ADELINE - AN INTEGRATED APPROACH TO LIGHTING SIMULATION

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ABSTRACT

The use of daylighting and artificial lighting simulation programs to calculate complex systems and models in the design practice often is impeded by the fact that the operation of these programs, especially the model input, is extremely complicated and time-consuming. Programs that are easier to use generally do not show the calculation capabilities required in practice. A second obstacle arises as the lighting calculations often do not allow any statements regarding the interactions with the energetic and thermal building performance.

Both problems are mainly due to a lacking integration of the design tools of other building design practitioners as well as due to insufficient user interfaces. The program package **ADELINE** (Advanced Daylight and Electric Lighting Integrated New Environment) being available since May 1996 as completely revised version 2.0 presents a promising approach to solve these problems.

This contribution describes the approaches and methods used within the international project IEA Task 21 for a further development of the ADELINE system. Aim of this work is a further improvement of user interfaces based on the inclusion of new dialogs and on a portation of the program system from MS-DOS to the Windows NT platform.
Additional focus is laid on the use of recent developments in the field of information technology and experiences gained in other projects on integrated building design systems, like for example EU-COMBINE, in a pragmatical way. An integrated building design system with open standardized interfaces is to be achieved inter alia by using ISO-STEP formats, database technologies and a consequent, object-oriented design.

THE ADELINE PROGRAM SYSTEM

The initial version of the ADELINE program system, released in 1994, was developed by an international working group within Subtask A.2 in the framework of IEA Task XII. Involved in the development of the design tool have been

- Fraunhofer Institute of Building Physics, Germany (Task lead),
- Danish Building Research Institute, Denmark,
- Ecole Polytechnique Fédérale de Lausanne, Switzerland,
- Lawrence Berkeley Laboratory, U.S.A.,
- Swiss Material Testing Institute EMPA, Switzerland.

The objective was to develop an integrated lighting analysis tool for building design purposes which is intended to assist the building designer and consultant in all issues associated with daylighting and electric lighting design.
In May 1996 the completely revised version 2.0 was released as result of the continous collaborative work of the international working group [Erhorn and Stoffel 1996]. Since the first release of the software package more than 250 copies have been distributed world-wide. The majority of the users are coming from the private and industrial sector, i.e. lighting and energy consultants, architects, lighting and glazing industry. The program is also widely used at universities and other research institutes. Extensive support like introductory seminars and hotline service is offered to assist users in the application of the program system.
The ADELINE program system [Figure 1] represents an integration of several program modules required for an integrated lighting design enabeling

- day- and artifical lighting simulation as well as consideration of
- the energetic and thermal impact of the lighting strategies under investigation.

Geometric input of the lighting simulation programs is handled by a common CAD program, SCRIBE MODELLER [Green, Cooper and Wells 1989] and special converters. In addition, a 3D-DXF interface enables the user to use any CAD program that can handle drawings in 3D-DXF format. The generated geometric entities are attributed with material properties which can either be selected from an included material database of more than 250 different opaque or transparent materials or can be specified parametrically. The interface program PLINK [Compagnon and Green 1994] will convert all geometry and material data of the CAD input into the

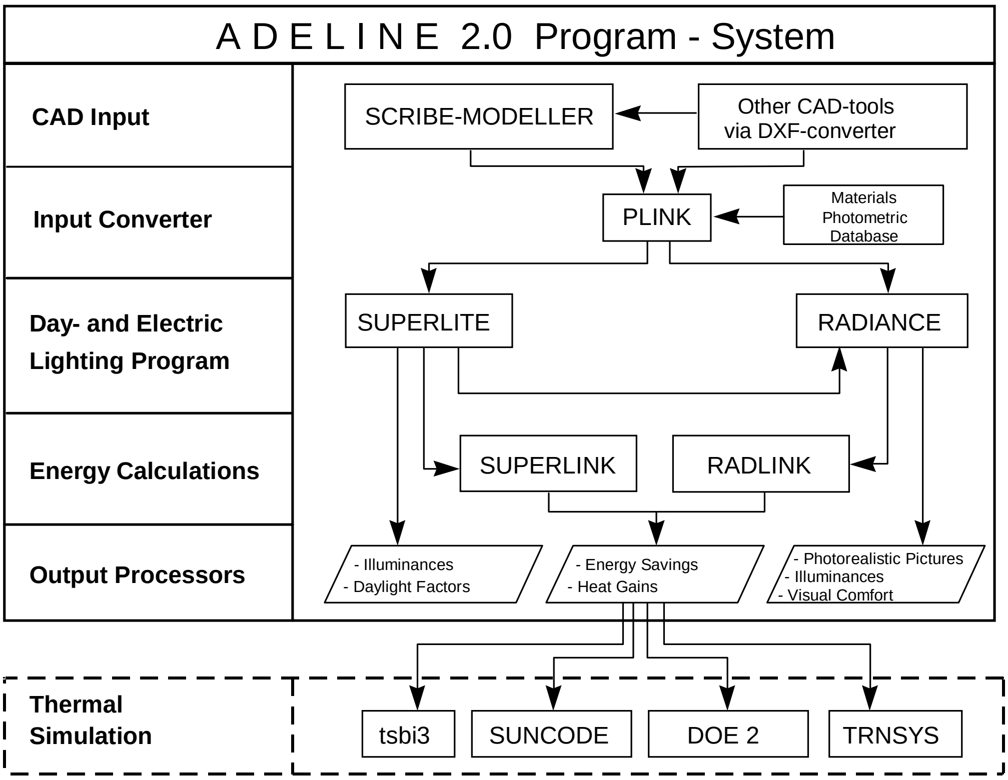


Figure 1: Structure of the ADELINE 2.0 lighting design tool.

different input formats required by the simulation programs.

The lighting calculations are executed by the international validated programs SUPERLITE IEA 2.0 and RADIANCE PC.

- SUPERLITE IEA 2.0 (based on a radiosity method) is an optimized and improved version for the use within ADELINE of the stand-alone SUPELITE 2.0 version distributed by Lawrence Berkeley Laboratory [Lawrence Berkeley Laboratory 1986]. Even though SUPERLITE's range of application is much more limited than the one of RADIANCE, it has proven to be an excellent tool for the early design phases. The so-called SUPERLITE *Simple Input Mode* is fully supported by the ADELINE graphical user interface. SUPERLITE delivers illuminance and daylight factor distributions on worksurfaces; within the ADELINE system also luminance visualisations using special RADIANCE programs are available.
- RADIANCE PC (using raytracing techniques) is a port of the RADIANCE synthetic imaging system [Ward 1993] to the DOS operating system. The typical output of RADIANCE includes photorealistic pictures of the building model (luminance visualisation), illuminance levels, daylight factors and visual comfort calculations.

SUPERLINK and RADLINK [Szerman and Stoffel 1996] are a linkage between daylighting and other energy analysis tools used for predicting the dynamic, thermal and energetic performance of a building. SUPERLINK calculations are based on SUPERLITE, whereas RADLINK uses RADIANCE for the lighting simulations. The thermal and energetic behaviour of buildings can be analysed by using the simulation tools DOE, SUNCODE, TRNSYS and tsbi3 (which are not part of the package). All programs are integrated within a common graphical user interface (GUI) [Figure 2].

The current version of the entire ADELINE software package operates on a PC under DOS, with at least an 80486 processor. Choosing this most common hardware platform has been proven to be necessary in order to address the needs of most of the users above. ADELINE version 2.0 currently forms the major basis for further developments of daylighting design tools within IEA Task 21 *Daylight in Buildings* which started in August 1995. IEA Task 21 is an international four-year research program. One of the

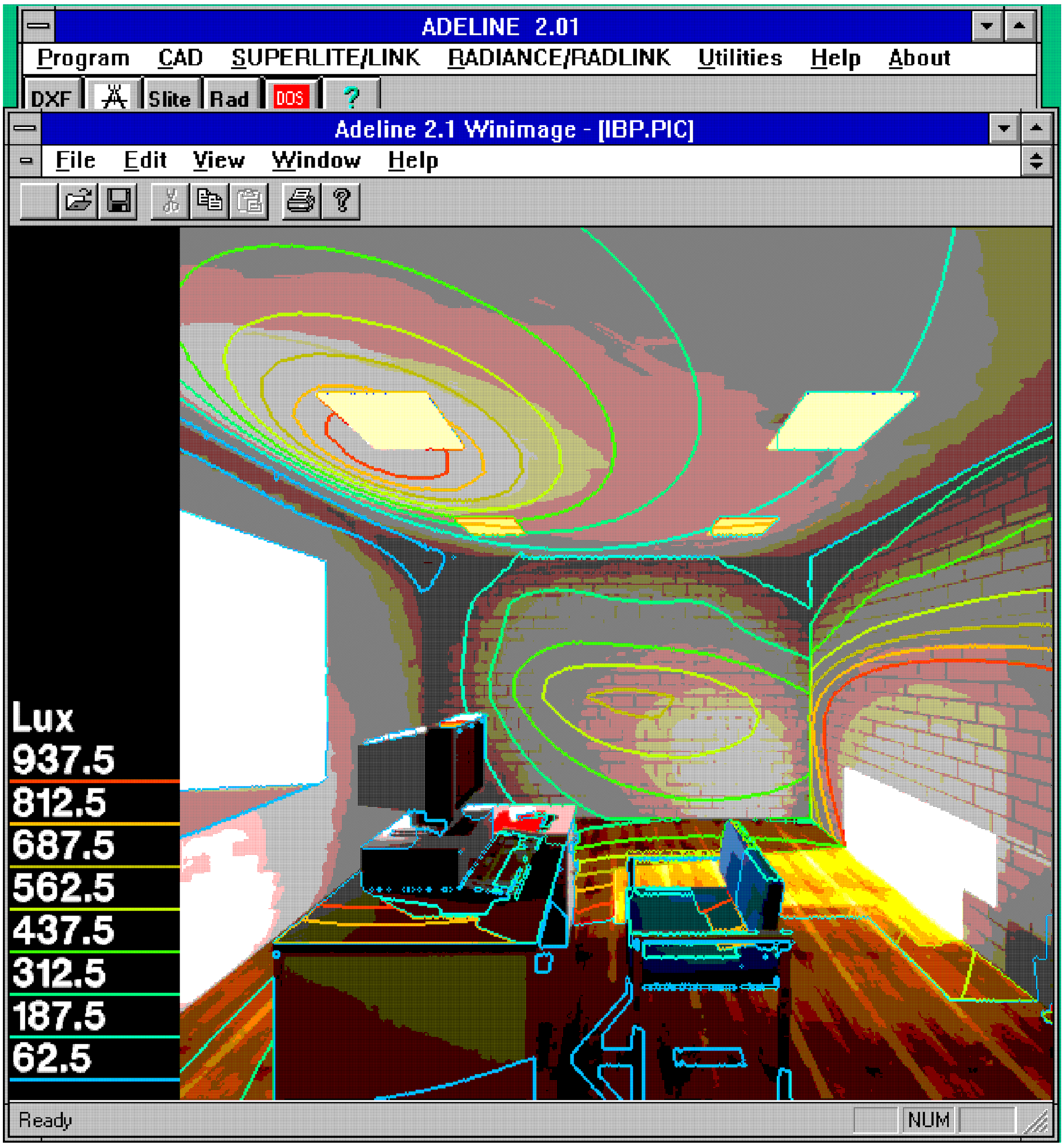


Figure 2: ADELINE graphical user interface under Windows NT. The image background shows the ADELINE main menue, the front shows a photorealistic visualisation generated with RADIANCE NT, displayed from within the ADELINE GUI.

four subtasks is dealing with the development, improvement, testing and validation of daylighting design tools.

CURRENT DEVELOPMENT

At the beginning of the work of Task 21 it was decided to port the program system from MS-Dos to the 32-bit-operating systems Windows 95 and Windows NT, taking into account the development of the software market and the user demands. This allows for conforming the system, its functionality and handling to most of the programs nowadays in use. This portation also offered the inclusion of already existing software, as well as the use of improved graphics libraries and advanced development tools.

The ADELINE 2.0 graphical user interface (GUI) [Figure 2] has now been ported together with the programs SUPERLITE, RADIANCE (current version 3.0), SUPERLINK and RADLINK. The portation of the GUI was facilitated as it was developed with a platform independent tool. The Windows NT version will be available in October 1997.

The transition from ADELINE version 2.0 to version 3.0 focuses on two major aspects:

- further improvement of user interfaces and
- further integration of the diverse program modules.

Partly, these aspects interact and benefit from each other. In addition, the program system will benefit from other research activities within Task 21, like the inclusion of material descriptions of innovative daylighting systems.

IMPROVEMENT OF USER INTERFACE

From user feedback (hotline support and user club meetings) two basic demands could be identified, which are on the one hand the need of extended simple modeling capabilities for the early design phase and, on the other hand, facilitated handling of the RADIANCE program system which is usually applied for detailed studies and visualization:

1. Extension of Simple Input Mode

Early design phases account for the basic and often irreversible decisions concerning daylight supply. The general floor layout, size and position of daylight openings decide whether daylight penetration is sufficient or not. At this design stage, basic decisions are to be fast and cost-efficient. A tool to be used at this stage thus should allow for fast handling and access to the requested information while avoiding complex geometric modeling. ADELINE 2.0 offered already a Simple Input for shoebox type rooms based on the SUPERLITE Simple Input Mode. In version 3.0 it is planned to have a geometrical and functional extended mode integrated with dialogs supporting a set of simple floorplan layouts, which can parametrically be specified. In addition, other modules for accessing luminaire databases and automatic luminaire placement are to be added, thus taking into account an increasing user demand for integrated lighting design to deal with high-level daylighting and artificial lighting problems as well. Through a proper integration of these modules into the program package [Figure 3], it will be possible to use this simple scene composition for both calculation programs, SUPERLITE as well as RADIANCE. By linking the module to the data structure, scenes can be reedited within the CAD tool SCRIBE, i.e. the simple scene descriptions may serve as starting points for further refined models.

2. Graphical Scene Editor for Radiance

In RADIANCE the geometric models can be composed of different scene descriptions. A so-called "scene file" may contain the room description, other luminaires, daylighting systems and furniture

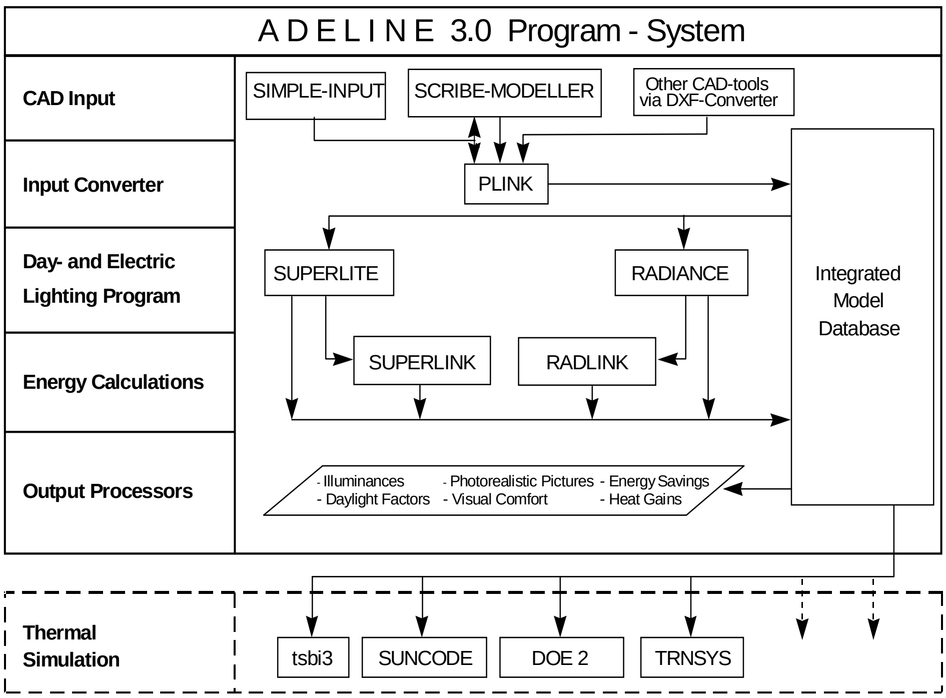
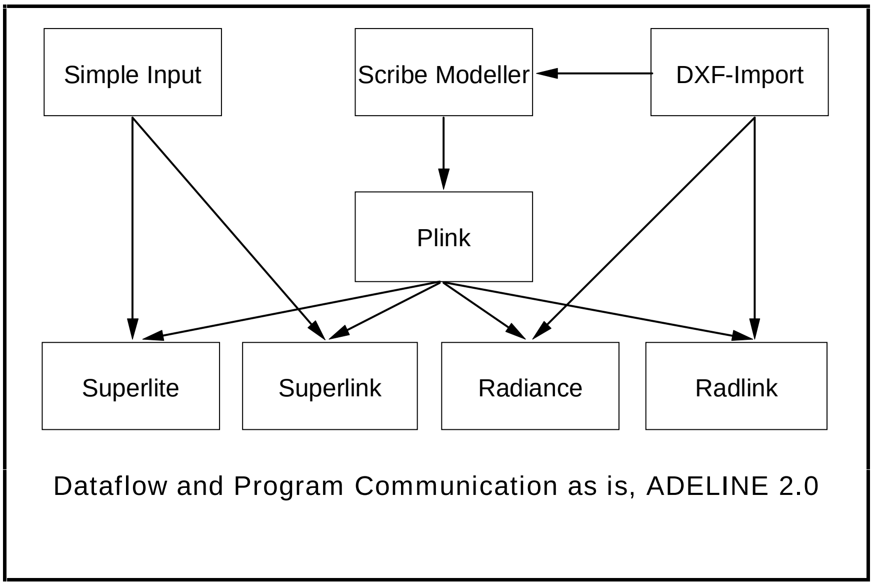


Figure 3: Structure of the future ADELINE 3.0 lighting design tool.

descriptions. This concept allows for a good structuring of the entire model as well as for the reuse of already predefined objects which can be organized efficiently in object libraries. So far, model composition within ADELINE required the placement of objects within a scene by numerical description of the transformation coordinates, using the RADIANCE program *xform*. The Scene Editor will allow for an interactive graphical composition of models made up of different objects. The graphical representation will be based on wire frame representation with optional hidden line removal.



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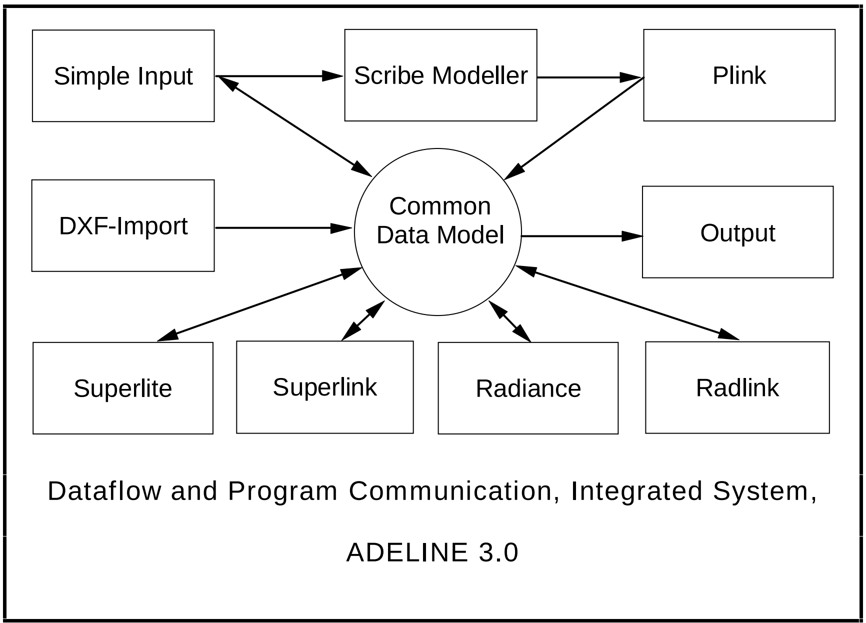

Dataflow and Program Communication, Integrated System,

ADELINE 3.0

Figure 4: Graphic showing the integration of the different program modules with the common data model.

With this module, an easy definition of rendering views will be possible. This Scene Editor is intended to shorten the modeling process significantly by circumventing the numerical scene composition and definition of views.

In addition to the inclusion of these two new modules, version 3.0 will incorporate new and common output processors for SUPERLITE as well as for RADIANCE. The output plots will be identical for both lighting simulation programs.

The general menu structure of ADELINE will be reorganized in a more design-process-oriented way, thus offering for example separate menus for the different simulation steps: CAD modeling, specification of general simulation parameters, lighting simulation and output of calculation results. The future structure of ADELINE 3.0 is shown in Figure 3.

INTEGRATION OF THE PROGRAM MODULES

The different programs included in the ADELINE Program Package currently use different file formats to load and save data. The graphical user interface and the program PLINK are used to convert the data from one file format to another. This is a major disadvantage, because files already used with one of the calculation programs (SUPERLITE, SUPERLINK, RADIANCE and RADLINK) cannot be used with another simulation program. The procedure of conversion and parameter specification has to be done once again, based on the CAD-data.
The new common data structure is to be used to overcome this problem [Figure 4].

The data model will include the experiences and approaches made in the EU-COMBINE project [Augenbroe (ed.) 1995]. The COMBINE project was based on studies for an Integrated Data Model (IDM) using STEP format (Standard for the Exchange of Product Model Data) [ISO standard 1993; Fowler 1995] for data exchange. The scope of the project was to develop prototypes of integrated systems for different building analysis tools. This was an even broader range of programs to be integrated into ADELINE than originally intended. In the first phase of development of ADELINE, a common data model based on STEP will be implemented. Then, this model can be enlarged, which was already done in the COMBINE project, in order to include a database for components described with the common data model. The stucture will inclose CAD data, geographical specifications and parameter settings for the calculation programs. The calculation parameters will have to be identified separately because they are specific to the program.

The CAD data will be kept within the structure as defined by STEP, according to ISO standard 13030. Based on this, the model will be enlarged to include the information of geographical site, occupancy of the building or room, desired luminance levels of worksurfaces, settings for the simulation programs, etc..

The programs integrated as CAD input are a Simple Input module and the Scribe-Modeller. An import of DXF-files exists already, while STEP-files still are to be included. Calculation will be done by the SUPERLITE and RADIANCE routines; energetic and thermal simulations (for lighting aspects only) will be done by using SUPERLINK and RADLINK which are both based on the SUPERLITE and RADIANCE programs.

The calculation results will be stored within the common data model and will use an identical format when containing the same kind of information. Thus, a common output processor can be used to display and/or print them. Export options are planned for graphics and numerical results.

The integration of the single programs will be done by new functions providing access to the common data. Some programs will be connected by import and export filters reading and writing program-specific files.

CONTACT PERSONS

Responsible institutions for long-term maintenance, enhancement and distribution of the ADELINE program system are the Fraunhofer Institute of Building Physics (Germany) and the Ecole Polytechnique Fédérale de Lausanne (Switzerland) in Europe and the Lawrence Berkeley Laboratory in the U.S.. The current version 2.0 of the complete ADELINE software package is available at a fee covering the costs for printing of the documentation, handling and shipping.

ACKNOWLEDGEMENTS

The work on the ADELINE 2.0 program system and ongoing work within Task 21 described in this contribution was and still is performed by the members of the international IEA Working Group: Raphael Compagnon, Jan de Boer, Michael Dirksmöller, Hans Erhorn, Karl Grau, Jean-Louis Scartezzini, Steve Selkowitz, Jürgen Stoffel, Nils Svendenius and Greg Ward.

REFERENCES

Augenbroe, G.L.M. (Ed.), *Combine Final Report.* University of Delft, Nov. 1995.

Compagnon, R., C. Green, *PLINK User's Manual.* Ecole Polytechnique Fédérale de Lausanne, 1994.

Erhorn, H., Stoffel J. (Ed.), *Documentation of the Software Package ADELINE 2.0.* Fraunhofer-Institut für Bauphysik, Stuttgart, 1996.

Green, C., D. Cooper and J. Wells, *SCRIBE-MODELLER Operating Manual*. Ecotech Design, Sheffield, 1989.

ISO 13030, Industrial automation systems and integration - Product data representation and exchange (STEP). International Organisation for Standardization. Various parts from 1993 and onwards. Available from national standardization bodies.

Lawrence Berkeley Laboratory (Ed.), *SUPERLITE 1.0 Manual.* Berkeley, 1986.

Szerman, M., J. Stoffel, *SUPERLINK/RADLINK Manual*. Fraunhofer-Institut für Bauphysik, Stuttgart, 1996.

Ward, G., *The RADIANCE Synthetic Imaging System*. Lawrence Berkeley Laboratory, Berkeley, 1993.