



## 1 General

1. These release notes are describing changes in LIMES 2000 since version 21.0219.1171. The new release 23.0406.1285 is a **major release** which merges also all software developments which have been done in the past exclusively for LMT GO-R 3000 series goniophotometers.
2. Therefore, this version can be used for
  - GO-H: 800 / 1000 / 1200 / 1300 / 1400 / 1500 / 1600 / 1660 / 1860 / 2060
  - GO-DS: 1600 / 2000
  - GO-V: 1900 / 1920
  - GO-FI: all versions
  - GO-R: all versions, general and automotive lighting application
3. Due to the huge number of new features, only the most important bug fixes are included in these release notes. In order to focus on the important topics only, a lot of small improvements are not mentioned.
4. **All new features are tested on up-to-date Win-7/Win-10 operating systems only.**
  - WIN 7: the latest service pack must be installed.**
  - Win-XP: LMT recommends updating to Win 10 or stay with Limes Version 18.1117.1038.**
5. Furthermore, it is essential, that Win-7/Win-10 operating systems are up-to-date, especially, Win-7 must have the latest service pack installed.

## Installation / Software requirements

Please follow the steps as listed below.

1. **.NET Framework 4.8 must be installed.**
2. Unpack Limes Update zip-File
3. Replace *Limes.exe* and *LimesControl.exe* with the latest version, usually located in *C:\LMT\Limes 2000*.
4. Copy *l4n.limes.xml* and *l4n.control.xml* into the same folder where *Limes.exe* and *LimesControl.exe* are located, i.e. *C:\LMT\Limes 2000*.
5. Copy the CHM-file into the folder *~\Limes 2000\Help*
6. Install LMTAO version 1.2.280 or higher
  - NOTE 1 If the LMTAO library is not installed or shows an outdated version, Limes and LimesControl will not start.
7. In case a spectroradiometer is used, Limes 2000 requires to install spectrometer software 3.0.4.8409 or later.
  - NOTE 2 The interface between LimesControl and the spectrometer service is permanently improved and new features will be available only in case both software packages



are up-to-date.

NOTE 3 In case a goniometer laboratory contains a spectrometer and the version of the spectrometer software does not fit, LIMES 2000, respectively, LimesControl will not execute any measurement commands using the spectrometer!

### Overview of new features (extract)

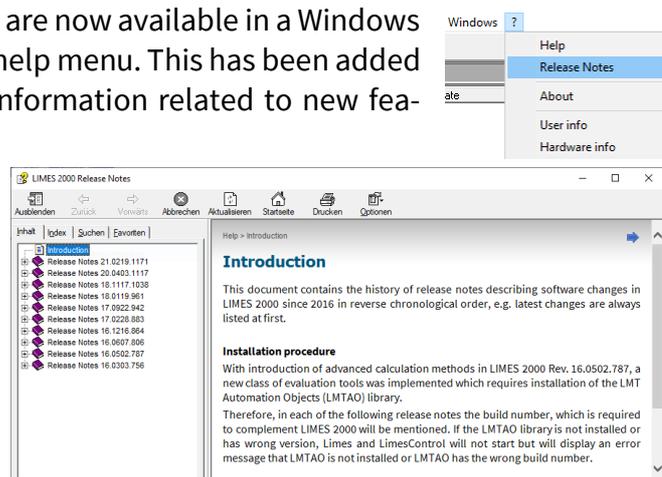
1. Multi-Sensor hardware for automotive lighting has been implemented in LIMES 2000. For details, please check the chapters on automotive lighting and Multi-Sensor implementation below.
2. A scanning double-monochromator, i.e. the DMc150 from Bentham, is now available for spectroradiometric evaluation in LIMES 2000.
3. The release notes from 2016 on and later are now available in a Windows CHM help file which is accessible via the help menu. This has been added to give the user quick access to latest information related to new features.

A click on *Release notes* will open a new window which displays the release notes in reverse chronological order. A full text search is possible.

In case the file cannot be found in the folder `./Limes 2000/help`, a message will tell the user that the CHM file from the distribution should be copied into this place.

The latest CHM file will be always part of the update distribution, but must be copied manually to the correct location. See the chapter on Installation for details.

4. Scientific notation was implemented in order to serve latest requirements from the UN regulatory framework for automotive lighting (see chapter 4 for details).
5. Release 23.0406.1285 supports the graphical user interface design of the TeleControl, i.e. in addition to the traditional interface, multiple screens for special purposes have been added.
6. Ambient sensor functionality has been expanded. More details can be found in the corresponding chapters on general or automotive lighting.
7. Horticultural Lighting Evaluation (HCLE) and Television Lighting Consistency Index (TLCI) have been added both to the spectrometer software and to Limes 2000. See chapters 2 and 4 for details.

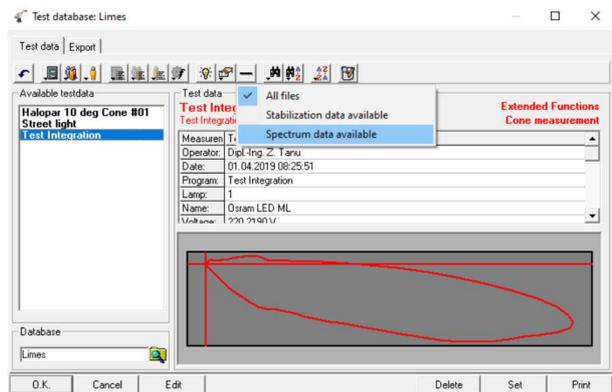


8. Measurement in flashing mode for turn indicators has been improved. Besides photometry, it is now possible to measure colour in blinking mode. This includes as well the stabilisation process.

## 2 General Lighting

**Open Files** – Similar to the automotive application, opening files in the general lighting application now allows filtering for certain features.

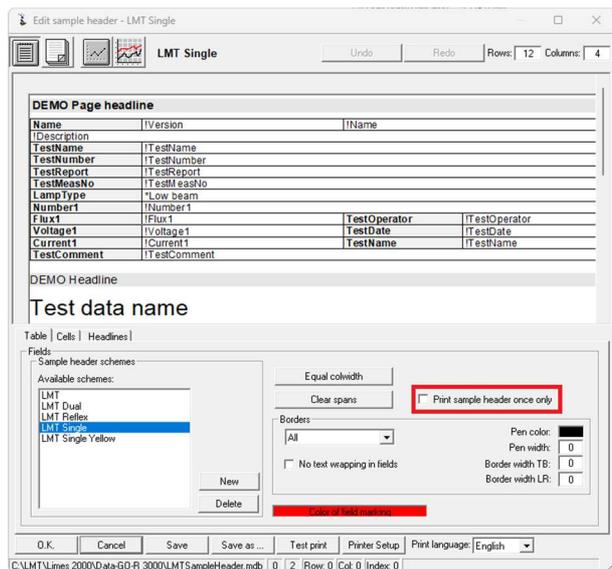
The filter button in the *TestData* dialogue is also visible in the general lighting branch. The user can set certain filters, for instance showing only files which contain stabilisation or spectroradiometric data.



**Table Header** – LM 79 and CIE S025 may require a rather long report header for documentation of test environment, maybe even containing multiple pages. Therefore, in order to improve reporting, the header may be printed only once before multiple evaluation pages are printed without header.

The check box which activates this option, i.e. that the sample header shall be printed only once has been added to the *EditTables* dialogue (see picture on the right-hand side).

Therefore, the user has to make sure, that the chosen page layout has this option activated in order to do a printout with header printed only once.



A number of changes have been made to the settings in *Options* → Program Tab *Diverse*:

- **New Auto-Text** – The user may choose to use the short format for automatically generating the displayed text of a certain test function. For instance, the short format for a C-plane scan will display *C0/270/90 - G0/90/1*. This means that C planes are measured from 0° to 270° with step of 90° for C and Gamma from 0° to 90° with step 1°.



- **Default Unit** – A new option has been generated for the zonal flux table. Per default  $I_{\min}$ ,  $I_{\max}$  and  $I_{\text{mean}}$  are given in “cd/klm” for general lighting applications but instead the user can choose “cd” as the default unit.
- **LOR** – In the total luminous flux table, one can select calculating the LOR in lm/klm instead of percent **LOR**. All settings are stored to the registry. The header for LOR was not printed correctly if the entry for LOR was larger than zero. This could force shifting of rows and the header names did not match anymore the values after LOR (shifted by one row). The bug has been fixed.

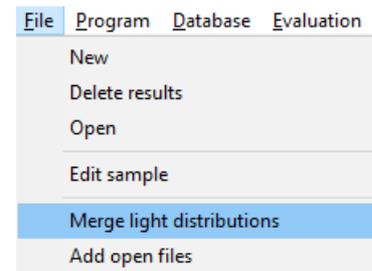
Further improvements in the general lighting branch of Limes 2000 are:

- **Colour scan** measurements with slow measurement devices (e. g. spectrometer or C1210 measurements) are always transformed into point-by-point measurements in order to always adjust for optimum dynamic range. However, if the user has chosen to change step size in horizontal or vertical direction, for instance to save time, these time savings are now as well available, when the scan has been transformed into a point-by-point measurement.
- Average **CCT** and Average **CRI  $R_a$**  have been added as well as variables which may act as entries for the report header. In addition, the stabilisation time of a lamp or luminaire may be added to the report header (*BurninTime1* and *BurninTime2*).
- From now on, weighted **colour uniformity** will be evaluated based on LM79-19. The average colour coordinate will be calculated using all available measured colour points while LM79-08 suggested to include only values with more than 10% of maximum intensity. However, in order to calculate the maximum  $\Delta u'v'$ , only colour points with more than 10% of maximum intensity are included.
- Information about correction for lamp flux in the **UGR** table has been improved.
- **Alignment of light distribution** – In case of (C, $\gamma$ ) measurements, the light distribution may be rotated in such a way that either peak intensity or centroid intensity is located at  $\gamma = 0^\circ$  (right image above). This option is available via the Edit Data tab. The 2nd option, i.e. centroid at  $\gamma = 0^\circ$ , was introduced based on CIE TN 10 (Determination of the Optical Beam Axis, Centre Beam Intensity and Beam Angle).
- Average values from the **Ambient Sensor** have been made available for the report header. The average is taken from the values measured for every C-plane. The unit is taken from the configuration file and depends which sensor is used at a given position. This feature has been introduced to document ambient temperature during the measurement, for instance to satisfy requirement from CIE S025.

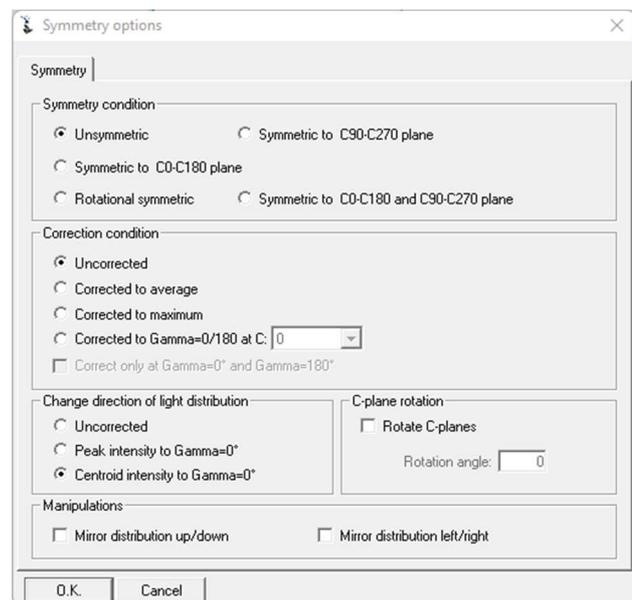
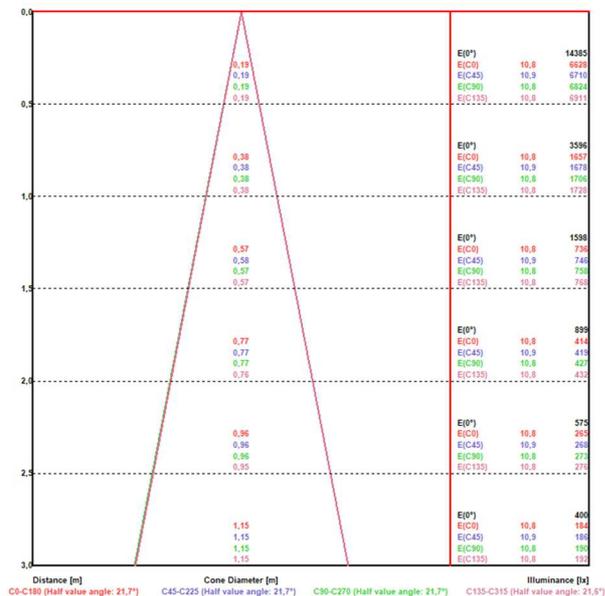
## Merging of light distributions

Merging of light distributions, for instance up-light and down-light distributions, has been implemented (lamps measured as up-light can also be used as down-light in merging and vice versa).

- In advance of the merging operation, the direction of the individual contributions may be optionally corrected, either with
  - the peak intensity located at  $\gamma = 0^\circ$ , or
  - the centroid intensity directed towards  $\gamma = 0^\circ$
- In case a merged light distribution is exported to EULUMDAT format, the file export will show both lamps from up- and downlight separated by a semicolon. Lamp power will be saved as the sum of both lamps.
- Merging is also available for cone measurements.



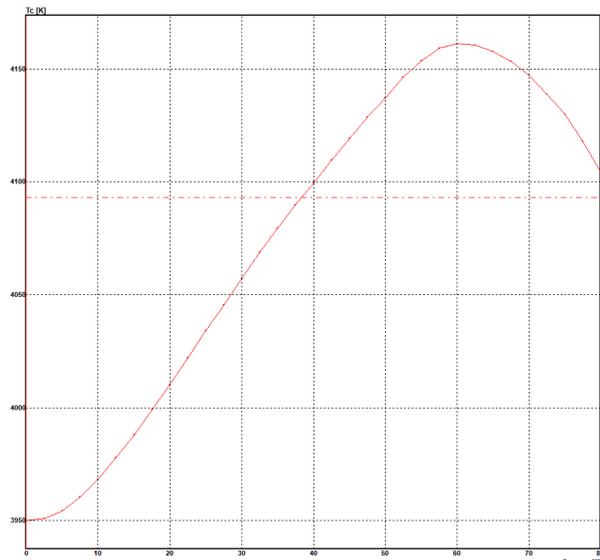
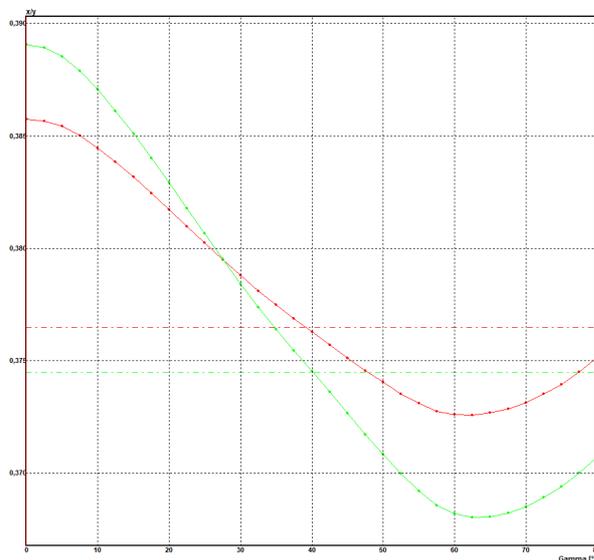
A new diagram, the **illuminance cone diagram** of a light distribution has been implemented in Limes (left image below). The diagram must be enabled via the user database.



## Colour over Angle diagram – Two additional new diagrams have been added:

- Colour over angle  $\alpha$  (left)
- Colour over angle  $T_c$  (right)

Values can be restricted to angles with more than 10% of peak intensity. The average of  $\alpha$ ,  $\gamma$  or  $T_c$  will be plotted in the diagram, too.



The user can now define an arbitrary point in the **CIE 1931 colour diagram** as the centre of a **MacAdam ellipse**. The centre point will also be visible in the CIE 1931 colour diagram. As a default, the average colour coordinate of the measured data will be used but may be changed by the user. If this is done, the ellipse centre will have another colour than the default point.

The **Polar Diagram** shown in the main window did not take into account the actual symmetry and correction settings. The bug was fixed.

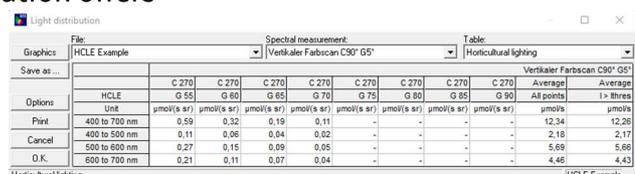
Table evaluation of **Isoline Flux** did not work properly for (C,  $\gamma$ ) data. This has been fixed.

## Horticultural Lighting Evaluation

Horticultural Lighting Evaluation (HLCE) has been added as an optional feature. **Photosynthetic Photon Intensity** is calculated in  $\mu\text{mol}/(\text{s} \cdot \text{sr})$  for the total wavelength interval [400 nm, 700 nm] and in addition for the partial intervals [400 nm, 500 nm], [500 nm, 600 nm] and [600 nm, 700 nm].

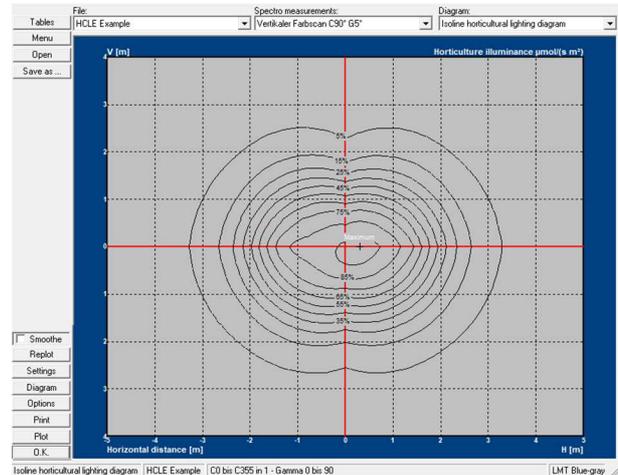
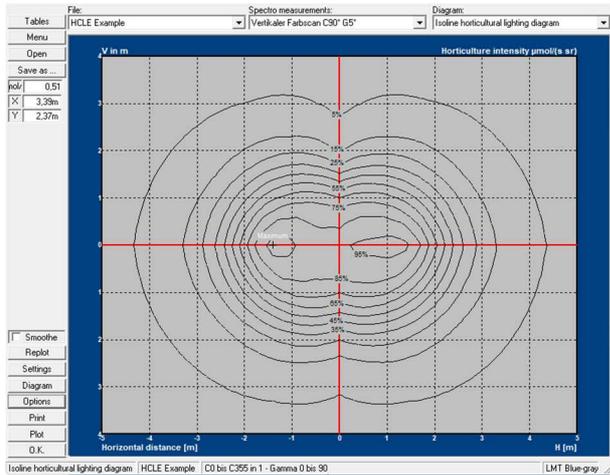
The corresponding spectral and angular evaluation offers

- goniophotometric tables based on  $\mu\text{mol}/(\text{s} \cdot \text{sr})$  with integration to total photosynthetic photon flux in  $\mu\text{mol}/\text{s}$  (see screenshot on the right-hand side)



Options	Unit	$\mu\text{mol}/(\text{s} \cdot \text{sr})$	$\mu\text{mol}/\text{s}$	$\mu\text{mol}/\text{s}$						
Print	400 to 700 nm	0.59	0.32	0.19	0.11	-	-	-	12.34	12.26
Cancel	400 to 500 nm	0.11	0.06	0.04	0.02	-	-	-	2.18	2.17
	500 to 600 nm	0.27	0.15	0.09	0.05	-	-	-	5.69	5.66
D.K.	600 to 700 nm	0.21	0.11	0.07	0.04	-	-	-	4.46	4.43

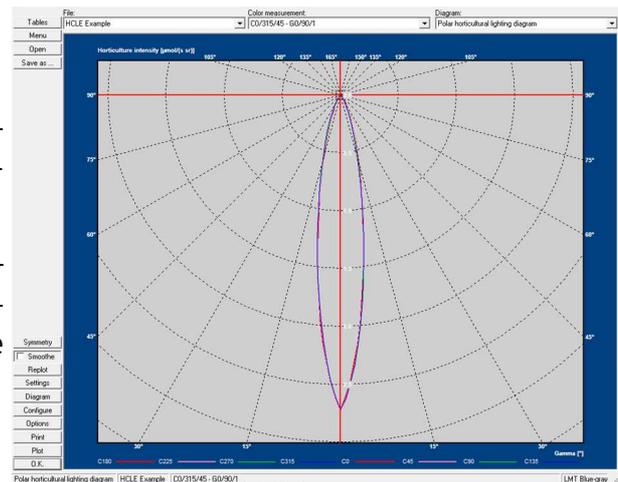
- Angular resolved ISOLINE graphics (see below) for intensity ( $\mu\text{mol}/(\text{s} \cdot \text{sr})$ ) and illumination ( $\mu\text{mol}/(\text{s} \cdot \text{m}^2)$ )



- Angular resolved polar plot (see right-hand side) for intensity ( $\mu\text{mol}/(\text{s} \cdot \text{sr})$ )

The polar diagram for HLCE evaluation allows usage of all known symmetrisation options.

This feature has been implemented as an option and must be activated. The default settings for the HLCE polar diagram may be chosen in Options->Configuration.



## Data Export

Saving to file, e.g., \*.txt or \*.csv is now available for zonal flux evaluation.

Export to **EULUMDAT** format will now store the complete name of the lamp. Up to now this was restricted to 24 characters which is the standard for EULUMDAT.

In the past the user was not able to export light distributions in EULUMDAT format for full C-planes and step sizes of  $\gamma < 1^\circ$ . This has been corrected. The export functionality is now available, even if the electrical values are missing.

## GO-V Specials

- The **Default Measurement Symmetry Setting** for new measurement programs using GO-V has been changed to no symmetry, which results always in measuring the full light distribution.



In the past, the default setting had been symmetry with regard to C0 - C180 which in turn had the effect that the goniometer measured only half of the light distribution and copied the results into the symmetrical part. Of course, this feature is still available, but must be actively selected by the user.

- In connection with above item, formerly, in measurements with an a priori symmetry setting the table for thermal and electrical values was not completely filled. The bug was fixed.
- **Symmetry** or correction settings are now also accessible via the symmetry option field available in tables and diagrams. If the operator confirms the settings for a given set of test data and the measurement is saved, then the chosen symmetry and correction will be saved as well and will be applied if the measurement is opened again. However, the original measurement data will not be overwritten or changed.
- The **B-plane adapter** could not be used anymore with the GO-V (since introduction of version 21.0219.1171). In the frame of fixing this bug, further improvements in conjunction with the B-plane adapter were done.
  - During B-plane measurements, labels in LimesControl are now B for B and b for  $\beta$ .
  - Customisation of step size for B-angles has been improved.
  - An error with regard to the index of electrical values in B-plane measurements was corrected.
  - Auto text in measurement functions with GO-V and B-Plane adapter has been introduced.
- The **Monitor Detector** developed for GO-R can be used as well with GO-V. However, it is not possible to measure the lamp position conversion factor since the lamp orientation cannot be changed with the GO-V. More details with regard to this functionality are available in the chapter on GO-R.



### 3 GO-R 3000 implementation

LMT's METROGON® GO-R goniophotometers have been initially implemented in LIMES 2000 for measurements using the CIE (C, $\gamma$ ) coordinate system in general lighting applications. However, since GO-R 3000 systems are as well capable to record data in the CIE (B, $\beta$ ) coordinate system, they have been used now for a while as well for automotive measurement applications (see chapter on automotive lighting for details).

All necessary menu windows to configure GO-R hardware settings have been implemented. Similarly, the goniometer control window and the hardware test for GO-R has been added in LimesControl.

Due to the **hardware architecture** (main axis moving), all general lighting dialogues valid for GO-V are now as well available for GO-R. With regard to automotive applications, the dialogues valid for GO-H 800 are now assessable as well for GO-R-A.

New features of GO-R 3000 series have been implemented as listed below:

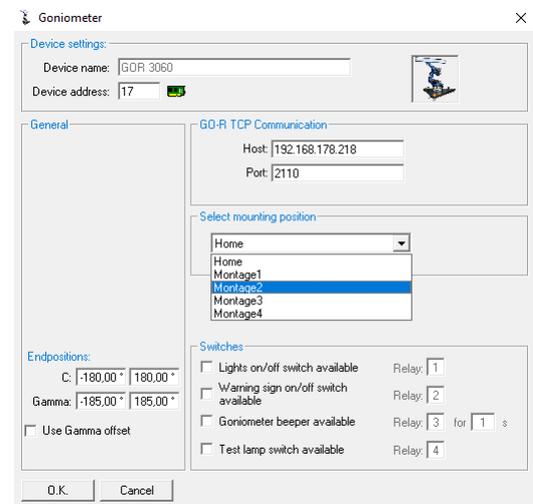
- In addition to **(C, $\gamma$ ) Geometry**, movement within **(B, $\beta$ ) Geometry** has been implemented for automotive lighting measurement applications. However, program control is based on (A, $\alpha$ ) coordinates which are transformed into (B, $\beta$ ) movement. In order to switch between (C, $\gamma$ ) and (B,  $\beta$ ) measurements, two different applications must be introduced.
- In order to reach B-angles up +90°, axis 6, and with axis 6 the device under test, will be usually inverted when the angle is beyond 0°.
- The angle to invert axis 6 is usually B=-90°, however, it may be different if the laboratory geometry or size of DUT offers sufficient safety for other inversion angles. In future, this angle will be variable and part of the hardware settings.
- In addition, axis 6 of a GO-R system may be used for setting the **Epsilon** angle when measuring retroreflectors.
- In contrast to GO-V or GO-H 800, GO-R-A 3000 series goniophotometers provide the functionality of a **Computer-Controlled-Table**, i.e. via program control it is possible to centre the light source in the origin of the goniometer coordinate system. After adjustment, the distance from GO-R-A mounting plate to the light centre will be saved together with the lamp data.
- The maximum distance of **Light Centre** within the measurement axis (i.e. towards the photometer) depends on both the type of the robot and the coordinate system. The individual light centre distance towards the photometer is shown in the *Data* tab of the measurement test data and may be added as an entry of the report header.
- The **TeleControl** used for GO-R 3000 features a key switch. Only with the key switch in the middle position (automatic mode) the goniometer can be controlled by LimesControl.



- In order to enhance angular precision and to protect the system against overloads, GO-R 3000 goniophotometers perform a **Mass and Torque Measurement** in advance of program execution. If one of the parameters is above specification, LIMES 2000 will inform the operator that the measurement cannot be started. The weighing process may be stopped via the stop button located in the hardware test dialogue. Weighing will be done in mounting position 1 only.
- The small version of GO-R-A goniophotometers may be equipped with a 6 channel **PWM Multiplexer**. In addition to simple switching, the software allows for all 6 channels to set duty cycle (0 – 100%) and frequency (0.1 – 1000 Hz) individually.
- In addition to **Stabilisation** using the photometer, both temperature and electrical power may be used for stabilisation with GO-R.
- GO-R goniophotometers may be equipped with a photometer unit having a **Monitor Option**, i.e. the unit can read the input of an auxiliary sensor. This monitor sensor is mounted close to the luminaire, usually, at a peripheral angle without blocking the light towards the photometer. Of course, the monitor sensor may be mounted as well in between the C-planes that are usually measured.  
LIMES 2000 will collect both the photometer and monitor sensor values in one reading procedure, thus making sure, that the standard photometer and monitor photometer are recorded synchronously.  
The values of the monitor sensor will be read as well during stabilisation. If stabilisation data are saved, then the monitor sensor values will be saved, too.
- Values of the **Monitor Photometer** recorded during the measurement are also available via *Evaluation* → *Tables Intensity [cd]* and *Intensity [cd/klm]*.
- In case a monitor sensor is installed, it can be used to determine the **Measurement Correction Factor** with regard to lamp or luminaire operating position. See for instance CIE S025, clause 4.2.5, for details.  
This measurement may be even done during the stabilization procedure, however, only in case photometric stabilisation is chosen. The DUT is usually stabilised first in design operating position and afterwards in measurement position. The ratio of stabilised values recorded by the monitor photometer in both positions delivers the lamp position factor.  
The measurement correction factor for operating position may be added as an entry to the report header. It is possible to unmount the monitor sensor after stabilisation is finished.



- Once a measurement is finished, GO-R will move to (C=0,γ=0) by default. Moving to mounting position will be done only in case this option is chosen in the program flow.
- The **Mounting Position** may be chosen from a pre-defined selection of up to 4 positions. This is done in *Option*→*Hardware*→*Goniometer*. In order to handle different luminaire geometries, multiple mounting positions can be defined.
- All entries with relevant information are located in this sub-menu.



GO-R 3000 goniophotometers have been integrated in the **Automotive Lighting Application**. Internally, the designation is GO-R-A 3000 instead of GO-R 3000. Although these systems measure in (B,β)-geometry, program control is still defined via (A,α), i.e. rotation over elevation as required by different automotive regulatory frameworks around the globe.

- For all point measurements, LIMES 2000 will calculate the corresponding (B,β) angles, however, LimesControl will still display (A,α) coordinates as (H,V).
- For all scans, LimesControl will measure in (B,β)-geometry and afterwards, LIMES 2000 will transform the data to angles to (A,α). During a scan, the measurement window will show the (B,β) data.

The typical **Vertical Range** of GO-R system is  $-90^\circ < V < 20^\circ$ . If positive angles beyond  $20^\circ$  shall be measured (i.e.  $20^\circ < V < 90^\circ$ ), the 6<sup>th</sup> axis is rotated and the DUT is measure upside down for V-angles  $> 0^\circ$ .

As mentioned already for general lighting, the robotic system offers as well the CCT functionality, i.e. the DUT may be moved in 3 directions (left-right, up-down, distance to photometer) to set the light centre.

In addition, the following features were implemented:

The complexity of a GO-R system requires additional operations and **Failure Handling**. If the robot is in an undefined position, LimesControl will do the following steps after the user starts operation:

1. Moving to (C=0,γ=0) with speed 3°/s
2. Moving to mounting position 1 with maximum speed



3. LimesControl is able to move the system to teach points, i.e. pre-defined positions of all axes.
4. In case of errors originating from the power converters of the engines, a window will pop up, informing the user that a *Severe exceptional error in GO-R inverters occurred*. The dialogue may be left with *Quit Error*, but in case the dialogue comes back, the operator can choose *Restart* which restarts the robot control software and initialises the complete system without the need to shut down power completely. Restart and of robot software and re-initialisation of power converters is as well possible via the *Advanced Test dialogue* in LimesControl.

## 4 Automotive Lighting

**Ambient sensor** (temperature / humidity) readout has been also added to the automotive application, e.g., it is possible to read temperature or humidity during execution of each measurement function. For instance, the temperature / humidity displayed for scans is the average temperature/humidity during the scan. In case a distribution is saved, for each line scan the temperature/humidity will be stored, and the user can display the temperature/humidity which was recorded during the scan.

Two tables may be displayed. The first table shows the temperature/humidity during scans. Within the automotive lighting application, a second table is available which displays the average temperature/humidity for every measurement function. It is called temperature report as it shows the ambient sensor values for each measurement function.

The values of  $T_{max}$ ,  $T_{min}$  and  $T_{avg}$  recorded during a measurement are available for printing in the sample header.

In addition to **Stabilisation** using the photometer, both **temperature** and electrical power may be used for stabilisation (see also GO-R applications).

### New features:

Since 2017, the **TeleControl** has been alternatively delivered with a **new interface design**. Communication with the enhanced functionality of the TeleControl was only available within special releases of LIMES 2000, but has been now included into the new release 23.0406.1285.

The new firmware of the TeleControl offers multiple screens for special purposes, for instance for visual aiming, CCT control or addressing special angles via numeric control.





- **Filtering of Measurements** containing a degradation factor or spectroradiometric data has been added.
- The hardware settings for **License Plate Measurement** have been expanded and allow to set a CCT offset in X-direction in addition to Y and Z. This has been implemented to compensate restrictions in laboratory space, e.g. if the default distance cannot be realised.
- In scan measurements the user can decide to print the **Collected Luminous Flux** of the measured area, however, so far it was not possible to set limits for the flux. This has been changed. In addition, cold flux values (initial values) will be calculated based on the degradation factor as measured during stabilisation.
- $I_{min}$ ,  $I_{max}$  and  $I_{mean}$  shown in the **Zonal Flux Evaluation** within the automotive application have been formerly calculated as cd/klm. This has been changed and the data are now presented in cd.
- In case actual head is chosen within the **Aiming** routine, the head defined by the measurement will be used for aiming. This affects as well the fast/slow choice. Therefore, when editing the aiming database, the radio buttons for fast/slow will be replaced by the text "Set by test function".
- In LMT goniophotometers, the **Rotational Speed** is usually slower for the main axis. In order to compensate for this, the measurement speed for gradient measurements, i.e. aiming, can now be chosen differently for vertical and horizontal line scan.
- Thermal data are now available also for all point measurements done in flashing mode, however, recording electrical data is deactivated since they are not reliable in this mode.
- Series 01 of UN regulations 148, 149 and 150, i.e. ECE\_TRANS\_WP.29\_2022\_92/93/94

will specify photometric requirements in **Scientific Notation** using 3 significant digits.

Therefore, in *Grid Options*, the data format may be alternatively defined based on exponential notation with mantissa and exponent.

The user can choose the number of digits freely, however, in the context of the UN regulatory framework two digits after the comma are advisable.

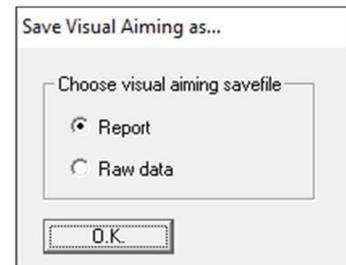
This feature includes of course rounding according to the number of significant digits in advance of evaluating the pass/fail criteria.

Parameter	Decimals	Exponent	Scientific
Illuminance [lx]	2	0.00e+0	<input checked="" type="checkbox"/>
Intensity [cd]	2	0.00e+0	<input checked="" type="checkbox"/>
Luminous flux [lm]	2	0.00	<input type="checkbox"/>
Luminance [cd/m2]	2	0.00	<input type="checkbox"/>
Reflex [mcd/lx]	1	0.0	<input type="checkbox"/>
Rel. Reflex [cd/lx/m2]	3	0.000	<input type="checkbox"/>
Reflex [cd/lc]	2	0.00	<input type="checkbox"/>
Rel. Intensity [cd/klm]	1	0.0	<input type="checkbox"/>
Color temperature [K]	0	0	<input type="checkbox"/>
Chromaticity x,y	4	0.0000	<input type="checkbox"/>
Color Rendering Index	1	0.0	<input type="checkbox"/>
Voltage [V]	3	0.000	<input type="checkbox"/>
Current [A]	3	0.000	<input type="checkbox"/>
Power [W]	1	0.0	<input type="checkbox"/>

Of course, due to its nature, rounding has an influence on triggering the re-aim procedure and it is important to define the report grid correctly.

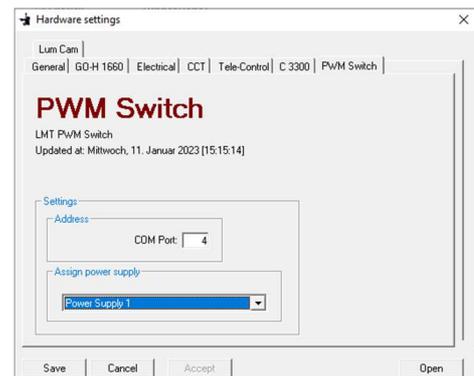
In addition, scientific notation fits much better to typical measurement uncertainties of photometric laboratories.

- It is now possible to save the **Raw Data of Visual Aiming** measurements. Usually, in table view of the aiming report, the visual aiming protocol is exported (extension [VISA]), but now it is alternatively possible to save raw data via the "Save as ..." button.



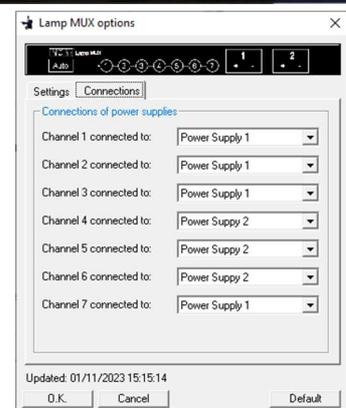
This option has been implemented for experienced users only, Therefore, the user has to activate saving raw data in the program tab *Options* → *diverse* by clicking on the checkbox "In aiming report". "Save As ..." will then save raw data to csv file with extension [VARAW].

- A number of LMT multiplexer types have a single pulse-width-modulated output (usually No. 7) connected to power supply 1 (left picture below). This device was initially controlled manually via an extra unit (so-called PMU) located in the rack. Instead, it is now possible to address the PWM output directly from Limes 2000. The device must be activated in the hardware settings as **PWM-Switch**.



This device may be used as well as an external relay for measurement of direction indicators in blinking mode. Of course, such a functionality is as well available for the 6-fold PWM multiplexer (right picture above).

During implementation of this this feature in Limes 2000, we have as well simplified the user interface for assigning the power supplies with individual multiplexer outputs.





- The hardware configuration allows **two C3300 colorimeter systems** now. This feature has been added for higher degrees of automation, i.e. having one colorimeter head for signal light signalling and a second one for road illumination devices. Therefore, the user does not need to manually move the colorimeter head from one position in the laboratory to another one, but colour measurements can be done at two distances without operator interference.
- 
- Besides photometry, **measurement in flashing mode** is now available as well with fast colorimeters like C3300. The chromaticity within a blinking period will be determined, when the illuminance, e.g. the Y-channel reaches its maximum during the on-cycle. Time resolved X, Y and Z data may be exported as csv file when clicking “Save As...” in the blinking diagram (save csv instead of bmp). In addition, stabilisation can be carried out in flashing mode, for instance to determine degradation factors in flashing mode.

### Bug fixes

- There was an error in the function when the **compare only max value of line scan** for minimum requirement was chosen. The min requirement was compared to the minimum value instead to the maximum value. This has been corrected.
- In the last release, the angular resolution was improved for line scans, especially when measuring gradients. However, on Windows operating systems that were not up-to-date, **LimesControl crashed** completely after calling LMTAO. The bug did not occur during testing at LMT but only on few PCs that turned out to have OS and .NET updates missing. Although LMT recommends to have the OS including all service packs on the latest level, we have found a work-around, that solves the issue of LMTAO crashing during line scan.
- Calculation of **Degradation Factor** requires properly acquired inputs, however, if degradation has been cancelled, the second value, i.e. after stabilisation, may be zero. Since it represents the denominator for the calculation of the degradation factor, a crash was imminent. In future, in this condition the degradation factor is set to 1 (unity) and a warning message is written into the logfile.
- Calculation of the gradient according to the **Pollack Formula** has been corrected. If during the measurement luminous intensity, i.e. candela, was recorded, a transformation to illuminance, i.e. lux, is performed first before the formula is evaluated.
- The functionality of **Adding Test Data** has been improved. In the past, if multiple distributions have been recorded by different functions within a program, the results within the “added measurement” may have been mixed up. This has been corrected.



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- Measurement in flashing mode using an external switching relay did not work reliably in the past and failed for some lamps, especially when ranging was required for high intensities. Therefore, the algorithm has been completely revised and will now detect the on and off states correctly.



## 5 Camera-based Goniophotometry

For the **ScreenCam** a new command called **Polygon CameraGrid** has been added to the list of available functions.

It allows using indirect measurement of luminous intensity based on screen photometry within the frame of a polygon check.

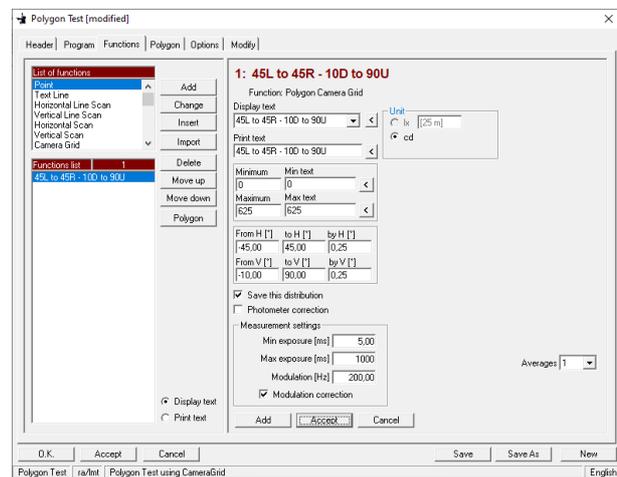
The new command works similar to the standard *Polygon* command, but performs a *CameraGrid* measurement. The result (min/max) will be evaluated based on a user defined polygon.

In addition, during a *CameraGrid* measurement the Stop Button now reacts as usual. If the stop button is hit, the current image will still be recorded, but afterwards the program flow will be interrupted.

In case the screen has no Horizontal Offset, the *CameraGrid* function now works in the range 90L to 90R - 85D to 85U. For screens positioned at a horizontal offset of 90°, the vertical range is limited by the screen size.

In addition, a number of bugs have been fixed:

- When using the *CameraGrid* function with extreme Horizontal Angles, for instance if the screen is positioned at 90°, the algorithm sometimes required to move the goniometer to angular positions beyond the end switch. This has been changed. If the position of the end switch is properly configured in the Limes 2000 configuration file, the goniometer is not moved anymore into the end position.
- We have observed during initialization of the luminance measurement camera (LMK) occasionally a Fatal Program Crash. It is not quite clear, which constellation triggers the crash, but a work around has been implemented which solves the problem.

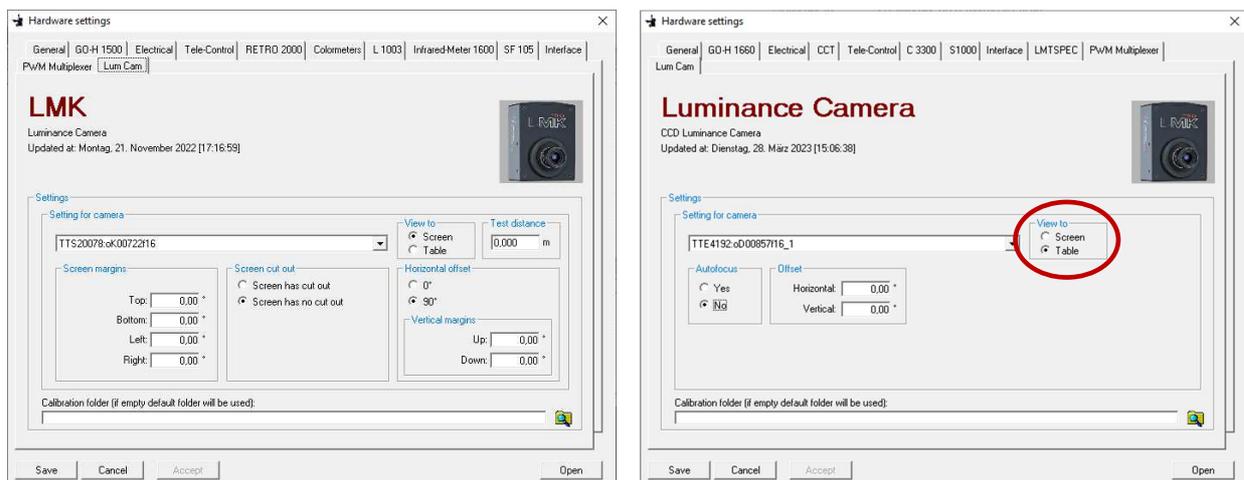


## TableCam

The dialogue to configure the setup with the LMK luminance camera viewing towards the goniometer table, i.e. the **TableCam**, has been improved. In *Options* → *Hardware*, the settings for luminance cameras now contain the option to differentiate between ScreenCam and TableCam. Of course, each of the camera sensors may be provided with an offset.

If TableCam is selected, different options appear, for instance the device offset within the goniometer's coordinate system. The lens which has been attached to the camera must be selected and whether it has auto-focus capability or not.

In case the TableCam is used in a GO-R laboratory, an optional height offset may be entered for configurations in which the luminance camera has a fixed height offset with regard to the photometer axis.



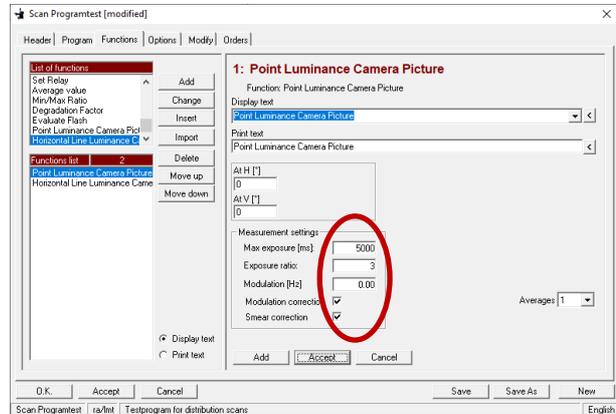
New measurement functions may be selected for TableCam:

- *Point Luminance Camera Picture* triggers LabSoft to record a single luminance image at a given angle
- *Horizontal Line Luminance Camera Picture* triggers LabSoft to record a series of luminance images in HighDyn mode by variation of  $\gamma$  (general lighting) or by variation of the horizontal angle in automotive lighting applications.  
After the images have been recorded, LabSoft will store them in the default storage folder.
- *NearCamPic* has been created for robot goniometers to take luminance images with the camera in the safety area of the robot.  
After the robot has moved to desired  $(C, \gamma)$  position of the intended picture, the user will get a message to position the camera and may change the capture settings before LabSoft will record the image and save it.



All commands offer as usual the definition of all capture parameters required by LabSoft as shown in the screenshot on the right-hand side:

- Maximum exposure time
- Exposure ratio (typically 3)
- Necessity of modulation correction and the corresponding frequency.
- Necessity of smear correction (CCD sensory only)

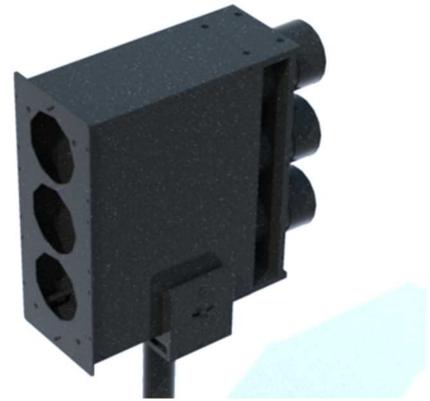




## 6 Multi-Sensor implementation

The **LMT Multi-Sensor upgrade** allows to accelerate horizontal scanning of light distributions by a factor of 3.

In contrast to indirect photometry using a luminance measurement camera with screen, a multi-sensor system does not require any additional laboratory space for illuminating the screen. The upgrade is available for headlamp evaluation, i.e. 25 m distance, or for signalling devices, i.e. 5 m distance.



The hardware consists of multiple photometer units, each equipped with up to 3 photometer heads. Equipment of individual units with heads is configured as usual via *Options* → *Hardware* in the tab *Goniometer* (left picture below).

LIMES 2000 will automatically detect a multi-sensor array, if 3 photometer heads have a similar distance, but different vertical offsets. The example in the left picture below shows a configuration where one multi-sensor array is located at a distance of 25.00 m and another one is positioned at 6.00 m.

If such a device is recognized, the user can choose the multi-sensor array in *test data* as measurement device, but only, if a horizontal scan function is part of the measurement program. All settings, for instance fast/slow, will be applied to all heads of the array (right image below).

Due to the geometric arrangement, a multi-sensor array can be used for horizontal scans only. Regarding vertical resolution, these scans may be done with any step size. If the vertical resolution does not fit to the offset of the multi-sensor array (i.e. multi-sensor offset modulo step size is not zero), the result will be generated by appropriate interpolation.

The corresponding photometer heads may be used individually or in combination as multi-sensor array, whatever the user likes to do (see picture on the right-hand side below).

If a Multi-Sensor array is selected, point measurements will be done by default with unit 1 and the chosen head. In a similar way, if a multi-sensor array is chosen as measurement device, the corresponding head connected to Unit 1 will be used for stabilisation.

Visual aiming may be done with any photometer head or photometer unit. The chosen head will be stored in the aiming results and/or protocol. If the head of the measurement is chosen and the measurement is done with multi-sensor, the visual aiming will be done with photometer Unit 1 and the chosen head.



**Photometer**

Default photometer head at program start:

Photometer head 1  
 Photometer head 2  
 Photometer head 3

---

Test distance:

Distance between the front surface (light sensitive area) of the photometer head and the photometric center (rotation center of the goniophotometer):

	Unit 1	Unit 2	Unit 3
Head 1:	<input type="text" value="25"/> m	<input type="text" value="25"/> m	<input type="text" value="25"/> m
Head 2:	<input type="text" value="6"/> m	<input type="text" value="6"/> m	<input type="text" value="6"/> m
Head 3:	<input type="text" value="3,16"/> m	<input type="text" value="0"/> m	<input type="text" value="0"/> m

Test screen distance:  m

**H-Scan with Multisensor**

Sample | Program | Lamps | Test | Data | Options

**Test**

Photometrical measurements are using the device

Unit 1 head 1 fast at default distance 25,000m

Unit 3 head 1 fast at default distance 25,000m

Unit 3 head 1 slow at default distance 25,000m

Unit 3 head 2 fast at default distance 6,000m

Unit 3 head 2 slow at default distance 6,000m

**Multisensor 1 fast**

Multisensor 1 slow

Multisensor 2 fast

Multisensor 2 slow

Re-aim is only possible for single line scans. If Multi-Sensor is selected, the Re-aim will be done with photometer Unit 1 and the chosen head.

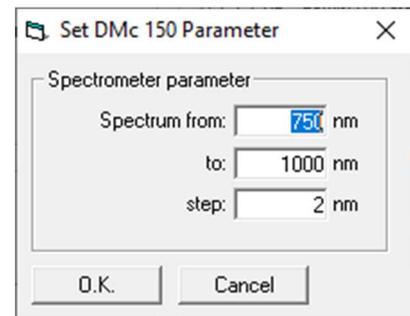
Besides the horizontal scan command, the acceleration benefit of a multi-sensor array is also available for the Polygon command.



## 7 Spectroradiometer

Spectrometer service version 3.0.4.8409 or later supports the **DMC150 Double-Monochromator** from Bentham. Device name in LIMES 2000 is DMC150.

Since the DMC 150 can be configured with various gratings and detectors, the user has to set the resolution and wavelength range within the test tab of the measurement. The available wavelength range will be requested from the spectrometer service which in turn reads it from the configuration file.



The hardware settings of the Bentham DMC 150 are accessible in the same tab as for other spectrometers, for instance the LMT far-field spectroradiometer. If more than one spectrometer type is available, a combo-box allows the user to select the spectrometer which hardware settings shall be edited.

If the Bentham DMC 150 is configured for an extended wavelength range in the IR or UV, LIMES 2000 is capable to calculate the calibration factor for potentially connected S1600 radiometer. This allows to automatically determine the correction factor with a preceding spectral measurement before a high sensitivity far-field radiometer measurement is performed. Of course, in order to do this, LIMES 2000 needs access to the responsivity spectrum of the radiometer head. The calculated correction factor, filename and path of the responsivity file will be saved to the database in combination with the measurement.

Name and path of the spectrum and responsivity file, respectively, can be selected as entries for the report header.

### New features

- The spectrometer may be used now at **Multiple Test Distances**, similar to other LMT sensors. The distance may be either changed via *Options*→*Hardware* or directly in the measurement tab *Test*. Of course, this requires to mechanically move the spectroradiometer in advance to a new position.
- **Correlated colour temperature**  $T_c$  will be displayed in the Control Goniometer window if a colorimeter or spectroradiometer is the active sensor.
- **S/P Ratio** will be displayed in *Weighted chromaticity evaluation* if measurement was performed with the spectrometer.
- If the spectrometer is not calibrated, the flux or intensity value in LimesControl will not be displayed. Instead, the unit will be displayed as nc (not calibrated, shown as well in the tooltip).

With an **uncalibrated Instrument**, in sphere measurements, the displayed flux value will



be "---" with unit nc. Within the diagram, the uncalibrated X, Y and Z values will be adjusted to arbitrary units.

- Similar to the TM30 evaluation, from now on the **Average Values for x, y, u',v' and CCT** are calculated from the summed spectrum and not anymore based on X,Y,Z as originally proposed by LM79-08. The new method satisfies as well requirements from Energy Star.
- The maximum possible **Number of Spectra** within a scan measurement was limited to 32768. This should be usually sufficient but during reliability tests at LMT this number was exceeded. Now, even very long-term measurement with more than 32768 individual points are possible.
- The time for opening measurements with a huge number of spectra may take a while. Therefore, a progress bar has been implemented during this operation.
- From spectrometer software version 3.0.4.8409 upwards, **Horticultural Lighting Evaluation** (HLCE) will be available. The photosynthetic Intensity is calculated in  $\mu\text{mol}/(\text{s} \cdot \text{sr})$  for the total wavelength interval of 400 nm – 700 nm as well as for the partial wavelength intervals [400,500], [500,600] and [600-700].  
The corresponding spectral and angular evaluation has been implemented in LIMES 2000. For more details, please check chapter 2 on general lighting.
- Starting with spectrometer software version 3.0.4.8409, the **Television Lighting Consistency Index 2012** (TLCI)  $Q_a$  will be calculated. The corresponding TLCI table may be activated as well within Limes 2000 via an upgrade procedure. TLCI evolution may be applied as well to spectra which have been recorded in the past.
- Colour calculations have been extended with a new option. Instead of calculating the integral from all measured or all valid points, this option provides two additional integral spectra. They are based on all points having either more than 50% or more than 10% of the maximum intensity value. This feature must be activated in the user data base.

### Miscellaneous

- The name of the summed spectral information has been changed from **Average to Integral** (for example in table spectral data and all colour rendering tables).

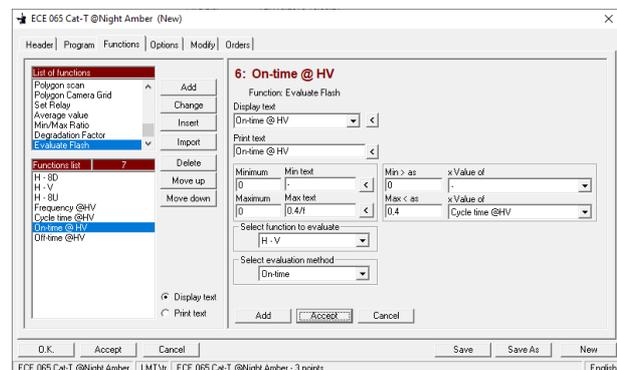


## 8 Flash measurements

The result of a flash evaluation is now available for checking against other values.

In the example on the right-hand side the *On-time* of a flash is compared with 40% of the cycle time, a well-known requirement in UN ECE R65.

Of course, for this example the *Use special function Min/Max* must be activated in order to enter the multiplier of 0.4 for the comparison.



In addition, the behaviour of the program has been changed for several situations.

- The x-axis in the **Diagram Flashtime** will display milli-seconds instead of micro-seconds.
- The diagram Flashtime was not visible, if it was the first element in the diagram list. Therefore, this behaviour occurred only for a few configurations but has been fixed now.
- In the **EvaluateFlash** function, the time result will be given in milli-seconds instead of seconds. Any measurement programs should be checked, if time values are extracted from flash data.
- If test data were not saved before doing a new measurement, the data of EvaluateFlash were not visible after the measurement. Now, evaluation will be performed during the measurement and the data will be instantaneously available.
- In case a measurement based on data from the SF 105 flashmeter has been loaded, changing of unit within the Control Goniometer window did not work. The unit in the Control Goniometer window was wrong, too, if lx was chosen as unit for flash measurement. Both issues have been fixed.
- Sometimes, the unit for optical power of flashes, i.e.  $\text{cd} \cdot \text{s}/\text{min}$ , was not correct. The behaviour has been corrected.
- The flashmeter may be used now at **multiple test distances**, similar to other LMT sensors. Although the standard test distance in UN R65 is 25m, other regulations requiring lower intensity values can only be properly tested, if the test distance is reduced.
- The path for LIMES 2000 to communicate with SoLiT Flash will now be saved in the ini/configuration file instead of the registry. The change will be made automatically.



## 9 Power supplies and power measurement

- LAN interface and serial interface access has been implemented for **TDK Lambda Genesis** power supplies. The device type is URI (Universal Resource Identifier) which must be set via the udb settings.
- Ramp-up and down times of lamps was adjusted with regard to the response time of LAN or serial interface.
- Measurement in *Blinking Mode* is now available with all TDK Lambda power supplies, i.e. by switching the output of the power supply.
- The TDK Genesys+ power supply family has been added as potential power supply devices to LIMES 2000. Its command set differs slightly from the standard TDK Genesys family. In addition, it is capable to be used as power meter.
- The **Stabilization Routine** has been enhanced for general lighting purposes. Now the user can decide if the lamp is stabilized directly after switching-on or after a pre-defined waiting time.  
This option has been introduced with regard to CIE S025, which allows certain lamps to light up for some time before starting the stabilization procedure.
- **4 Channel lamps** have been introduced, for instance to support LED luminaires with RGBW functionality. Such lamps or luminaires may be powered by up to 4 individual channels of electrical power, i.e. 4 power supplies may be used to power up the complete device, for instance to drive a string of RGBW-LEDs. This feature is only available for DC powered lamps, and of course only, if the hardware configuration contains 4 individual power supplies.  
If a *4 Channel lamp* is chosen, all 4 power supplies will be read out for each separate C-plane. The operator may give each channel an individual name for easy identification.
- If a *4 Channel lamp* is stabilized, the voltage, current and power will be saved for all 4 channels. For electrical stabilization the summed power of all 4 channels will be used while in the stabilisation table all 4 channels will be provided.
- Voltage ramp-up for **Chroma power supplies** has been improved. Depending on the target value, the appropriate range is chosen in advance of ramping up voltage.
- Frequency can now be set for the **HP6812A/B** and **HP6813A/B** power supplies.
- During program execution, the labels in the header showing electrical values (voltage, current, power and power factor) sometimes displayed non-stable values, especially after the power is switched on or off. Now these values will be suppressed and power is re-measured until stable values are available.
- Tolerance values for electrical and photometrical stabilisation values can be set from now on individually. The dialogue has been changed accordingly.



- On request of some customers, the last measured values of electrical properties like power, current, voltage, power factor, frequency and efficiency are now available to be used in the report.
- **Multiple Channel Power Measurement** with Yokogawa devices has been integrated, for instance, with WT 3000 up to 4 channels can be used or with WT 5000 up to 7 channels are available. However, this must be properly configured in advance. In case of questions, please check with LMT how to edit the configuration.
- From now on, the current setting of a power supply will be available as long as the LIMES 2000 is not closed. The default values will be offered only once when the power supply window is opened for the first time.

## 10 Miscellaneous

- The routine which converts measurement names into Windows filenames did not replace "<" and ">" characters with "\_". This prevented the software to properly save the data and was fixed.
- On a few occasions, the \*.rtf-files for header and footer were not correctly displayed, especially, if special fonts were used. The issue has been fixed by changing the import method.
- In the post-measurement analysis of stabilisation data, the relative deviation was calculated by division of maximum instead of minimum value. In addition, stability assessment of data sometimes showed a green tolerance box although the tolerance time was not fulfilled.  
These bugs may have occurred during data analysis, but never during execution of stabilisation and program and have been fixed.
- Within the functions *Textline*, *Set Relay* and *Pause*, the print names in the report were displayed even if the view for display name had been chosen. The bug was fixed.
- In case a "@" character is used as print text in one of the functions *Textline* or *Set Relay*, within the print report a new title line is inserted. This has not properly worked in the past.
- In the *Select Lamp* dialogue it was not possible to get a new list if in the *Export* tab another database was selected as in the first tab. The bug was fixed.
- After disabling read and write protection of databases, the element list in the *Open Database* dialogue was not completely shown, at least not immediately. This behaviour has been corrected.
- Update of angular values in LimesControl, especially for vertical and horizontal scans with GO-H goniophotometers at high scanning speeds has been improved.



- In multiple menus, file select dialogues have been replaced by folder select dialogues where appropriate.
- Editing of the sample header has been improved, especially for cases where text is left in spanned fields.
- The minimum dialogue size has been increased to allow for a larger area showing the sample header.
- The user can now add the average U-THD and I-THD to the protocol header.
- A bug was reported with regard to harmonic measurements. If the table harmonic THD has been enabled but in Limes no electrical device was yet set, the light distribution was saved with angle values for Gamma and C all zero. This bug has been fixed.
- Text fields in the “Special” section of the data tab had been locked for users with insufficient rights to edit measurement background information. It was decided that also the “standard” operator should be able to set the name of the luminaire manufacturer or change the name of the testing laboratory. Some of the buttons in this window did not work correctly and this behaviour was as well corrected.
- Photometer values having the wrong exponent (for instance due to transmission errors) will not be used anymore for calculation of the light distribution. In addition, such an error would be noted in the file control.log.
- In case the stabilization data are exported as a txt or csv file, the relative stabilisation values will be saved, too. This has been implemented for photometric and electrical data while for thermal data the deviation is given in °C, i.e. in absolute values.
- The *CanoeOptions* dialogue offers buttons to select file folders. However, in the past a file select dialogue had been used instead of folder select dialogue. The bug was fixed.
- Calculation of standard deviation when displaying file tables was done by dividing with  $n + 1$  instead of  $n - 1$ . The bug has been fixed.
- The functionality of the ESC key has been changed. Formerly, after pressing ESC, the measurement was terminated with no option to continue. Now the ESC key will behave similar like the interrupt button, i.e. it is possible to continue the measurement.
- The printout of multiple reports, e.g. for more than one file, did not work, but only the first selected file was printed multiple times. This bug has been fixed.
- We have deleted the OK button in the dialogue for editing hardware since temporary changes of hardware status are not properly communicated to LimesControl. Instead, the dialogue can only be left by either clicking SAVE or CANCEL.
- In the past, the sphere application was not designed to save the operator who performed the test. In the sphere application, test data are not saved in the usual way, but only the



lamp data are saved. Now, the operator doing the measurement will be added to the measurement metadata.

- If *Start* in LimesControl is activated, the goniometer and photometer unit will be read continuously. This interferes with measurements during program execution. Therefore, *Stop* will be activated during program execution and continuous reading will be interrupted. If LimesControl has been in *Start* mode before a measurement is executed, it will be re-activated afterwards.
- The *Control Goniometer* window now allows to read AMR heads in fast or slow mode. The AMR mode selection frame will be only visible for photometers connected to AMR units.
- **Individual machine IDs** may be assigned to each goniometer. This feature has been implemented to support the quality management for customers with multiple machines. If a measurement is performed with a goniophotometer having an ID assigned, this ID will be stored as part of the *test data*.

The machine ID will be shown if a measurement is opened and since it is stored as a field value, it can be used as well in the sample header.

The machine ID can be set in the hardware dialogue; however, it must be enabled in the configuration, i.e. in the udb file.