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Requirements for Thermal and Lighting Simulation Programs

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Contents

1. Introduction

A subgroup in the WinDat project was formed to analyse the needs of simulation programs for glazing data. The main objective of this sub-group was to:

> *define the requirements for output from WIS for thermal and lighting simulation programs.*

The secondary objective was to:

> *consider the output format from WIS in order to make it easy to import WIS data into thermal and lighting programs.*

The following were the participants of the sub-group:

- P Strachan, I Macdonald, J Hand: (ESRU, University of Strathclyde): subgroup leader
- J de Boer: Fraunhofer Institute (ISE)
- M Zinzi: Italian Agency for the New Technologies, Energy and Environment
- R Mitanchey: ENTPE, Lyon
- S Svendsen: Technical University of Denmark
- D van Dijk, P Nijnatten: TNO Institute of Applied Physics

At the start of the project WIS produced a range of derived information regarding window performance as a result of the calculation procedure. This sub-group was concerned with reviewing these outputs with regard to the current and perceived future requirements of simulation tools.

There is a current drive towards standardisation within Europe through the work of CEN. This work takes two approaches to standardisation: prescriptive and performance-based. Standardisation of calculation tools such as WIS fall into the former category. However, simulation tools which use WIS outputs generally fall into the latter category due to their complexity. Therefore there is a need for WIS to provide the data required by these simulation programs, both for use in Standards compliance and for their use in building design.

A review of simulation tools was undertaken to enable their current requirements to be classified, for both thermal and lighting analysis. Program developers were contacted to determine their current use of thermal and optical data for glazing systems.

Future requirements were determined by consulting program developers, taking into account the information produced by WIS currently and not used by simulation tools. A number of developments were identified which are likely to be required by simulation programs as they are configured to model increasingly complex glazing systems.

2. Current Capabilities of WIS

The following are the main outputs from WIS.

Basics (key thermal and solar properties) for the transparent system

- transparent system name
- U-value and U-value contributions (convective, longwave (infra-red) radiative, ventilation)
- solar factor (g) or total solar energy transmittance at its indoor side
- solar factor (g) components (solar transmittance, convective, ventilation, longwave radiative)
- solar direct transmittance on outdoor and indoor sides
- solar direct reflectance on outdoor and indoor sides
- light transmittance on outdoor and indoor sides
- light reflectance on outdoor and indoor sides
- UV transmittance on outdoor and indoor sides
- UV reflectance on outdoor and indoor sides
- general colour rendering index (Ra)

Visible and Solar Properties for each pane
All the following normal to the surface for each individual layer of glazing

- thickness
- thermal conductance
- solar direct transmittance on outdoor side
- solar direct reflectance on outdoor and indoor sides
- light transmittance on outdoor side
- light reflectance on outdoor and indoor sides
- UV transmittance on outdoor side
- UV reflectance on outdoor and indoor sides
- IR transmittance on outdoor side
- IR emissivity on outdoor and indoor sides
- general colour rendering index (Ra)

Detailed Thermal and Solar Properties
All the following at 10° intervals (-90° to +90°, or 0° to +90° if symmetrical) for direct radiation plus diffuse radiation:

- solar absorptance for each layer
- solar direct transmittance on outdoor and indoor sides
- solar direct reflectance on the outdoor and indoor sides
- light transmittance on outdoor and indoor sides
- light reflectance on the outdoor and indoor sides
- UV transmittance on the outdoor and indoor sides
- UV reflectance on the outdoor and indoor sides
- solar factor (total solar energy transmittance g)

For the case of systems with diffusing elements (blinds outside/within/inside the glazing assembly or diffusing glass) the following are also included for direct to diffuse radiation:

- solar direct to diffuse transmittance on outdoor and indoor sides
- light direct to diffuse transmittance on outdoor and indoor sides
- UV direct to diffuse transmittance on outdoor and indoor sides

The incidence angles are calculated with the elevation varying from -90° to +90°. For vertical glazing, this azimuth is assumed to be normal to the glazing.

Other

- WIS will invoke Therm (LBL 2004) if installed. Therm describes frame and mullion properties (dimensions, cross section, and composition) and evaluates 2D performance. Therm output is not currently imported by WIS.
- WIS will invoke a bundled version of KOBRA (version 1.6) or a full version of KOBRA if installed. Frame and mullion properties in KOBRA include details of the cross-section and composition.
- Basic WIS frames are otherwise defined as a U-value and frame width.
- Frame emissivity (indoor and outdoor).
- Glazing system air gap conductance, viscosity, density and specific heat (for the temperatures -10°C, 0°C, 10°C and 20°C).
- Blind properties:
    - horizontal blinds: slat width, angle and separation and emissivity (both sides), solar transmittance and reflectance (both sides), visible transmittance and reflectance (both sides), UV transmittance and reflectance (both sides).
    - roller blinds or diffusing glass: the slat width and separation are defined so as to define a continuous surface.

  Ray tracing calculations can be used to evaluate the angular performance of blinds.
- Ventilated windows – conform to ISO/FDIS 15099: 2003 and are defined either as a constant forced flow in a specified air gap or free ventilation within a specified air gap for specified environmental conditions. The latter requires the width of the upper and lower openings and the overall dimensions of the window. Outputs include flow rate, air speed, heat transfer coefficients and air temperatures.

3. Review of Current Requirements of Modelling Tools

3.1 Thermal

To determine what properties are currently required by thermal simulation programs, the program developers for a number of the more comprehensive commonly used programs were contacted. Documentation for these programs was also consulted. The following sets out the values used by these programs.

Table 3.1 Thermal analysis

Simulation Tool	Requirements
DOE-2	Name of construction Number of panes of glass, shading coefficient and conductance for each layer of glass. Windows have width and height, with optional setback and schedules of shading and conductivity. Window shading consists of overhangs and side-fins. Can import reports from Window 5.2.
ECOTECT	Basic glazing definitions include shading coefficient and, for each layer, the refractive index, visible transmittance, RGB glass colour, emissivity and specularity. As an alternative ECOTECT also imports data from Optic 5 and Window 5.2 of LBNL
EnergyPlus	EnergyPlus imports data from Window 5.2 and uses the following data: Glazing system name Average frame dimensions, conductivity, solar absorption and visible absorption and emissivity Average spacer dimensions, conductivity, solar absorption and visible absorption and emissivity Gap location and thickness and air properties (molecular weight, viscosity (at three temperatures), conductivity (at three temperatures), specific heat (at three temperatures) Solar direct transmission at 10° intervals from 0-90 and diffuse transmission Solar absorption at each layer at 10° intervals Solar reflection at front and back at 10° intervals Visible direct transmission at 10° intervals Visible reflection at front and back at 10° intervals Spectral data in a specific format derived from the Window 5.2 optical data library can be included and takes the general form of wavelength, transmittance, front reflectance, back reflectance. Alternatively the direct (normal) solar transmission and solar reflectance at each face, direct (normal) visible transmission and reflectance at each face, layer thickness and conductivity are required and the embedded Window 5.2 processor calculates the angular properties. Diffusing elements are not considered. Shading is via user specified surfaces and schedules or via specified overhangs and side-fins. Blinds can be located on the room side, between glazing layers or outside. Blind data includes: slat dimensions, spacing, angle, conductivity, solar and visible direct normal transmission, beam and diffuse solar reflectance each side, visible beam and diffuse

	reflectance both sides. Window shades have solar transmittance and reflectance, visible transmittance and reflectance (assumed to be the same on both sides and independent of angle), thickness, conductivity, shade-to-glass distance, effective air flow opening (top, bottom, left, right)
ESP-r	Name of optical property and construction Number of layers (including air gaps) and the thickness, density, specific heat, conductivity, emissivity and refractive index of each layer. Air gaps are typically represented as a resistance (including the thermal effect of coatings), but can also be represented as thermal zones or a CFD domain. Frames are defined as surfaces in the zone (i.e. with thermophysical properties and geometry). A basic blind representation is as a layer within a construction. Both its optical and thermophysical characteristics can be switched. If an air gap is treated as a zone then blinds can be surfaces within that zone. If blinds are within the room, blinds can also be surfaces which are subject to temporal shading an insolation patterns. External blinds can be defined as obstructions which shade the window. Overall direct to direct solar transmission (outside to inside) at 0°, 40°, 55°, 70° and 80° (with linear interpolation between these values). For each layer: solar absorptance at 0°, 40°, 55°, 70° and 80°. Visible (normal) direct transmission (outside face). Diffuse solar transmission is derived from the direct at 51°. Glazing systems are not assumed to have diffusing characteristics. Reverse transmission and absorption characteristics are derived from the outside-to-inside characteristics.
IES	Glazing system name and identification code Outside and inside face emissivity and heat transfer coefficients CIBSE U-value for glass, CIBSE net U-value (including frame) EN ISO U-value for glass, EN ISO U-value (including frame) Type of frame (composition) and percentage of overall area Location of shading device (internal/external) Percentage of sky blocked by other buildings For each layer: description, normal solar reflectance, solar absorptance, solar transmission, refractive index. If air gap, then also its thermal resistance.
TAS	TAS requires, for each layer, thickness, conductivity, (normal) direct solar transmittance, solar reflectance at each face, (normal) visible transmittance and reflectance at each face, emissivity at each face and a flag to identify whether a layer is a blind.
TRNSYS	A two-band model (visible and solar) based on data available

	from Window 4.1 or 5.2. The subset of data used in TRNSYS is: Glazing system description and identification code Number of glazings Identification code for frame and spacer Glass dimensions Gap thickness and thermophysical properties at various temperatures and emissivity Solar direct transmission at 10° intervals from 0-90 and diffuse transmission Solar absorption at each layer at 10° intervals Solar reflection at front and back at 10° intervals Visible direct transmission at 10° intervals Visible reflection at front and back at 10° intervals SHGC at 10° intervals

As can be seen in comparing the current requirements of these tools with the current capabilities of WIS, the majority of the data is already available.

Summarizing the table above, the following list sets out what the current requirements of simulation programs are for output from WIS, for "standard" glazing systems with no blinds or shading and no diffusing/scattering).

(i) Manufacturer's identification and short description of glazing type.
(ii) System transmittance for direct solar radiation at different angles of incidence.
  - Normal, 10˚, 20˚, 30˚ incidence angles should be sufficient, with programs interpolating if necessary
(iii) System transmittance for diffuse solar radiation.
(iv) Solar Heat Gain ("Total solar energy transmittance", g, solar factor) under standard conditions at the same angles of incidence.
(v) Layer absorptances at the same angles of incidence.
  - absorptance relative to incident radiation on outside of glazing system.
(vi) System U-value under standard conditions.
(vii) Thickness of all layers in the glazing system.
(viii) Air gap thermal resistance under standard conditions (CEN values).
(ix) Location of low-emissivity coatings.
(x) Emissivity of all surfaces, particularly low-emissivity coatings.
(xi) Conductivity, specific heat and density of each layer (thermophysical properties for thermal simulation)
(xii) Frame effective U-value and dimensions
(xiii) Extinction coefficients (can be used by EnergyPlus); most require refractive index.
(xiv) Shading coefficients are required by several tools.

In the case of glazing systems incorporating blind and shading systems, or with other scattering and diffusing elements, most simulation programs do not deal with these accurately, and often approximations and model "fixes" are applied. However, Energyplus can import the details of the blind system as detailed in the table above.

3.2 Lighting

The following table sets out requirements for a number of lighting simulation tools

Table 3.2 Lighting analysis

Simulation Tool	Requirements
Radiance	Radiance includes a general 'glass' material type as well as a 'trans' material type. Blinds in Radiance are usually represented as explicit surfaces (which may be curved) with specularity, RGB absorption, and roughness characteristics. Explicit blind representations can be computationally intensive, although such characteristics can be pre-computed. Angular transmission properties can be specified via bi-directional data files.
Daysim	Follows the general requirements of Radiance. As with Radiance, explicit representation of blinds is computationally intensive.
Lightswitch	Follows the general requirements of Radiance. Uses simple treatment of blinds – no blinds, blinds down (direct component removed and diffuse component reduced to 25%).
Lumen Micro	Integrated angular reflectance and transmittance data used, as well as index of refraction and extinction coefficient.
Lightscape	Uses transparency, reflectance and refractive index.

As can be seen Radiance is used as the calculation engine most of these tools. This is not an unexpected result as the Radiance engine was developed to be used in customised interfaces. A recent survey of lighting design tools showed that Radiance was used in more than 50% of the tools used by respondents (Reinhart C F and Fitz Annegret *Key Findings from an online survey on the use of daylight simulation programs,* eSim conference, Vancouver, Canada, 2004).

Radiance requires data at three spectral wavelengths (nominally red, green and blue) to specify the visible transmittance of glazing systems, although it is possible to use the MGF data format (see Section 5) where full spectral data (as produced from Window 5 or WIS) can be defined and then imported into Radiance and other lighting software.

Summarizing the table above, the following list sets out what the current requirements of simulation programs are for output from WIS

- (i) Visible spectrum system transmittance for direct solar radiation at normal incidence.
- (ii) Visible spectrum system reflectance for direct solar radiation at normal incidence.
- (iii) Visible spectrum diffuse transmittance and reflectance.
- (iv) Direct and diffuse transmission and reflection for radiation from the inside of the building.
- (v) Transmittance and reflectance at angles of incidence of 10˚, 20˚, 30˚ etc bi-directional incidence angles.
- (vi) Colour specified as CIE (x,y) chromaticity or (possibly) RGB values.

Note that WIS does not currently output the bi-directional data or the RGB values.

4. Future Requirements

Although most of the current requirements are met by the calculations within WIS, it is clear that simulation programs are currently being extended to cope with the need to model increasingly complex glazing systems, e.g. ventilated windows, double facades, glazings and blind systems where bi-directional properties are needed.

The following sets out areas where future developments of simulation tools are likely to use additional data already provided by WIS, and developments which would require enhanced output by WIS.

For thermal simulation, the following existing WIS data will become useful for thermal analysis:

(i) User selectable Air Mass (AM 1 or 2 currently available in WIS); note that AM1.5 may also be useful.

(ii) Direct-diffuse transmittance of the glazing system - i.e. the fraction of incident direct radiation that is transmitted diffusely.

(iii) Diffuse absorptance at each layer.

(iv) Optical properties for radiation leaving the room (i.e. from inside to outside). WIS currently calculates a subset of optical properties in both directions.

(v) Thermophysical properties of blinds/shading devices.

(vi) Frame and edge losses (these are generally not currently considered explicitly in most simulation programs).

For thermal simulation, the following data that WIS does not yet provide will be of interest:

(i) Bi-directional (azimuth and altitude) transmittance, reflectance and absorptance properties (for window/blind systems, redirecting glazing etc). Ideally, transmittance, absorptance and reflectance data would be sufficient for a grid of incident angles (-90˚, -80˚ …0˚, 10˚, 20˚ … 90˚ altitude and -90˚, -80˚ …0˚…+90˚ for azimuth). Possibly 5˚ intervals should be considered. Already some programs (e.g. ESP-r) can use this data if available.

(ii) All transmittance, reflectance and absorptance properties for radiation leaving the room. These are not all presently calculated because the spectral distribution will depend on the internal room properties. However, perhaps some standard spectrum could be assumed for representative values, as for some glazings where properties are significantly different depending on direction, this data will be important

(iii) User specified intervals for transmission, reflection and absorption. This may be important for glazings where the transmission curves have discontinuities.

(iv) WIS does not currently include a definition (geometry and construction) of the wall the glazing system is placed within. Window reveals can enhance as well as restrict the radiation and light arriving and leaving a glazing assembly.

(vii) Properties of semi-transparent PV glazing systems. In this case, the electrical properties of the PV will be required as well as the optical and thermal properties of the layers in the component.

(viii) Ventilated glazings – this requires further research to determine how output from WIS can be integrated into simulation programs. Due to the rapidly changing boundary conditions, the thermal /ventilation interaction would need to be modelled explicitly in the simulation programs. However, for simplified programs, perhaps some performance data at a range of boundary conditions could be usefully exported from WIS and used directly.

(ix) Transmittance, reflectance, solar heat gain and absorptance data at various opening positions of the blinds/shading devices.
- Fully closed, half open, and fully open is probably sufficient for the current generation of tools
- User defined slat angles may be useful

(x) The ability to handle vertical blinds as well as horizontal blinds.

(xi) The ability to handle laminated glazings.

For lighting simulation, the following data that WIS does not yet provide will be of interest.

(i) Bi-directional system transmittance and reflectance data for window/blind systems as obtained from photogoniometric measurements (format defined in IEA Task 21). By default the incident angles correspond to the 145 Tregenza zones, but other angles can be specified.

(ii) Light re-directing elements can alter the vector of direct transmission and thus the distribution of light within a room. Increasingly, designers will want to evaluate such optical systems. Consideration should be given to associating a bi-directional output angle with each bi-directional input angle.

(iii) Colour specification as CIE chromaticity.

(iv) Surface specularity.

5. Output Formats and Links to Other Software

It is suggested that there are three levels of reporting:

(i) Summary data describing the main glazing properties

(ii) Detailed listing of data

(iii) Output format suitable for parsing by thermal and lighting simulation programs

WIS currently outputs the detailed listing data at a sufficient level of detail. However, it is difficult for simulation programs to read this data easily as it is not adequately structured (see “listing one” below for an example). For this reason, several alternatives were investigated including:

(i) The use of MGF format for lighting data. The Materials and Geometry Format (MGF) is a description language for 3-dimensional environments expressly suited to visible light simulation and rendering (http://radsite.lbl.gov/mgf/HOME.html). There are translators to Radiance and VRML. Although primarily aimed at luminaires, diffuse and specular reflectances and transmittances can be specified. Colour is specified by CIE chromaticity and other methods, e.g. detailed spectral reflectance from spectrophotometer measurements. Also the index of refraction can be specified.

(ii) Tagged data. A prototype file structure was specified (see “listing two” below for an example) which would tag all the data. It would then be relatively easy for a filter program to read this data and transfer it to the internal databases of simulation programs.

(iii) XML. XML is becoming an industry standard for describing data. It has several benefits over tagged data. It is a formal definition which can be strictly parsed and verified and there are standard libraries containing methods for parsing, editing and checking data. Also XML is inherently extensible, so that new data structures can be added as WIS evolves. An XML specification for WIS is being developed (see “listing three” below for an example).

Listing one

```
--- Registered WIS user ---
Registered organisation : WinDat aaaa
Registered user name    : tester v. 2.0a2

--- Report transparent system : IP iplus nr 4-16-4 ---

--- Basics (key thermal and solar properties) ---

 name transparent system             : IP iplus nr 4-16-4
 U-value                             : 1.16 [W/(m2.K)]
 solar factor (g)                     : 0.607        [-]  (total solar
energy transmittance)

 solar direct transmittance          : 0.494 [-]
 solar direct reflectance outdoor    : 0.282 [-]
 solar direct reflectance indoor     : 0.235 [-]
 . . .
prop       0    10    20   30   40   50   60   70   80   90   diff
 abs   1 0.094 0.095 0.096 0.099 0.1 0.11 0.11 0.11 0.1  0    0.1
 abs   2   0    0     0    0    0    0    0    0     0    0    0
 abs   3 0.13  0.13  0.13 0.13 0.14 0.14 0.14 0.13  0.1  0    0.13
 t_sol  0.49   0.49  0.49 0.49 0.47 0.45  0.4 0.31  0.15 0    0.41
 r_sol_o 0.28  0.28  0.28 0.28 0.29 0.3 0.35 0.45 0.64   1    0.35
 . . .
```

Listing two

```
*wis_version,2.1   # file type tag and wis version number
organisation,WinDat aaaa
user_name,tester v. 2.0a2
transparent_system_report,IP iplus nr 4-16-4 ---

*basics            # each field in tag,data format
name,IP iplus nr 4-16-4
U-value,1.16
solar_factor_g,0.607
solar_direct_transmittance,0.494
solar_direct_reflectance_outdoor,0.282
solar_direct_reflectance_indoor,0.235
light_transmittance,0.758
light_reflectance_outdoor,0.133
light_reflectance_indoor,0.115
UV_transmittance,0.134
UV_reflectance_outdoor,0.22
UV_reflectance_indoor,0.102
colour_rendering_index,98
```

```
*solar_factor_indoor_side    # each field in tag,data format
transmittance,0.494
convective,0.0433
ventilation,0
thermal_radiative,0.0697

*calculations        # each field in tag,data format
angular,estimated
diffuse,estimated
setting,expert
solar_range,spectral
visual_range,spectral
uv_range,spectral
spectrum,PrEn410
air_mass,1

*layers_in_system
# (outside to inside)
# tag, layer number, type of layer, id, thickness, description
layer,1,Pane,430,4.0,IP flo04
layer,2,Gap,??,16.0,Air-Argon 10/90
layer,3,Pane,431,4.0,IP 7658nr with pane in flipped position.

*solar_properties
angle,0,10,20,30,40,50,60,70,80,90,diff
abs,1,0.094,0.095,0.096,0.099,0.1,0.11,0.11,0.11,0.1,0,0.1
abs,2,0,0,0,0,0,0,0,0,0,0,0
. . .
```

Listing three


```
<?xml version="1.0" encoding="UTF-8"?>
<WISOutput vers_WIS="2.0" vers_xml="0.10"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="WIS_WindowSystem.xsd">
    <Project>
        <User>Dick van Dijk</User>
        <Date>2004-02-24</Date>
    </Project>
    <Description>
        <Name>Test Window System</Name>
        <Geometry>
            <Height unit="m">2.2</Height>
            <Width unit="m">1.5</Width>
        </Geometry>
        <Orientation>
            <Azi unit="degrees from S. (E=pos.)">0.0</Azi>
            <Alt unit="degrees">0.0</Alt>
            <Tilt unit="degrees from hor.">0.0</Tilt>
        </Orientation>
    </Description>
    <Composition>
        <Frame_Id>Location_of_frame_output</Frame_Id>
        <Spacer_Id>Location_of_spacer_output</Spacer_Id>
        <TranspSystem_Id>Location_of_tr_system_output</TranspSystem_Id>
    </Composition>
    <Conditions>
        <Environment>
            <Description>
                <Name>My environment</Name>
            </Description>
            <EnvironmentSimple01>
                <TempIndoor unit="Celsius">20.0</TempIndoor>
                <TempOutdoorAir unit="Celsius">5.0</TempOutdoorAir>
```

```
                <TempOutdoorRad unit="Celsius">5.0</TempOutdoorRad>
                <SolarRad unit="W/m2">500.0</SolarRad>
                <hconvIndoor unit="W/m2K">3.0</hconvIndoor>
                <hconvOutdoor unit="W/m2K">15.0</hconvOutdoor>
            </EnvironmentSimple01>
        </Environment>
        <CalcProcedures>
            <CalcProcedure valid="true">Calculated according to XXX </CalcProcedure>
            <CalcProcedure valid="false">Calculated according to YYY </CalcProcedure>
            <CalcProcedure valid="true">Calculated according to ZZZ </CalcProcedure>
        </CalcProcedures>
    </Conditions>
    <Properties>
        <Thermal>
            <U_value unit="W/m2K">2.4</U_value>
        </Thermal>
        <Solar>
            <g_value unit="-">0.45</g_value>
        </Solar>
        <Light>
            <LightTransmittance unit="-">0.76</LightTransmittance>
        </Light>
    </Properties>
</WISOutput>
```


It was decided that XML format would be the most suitable for the WIS data. A draft of the format has been prepared by TNO and this work will be completed and a filter written to transfer the data into at least one simulation program (ESP-r) to test the data transfer.

Additional work was carried out by the subgroup to investigate how WIS could be more easily linked to other programs. A suggestion was made by ENTPE to use the Component Object Model (COM) software architecture to achieve such links between WIS and other programs. This suggestion is detailed in Annex 1.

Annex 1

A Suggestion for linking WIS with other Programs

Richard Mitanchey, ENTPE

This report deals with the priorities of software development with specific interests in
- *Link / interface to other component tools*
- *Link to building simulation & daylighting tools*

A1.1 Introduction : the notion of COM and software component[1]

Several important progress has marked out the Software Industry, and major improvements range from Objects Oriented Programming (OOP) to Component Software. To clarify, a component is some piece of compiled code that provides some service to the rest of the system.

The Component Object Model (COM) is a component software architecture that allows applications and systems to be built from components supplied by different software vendors. COM is the underlying architecture that forms the foundation for higher-level software services, like those provided by OLE. OLE services span various aspects of component software, including compound documents, custom controls, inter-application scripting, data transfer, and other software interactions.

These services provide distinctly different functionality to the user; however, they share a fundamental requirement for a mechanism that allows binary software components, supplied by different software vendors, to connect to and communicate with each other in a well-defined manner. This mechanism is supplied by COM, a component software architecture that:

- Defines a binary standard for component interoperability
- Is programming language-independent
- Is provided on multiple platforms (Microsoft® Windows®, Microsoft Windows NT™, Apple® Macintosh®, UNIX®)
- Provides for robust evolution of component-based applications and systems
- Is extensible

In addition, COM provides mechanisms for the following:

*0 Communications between components, even across process and network boundaries

*1 Shared memory management between components

*2 Error and status reporting

---

[1]Adapted from the paper « The Component Object Model: A Technical Overview », Sara Willliams and Charlie Kindel, Developer Relations Group, Microsoft Corporation
Created: October, 1994

*3 Dynamic loading of components
It is important to note that COM is a general architecture for component software. While Microsoft is applying COM to address specific areas such as controls, compound documents, automation, data transfer, storage and naming, and others, any developer can take advantage of the structure and foundation that COM provides.

A1.2.The fundamentals of COM

All fundamentals of COM may be found in more specialized papers; however, the fundamental concepts include :

- A binary standard for function calling between *component objects*.
- A provision for strongly-typed groupings of functions into *interfaces*.
- A base interface providing:
  - A way for components to dynamically discover the interfaces implemented by other components.
  - Reference counting to allow components to track their own lifetime and delete themselves when appropriate.
- A mechanism to uniquely identify components and their interfaces.
- A "component loader" to set up component interactions and additionally in the cross-process and cross-network cases to help manage component interactions.

Component objects usually have some associated data, but unlike C++ objects, a given component object will never have direct access to another component object in its entirety. Instead, component objects always access other component objects through interface pointers. This is a primary architectural feature of the Component Object Model, because it allows COM to completely preserve encapsulation of data and processing, a fundamental requirement of a true component software standard.

In COM, applications interact with each other and with the system through collections of functions called ***interfaces***. Note that all OLE services are simply COM interfaces. A COM interface is a strongly-typed contract between software components to provide a small but useful set of semantically related operations (methods). An interface is the definition of an expected behavior and expected responsibilities. OLE's drag-and-drop support is a good example.

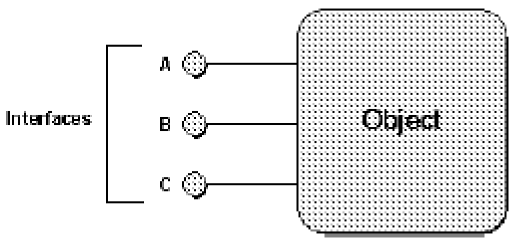

Figure 1. A typical picture of a component object that supports three interfaces A, B, and C.

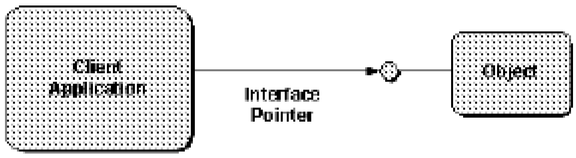

Figure 2. Interfaces extend toward the clients connected to them.

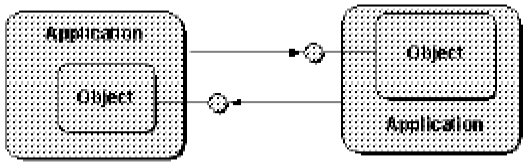

Figure 3. Two applications may connect to each other's objects, in which case they extend their interfaces toward each other.

A1.3The potential benefits of using the COM Software architecture within our project

Generally speaking, the unique use of interfaces in COM provides five major benefits :

(iv) The ability for functionality in applications (clients or servers of objects) to evolve over time,
(v) Fast and simple object interaction,
(vi) Interface reuse,
(vii) Local / Remote Transparency,
(viii) Programming language independence.

Furthermore, COM addresses the four basic problems associated with component software:

1. Basic component interoperability
2. Versioning
3. Language independence
4. Transparent cross-process interoperability

Among all potential benefits, like hardware platform independence, and ease of maintenance thru versioning, COM provides a high-performance architecture to meet the requirements of specialized component market for daylighting tools and applications. (*The annex of this documents introduces the example of an ActiveX control to manage sky distributions*). At middle or more or less long term, we might think that other software vendors (CAD Software vendors for example) would be more concerned with daylighting interest and specifications in their implementations.

A1.4 Concrete job to meet the requirements of COM Software architecture

a) *Existing WIS C++ classes :* only classes that need to be visible should be exposed thru COM interfaces, thus turning into COM objects with little adptation, the other classes may remain unchanged; however, the keypoint addresses the definition of good (reusable) interfaces.

b) *New C++ classes :* COM software architecture principles should be used at the early conception phase; however, good (reusable) interfaces should be defined with care.

c) *Existing WIS Database and extensions :* the detail of database implementation has no concern with COM, except to be SQL compatible; however, complex binary files need to be implemented using the technique of BLOBs

d) *Input / Output :* text files may still be used for I/O operations, but the potential of COM also resides in complex document architecture, with structured recording of complex binary / text data (for example like the format of a Microsoft Word Document). Please also note that thru COM Automation of Microsoft Word®, Microsoft Excel® or Adobe Acrobat® for example) reports may be generated, or files imported without the needs to use intermediate text files. Legally and practically speaking, such functionality is available only if the client (or the server, depending of the mechanism) has a license for the installed components of the relevant software.

e) *Interaction with other software :* at a minimum, WinDat components have to expose interfaces of conversion of internal data, to be compatible at the file format level of other software. But again, if other target software also use the COM architecture, compatibility might be assured at the interface level thru COM automation.

A1.5 Conclusion

Software industry and techniques are a continuously evolving domain, and it is a part of our responsibility to make good software architecture choices for a window component database addressing not only existing data, but also the future needs, as well as all accompanying software. The COM Software architecture is an interesting answer to such a concern, but if potential benefits are quite high with daylighting components software developed by and for the daylighting community first, implementation difficulties should also be clearly identified to keep the success insurance.

5.1.2 Annex : *Example of an ActiveX control to manage sky distributions*

E:\...\Tests\MoonSpencer.sky

Cell#	ZenI Dg	ZenS Dg	AziI DgN->E	AziS DgN->E	SolidAngle Sr	Luminance Cd/m2
1	0.00	5.00	0.00	90.00	0.00597735	4087.66
2	0.00	5.00	90.00	180.00	0.00597735	4087.30
3	0.00	5.00	180.00	270.00	0.00597735	4087.66
4	0.00	5.00	270.00	360.00	0.00597735	4087.47
5	5.00	10.00	0.00	36.00	0.00715463	4066.39
6	5.00	10.00	36.00	72.00	0.00715463	4067.08
7	5.00	10.00	72.00	108.00	0.00715463	4066.70
8	5.00	10.00	108.00	144.00	0.00715463	4067.08

Figure 4. The TEXT file describing the Moon & Spencer sky data in ENTPE Meteolux® / sky file format

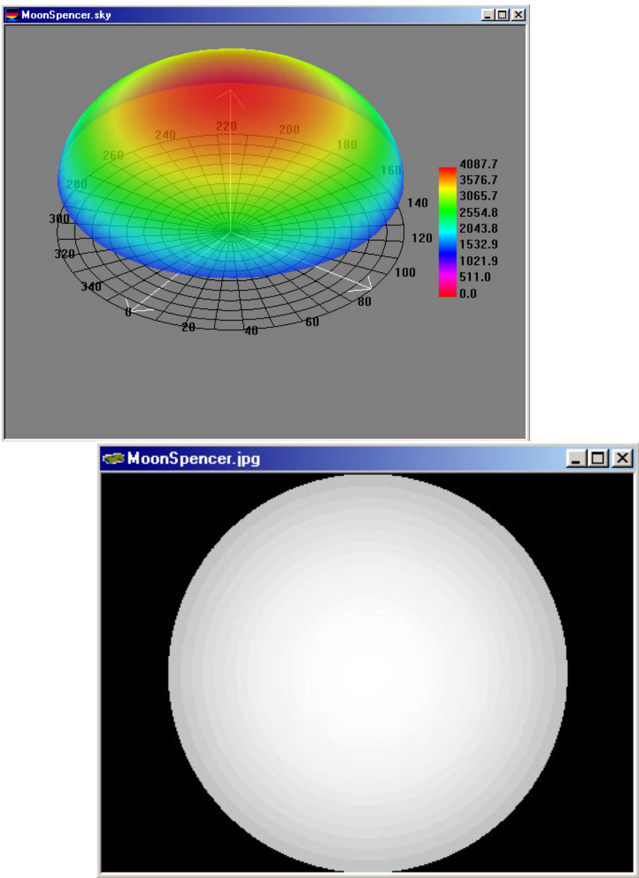

Figure 5. ActiveX control showing a Moon & Spencer sky distribution, and result of a data conversion compatible with EXIF Format (digital photography).

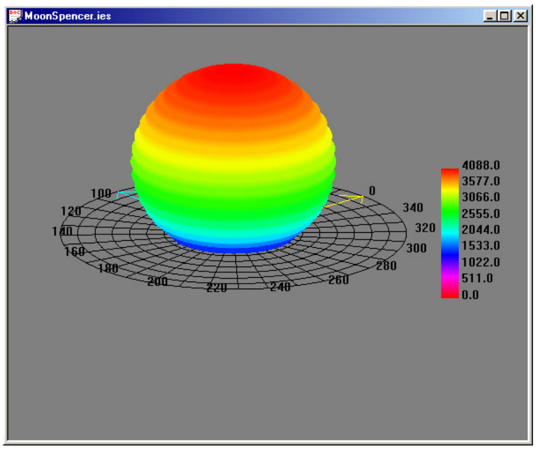

Figure 6. The same Moon & Spencer data, but interpreted as IES luminaire data