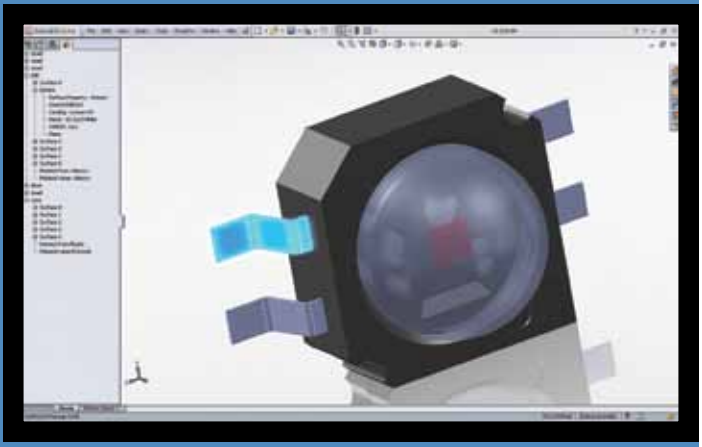
3D Illuminance True Color Plot Versus a Photorealistic Rendering

TracePro illumination design, analysis, and optimization software has enabled product innovation and research discovery across a breadth of applications:

- **Luminaire Design**
- **LED Optical Integration**
- **Lightpipe Design**
- **Design Optimization**
- **Biomedical Optics**
- **Stray Light Analysis**
- **Display Illumination**
- **Solar Energy Collection**
- **Daylighting**



Biomedical Simulation



TracePro Bridge for SolidWorks

CAD Integration

TracePro offers seamless integration with SolidWorks using the TracePro Bridge™ for SolidWorks, an add-in to SolidWorks that allows optical properties to be added and saved directly to the SolidWorks model, preserving mechanical and optical properties as models are exported from SolidWorks to TracePro. As a result, design productivity is dramatically improved without sacrificing performance or functionality.

Reporting

TracePro can generate a variety of ray trace and property reports. For example:

Flux Reports provide a summary of surface area, number of incident rays, incident and absorbed flux, and lost flux for all defined sources or as a function of the selected source or wavelength. Bulk absorption and incident flux are displayed for each object. Property Data Reports display the model's optical surface and object property definitions. Ray Trace Reports display physical and virtual memory usage and elapsed ray trace time.

Editions

Three editions of TracePro are available with increasing levels of functionality and sophistication suitable for all user levels and virtually any application. This provides a convenient and practical upgrade path as a user's needs and experience increase. The LC edition is targeted at standard lighting and lightpipe applications. The Standard edition is perfect for most optical and illumination design, analysis, and stray light tasks. When advanced capability is needed for textured backlight design or life science applications, the Expert edition has the superior capability to model millions of scattering dots and bulk scatter functionality for simulating biological tissue.

See table on the next page for details or contact our sales team with any questions at sales@lambdares.com.

TracePro Editions Comparison

Three Editions of TracePro are available to cost-effectively accommodate your design and analysis needs

	LC	Standard	Expert
FEATURES			
User-Friendly CAD Interface, Interoperability with commercial CAD software through the SAT (ACIS) file format and Lens Design Software	YES	YES	YES
Scheme Macro Language, Recorder, and Editor	NO	YES	YES
Material, Surface, Lens, Lamp, and LED catalogs of commercially available glass, plastics, metals, anodized surfaces, paints, lamps, and LEDs	YES	YES	YES
2D and 3D Optimization	NO	YES	YES
SOLID MODELING			
SAT Import and Export with Healing Utility	YES	YES	YES
Lens Design Import for all commercial design programs including OSLO	YES	YES	YES
TracePro Bridge 7.x requires SolidWorks 2010 SP 3.0 or later	YES	YES	YES
CAD features including solid modeling, Boolean Operations, 3D interactive view, 3D Rendered, transparent, wireframe, hidden view, and measurements	YES	YES	YES
Multiple Optional CAD translators including, STEP, IGES, and Pro/E	OPTIONAL	OPTIONAL	OPTIONAL
PROPERTIES			
Surface Property modeling includes absorption, reflection, refraction, scatter off any surface, and bulk absorption	YES	YES	YES
Diffraction, Bulk Scatter, Grin, Thin Film Stacks, Polarization, Diffraction Gratings, Temperature Dependent, Anisotropic Properties, and Tabular Scatter Models	NO	YES	YES
Repetitive Tile (RepTile) Surface, Temperature Distributions, Birefringence, Wire Grid Polarizers, and Fluorescence	NO	NO	YES
Scatter Models	SYMMETRIC	SYMMETRIC & ASYMMETRIC	SYMMETRIC & ASYMMETRIC
SOURCES			
Grid and Ray Sources	YES	YES	YES
Surface Sources	YES	YES	YES
Blackbody/Greybody Sources	YES	YES	YES
Bitmap and Source Files (ProSource – Radiant Imaging)	YES	YES	YES
RAY TRACE			
Monte Carlo with Ray Splitting	YES	YES	YES
Simulation Mode (single or multiple exit surfaces to see results) or Analysis Mode (infinite surfaces to see results)	YES	YES	YES
ANALYSIS			
Irradiance/Illuminance and Candela Maps (Intensity) for both Photometric and Radiometric output, CIE(x,y), CIE(u,v), and True Color plots	YES	YES	YES
3D Irradiance Maps, Photorealism, and Luminance/Radiance (Lit Appearance)	YES	YES	YES
Flux, Ray History, Ensquared Energy, and Path Sorting	YES	YES	YES
Polarization Maps, Volume Flux, OPL, and Time-of-Flight Report	NO	YES	YES
UTILITIES			
2D and 3D Interactive Optimizer	2D AND 3D GEOMETRY MODELER ONLY NO OPTIMIZATION	FULL OPTIMIZATION	FULL OPTIMIZATION
BSDF Converter	SYMMETRIC PROPERTIES	SYMMETRIC & ANISOTROPIC PROPERTIES	SYMMETRIC & ANISOTROPIC PROPERTIES
Source Property Generator	YES	YES	YES
IES Analysis Utility	YES	YES	YES
Texture Optimization	NO	NO	YES
Fluorescence Property Utility	NO	NO	YES
Solar Utility	YES	YES	YES

TracePro

Lambda Research Corporation, a privately-held company founded in 1992, is an industry leader in optical analysis, illumination system design and analysis, and custom software development. Lambda Research Corporation publishes TracePro, an award-winning opto-mechanical design software used for designing and analyzing illumination and optical systems. TracePro streamlines the prototype to manufacturing process by combining an intuitive 3D CAD interface, advanced utilities, and seamless interoperability with other mechanical design programs.

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