QUANTITATIVE TOOLS FOR ON-SITE VISUAL COMFORT ASSESSMENT

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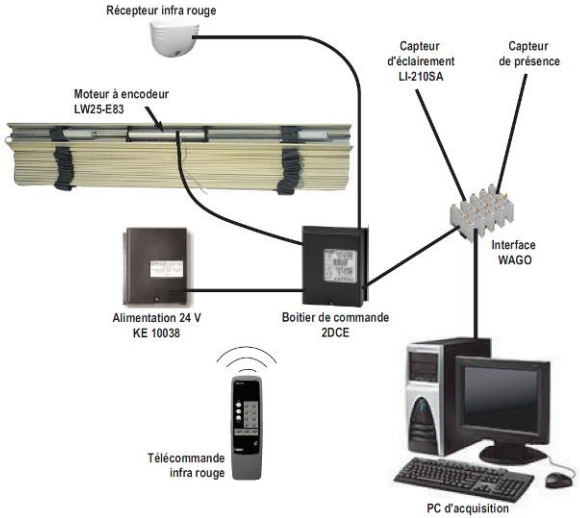
LIGHTING FIELD STUDY

In 2002…







The set-up of this field study took

2 months

Drilling,
Wiring,
Coding….

LIGHTING FIELD STUDY

In 2018…

20 sensors that measured illuminance every 5 minutes for 3 weeks

The set-up of this field study took **30 minutes**

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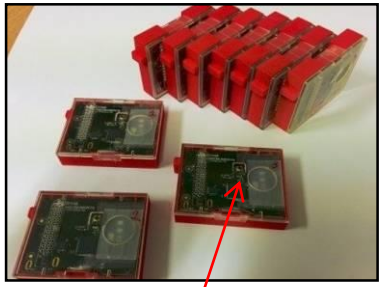
MEASUREMENT - Multi comfort lux box

AN EASY WAY TO MEASURE DAYLIGHT IN OCCUPIED OFFICES

The Multi Comfort LUX BOX, a wireless setup to measure light in occupied spaces
SG is developing the tool for past or future in situ measurements *(SG general delegation in Germany, SG headquarters in La Défense, new SG tower in La Défense currently under construction…)*

At a R&D stage.

- 10 luxmeters ➔ mapping the room to assess homogeneity
- Small footprint
- Light and portable
- **Wireless**
- Flexible
- Battery operation time of 1 month
- Low cost (30 times less than a Li-Cor set-up)
- Reliable
- Programmable measurement time-lapse



SensorTag with luxmeter

Raspberry Pi

Duration:

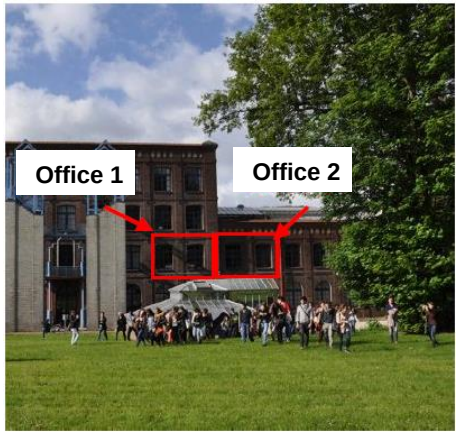
-Setup installation 30 minutes
-Measurement duration : from few hours to weeks or month

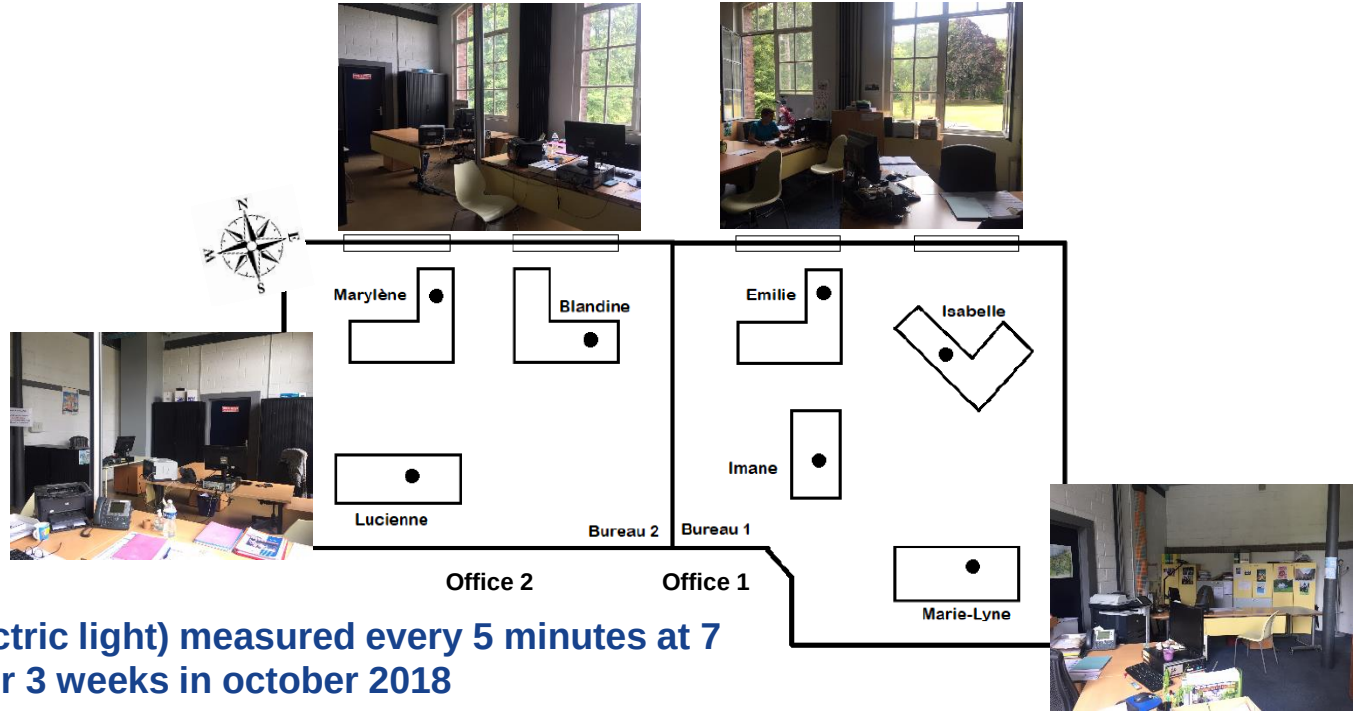
Output: Illuminance at 10 points in the room for the measurement period

FIRST FIELD STUDY IN ROUEN (FRANCE) – OCTOBER 2018

3 WEEKS TO MEASURE LIGHTING CONDITIONS IN OFFICES AND COMPARE WITH INDIVIDUAL ASSESMENTS

School of Architecture of Normandy



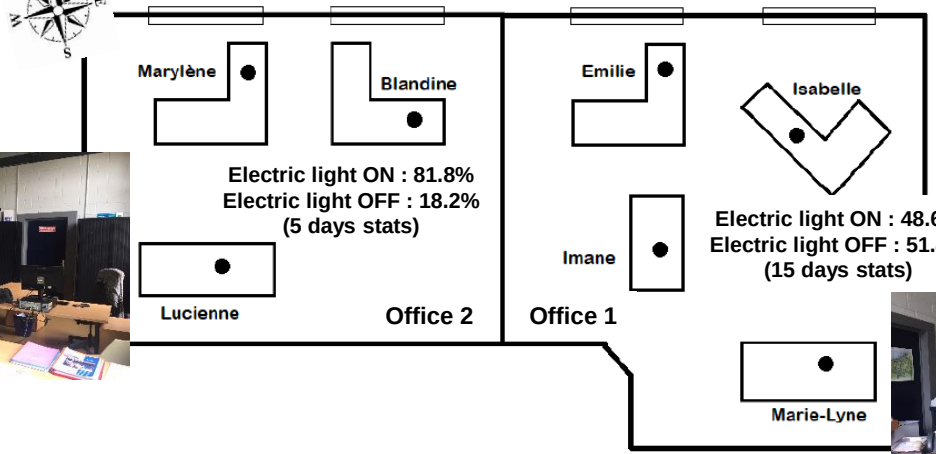


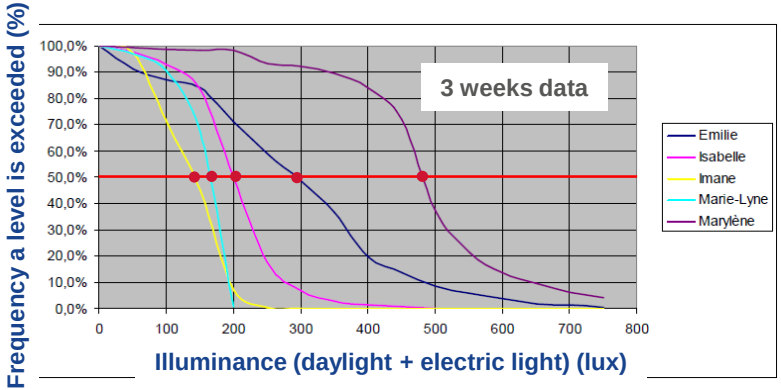
Illuminance (daylight + electric light) measured every 5 minutes at 7 workstations and stored for 3 weeks in october 2018

Objective : Implement and test a measurement methodology of daylight in offices to assess lighting conditions. Establishing correlation with individual assessments.

FIRST FIELD STUDY IN ROUEN (FRANCE) – OCTOBER 2018

3 WEEKS TO MEASURE LIGHTING CONDITIONS IN OFFICES AND COMPARE WITH INDIVIDUAL ASSESMENTS

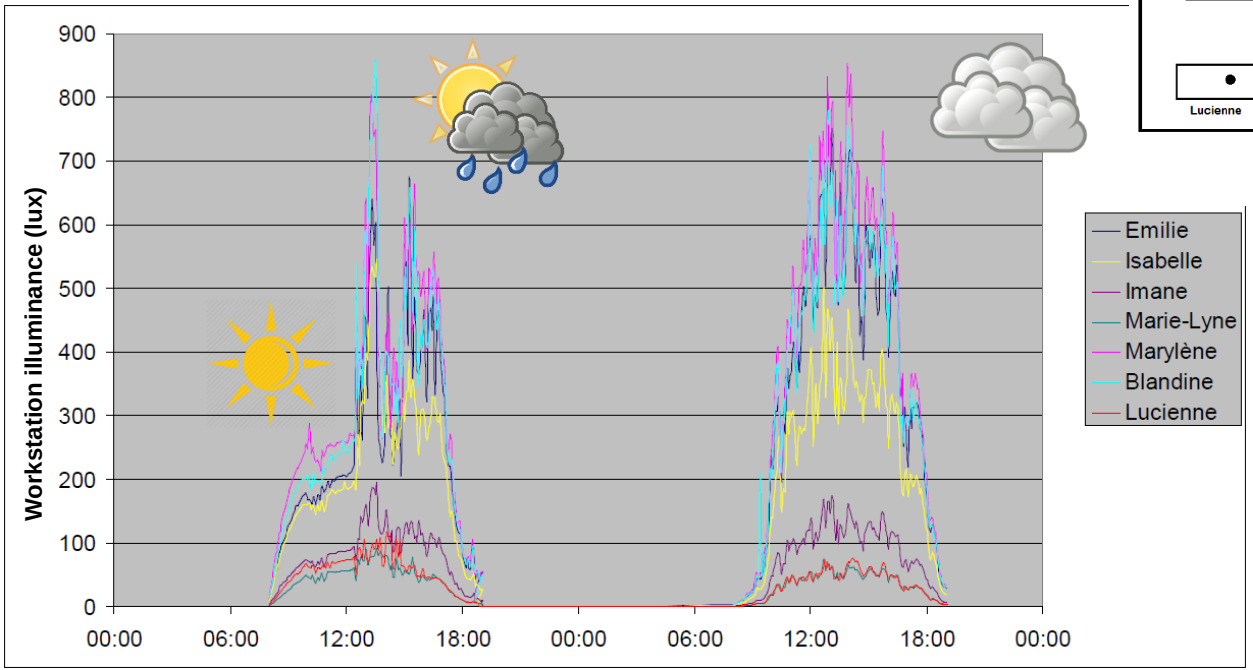


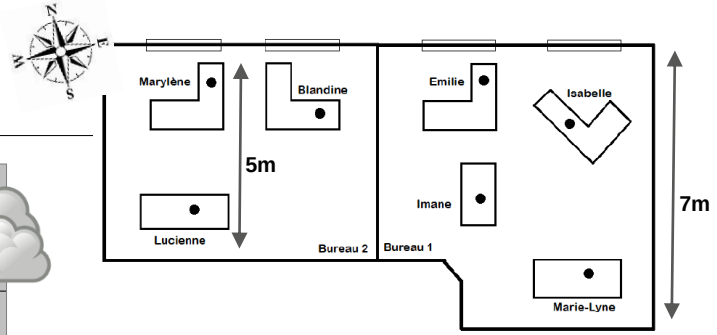


	E median (day + elec)	E electric
Imane	165 lux	120 lux
Marie-Lyne	185 lux	82 lux
Isabelle	218 lux	27 lux
Emilie	319 lux	184 lux
Marylène	507 lux	337 lux
Blandine	-	330 lux
Lucienne	-	337 lux

FIRST FIELD STUDY IN ROUEN (FRANCE) – OCTOBER 2018

DAYLIGHTING PERFORMANCE IN OFFICES WITHOUT OCCUPANTS DURING 2 DAYS





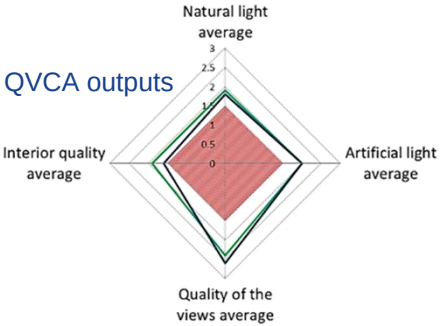
	E median 8am – 6pm	DA 300 lux 8am – 6pm
Emilie	308 lux	50.4 %
Isabelle	238 lux	34.3 %
Imane	88 lux	0 %
Marie-Lyne	45 lux	0 %
Marylène	352 lux	57 %
Blandine	341 lux	54.1 %
Lucienne	48 lux	0 %

FIRST FIELD STUDY IN ROUEN (FRANCE) – OCTOBER 2018

CONCLUSIONS & PERSPECTIVES

- ✓ Quantitative assessment of lighting quality in two offices.
- ✓ Identification of lighting issues depending on the location of the workstations in the space.
- ✓ Quantitative results were compared with occupants assessments of their daylighting conditions obtained with a questionnaire (Saint Gobain QVCA)

QVCA outputs



Occupant opinion	Blandine	Marylène	Lucienne	Emilie	Isabelle	Imane	Marie-Lyne
Natural light (QVCA score on 3pts)	**2,1**	**1,9**	**1,5**	**1.9**	**2.5**	**1.5**	**0,6**
Measured DA 300lux	54.1%	57%	0%	50.4%	34.3%	0%	0%

- ➢ How to assess EN17037 compliance with on-site measurements ?
- ➢ Complementary measurement needed to assess the lighting quality during summer time. A second measurement campaign has been performed in July.

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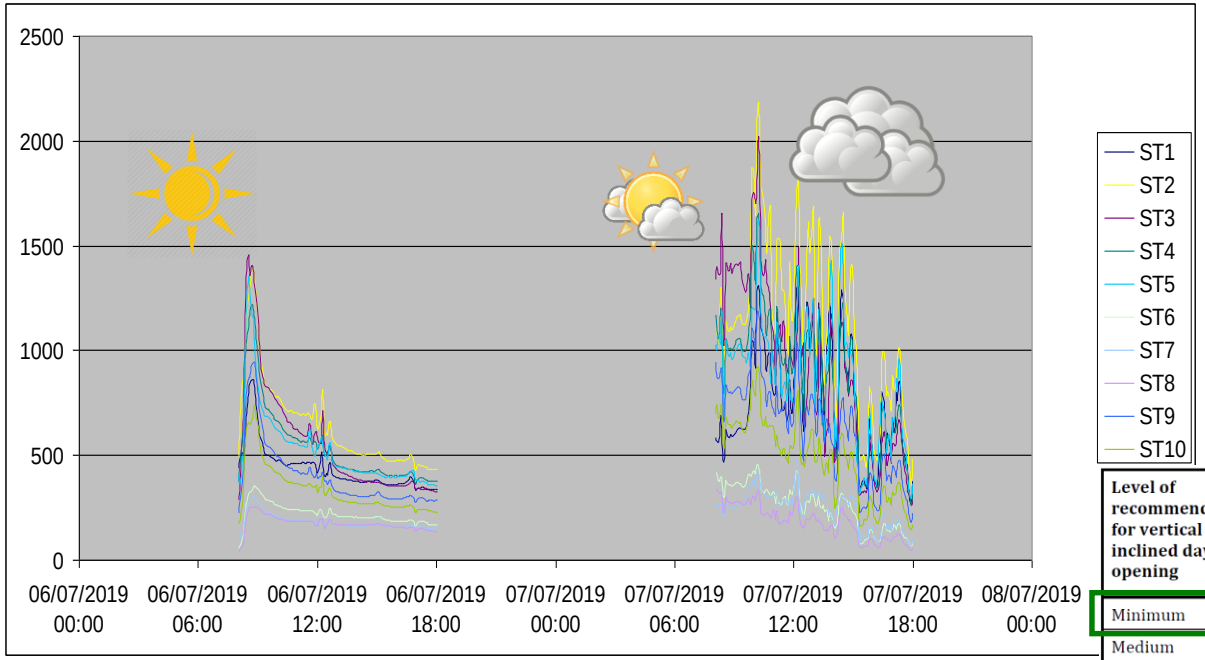
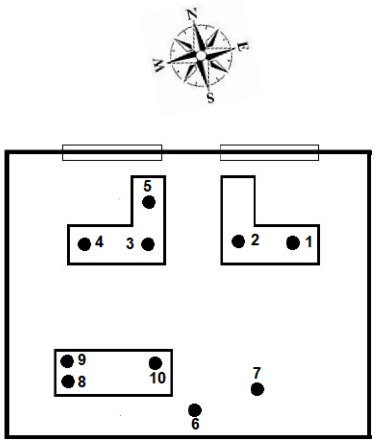
SECOND FIELD STUDY IN ROUEN (FRANCE) – JULY 2019

MEASURING DAYLIGHT AUTONOMY DURING A WEEKEND





Sensors	E median
1	500 lux
2	778 lux
3	613 lux
4	603 lux
5	592 lux
6	227 lux
7	191 lux
8	173 lux
9	436 lux
10	363 lux

Level of recommendation for vertical and inclined daylight opening	Target illuminance E_T lx	Fraction of space for target level $F_{plane,\%}$	Minimum target illuminance E_{TM} lx	Fraction of space for minimum target level $F_{plane,\%}$	Fraction of daylight hours $F_{time,\%}$
Minimum	300	50 % / 70%	100	95 % / 100%	50 %
Medium	500	50 % / 50%	300	95 % / 70%	50 %
High	750	50 % / 10%	500	95 % / 50%	50 %

NOTE Table A.3 gives target daylight factor (D_T) and minimum target daylight factor (D_{TM}) corresponding to target illuminance level and minimum target illuminance, respectively, for the CEN capital cities.

EN 17037 recommended performance thresholds

How could we assess the annual EN 17037 performance using measurements ?

METHODOLOGY

HOW COULD WE ASSESS THE ANNUAL EN 17037 PERFORMANCE USING MEASUREMENTS ?

Two interesting methodologies :

1. *A simple method to significantly lower daylight simulation time*, J. Sulivan & M. Donn, 2016

For an annual daylight simulation, selecting :

• 10 random days per month leeds to less than 6% error

• 5 random days per month leeds to less than 10 % error

• 5 « representative » days per month leeds to less than 5 % error

Could we apply this to measurements ?

2. LEED EQ CREDIT: DAYLIGHT

Option 3. Measurement (2-3 points, 1-2 points Healthcare)

Achieve illuminance levels between 300 lux and 3,000 lux for the floor area indicated in Table 3.

Table 3. Points for daylit floor area: Measurement

New Construction, Core and Schools, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		*Healthcare*	
Percentage of regularly occupied floor area	*Points*	*Percentage of perimeter floor area*	
75	2	75	1
90	3	90	2

With furniture, fixtures, and equipment in place, measure illuminance levels as follows:

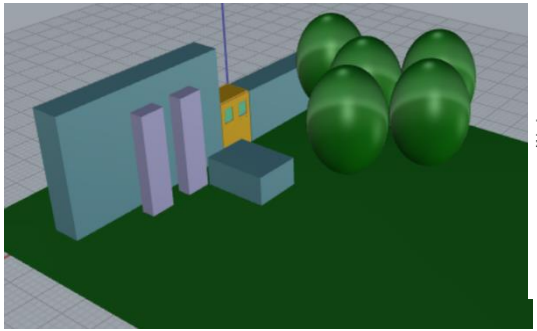
- Measure at appropriate work plane height during any hour between 9 a.m. and 3 p.m.
- Take one measurement in any regularly occupied month, and take a second as indicated in Table 4.
- For spaces larger than 150 square feet (14 square meters), take measurements on a maximum 10 foot (3 meter) square grid.
- For spaces 150 square feet (14 square meters) or smaller, take measurements on a maximum 3 foot (900 millimeters) square grid.

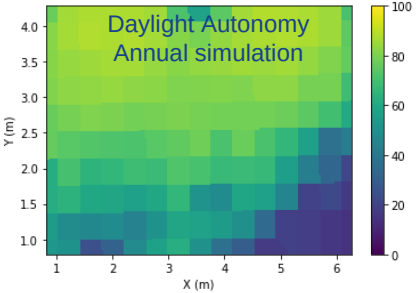
Table 4. Timing of measurements for illuminance

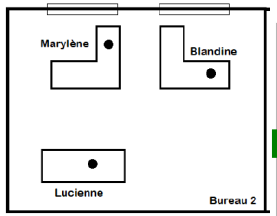
If first measurement is taken in …	*take second measurement in …*
January	May-September
February	June-October
March	June-July, November-December
April	August-December
May	September-January
June	October-February
July	November-March
August	December-April
September	December-January, May-June
October	February-June
November	March-July
December	April-August

CASE-STUDY AT ROUEN (FRANCE)
TOOLS TO ASSESS THE REQUIREMENTS IN THE NORM

Using daylight simulations to define a protocol.







DA 300 lux year – simulation
DA 300 lux>50% of the time for **74,75%** **fraction of space**
DA 100 lux>50% of the time for **100%** **fraction of space**

Level of recommendation for vertical and inclined daylight opening	Target illuminance E_T lx	Fraction of space for target level $F_{plane,\%}$	Minimum target illuminance E_{TM} lx	Fraction of space for minimum target level $F_{plane,\%}$	Fraction of daylight hours $F_{time,\%}$
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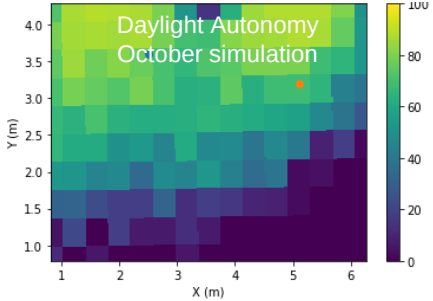
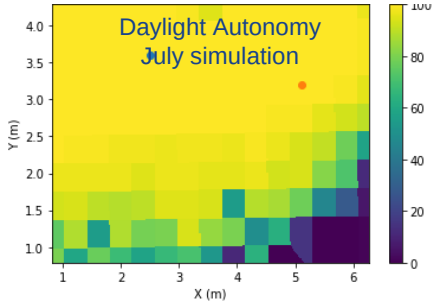
EN 17037 recommended performance thresholds



DA 300 lux>50% of the time for 52,7%
DA 100 lux>50% of the time for 100 %



DA 300 lux>50% of the time for 92,5%
DA 100 lux>50% of the time for 100 %

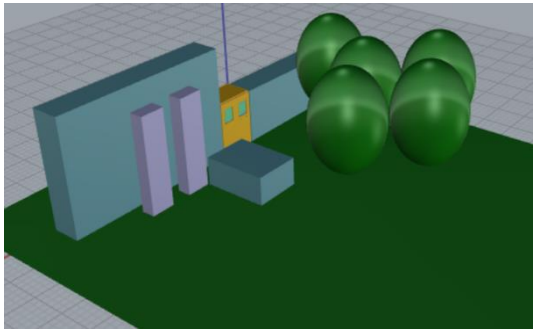
Mean value

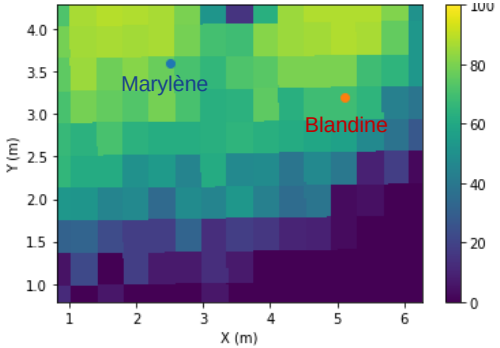
Average DA 300 lux year from Oct and Jul
DA 300 lux>50% of the time for **72,6%** **fraction of space** (error 2%)
DA 100 lux>50% of the time for **100%** **fraction of space** (error 0%)

Promising approach for measurement data processing ?

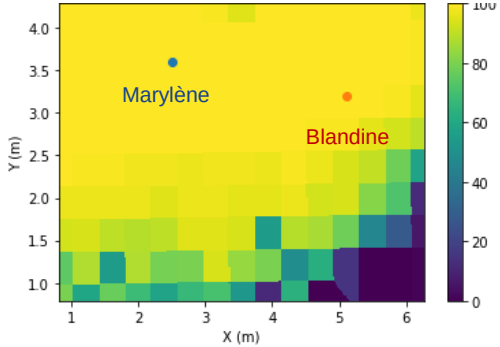
CASE-STUDY AT ROUEN (FRANCE)
TOOLS TO ASSESS THE REQUIREMENTS IN THE NORM

Comparison of simulation with measurement results at two workstations.





DA 300 lux October – simulation
DA 300 lux>50% of the time for 52,7%



DA 300 lux July – simulation
DA 300 lux>50% of the time for 92,5%

	Measure	Simulation
	DA 300 lux (2 days)	DA 300 lux (1 month)
Blandine July	99.6 %	100%
Marylène July	99.6 %	100%
Blandine October	54.4 %	69%
Marylène October	57.3 %	77%

- **Simulation > Measurement (obstacles, occupants, furnitures, room materials…)**
- **Applying the protocol defined on simulation with measurements seems promising to approach the closest assessment of daylight by mapping the room with sensors**

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CONCLUSION & PERSPECTIVES

Results:

- The **wireless** set-up of an on-site lighting field study takes **less than an hour** with the MCLuxBox.
- Daylight autonomy of a space can be measured during a selected period.
- Assessment of the compliance with EN17037 over a selected period of time is possible using the measurement set-up.

Questions raised:

- Is it possible to extrapolate the assessment over selected periods of time to an annual performance?
- What is the optimum measurement duration to increase the accuracy of the extrapolation ?

Perspectives:

- Next steps will be to test a protocol to approximate annual metrics from repeated daily measurements over a longer period.
- Could we imagine a **measurement methodology**, an “option 3”, to assess daylight quantity performance in EN 17037 ?

THANK YOU FOR YOUR ATTENTION

BACK UP

QUICK VISUAL COMFORT ASSESSMENT (QVCA)
FOCUSED ON THE OCCUPANT'S PERCEPTION

Summary	Expert	Occupant
Natural light	1,6	1,5
Artificial light	1,5	1,4
View	1,4	1,8
Office quality	1,9	1,6

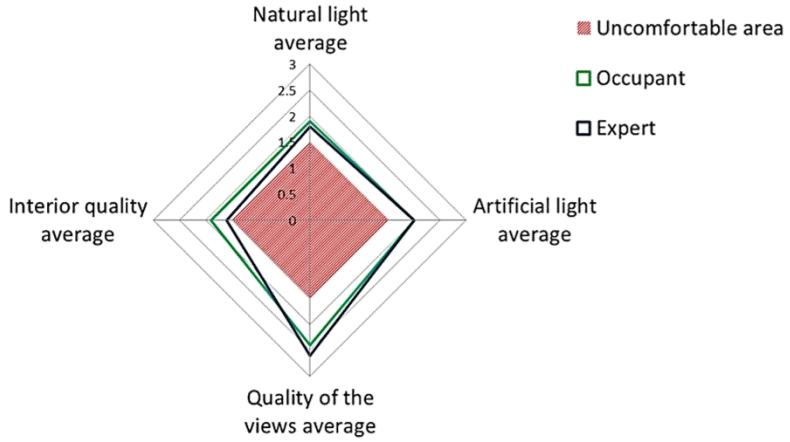
Tool for a global assessment of visual comfort in offices

Focused on human perception

Approx. 40 measurements and questions

Meant for both occupants and experts

Expert : 15 minutes
Occupant : 5-10 minutes



online

It takes into account **all the dimensions** of visual comfort:

- Artificial lighting
- Natural light
- Views

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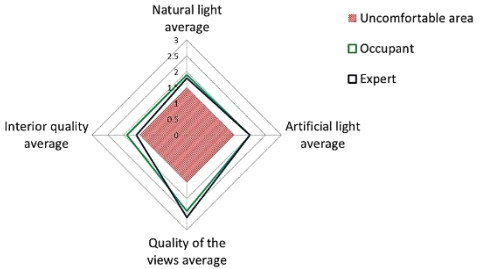
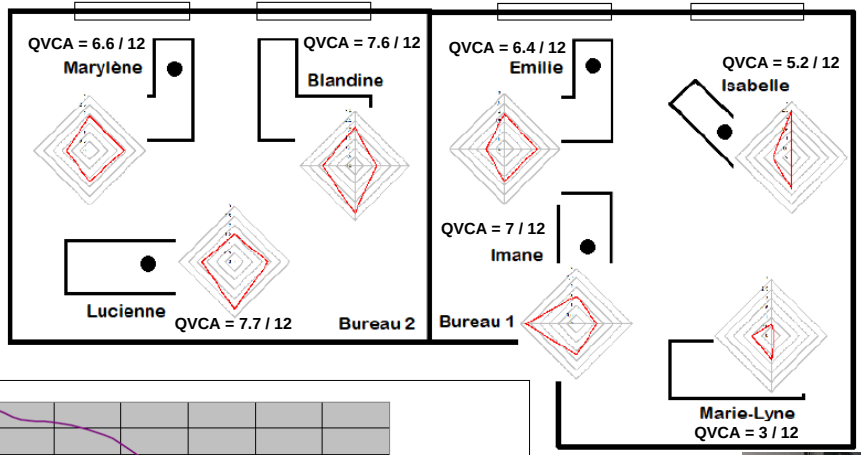
FIRST FIELD STUDY IN ROUEN (FRANCE)

3 WEEKS TO MEASURE LIGHTING CONDITIONS IN OFFICES AND COMPARE WITH INDIVIDUAL ASSESMENTS

QUICK VISUAL COMFORT ASSESSMENT (QVCA)
A lighting quality questionnaire developped by SGR





Daylight + electric light