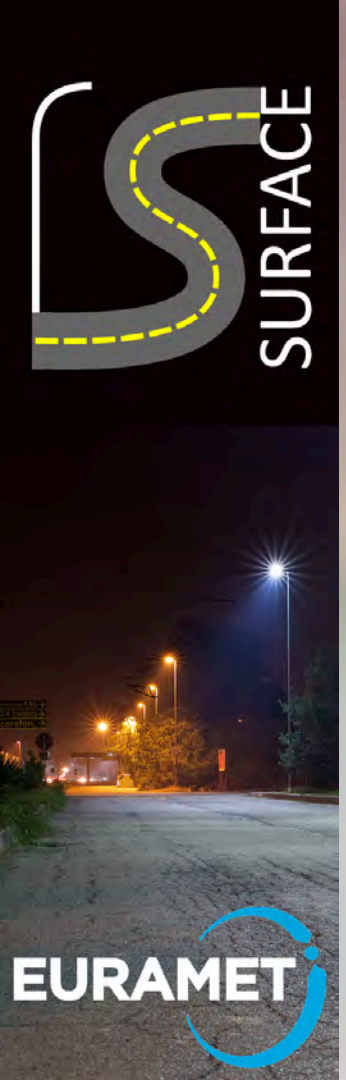
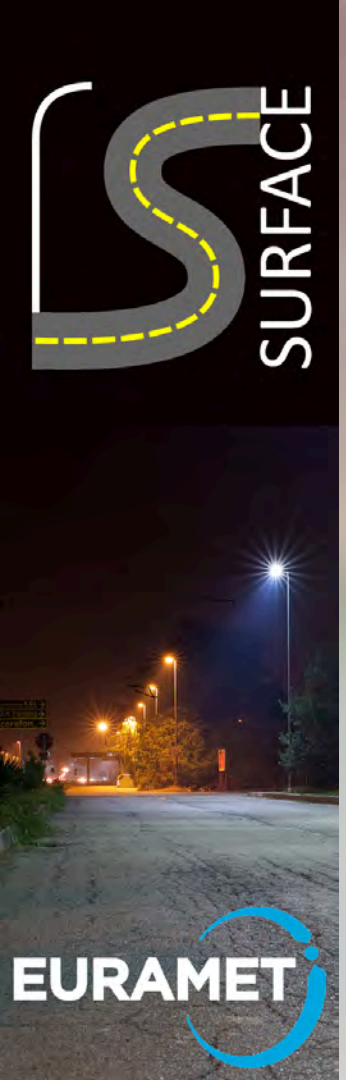


First Stakeholder meeting

Berlin, May 25th 2018

Paola Iacomussi - Surface co-ordinator

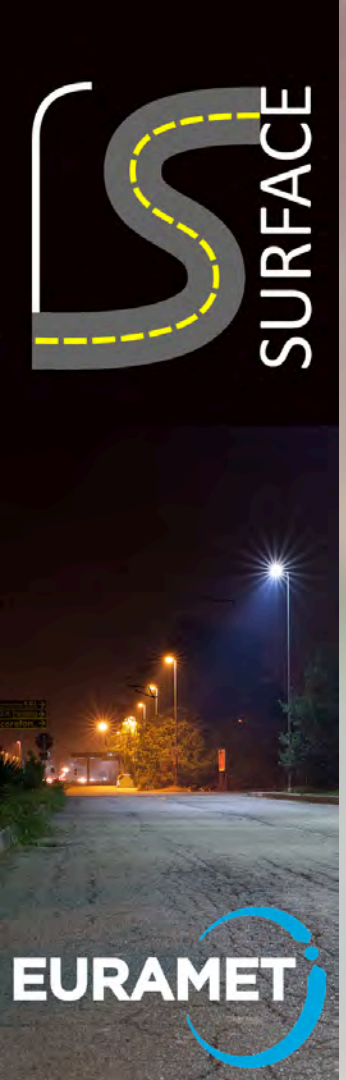


Agenda

14:00 – 15:30 Part 1

Overview and first acheivements

- **Overview of the project**
  P. Iacomussi
- **WP 1**
  J. Reber
- **WP2**
  V. Muzet



Agenda

16: 00 – 17:40 Part 2

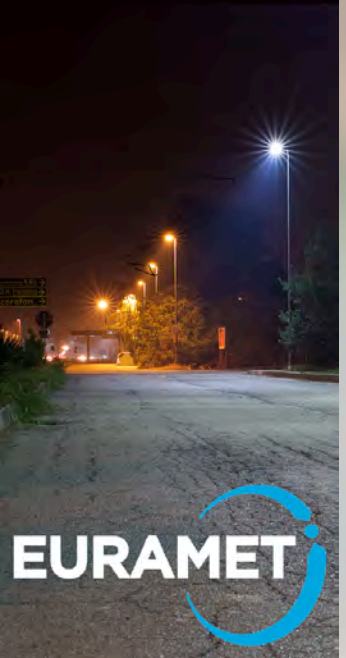
Stakeholder – consortium interaction

Data Collection
Corcerning geometries
V. Muzet

Lighting pollution geometries related
G. Rossi

Intercomparison
P. Iacomussi

Road administration involvement and dissemination
M. Lindgren



Fist of all,

THANK YOU! AND WELCOME

Stephan Voelker
Lighting Technology Group

Christine Kluge

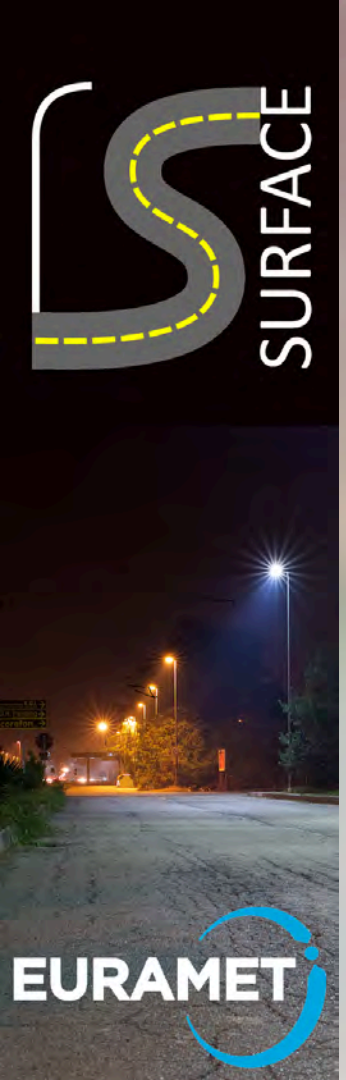
SURFACE

OVERVIEW 16 NRM02 SURFACE

PAVEMENT SURFACE CHARACTERISATION FOR SMART AND EFFICIENT ROAD LIGHTING

EURAMET

EMPIR 16 NRM02 SURFACE



EMPIR

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

European **M**etrology **P**rogramme for **I**nnovation and **R**esearch

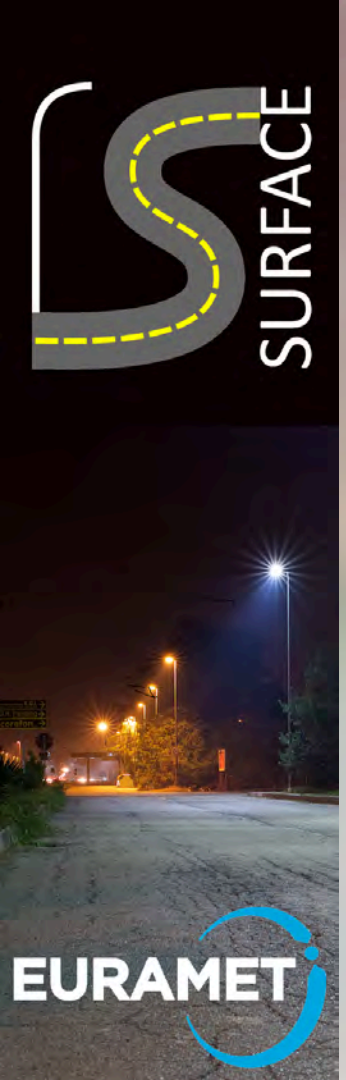
Initiative co-funded by European Union's Horizon2020

between 2014 and 2020

EURAMET

EURAMET

The European Association of National Metrology Institutes



EMPIR 16 NRM02 SURFACE

EMPIR
call 2014 – 2020

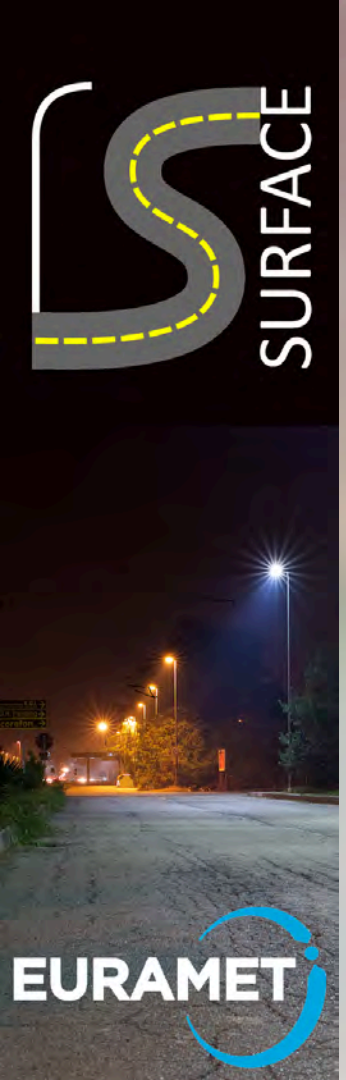
Total **budget**: of 600 M €

- 300 M € from the participating states
- up to 300 M € from the European Commission

Priority areas:

Health, Energy, Environment, Industry, Fundamental metrology

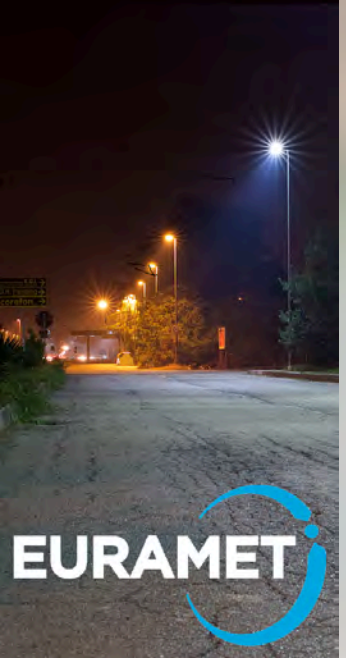
Standardization



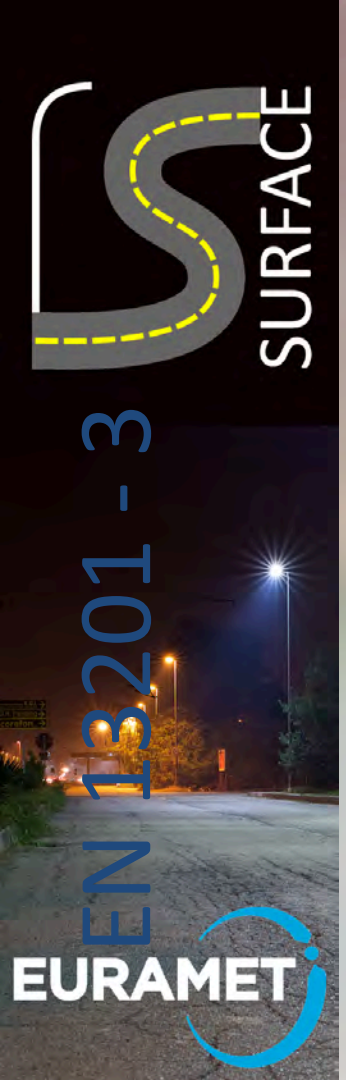
Standardization EMPIR call

3 stages selection:

- PRT – Feb. year 0
- SRT – May year 0
- JRP – Jan year 1



Kick off on July 2017



16 NRM02 SURFACE NEEDS

EUROPEAN STANDARD **EN 13201-3**

NORME EUROPÉENNE

EUROPÄISCHE NORM December 2015

ICS 93.080.40 Supersedes EN 13201-3:2003

English Version

Road lighting - Part 3: Calculation of performance

Eclairage public - Partie 3: Calcul des performances

Straßenbeleuchtung - Teil 3: Berechnung der Gütemerkmale

This European Standard was approved by CEN on 6 June 2015.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Ref. No. EN 13201-3:2015 E

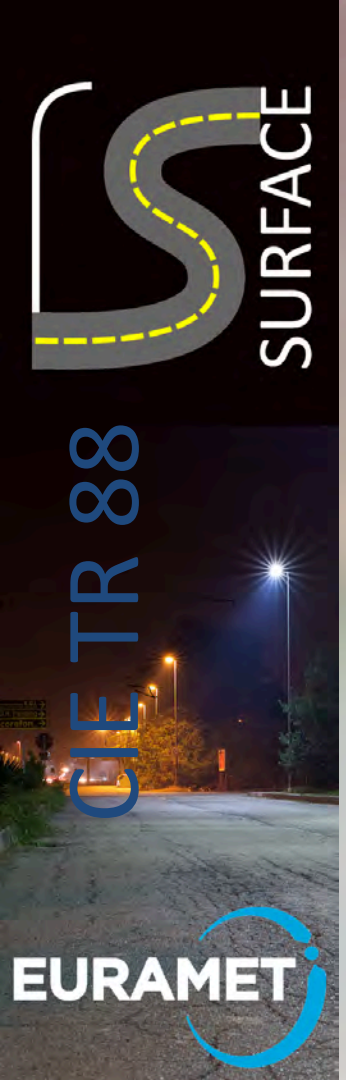
Table 3 — Angular intervals and directions to be used in collecting road surface reflection data

tan ε	β in degrees																			
	0	2	5	10	15	20	25	30	35	40	45	60	75	90	105	120	135	150	165	180
0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0,25	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0,5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0,75	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1,25	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1,5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1,75	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2,5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3,5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4,5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5,5	X	X	X	X	X	X	X	X	X	X										
6	X	X	X	X	X	X	X	X	X											
6,5	X	X	X	X	X	X	X	X	X											
7	X	X	X	X	X	X	X	X												
7,5	X	X	X	X	X	X	X													
8	X	X	X	X	X	X	X													
8,5	X	X	X	X	X	X	X													
9	X	X	X	X	X	X														
9,5	X	X	X	X	X	X														
10	X	X	X	X	X	X														
10,5	X	X	X	X	X	X														
11	X	X	X	X	X	X														
11,5	X	X	X	X	X															
12	X	X	X	X	X															

A cross in Table 3 indicates the required *r*-value that shall be known.

NOTE In Table 3, blank cells indicate directions that should not be used for calculation, therefore the knowledge of *r* of these directions is not relevant in this standard.

16 NRM02 SURFACE NEEDS



ISBN 3 901 906 12 6

CIE

COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

TECHNICAL REPORT

ROAD SURFACE AND ROAD MARKING REFLECTION CHARACTERISTICS

CIE 144:2001

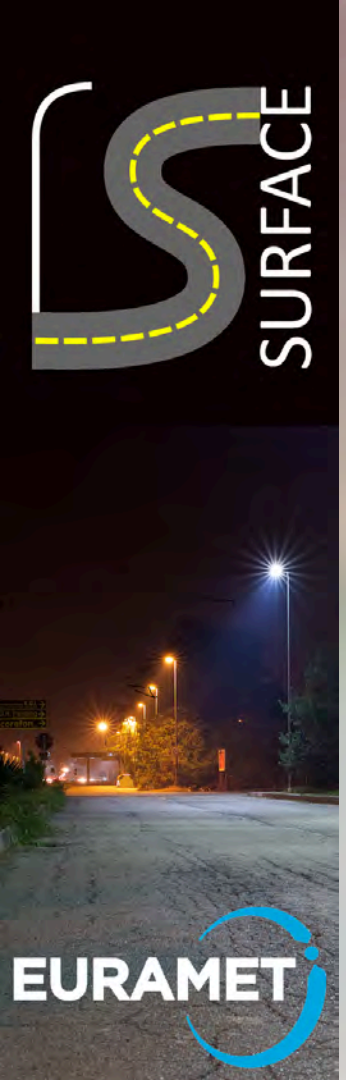
UDC: 535.312 Descriptor: Regular reflection
535.361.3 Diffuse reflection. Scattered reflection
628.971.6 Street lighting
628.971.85:629.113.06 Lighting by motor vehicle lamps

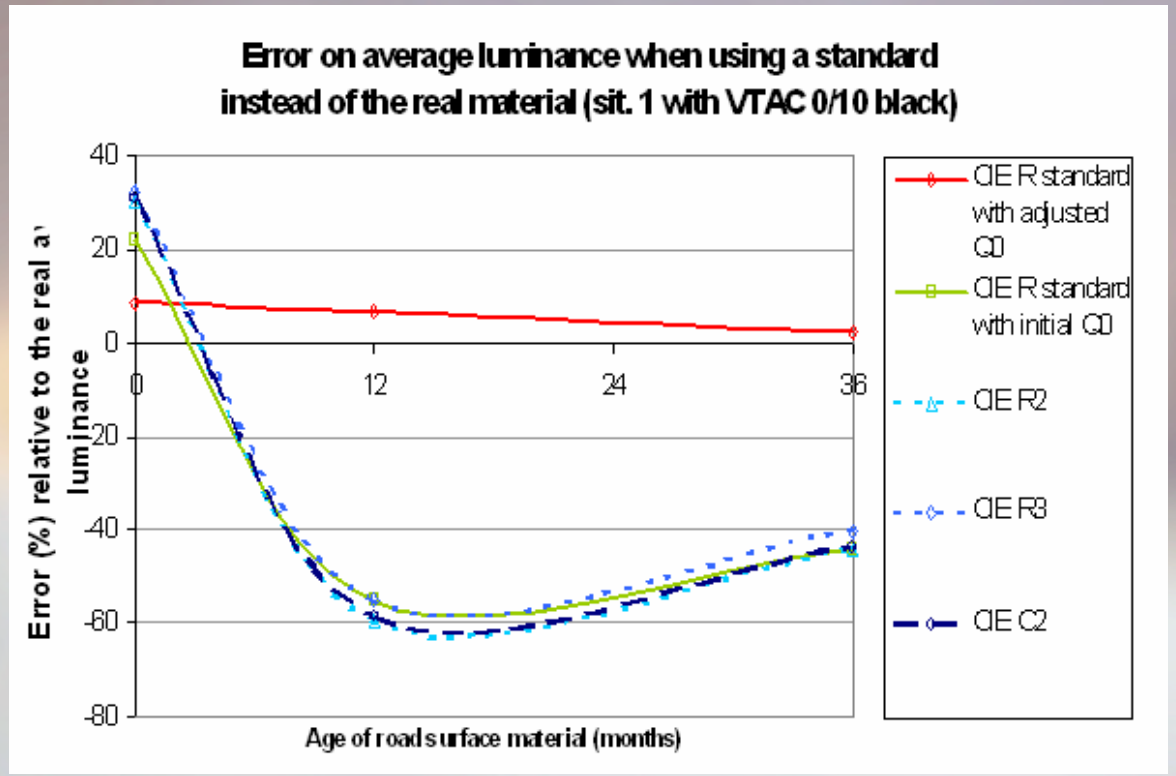
ANNEX B - STANDARD REFLECTION TABLES

Table C1

	β(°)																			
tgγ	0	2	5	10	15	20	25	30	35	40	45	60	75	90	105	120	135	150	165	180
0	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770	770
0,25	710	708	703	710	712	710	708	708	707	704	702	708	698	702	704	714	708	724	719	723
0,5	586	582	587	581	581	576	570	567	564	556	548	541	531	544	546	562	566	587	581	589
0,75	468	467	465	455	457	446	430	420	410	399	390	383	373	384	391	412	419	437	438	445
1	378	372	373	363	347	331	314	299	285	273	263	260	250	265	278	295	305	318	323	329
1,25	308	304	305	285	270	244	218	203	193	185	179	173	173	183	194	207	224	237	238	245
1,5	258	254	251	229	203	178	157	143	134	128	124	120	120	132	140	155	163	177	179	184
1,75	217	214	205	182	153	129	110	100	95	90	87	84	88	98	103	116	123	134	137	138
2	188	181	174	142	116	95	80	73	69	64	62	64	64	72	78	88	95	105	108	109
2,5	145	136	121	90	66	53	46	41	39	37	36	36	39	44	50	55	60	66	69	71
3	118	108	87	57	41	32	28	26	25	23	22	23	25	28	31	37	41	45	47	51
3,5	97	87	64	39	26	20	18	17	16	15	15	16	17	19	23	27	30	33	35	37
4	80	69	50	29	17	14	13	12	11	11	11	11	13	15	17	19	22	26	27	29
4,5	70	58	37	21	13	10	9	8	8	8	8	9	10	12	14	16	17	20	21	22
5	60	51	29	15	9	7	7	6	6	6	6	7	7	9	10	12	14	17	17	18
5,5	52	41	23	12	7	6	6	6	5	4										
6	48	36	19	8	6	5	5	5	5											
6,5	44	32	17	7	6	5	5	5												
7	41	28	14	6	5	4	4	4												
7,5	37	26	12	6	4	3	3													
8	34	23	11	5	4	3	3													
8,5	32	21	9	5	4	3	3													
9	29	19	8	4	3	3														
9,5	27	17	7	4	3	3														
10	26	16	6	3	3	3														
10,5	25	16	6	3	2	1														
11	23	15	6	3	2	1														
11,5	22	14	6	3	2															
12	21	14	5	3	2															

Table C1 Qd/Q0 = 0,090/0,100 S1=0,24


SURFACE
EURAMET


Error on average luminance when using a standard instead of the real material (sit. 1 with VTAC 0/10 black)
Error (%) relative to the real a' luminance
40
20
0
-20
-40
-60
-80
0
12
24
36
Age of road surface material (months)
CIE R standard with adjusted Q0
CIE R standard with initial Q0
CIE R2
CIE R3
CIE C2

16 NRM02 SURFACE NEEDS

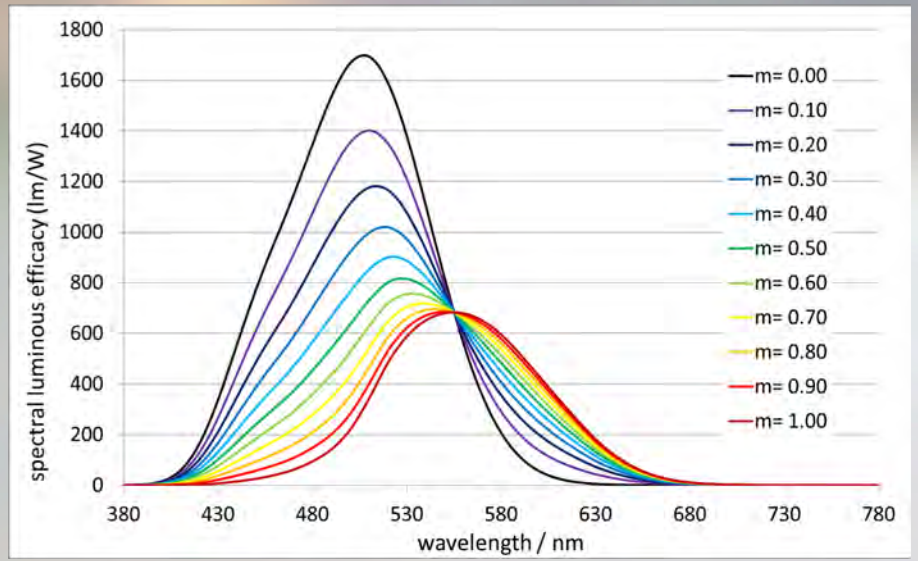
16 NRM02 SURFACE NEEDS

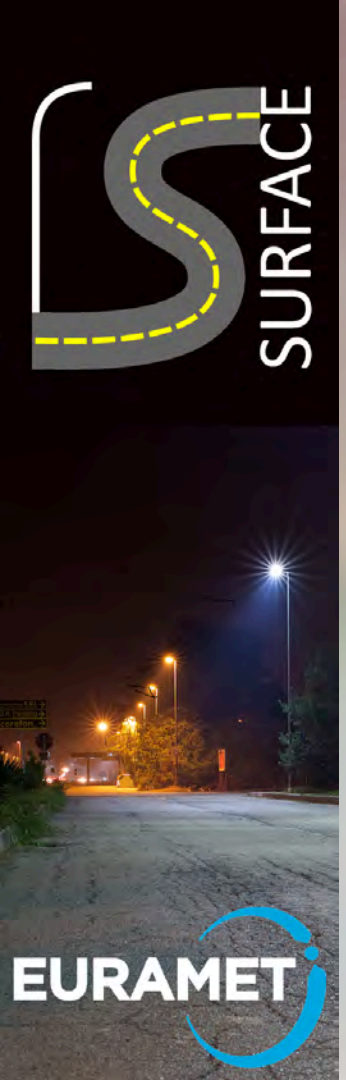
You really design it??

New aspects

Spectral characterization

- Mesopic conditions
- The spectral distribution of the light reflected by the road surface should be considered





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INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

Italy

Aalto University

Finland

LNE Le progrès, une passion à partager

France

METAS

Switzerland

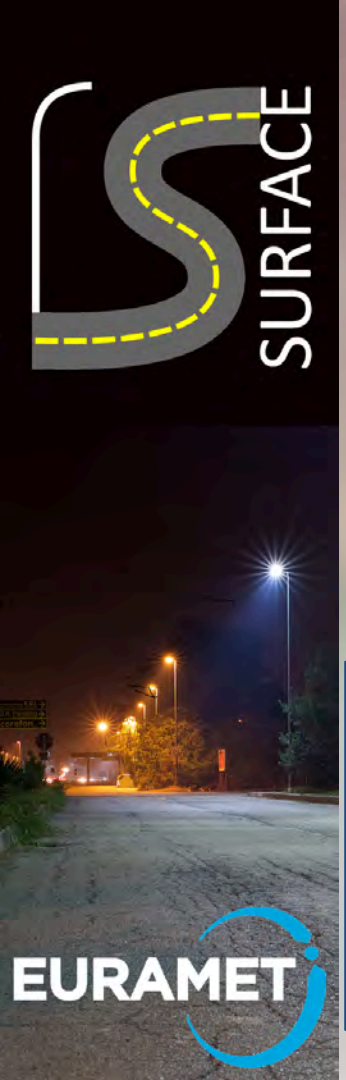
METROSERT

Estonia

RI SE

Sweden

CONSORTIUM – INDUSTRIAL PARTNERS



Funded

Unfunded

Cerema

France

Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement

OPTIS

France

IT Company
Simulation software for ligh and virtual reality

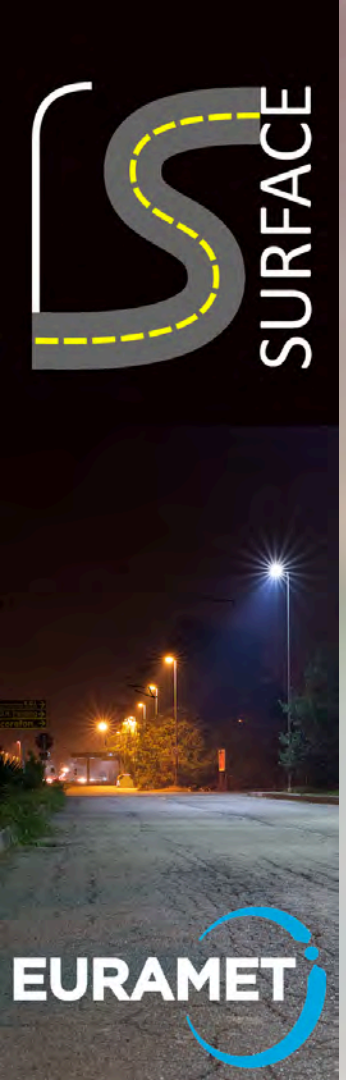
proceq

ZEHNTNER TESTING INSTRUMENTS

Switzerland

Manufacturer of high level measuring and testing instruments
Large domain of measuring techniques
IOT

Stakeholder



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cie

LiCon-AT

TRAFIKVERKET

ISO

englo

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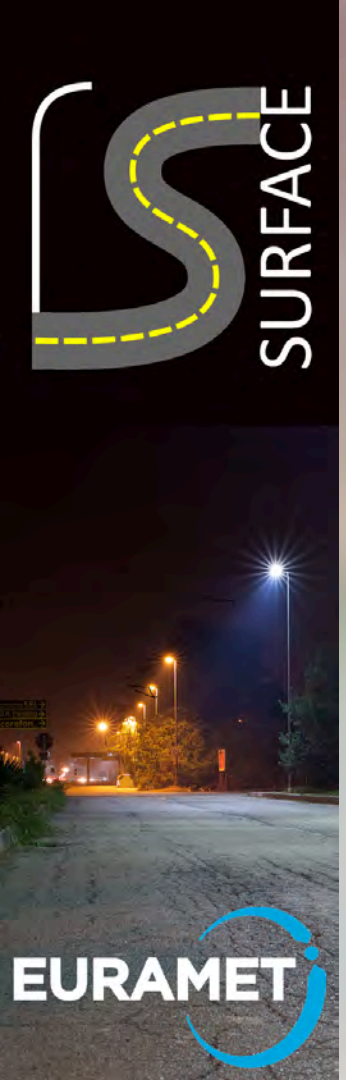
Commission Internationale de l'Éclairage

ZUMTOBEL

More than 40 Stakeholders



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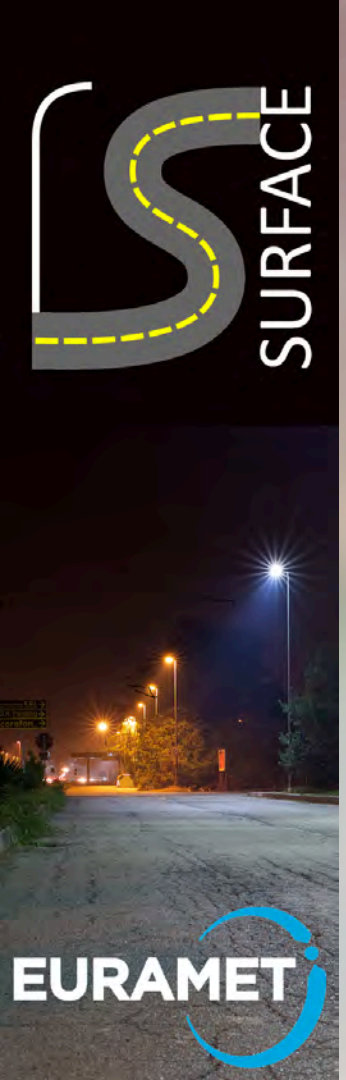
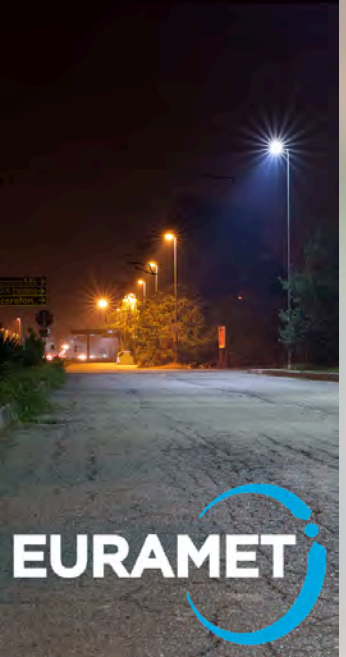


Objectives

1. optimised **measurement geometries** for *q* (*r*) coefficient (WP3)
2. **technical** and **metrological specifications** for instruments (WP1)
3. pre-normative **guidelines** for **measurement methods** and **procedures** (mesopic conditions, obtrusive light, and light pollution) (WP3)
4. pre-normative **guidelines** for **road characterisation** (aging, wet conditions, spectral properties, adaptive lighting systems, luminous intensity distribution, uncertainty in tolerance) (WP3)
5. contribute to works of **CEN TC169/WG12** and **CIE TC4-50** (WP3, WP4)



16 NRM02 SURFACE IMPACTS

EU 2020 ACTION

$5{,}5\ 10^6$ km

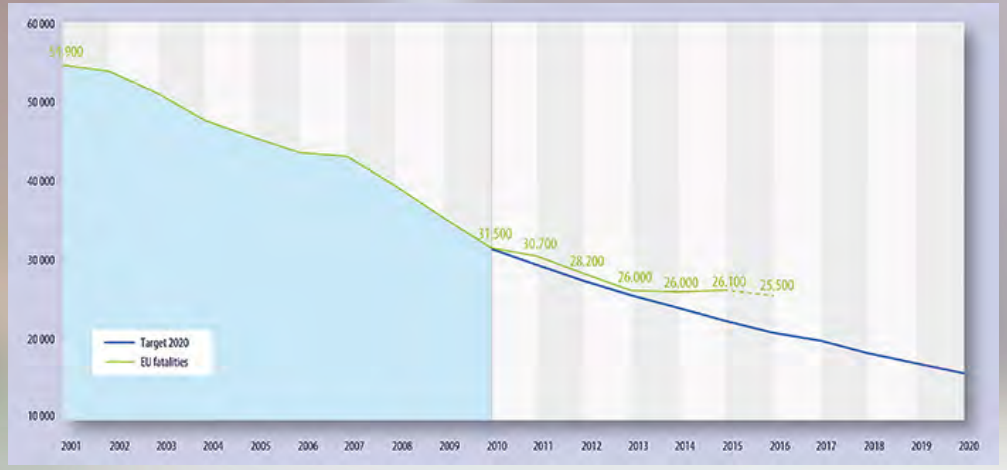
40% road lighting

50 % of city energy

70% OFF

PAVEMENT SURFACE CHARACTERISATION FOR **SMART** AND **EFFICIENT** ROAD LI

16 NRM02 SURFACE IMPACTS

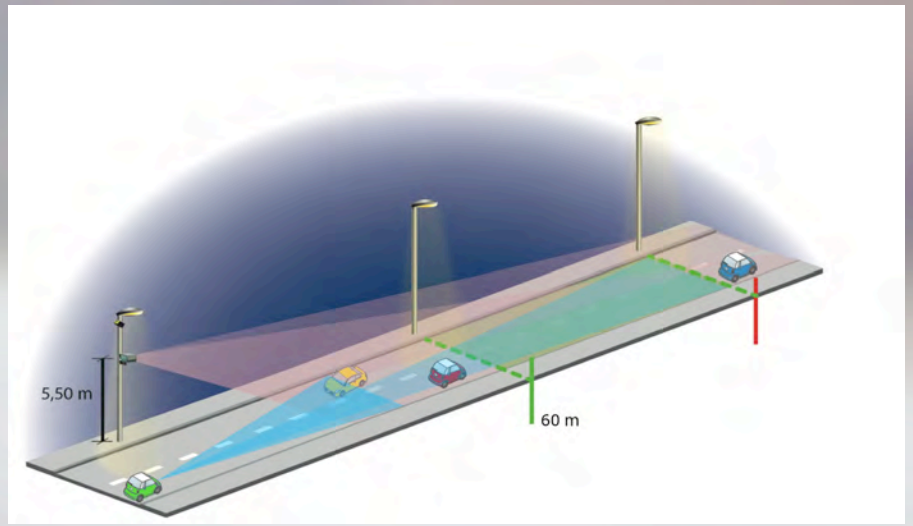


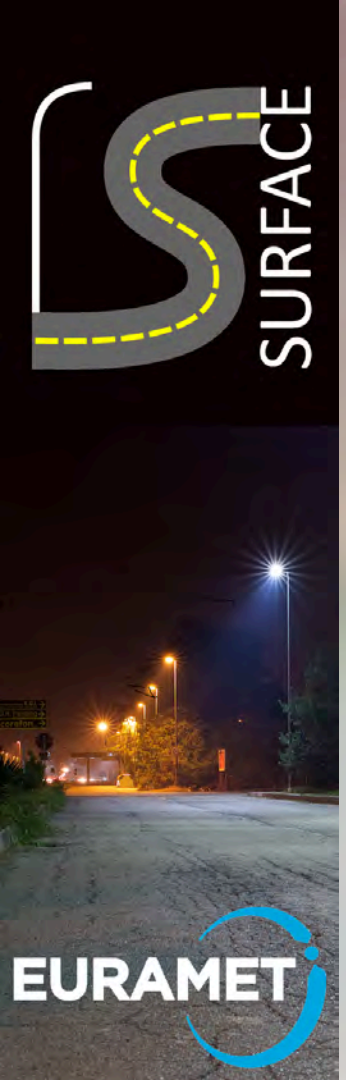
8 % Motorway

37 % Urban areas

55 % Rural roads

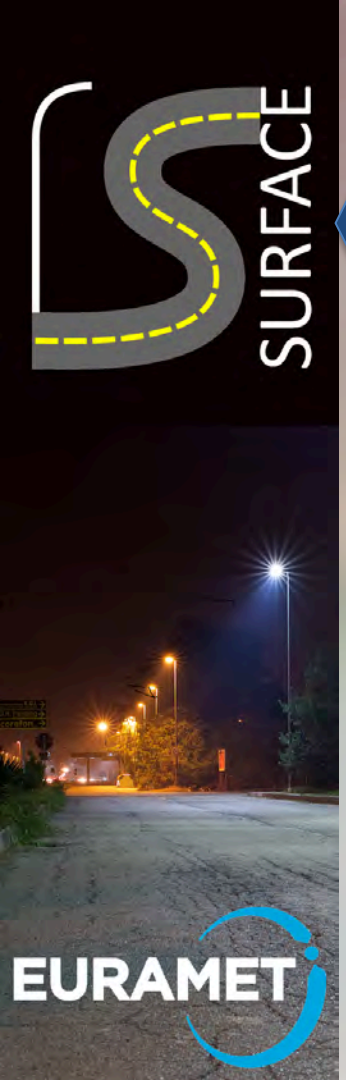
Smart lighting





Relevant objective	Deliverable number	Deliverable description	Deliverable type
1	D1	Report on photometric quantities for road surface materials to support EN 13201 reference tables.	Report
1	D2	Report on optimised geometries in real conditions for the characterisation of photometric quantities for road surface materials to support CIE TC4-50 actions, EN 13201 and its future revisions.	Report
2	D3	Specification document for using Reference Materials to establish traceability and evaluate measurement uncertainty for instruments used to measure luminance and reduced luminance coefficients of road surfaces.	Specification document
2	D4	Report on the intercomparison of reference materials used to measure luminance and reduced luminance coefficients of road surfaces in the laboratory and on-site software for q measurement uncertainty evaluation (target uncertainty (2 – 10 %).	Report
3	D5	Pre-normative guidelines for measurement methods and procedures, including spectral properties, effects of measurement uncertainty in tolerance calculations obtrusive light and light pollution of road lighting installations.	Guidelines
4	D6	Pre-normative guidelines for photometric characterisation of road and pavement surfaces, including aging of road surfaces, wet conditions, mesopic visual conditions, and adaptive lighting systems (smart lighting).	Guidelines

SURFACE
EURAMET
WP 1
INSTRUMENTS
WP 2
APPLICATION
WP 3
DATABASE
GUIDELINES
WP 4
IMPACT

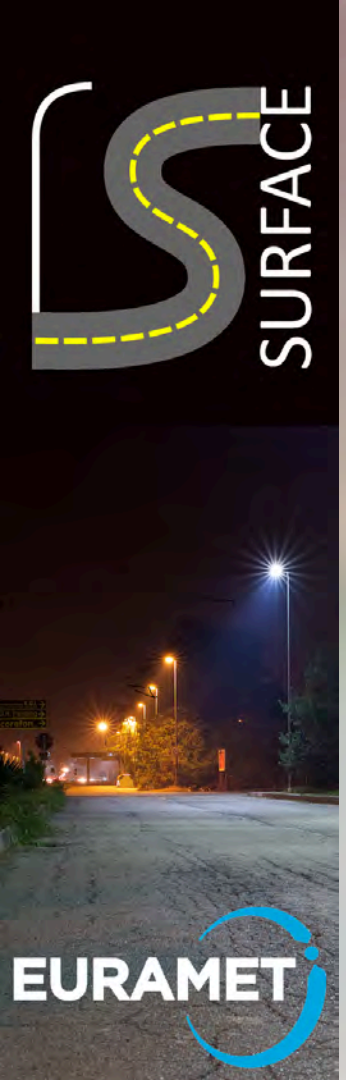


WP 1
INSTRUMENTS

Metas leadership
Peter Blattner

WP1 highlights

- Reference materials
- Intercomparison
- TRACEABILITY of data
- Uncertainty software
- Technical specification for instruments

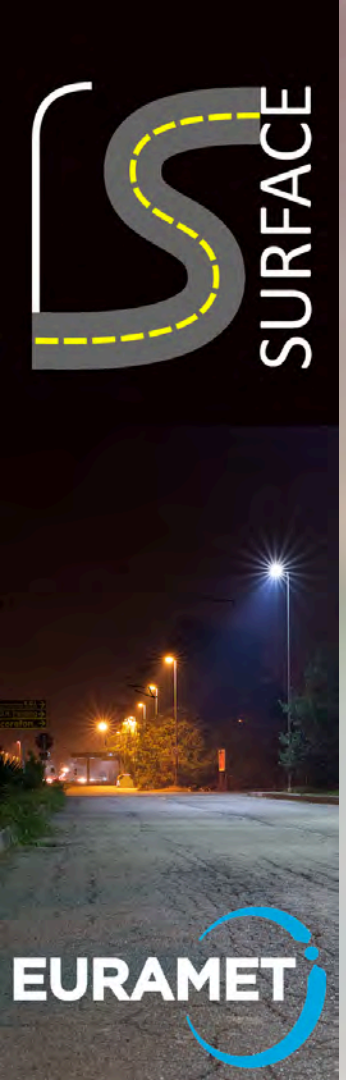


WP 2
APPLICATION

WP2 highlights

- GEOMETRIES
- Data Collection
- Instrument prototype
- Tolerances vs uncertainty

Cerema leadership
Valerie Muzet

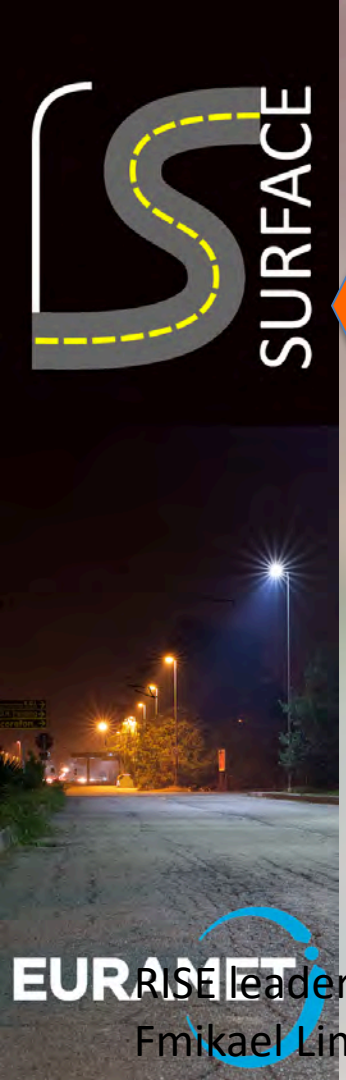


WP 3
DATABASE
GUIDELINES

WP3 highlights

AALTO leadership
Farshild Manoocheri

- Guidelines on instruments requirements
- Guidelines on measurement procedures
- Guidelines on additional aspect (mesopic aeging, wet surfaces, adaptive lighting system)
- Database of q data in current r-table
- Database of q in new r-tables

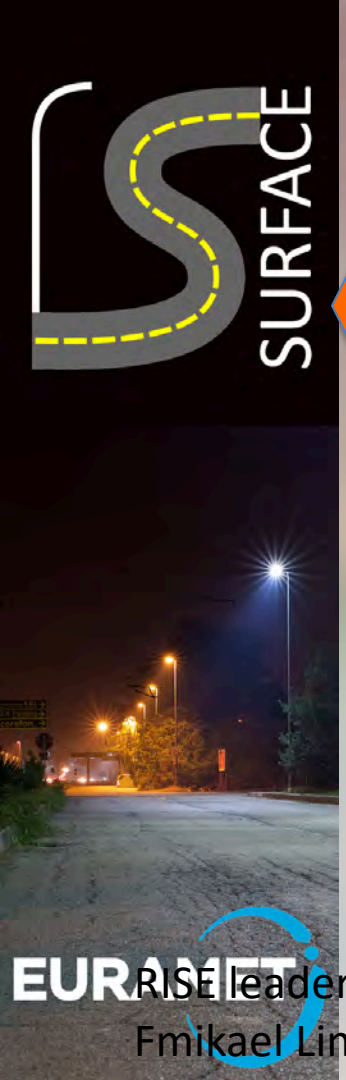


WP 4
IMPACT

WP4 highlights

1. CIE
   - TC4-50: Road Surface Characterization for Lighting Applications
   - TC 4-51: Optimizing of Road Lighting
2. CEN TC169/WG12,
   - EN 13201 revision and new edition
3. National SDO
4. Brochure / national level
5. PIARC

RISE leadership
Fmikael Lindgren



WP 4
IMPACT

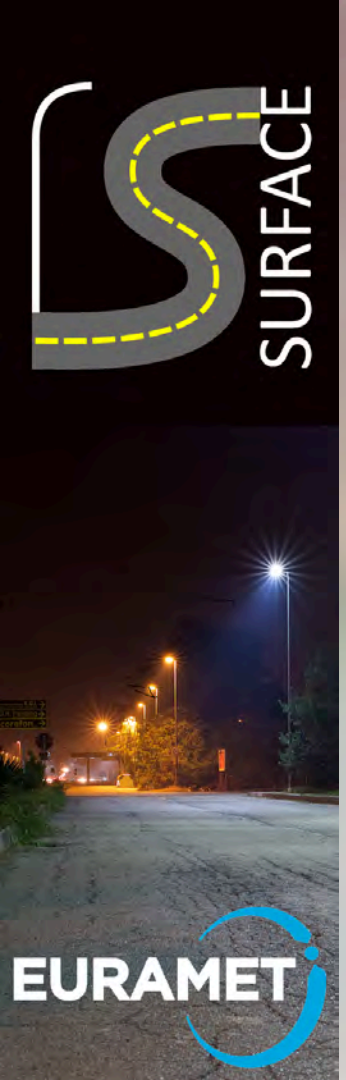
WP4 highlights

Consortium meeting in Optis November 2018

Next Stakeholder meeting

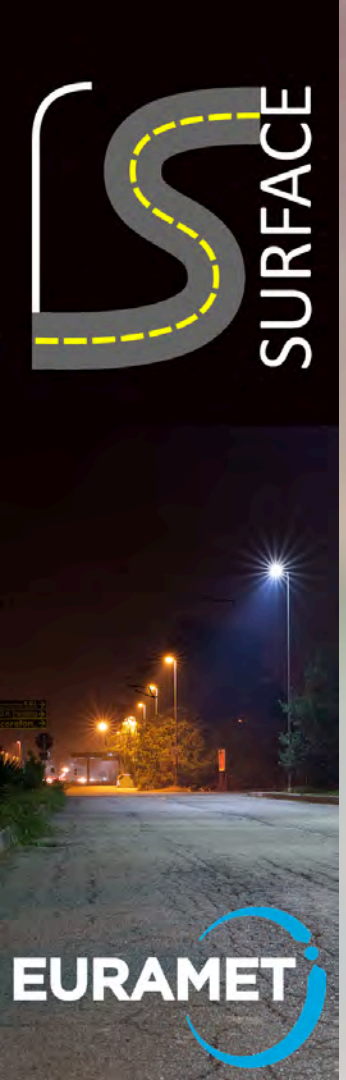
Final Event @CEREMA June 2020 workshop on road surface, call for abstract

RISE leadership
Fmikael Lindgren



ROAD TO SUCCESS

- Standardization body support
- NMI - INDUSTRY consortium
- Industrial support
- **Stakeholder**
- **Collaborators**



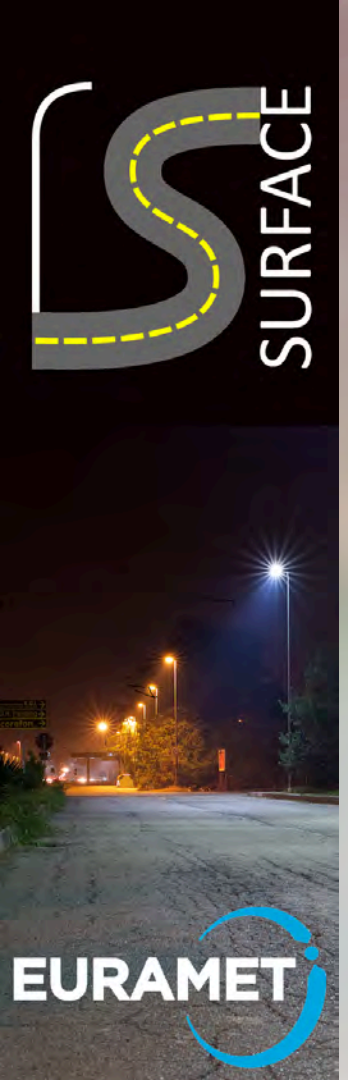
STAKEHOLDER

- Interested entities **general topics** of the project

- Stakeholder Committee
- Will receive update information
- Got the chances to attend stakeholder meetings and interact with consortium
- No commitments nor $

COLLABORATOR

- Interested entities **general and <u>specific</u> topics** of the project
- **It signs a letter of agreement**
- Stakeholder Committee
- Will receive update information
- Got the chances to attend stakeholder meetings and interact with consortium
- No commitments nor $



LETTER OF AGREEMENT

JRP16NRM02-Consortium
Represented for the purpose of this Letter of Agreement

by the Coordinator

Paola Iacomussi
Istituto Nazionale di Ricerca Metrologica
Str. Delle Cacce 91, 10135 Torino, Italy
Phone: +39 011 3919 228
e-Mail: p.iacomussi@inrim.it

To the Collaborator

……. (*Name of Institute/Organisation)'*
Address

CONCERNING COLLABORATION IN THE FIELD OF …… (*specifying collaboration field*)

Dear … (*Contact of Collaborator*)

This LETTER confirms the agreement and the relationship between the JRP16NRM02-Consortium, represented by the Coordinator and (Name of Collaborator), detailing the responsibilities of collaboration in the field of ……

The 16NRM02-Consortium and (Collaborator), in the following referred to as "Correspondents" shall indicate their agreement by signature of this LETTER, with the arrangement running until 30 June 2020.

The JRP16NRM02-Consortium is conducting a research project in the frame of the European Metrology Programme for Innovation and Research (EMPIR). EURAMET e. V. is the dedicated implementation structure for EMPIR.

The Collaborator has advised the Consortium that their organisation is also active in the relevant field of research and expressed an interest in collaborating with the Consortium.

The collaboration addressed in this LETTER is complementary to the JRP16NRM02-Grant Agreement between EURAMET and the JRP16NRM02-Consortium and shall not be regarded as part of that agreement or vice versa. The Coordinator is acting as the intermediary between the Collaborator and the JRP16NRM02-Consortium.

PURPOSE OF COLLABORATION

The expected relevant activities undertaken by the JRP16NRM02-Consortium are defined in the attached Annex 1.

The expected relevant activities undertaken by your organisation (the "Collaborator") are defined in the attached Annex 2.

Sharing appropriate information related to the activities in the field of research would have clear benefits for (Collaborator) and the JRP16NRM02-Consortium. Therefore, for the collaboration to be meaningful the Correspondents shall endeavour:

1. to perform and fulfil, promptly, actively and on time, all stated intentions, including in particular the submission of sufficient information to each other to enable meaningful reporting of the collaboration conducted under this LETTER.
2. to notify each other promptly of any significant problem and delay likely to affect the intended collaboration and to use reasonable endeavours to ensure the accuracy of any information or materials it supplies hereunder and promptly to correct any error therein of which it is notified.

Any activities under this LETTER shall be subject to the availability of appropriate funds, personnel and other resources. Each party of this LETTER shall bear the costs it will incur in connection with the implementation of this collaboration.

CONFIDENTIALITY

A prerequisite for successful collaborating in the field of research specified above is the sharing of information, including but not limited to written documents, data carriers, drawings, devices and software.

The Correspondents may use any information obtained within the activities conducted pursuant to this LETTER for the purpose of this collaboration and for non-commercial purposes. The providing correspondent retains ownership of the transferred information.

The Correspondents undertake to treat confidentially all information exchanged under this LETTER which is clearly identified as confidential or which is of a proprietary nature. They shall protect such confidential information against the risk of unauthorised disclosure and undertake

- not to use confidential information otherwise than for the purpose for which it was disclosed;
- not to disclose confidential information to any third party without the prior written consent by the disclosing correspondent;
- to ensure that internal distribution of confidential information shall take place on a strict need-to-know basis; and
- to return to the disclosing correspondent on demand all confidential information which has been supplied including all copies thereof.

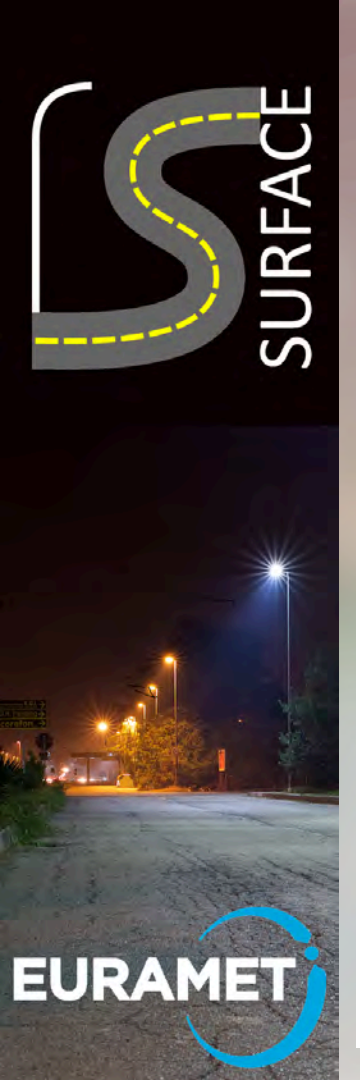
The confidentiality and non-use provisions shall not apply to any confidential information which:

- is given to EURAMET, the EURAMET Management Support Unit, and the European Commission insofar as needed for the proper carrying out of the contractual obligations in respect of EMPIR;
- is already known to the receiving correspondent at the time of receipt;
- is or becomes public knowledge otherwise than through default on the part of the receiving correspondent;
- must be disclosed by the receiving correspondent pursuant to a legal obligation;
- is no longer confidential as subsequently informed by the disclosing correspondent to the recipient.

The provisions regarding confidentiality shall terminate three years after the termination of the JRP16NRM02-project.

USE OF RESULTS

If any results or findings capable of being protected are generated within the scope of the collaboration between the Correspondents in the field of research specified above, the use, the application for protective rights and the exploitation shall be settled in the individual case and by mutual written agreement between the JRP16NRM02-Consortium and the Collaborator.



The Correspondents agree to respect their individual Intellectual Property Rights.

PUBLICATIONS

Publications are to be agreed in writing, and the research collaboration is to be clearly referred to.

GENERAL OBLIGATIONS

The Collaborator agrees that EURAMET or anyone acting on EURAMET's behalf may contact the Collaborator to gather information about the experiences of involvement in the collaboration and any benefits the organisation has gained.

The relationship between the JRP16NRM02-Consortium and the Collaborator established by this LETTER is that of independent collaborators. This LETTER does not create a partnership or agency between the Correspondents.

Either the JRP16NRM02-Consortium or the Collaborator may terminate this collaboration at any time upon written notice to the other. Activities in progress on the date of such written notice may proceed to completion. In the event of termination, the Correspondents shall remain bound by the provisions regarding confidentiality with respect to any information obtained.

The JRP16NRM02-Consortium, including the Coordinator shall not be liable to the Collaborator and vice versa for damages caused in the scope of the collaboration unless such damages are caused intentionally or by gross negligence.

Yours sincerely,

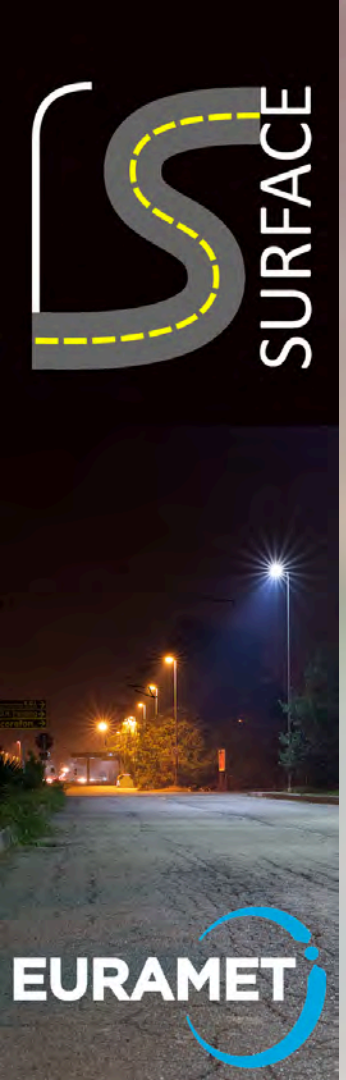
Place & Date	Signature of the JRP16NRM02-Coordinator

The foregoing is accepted by ... (*Name of Collaborator*) and therefore in this reply I confirm that this LETTER together with its Annexes constitutes the mutual acceptance of the provisions of the foregoing.

Yours sincerely,

Place & Date	Signature of the Collaborator

Annex 1 (Activities of Consortium)
Annex 2 (Activities of Collaborator)

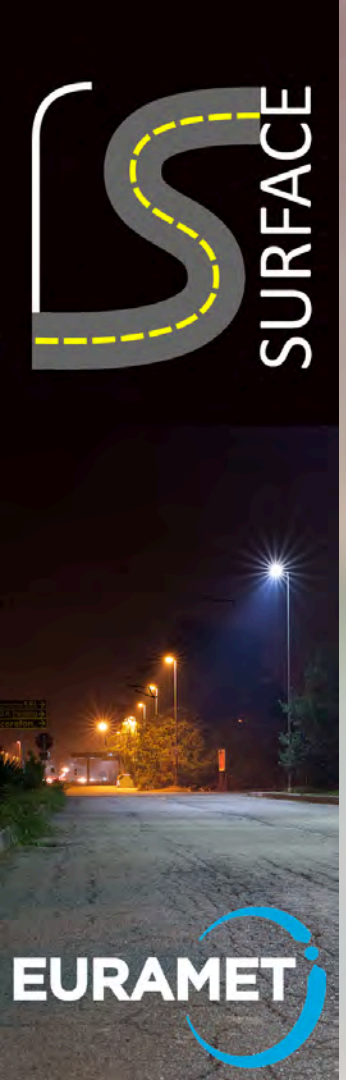


Agenda

14:00 – 15:30 Part 1

Overview and first acheivements

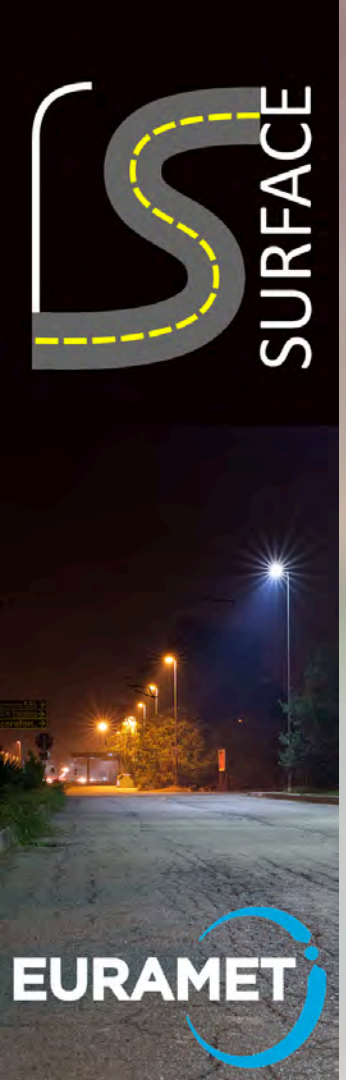
- **Overview of the project**
  P. Iacomussi
- **WP 1**
  J. Reber
- **WP2**
  V. Muzet



Steakholder Meeting
WP1: Instruments

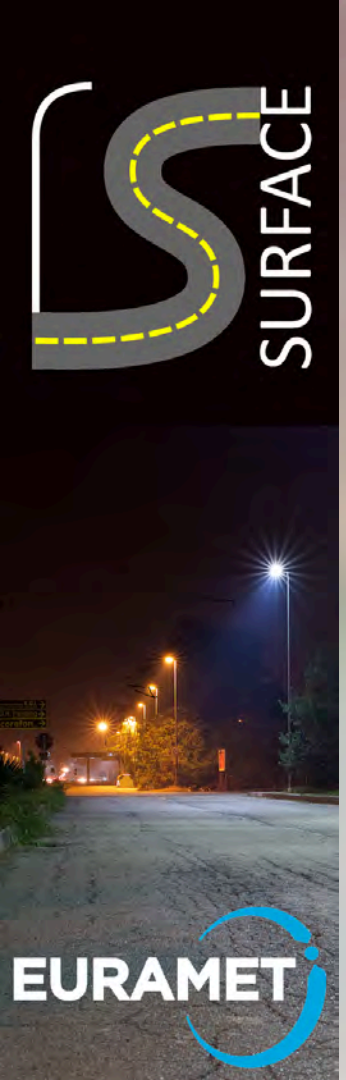
Peter Blattner & Jürg Reber

Berlin, 25.05.2018



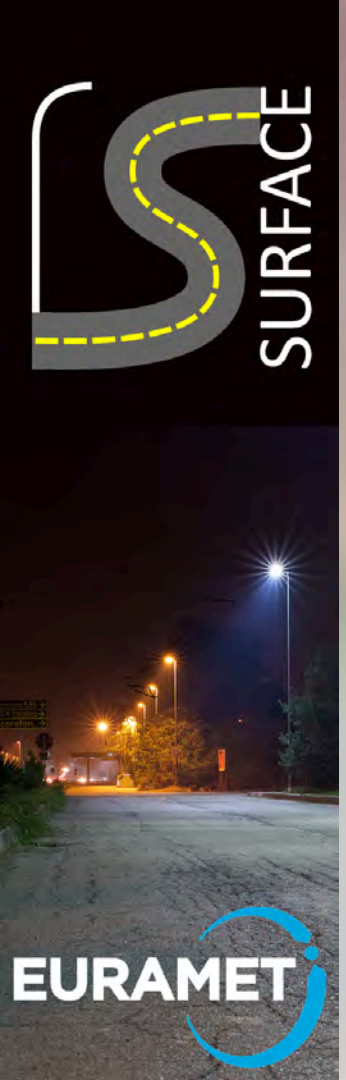
WP1: Instruments

The aim of this work package is to produce technical and metrological specifications for instruments used to measure luminance of road surfaces in laboratories or on-site



Tasks in WP 1

- Task 1.1: Laboratory measurement methods
  (review -> summary -> guidance)
- Task 1.2: On site measurement methods
  (review -> summary -> guidance / standard method)
- Task 1.3: Traceability & uncertainty
  (reference material, MU-model, comparison)
- Task 1.4: Influence of spectral distribution



Database of existing measurement devices

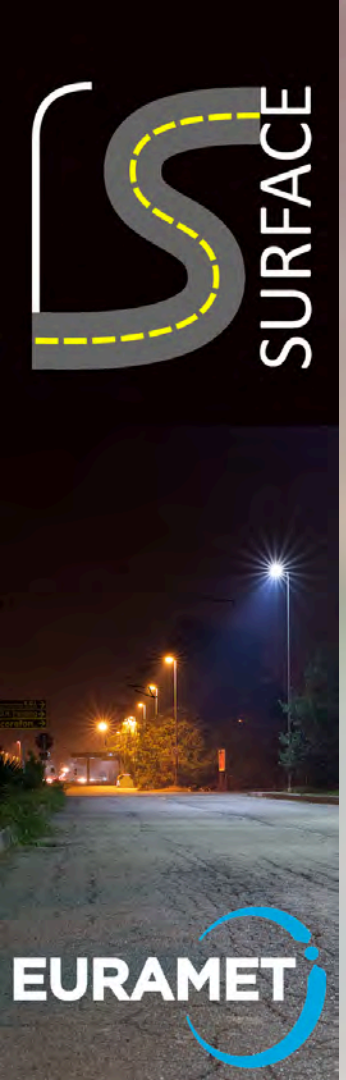
Definition of parameters

SURFACE WP 1- List of instruments - Definition of Parameters V1.1	
General	
	Manufacturer (Company / Institution,…)
	Model
	commercially available, prototype, lab-setup
	year of construction
	Measuremet method (scanning source, multi angle,…)
	Geometry (measurement field vs illumination field)
	Sample size (min, max,…)
	Volume of the instrument
	Weight
	Prize
	Software
	Interface

Parameters(2)

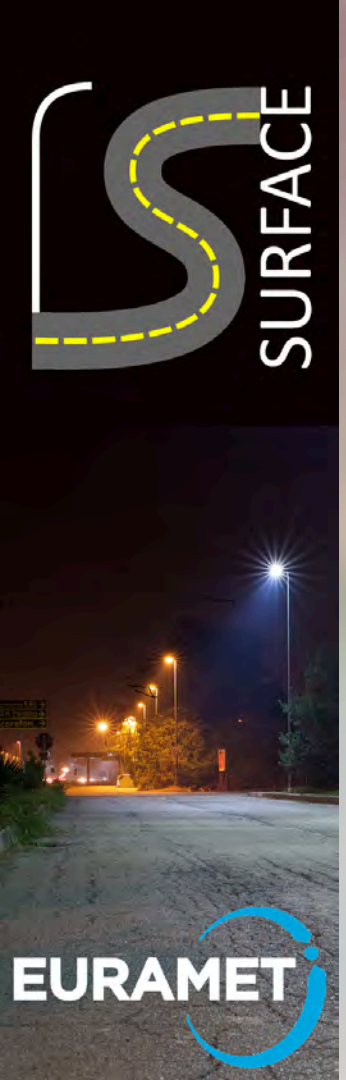
Usage	
	on-site use / laboratory use?
	Condition of use (temperature range, etc)
	Power-supply
	Frequency usage
	Portablility, Fixed, hand carry,…
	Installation time
	Measurement time
Output (Measurand)	
	Q0
	Qd
	S1
	S2
	r-table
	Range measurands (typically expressed in sr-1)
	File format of results

Light source	
	source type, event. spectral distribution
	dc/ac/pulsed
	light output monitoring / regulation?
	Number of light sources
	illumination range (lx,…)
Detector	
	detector type
	spectral V(lambda) match, f1'
	linearity (f3)
	measurement range (expressed in cd/m2,...)



Parameters(3)

Angles	
	Observation angle(s), alpha
	Observation angle(s), beta
	Illumination angle (s), gamma
	Illumination angle (s), delta
	Angular substent of source (size of source as seen from sample
	Angular substent of detector (size of detector as seen from sar
Distance/Sizes	
	Measurement field size
	Illumination field size
	Distance Sample to detector
	Distance source to sample
Uncertainty and traceability	
	Declared Uncertainty of measurand(s)
	Declared Uncertainty in angle
	Traceability (incl. Methodology)

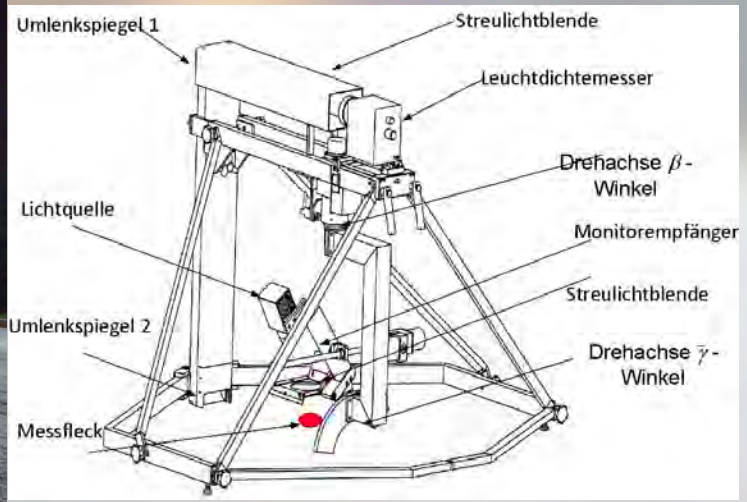


List of instruments

METAS: LTL-200
METAS: MoFOR
METAS: LaFOR
LCPC/ CETE/ CECP (Cerema): Coluroute with optical fibers
LCPC/ CETE/ CECP (Cerema): Coluroute with LED sources
Cerema : Coluroute2
Cerema Clermont-Ferrand: Goniophotometer
IFSTTAR : custom
Technical University of Sofia
Zhejiang University
DELTA : Mobile reflectometer QD30
University of Padova: Portable gonio-reflectometer
LUT – Lappeenranta Univ. of Tech. (Finland): Mobile reflectometer
Moscou Power Engineering Institute: 2 gonioreflectometer
University of Helsinky: ???
University of Dresden: ??? ……. Please help!!!

METAS-MOFOR

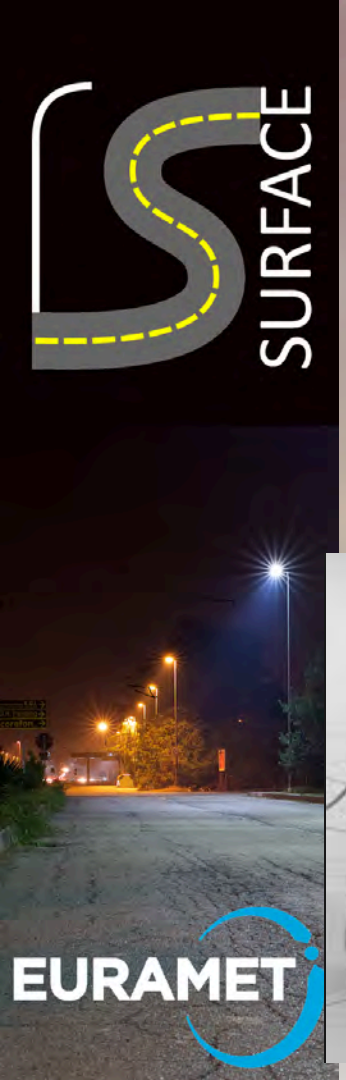
-Observation angle: 1°
-Illumination angles up to gamma = 85°
-Measurement field: 11 cm x 9 cm

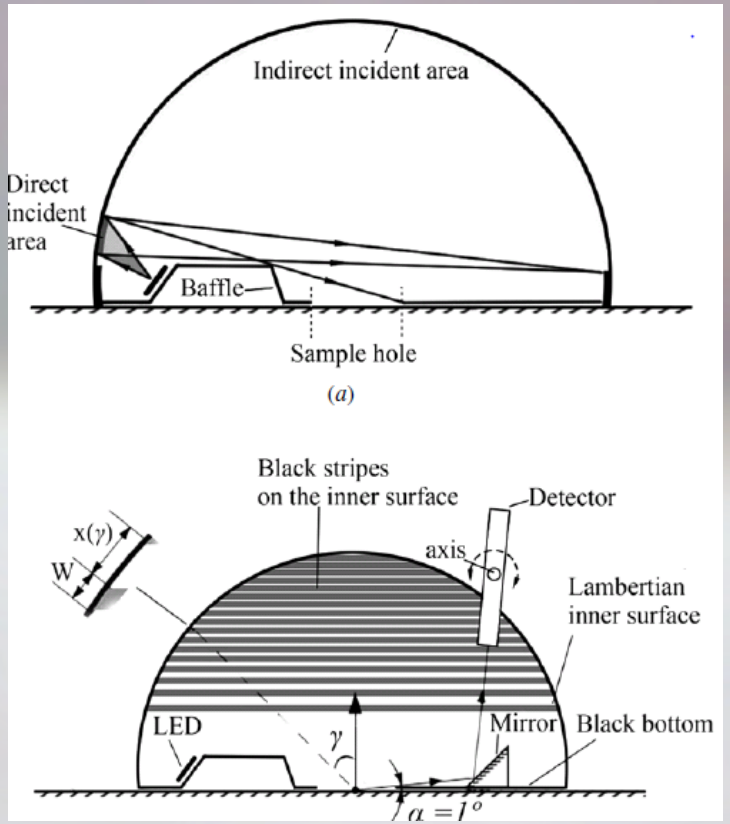


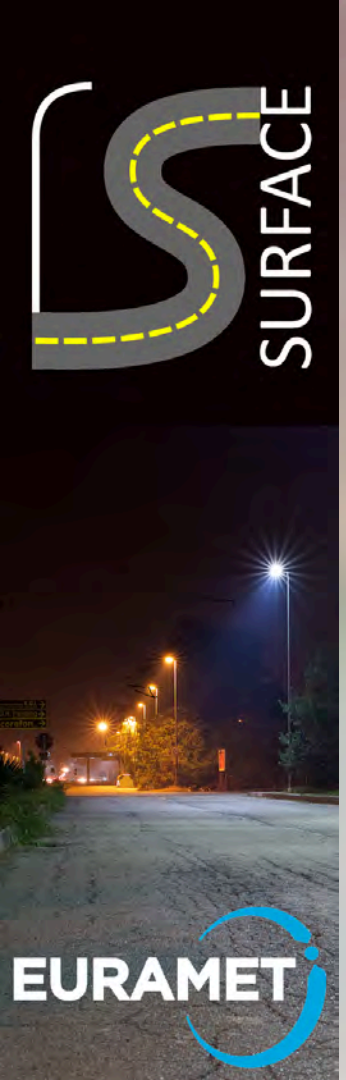
CEREMA: Coluroute

(http://www.ouest.cerema.fr/IMG/pdf/06-_Outil_Coluroute_cle0dc19a.pdf)

- Zhejiang University: http://iopscience.iop.org/article/10.1088/0957-0233/25/3/035203





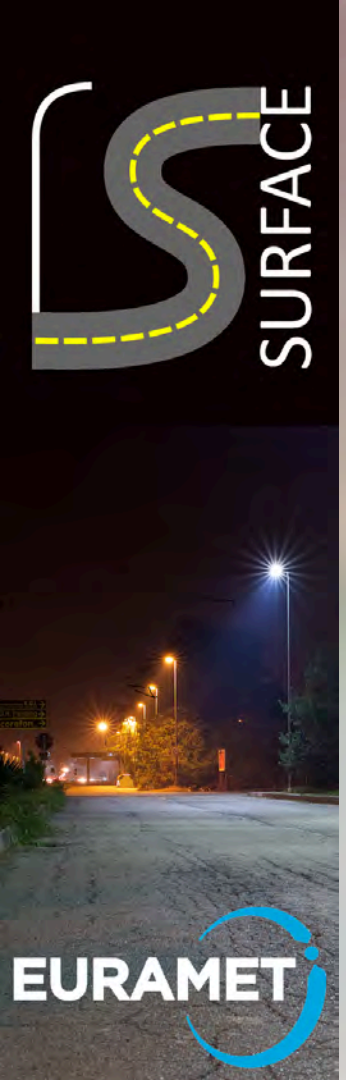


Influence of the light source spectrum of instruments

Task 1.4

Study of the effect of the light source spectrum on the determination of luminance coefficient of pavements

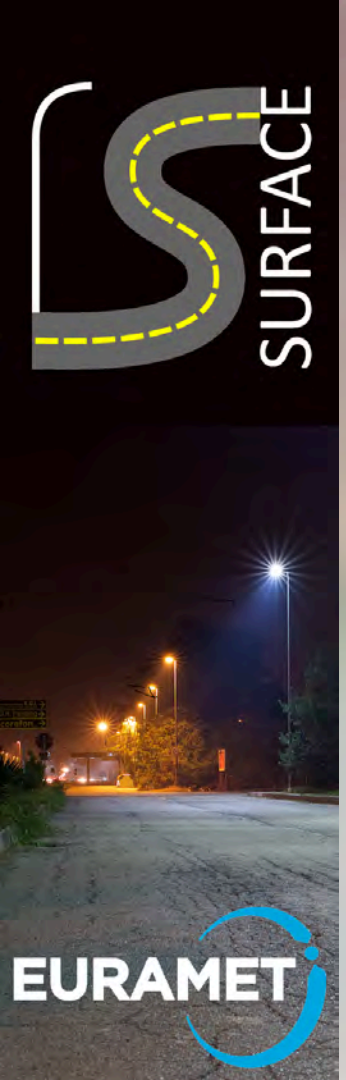
(D.RENOUX – LNE / V. MUZET CEREMA)



Influence of the light source spectrum - s1

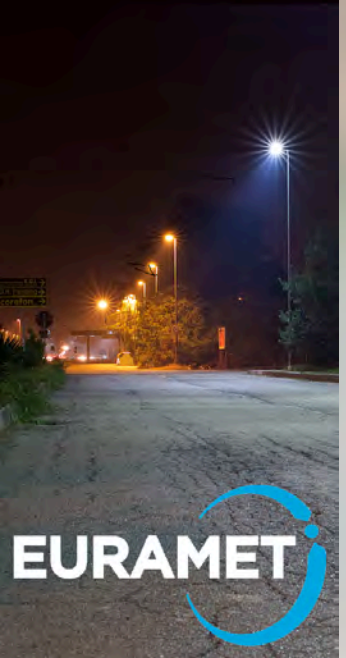
The study is developped on data considering :

1. Review of spectral characteristics of road and general lighting
2. Review of spectral characteristics of pavements
3. Review of light sources of instruments
4. Future CIE illuminants based on LED technology



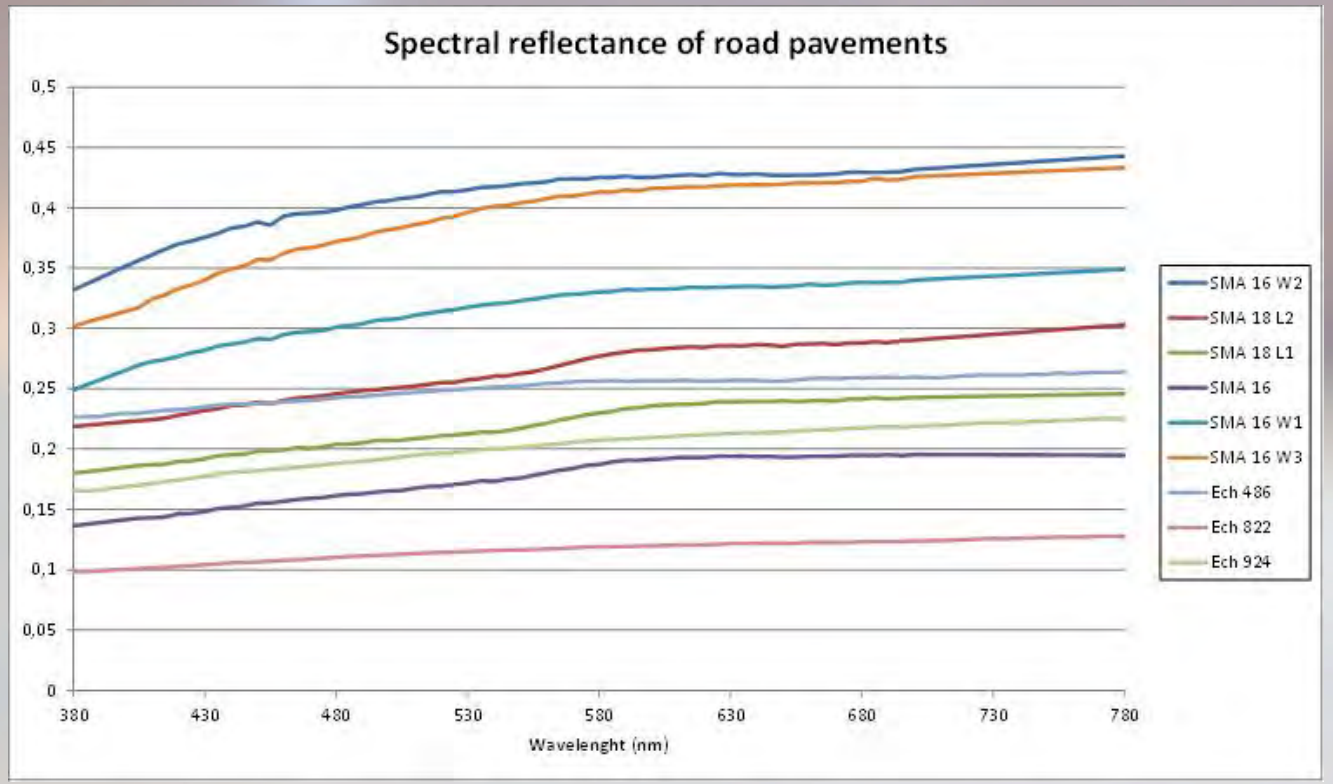
Influence of the light source spectrum – s2

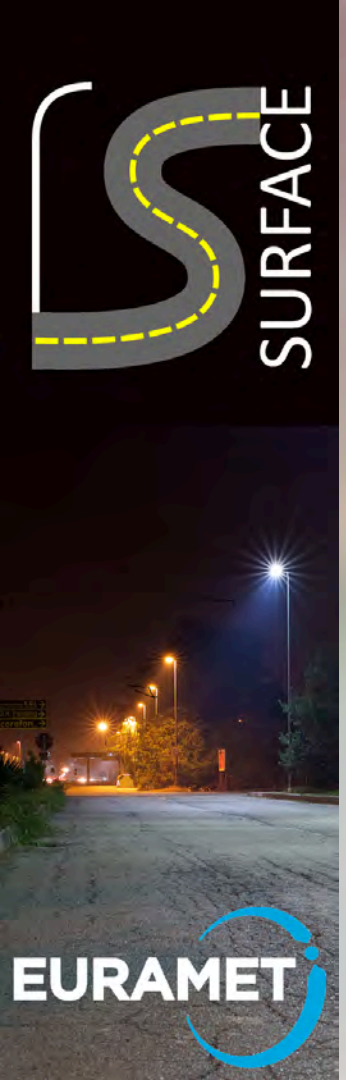
1. Lighting spectral power densities: 185 representatives SPD from lab measurements, standards, publications, manufacturer specifications ,..)
2. Spectral reflectances of pavements: collected from two sources (IFSTTAR measurements, A. Ekrias study).



Influence of the light source spectrum – s3

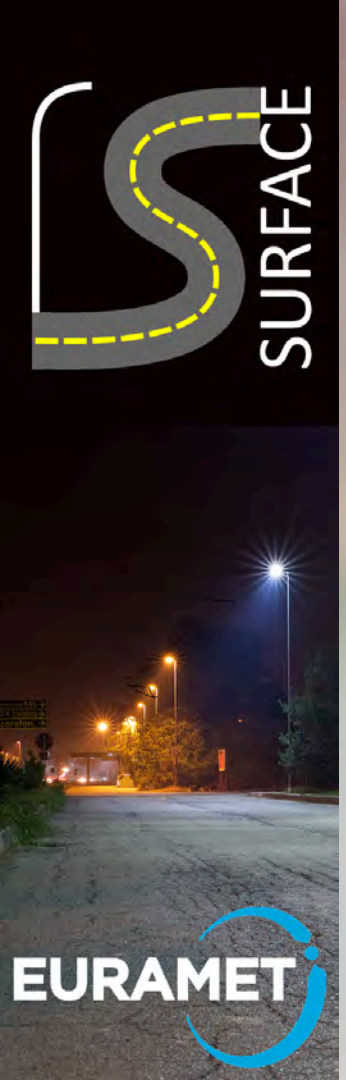
Spectral reflectances of pavements of the study





Influence of the light source spectrum – s2

1. Lighting spectral power densities: 185 representatives SPD from lab measurements, standards, publications, manufacturer specifications ,..)
2. Spectral reflectances of pavements: collected from two sources (IFSTTAR measurements, A. Ekrias study).
3. Light source instruments reviewed: halogen (~10 instr.) , Led (~ 8 instr.), HPS (1 instr.), MH (2 instr.).
4. Future CIE Illuminant (LED based):CIE will publish soon an update of publication n°15 - Colorimetry – which will include a set of typical LED spectra. Out of this set the reference spectra LED-B3 which has a CCT of about 4000 K has been considered for this presentation.

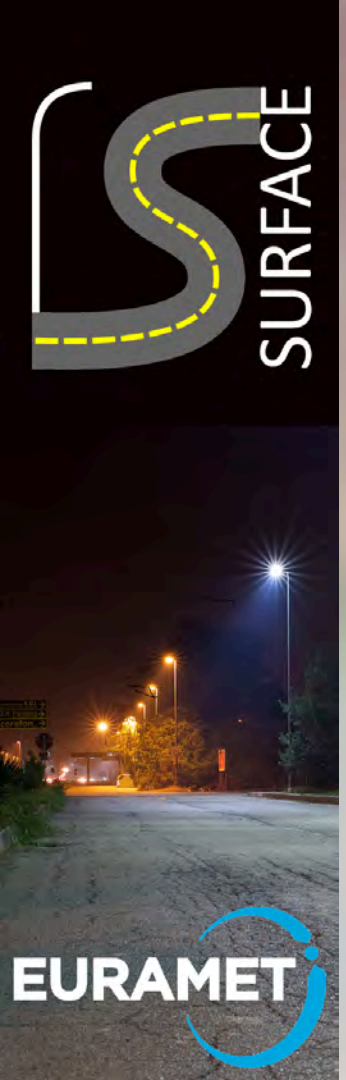


Influence of the light source spectrum – s3

To compare light source spectra effect we used *relative luminance coefficients* computed with the following formulae :

$$Cr = \frac{\int_{380}^{780} R(\lambda) \times SPD\ (\lambda) \times V\ (\lambda) \times d\lambda}{\int_{380}^{780} SPD(\lambda) \times V\ (\lambda) \times d\lambda}$$

- $V\ (\lambda)$: CIE spectral luminous efficiency
- $SPD(\lambda)$: Relative spectral power density of the light source
- $R(\lambda)$: spectral luminance coefficient of the pavement.



Influence of the light source spectrum – s4

With the 185 lightings as light sources instrument: computation of the average luminance coefficents and chart of the cumulated deviations from the average coeff

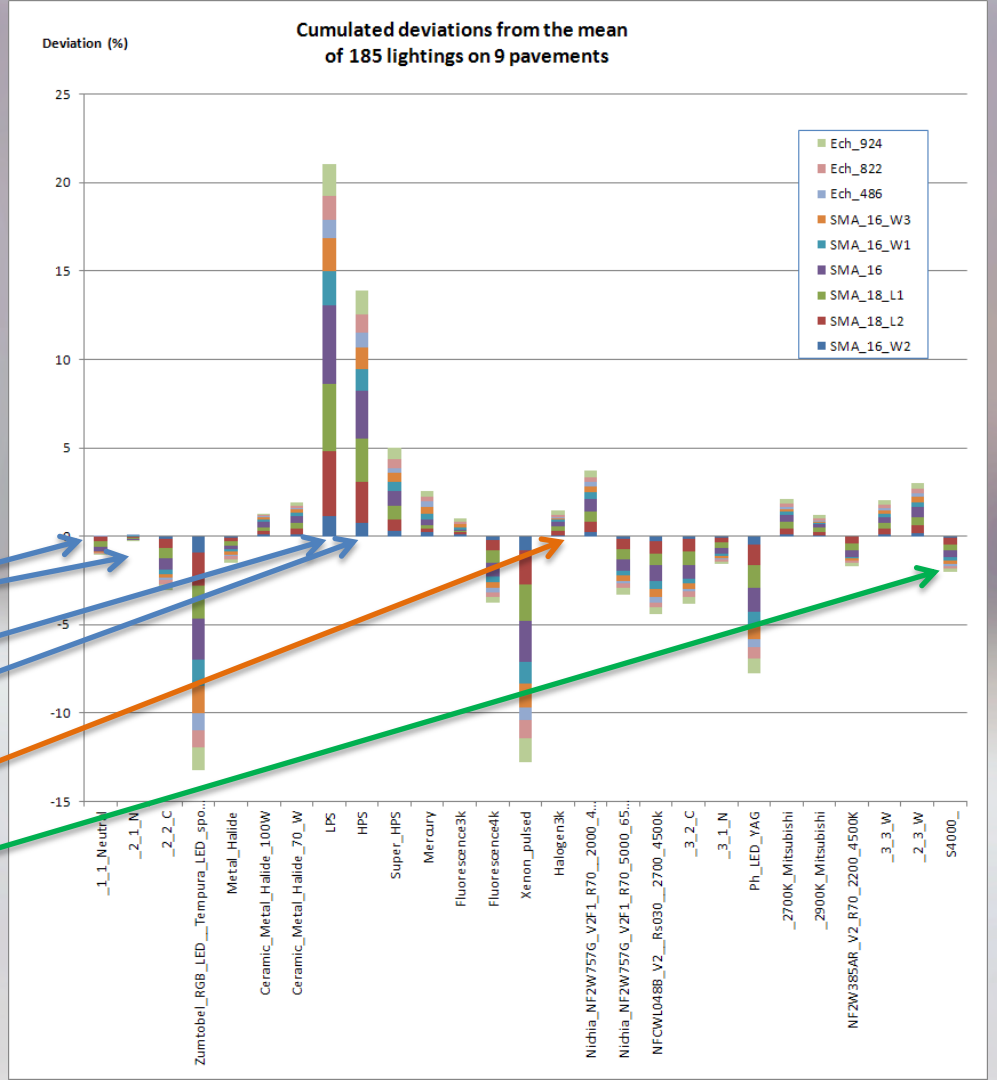
Neutral LED

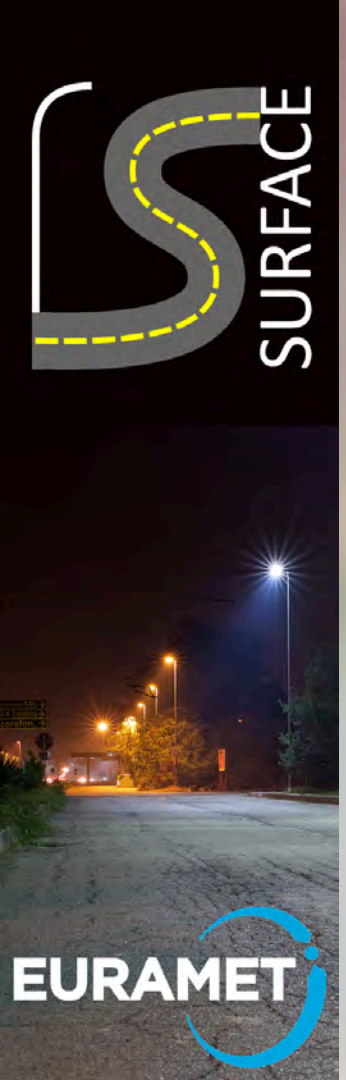
LPS

HPS

Halogen

LED-B3



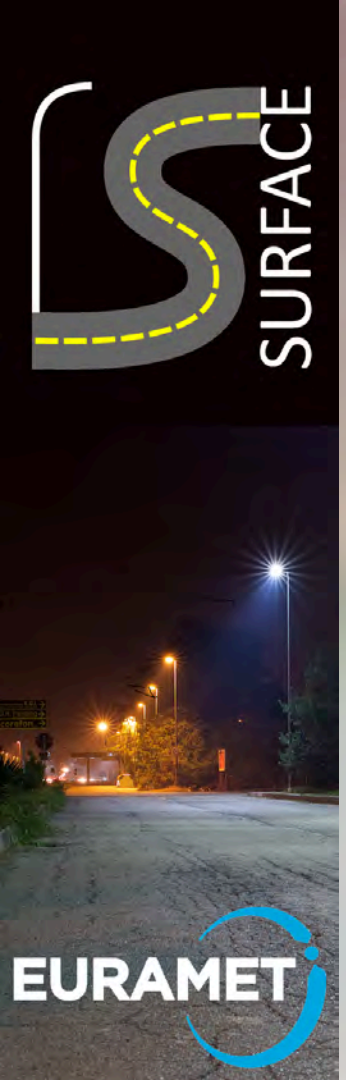


Influence of the light source spectrum – s5

It is observed from the previous chart that neutral LEDs (1_1_neutral, 2_2_C, S4000) provide low deviations for a large panel of lightings, then leading to low discrepenacies for general and road lighting.

For integration in a measuring instrument the LED-B3 is compared to other reviewed instrument light sources, and deviations are given in the table bellow. Deviations are weak (<1%).

Deviation %	Reference instrument						
Instrument	LED-B3	Illuminant A	Metal_Halide	Super_HPS	Fluorescence4k	_1_1_Neutral	_2_2_C
LED-B3	X	0.38	0.07	0.78	0.19	0.11	0.11
Illuminant A	0.39	X	0.33	0.39	0.58	0.28	0.50
Metal_Halide	0.07	0.33	X	0.72	0.25	0.09	0.17
Super_HPS	0.78	0.40	0.73	X	0.98	0.68	0.90
Fluorescence4k	0.19	0.57	0.25	0.97	X	0.30	0.08
_1_1_Neutral	0.11	0.28	0.09	0.67	0.30	X	0.22
_2_2_C	0.11	0.49	0.17	0.89	0.08	0.22	X

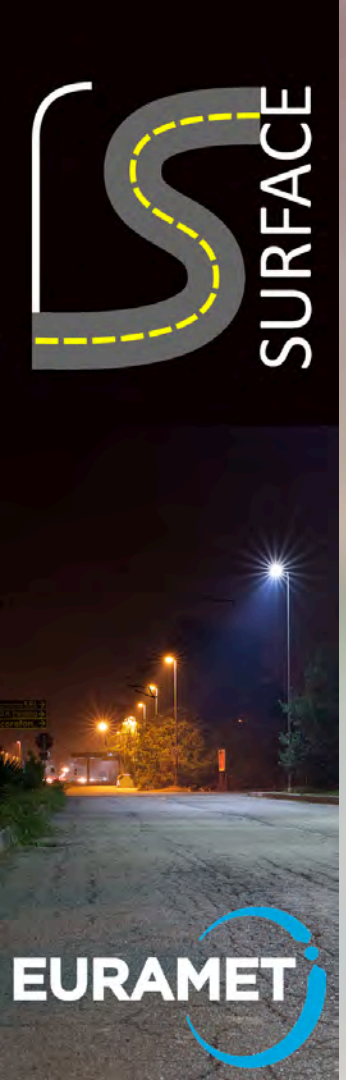


Influence of the light source spectrum – s6

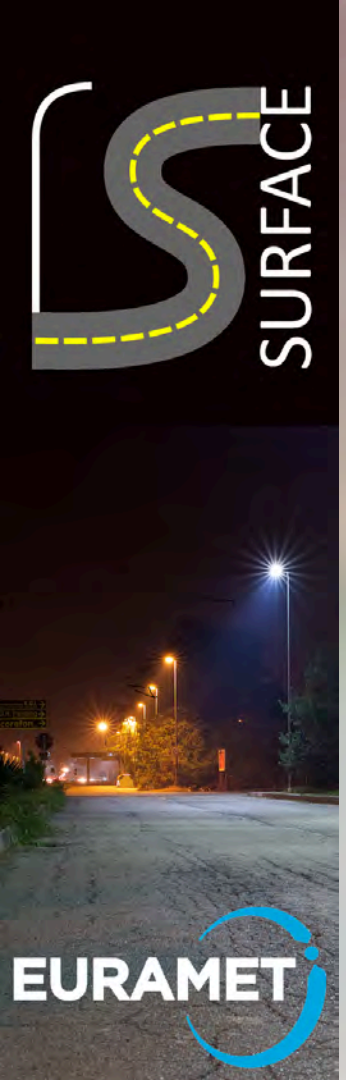
Conclusion

This preliminary study shows that a LED source with CCT ≈ 4000 K used as the reference light source for luminance coefficient measuring instruments is suitable as it would provide a comparable or even lower discrepancy with respects to other light sources.

Note: more coloured pavements can be considered but data are also missing.



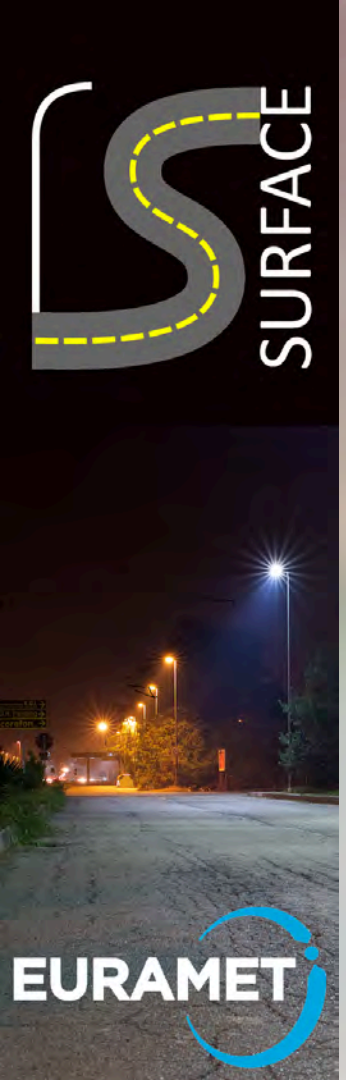
Thank you for your attention



Stakholder meeting - Part 1

Surface WP2: Applications

Valérie MUZET Cerema



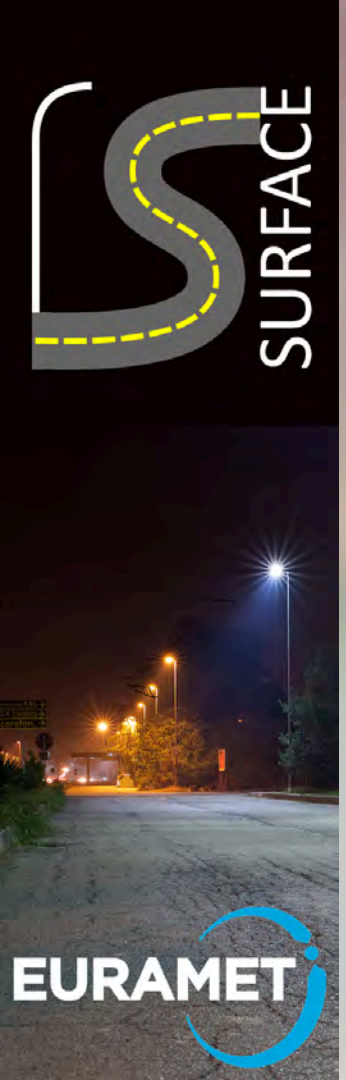
WP2 Applications

Aims:

Support current, future needs and applications in road lighting

- Improved r-tables
- New lighting and observation geometries
  - New needs (different users) and technologies
  - Metrology
- New measurements devices
- New methodology of measurements and calculations
  - Impact of new measurement geometries
  - Modification of lighting calculation software

FOCUS



Improved r-table

A2.1.1 Comparison between current CIE standards and the r-tables of widely used pavements

- History of CIE standard

Standard table	Q0	S1	S1 boundary
R1	0.1	0.25	0.42
R2	0.07	0.58	0.85
R3	0.07	1.1	1.35
R4	0.08	1.5	
N1	0.1	0.18	0.28
N2	0.07	0.41	0.6
N3	0.07	0.88	1.3
N4	0.08	1.55	
C1	0.1	0.24	0.4
C2	0.07	0.97	

The standard R tables developed by Philips (early 1970'ties) - based on a relatively small number of r-tables

Standard N tables (N1, N2, N3 and N4) developed by Sorrensen with 285 tables of LTL report n°10 1975
Tables from Denmark (148), Sweden (135), UK (2)

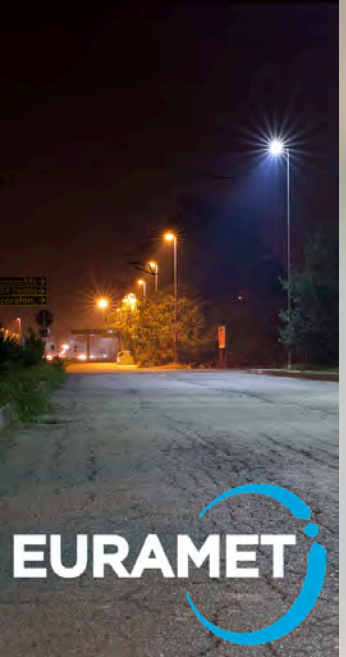
The standard C tables (C1 and C2) developed by Burghout (Dutch) with same LTL tables

Improved r-table

- Context
  - All the CIE standard r-tables are based on old data from the seventies.
  - Evolution of pavement technology
  - These data are no more representative*

- Our need
  - To collect recent r-tables from everywhere
  - To have an idea of the representativity of these table

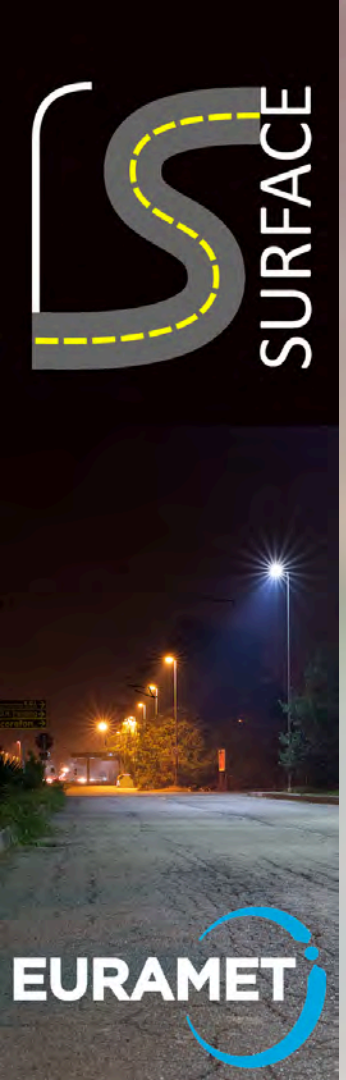
  => We are also looking for documents describing the different types of european roads and especially their percentage of occurrence.



*E. Dumont, J-L Paumier, Are standard tables R still representative of the properties of road surfaces in France ?, CIE, July 4-11 2007

Collection of tables

- French project “Revêtement et Lumière”
  - Collaboration between Lighting designers and road builders
  - Selection of bituminous, cement concrete and asphalts (classic and innovative)
  - Caracterisation at T0 and after 3 years of outside exposure



Comparison between current CIE standards and the r-tables of widely used pavements

- SURFACE actions
  - First call for tables in july 2017
  - Nearly no return, problem of data confidentiality
  - New call for tables during CIE meeting in October
  - Another call today

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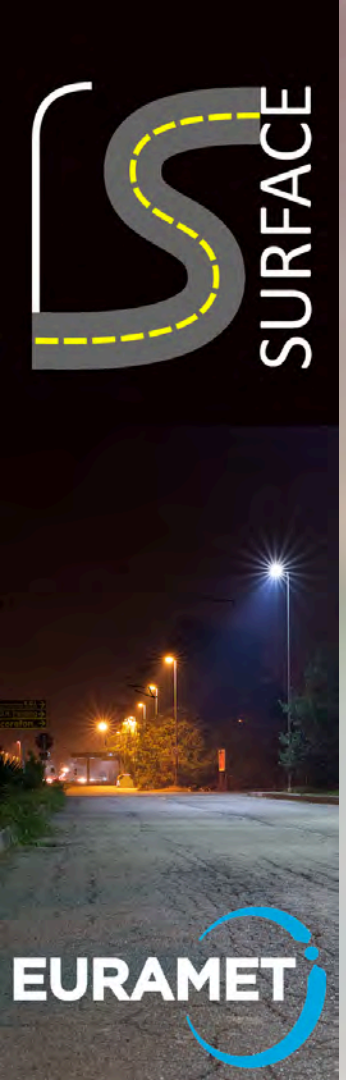
=>The tables will remain anonymous (no conflict of interest)



Collection of tables

- Our minimal needs
  - **Photometric factors: Q_0, S_1**
  - **Available description of pavement**
    - **Type of pavement**:
      aggregate (size and color), type of binder, surface treatment,…
    - **Date of measurement**, Age of the pavement
    - Localisation (**country** at least)
    - **Measurement device**

- If possible:
  - a picture
  - r-table in a text format

Format for the data

- R-table in a text format:
  - C.I.E: Table of 29x20
  - **“.rtb”** format

    used for DIALUX importation

    One column, dot separator

Fixed text	RTable.v1
Name of the data	Example
γ line number	29
Values of tan γ	0 … 12
β column number	20
Values of β	0 … 180
Q_0 value	
r values for β=0°	Value1 … Value 29
r values for β=2°	Value1 … Value 29
……	
r values for β=180°	Value1 … Value 29

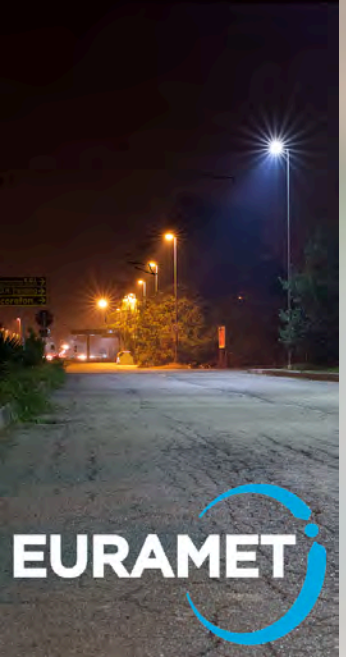
State of the data collection

Country	nb tables	Apparatus	Comments
Danemark	**285**	Danish gonio	**1975, Dry**
Danemark	**approx 200**	Danish gonio	**1975, Wet**
Finland	**17**	Finish gonio	**1980 data**
France	**71 (x3)**	Cerema gonio	**2000-2005**
Swiss	**67**	METAS - LaFOR (2017)	**Date of measures : ?**
German	**3**	Dresden TU gonio	**Date of measures ?**
France	**10**	Cerema gonio	**2005-2007, concrete**
France	**40**	Cerema gonio	**2013-2017 data**

Only old data, no data from the south of europe
What about their representativity ?

=> New call for data

SURFACE



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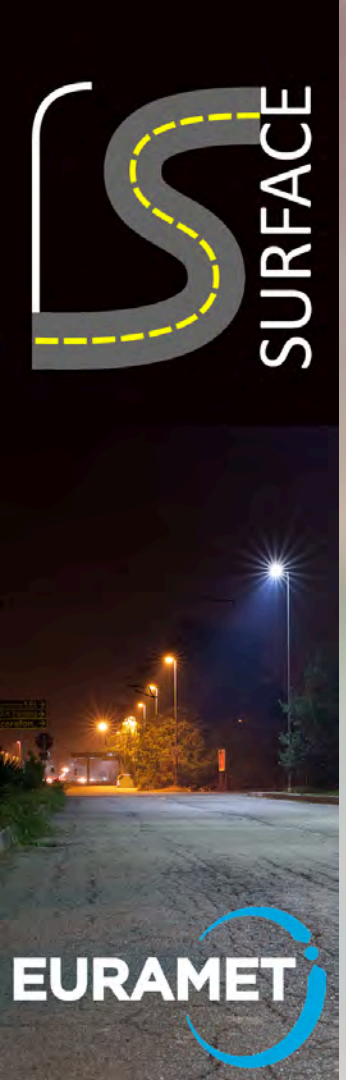
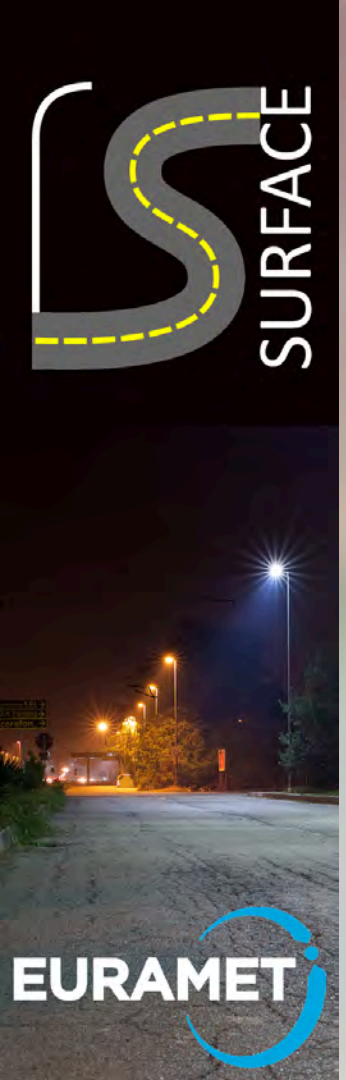


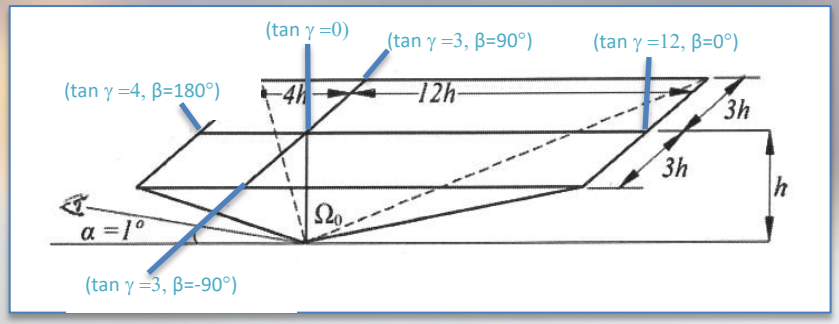
Definition on geometries related to lighting situations

- Aims :
  - To illustrate the need for new geometries and identify them for different applications regarding urban lighting.
  - Consider different users (including the elderly and visually impaired),
  - Consider different speeds, the influence of headlamps, observations from the sky, and harmonisation with road marking standard requirements.

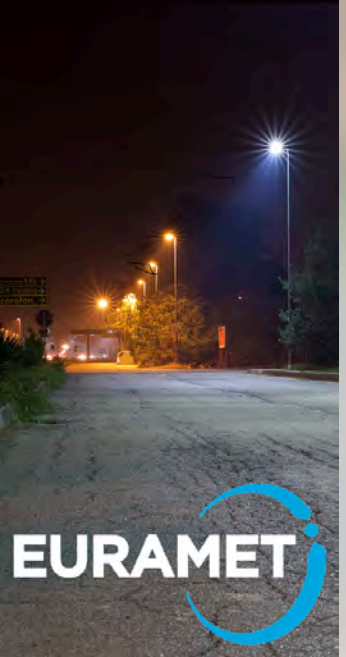


Definition on geometries related to lighting situations

- Illumination angles
  - C.I.E : From 0 et 180° for β and from 0 and 12 for tan(γ) with some missing angles



  - Use of the extended table of EN13201-3 (annex B) for low mounting luminaire extended in tan γ up to 20 by 0.5 increment for every β angle



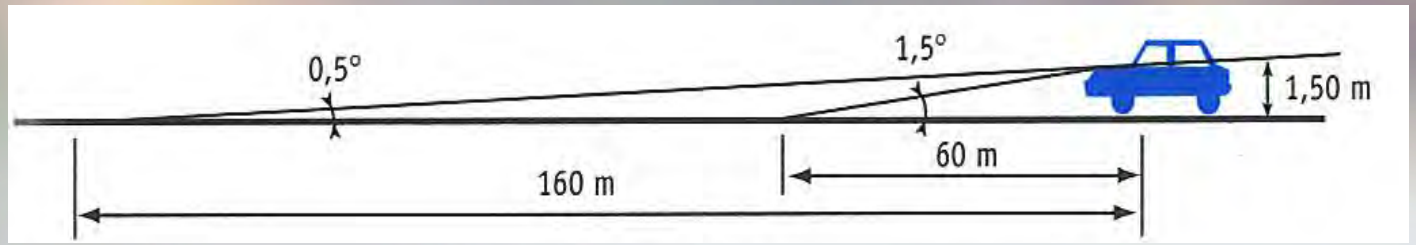
Definition on geometries related to lighting situations

- Illumination angles
  - Use of the extended table of EN13201-3 (annex B)

  - **SURFACE PROPOSAL: use this extended table**
    - **⇒ Different Q_0 calculation**
    - **⇒ Need for data**

Definition on geometries related to lighting situations

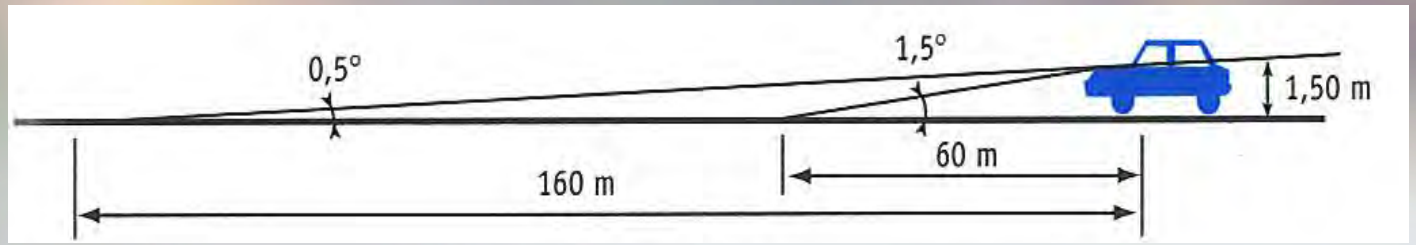
- Why changing the observation angle ?
  - C.I.E 144 :
    - Eye of the driver : 1.5m,
    - Angle of observation 0,5 to 1,5° => 60-160m
    - Measurement at 1°

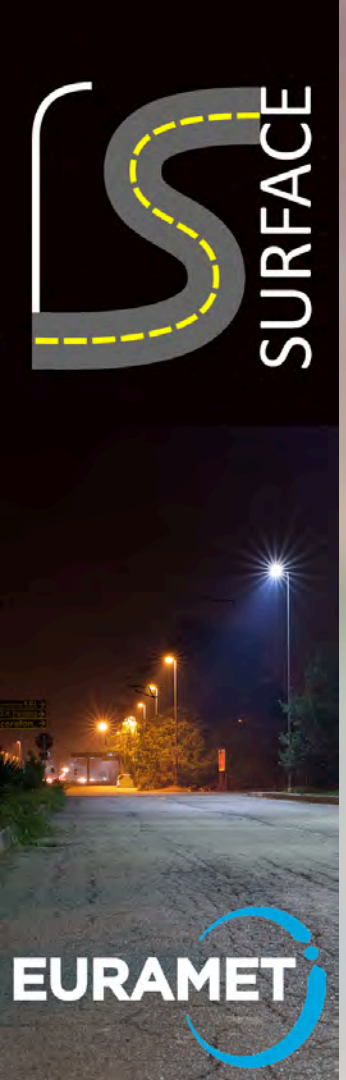


  - Road marking (EN1436)
    - Eye of the driver : 1.2m,
    - Angle of observation 2,29° => 30m

Definition on geometries related to lighting situations

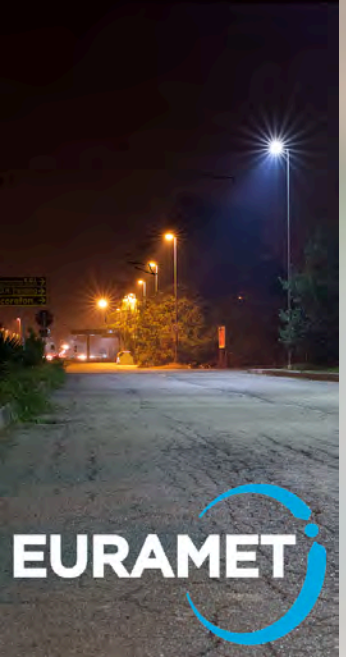
- Why changing the observation angle ?
  - Vision at 60-160m is not appropriate for
    - Urban environment
    - Cyclers and walking people
    - Visually impaired people





Definition on geometries related to lighting situations

- Litterature review : very few references
  - Guidelines and standards regarding geometry :
    - just 1° for pavements
    - 2,29° for road marking => 30m
  - Proposal of other geometries and impact
    - Very old works talking about 1°, 1.5, 2.29°
    - Recent bibliography : only 3 references



Definition on geometries related to lighting situations

R-tables for other observation angles: specific needs for two applications in the field of public lighting. Chain, CIE 2008

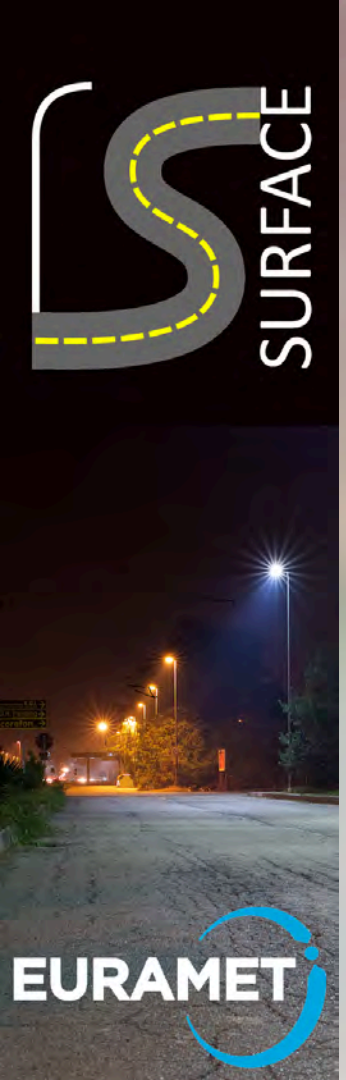
Airplane and light pollution => 90°,
Cyclist + pedestrians: 8-10m=> 10°,
Urban application: 30m=> 3°,
Visually impaired people: 45°

Extension of the luminance concept of the luminance concept in road and tunnel lighting. Stockmar, CIE2015

Propose 3° => impact on Q_0: decrease of 10%
Impact on veiling luminance: reduction of 20%

Reflection properties of road surfaces in Denmark, Sørensen, 2017.

Measurement at 1, 1.5 an 2.29° of 2 pavement on site = > impact on Q_0 and S_1 is weak especially for Q0 (and Qd), S1 drops with increasing angle



Definition on geometries related to lighting situations

- Observation angle
  - Eye of the observer
    - 1.5m (CIE, EN13201) versus 1.2m (EN1436)

    => Our proposal : to keep 1.5m

  - For new angles: a question of observation distance
    - Why not using the Stopping distance (Reaction time + braking distance)

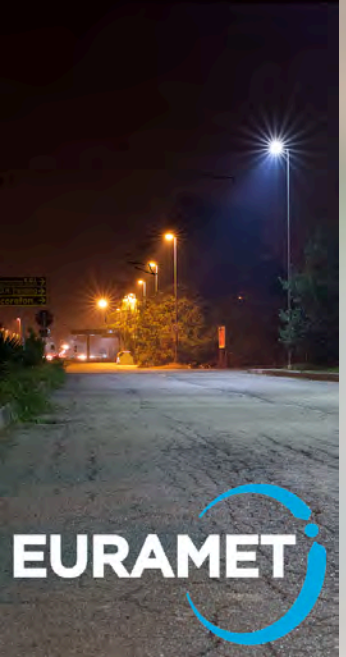
Definition on geometries related to lighting situations

- Stopping distance

	SPEED	Dry pavement	Wet pavement
Urban	20km/h	8m	9m
	30km/h	13m	14m
	50km/h	27m	34m
Inter urban	90km/h	68m	89m
	120km/h	108m	144m

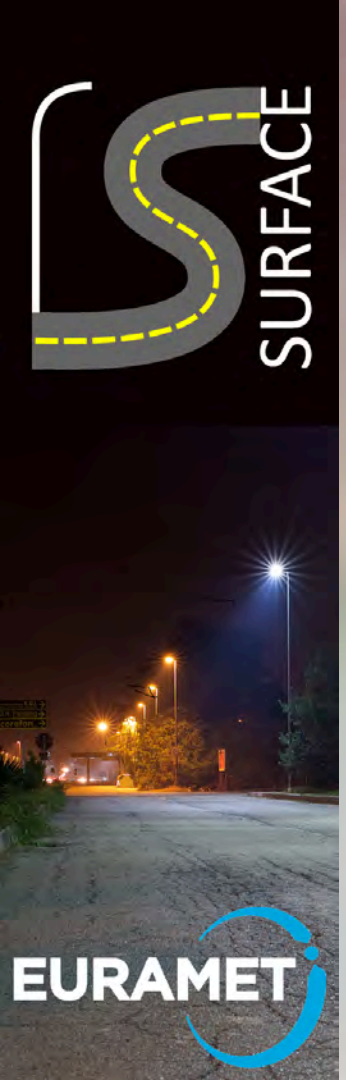
- Observation distance

α (°)	d (m)	
1	85,9	Surface proposal for urban
2,29	37,5	
3	28,6	
5	17,1	
7	12,2	Other users ?
10	8,5	
45	1,5	



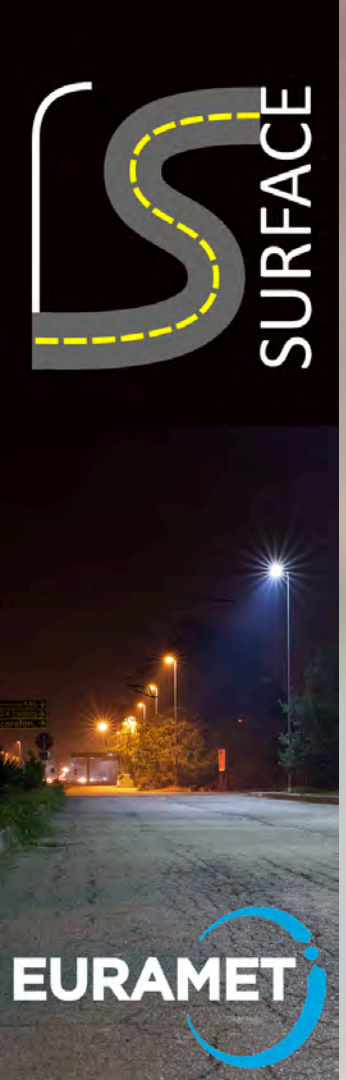
Definition on geometries related to lighting situations

- SURFACE Proposal (to discuss later)
  - Define an angle for urban lighting
    - Eye of the driver : 1.5m,
    - Angle of observation 2,29° => 37m
  - An other angle for cyclers, pedestrians ? What about visually impaired ?

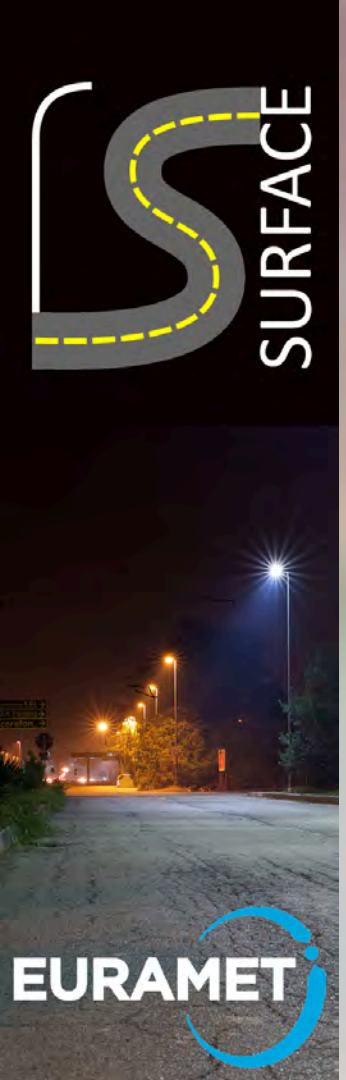


Definition on geometries related to lighting situations

- What about obtrusive light ?
  - 90°: useful for airplaine/ satellite observation
  - light pollution concerning astronomical observation
    - Giuseppe Rossi



First stakeholder meeting
Part 2



Data collection: Our needs

- **Photometric factors** (Q_0, S_1)
- **Available description of pavement**
  - **Type of pavement**: aggregate, binder, surface treatment, granular color,…
  - **Picture** (if available)
  - **Date of measurement**, Age of the pavement
  - Localisation (**country** at least)
  - **Measurement device**
- r-table in a text format
- Representativity of the pavement

- The tables will remain anonymous (no conflict of interest)

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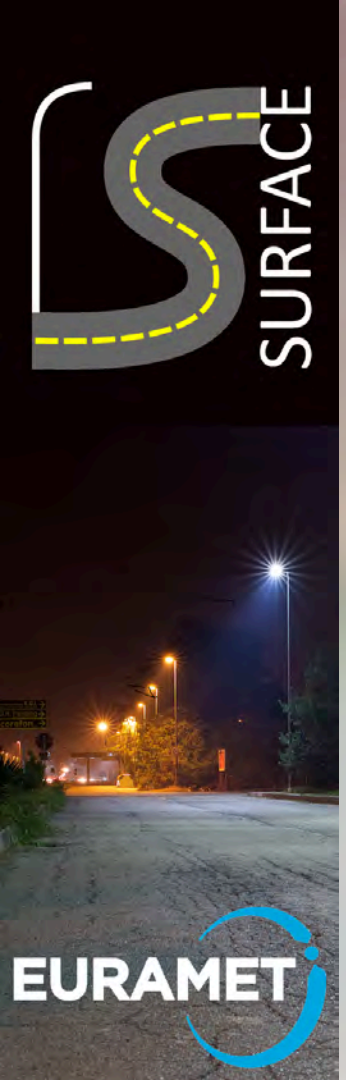


Data collection

- **First selection of tables**
  - New pavements (1 year or less)
  - Old ones (more than 2 years)
  - Selection of **representative tables** for different type of pavement

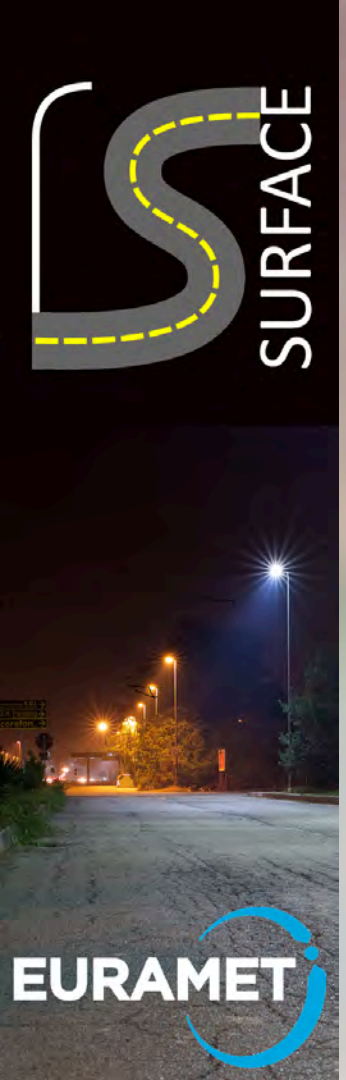
- **Impact on typical road lighting installation layouts,**

  Calculation with installation of EN 13201-3 : Error calculation ?
  Bodmann approach 1989 used by Fotios 2005

  % deviation D=((I*ref*-I*test*)/ I*test*)x100 with I=Lmoy, Uo, UI

  ref corresponds to calculation for chosen « reference r-table »,

  test corresponds to calculation for measured « test r-table ».



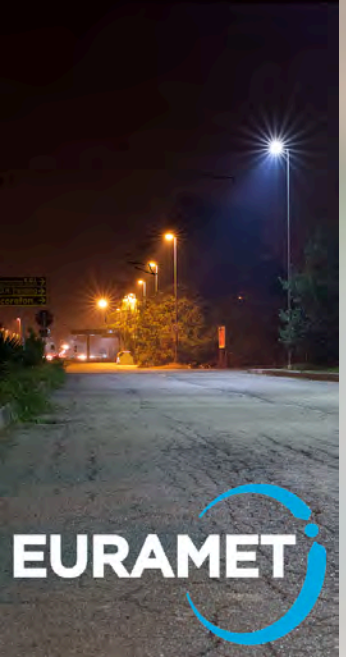
Data collection

- **Collection of table at 1°**
  - Representativity of the pavement
  - Dry and wet pavement
  - Extended tables
  - In laboratory

- **Collection of tables or data at other angles…**

Time for discussion

SURFACE



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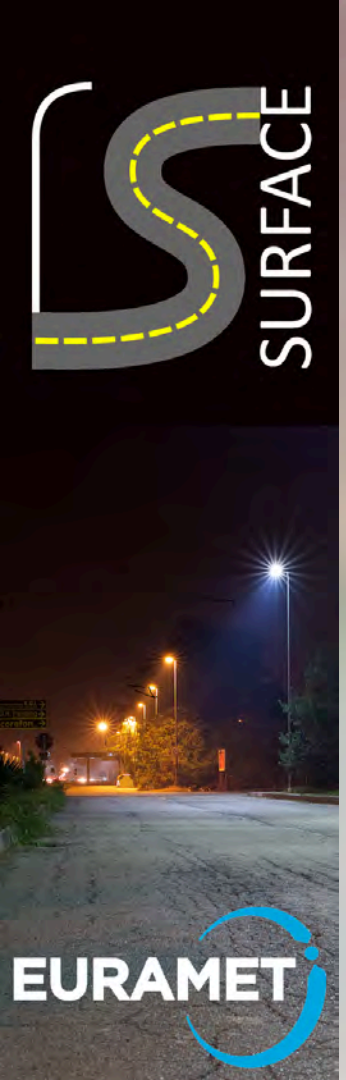


Definition on geometries related to lighting situations

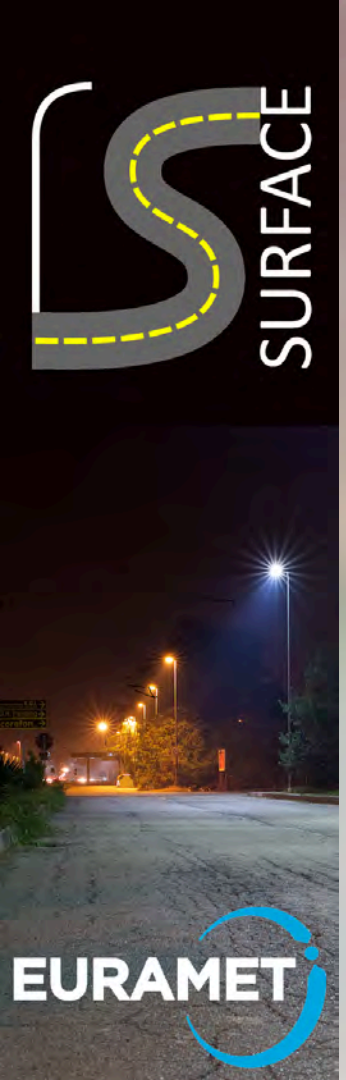
- Illumination angles
  - Use of the extended table of EN13201-3 (annex B) for low mounting luminaire

    tan γ from 0 to 20

SURFACE PROPOSAL: use this extended table

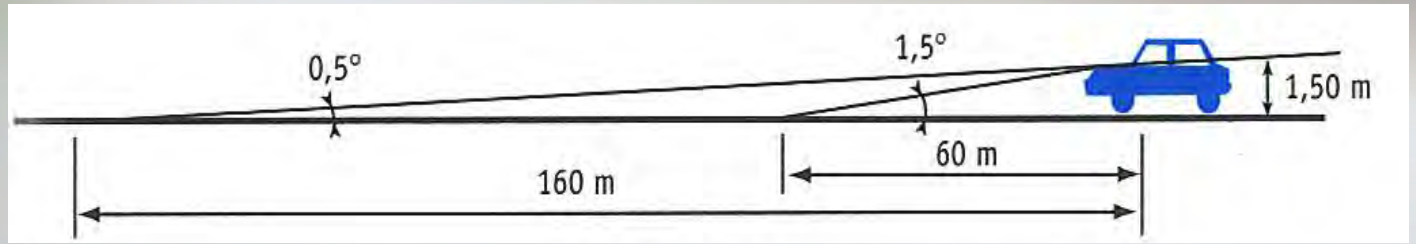
=> Implies changes of Q_0 value: different weighting factors

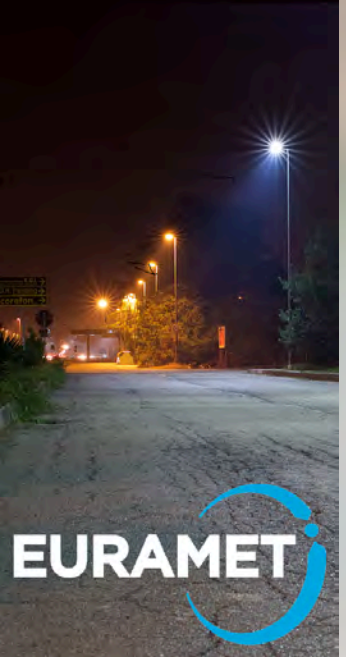
Time for discussion



Definition on geometries related to lighting situations

- Why changing the 1° observation angle ?
  - Vision at 60-160m is not appropriate for
    - Urban environment
    - Cyclers and walking people
    - Visually impaired people
    - Lighting pollution,…

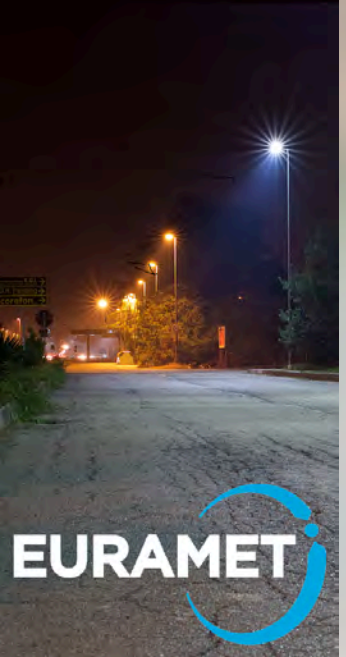




Definition on geometries related to lighting situations

- SURFACE Proposal
  - Define an angle for urban lighting
    - Eye of the driver : 1.5m,
    - Angle of observation 2,29° => 37m
  - An other angle for cyclers, pedestrians ? Visually impaired ?

Time for discussion



Definition on geometries related to lighting situations

- SURFACE Proposal
  - Obstrusive Lighting

Definition on geometries related to lighting situations

- Stopping distance

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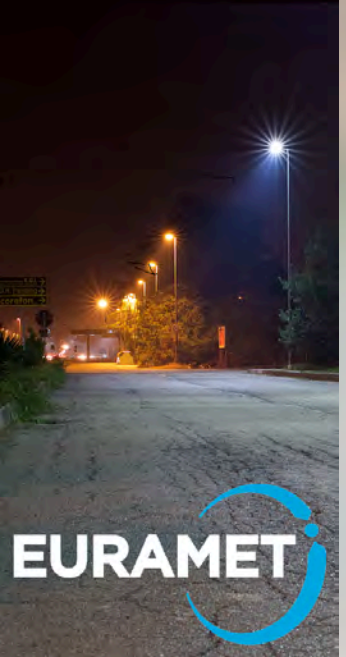
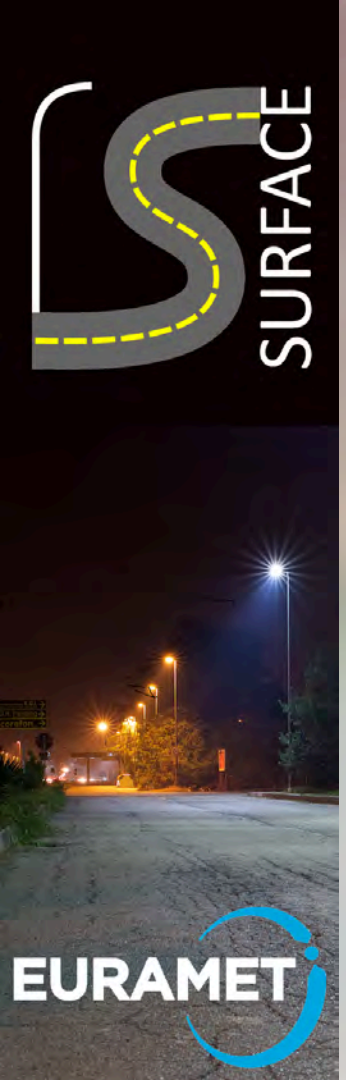


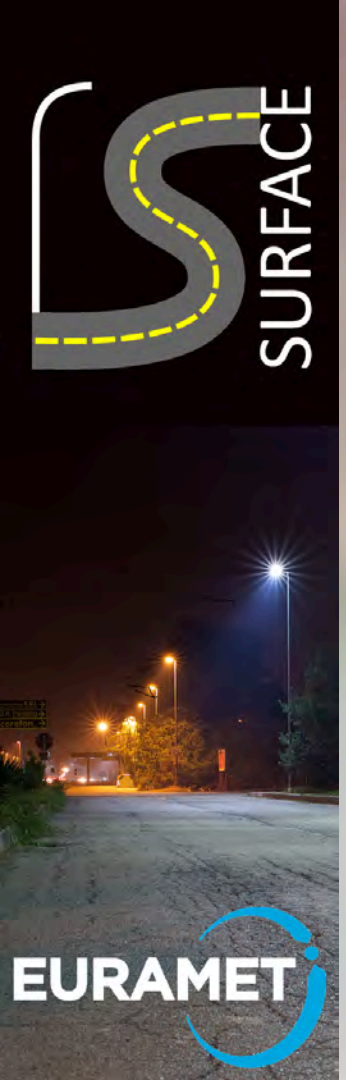


Special Geometries

Lighting pollution

Small Target Visibility

Berlin, May 25th 2018



Lighting pollution

CIE 150:2017

GUIDE ON THE LIMITATION OF THE EFFECTS OF OBTRUSIVE LIGHT FROM OUTDOOR LIGHTING INSTALLATIONS, 2ND EDITION

National Standards

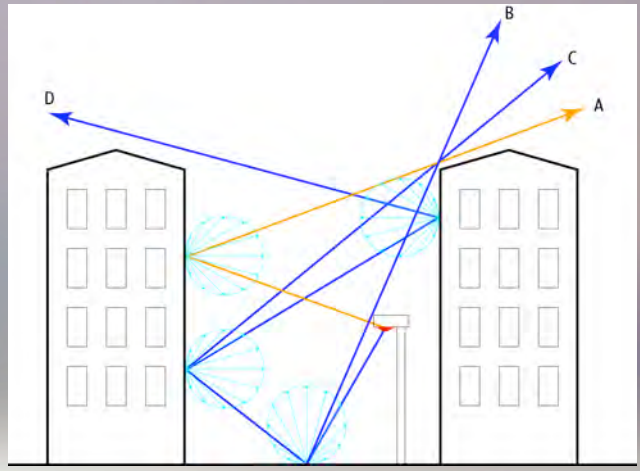
- UNI 10819 (under revision)
  - Light and lighting - Outdoor lighting installations
  - Requirements for the limitation of the upward scattered luminous flux

- Other national standards

Lighting pollution

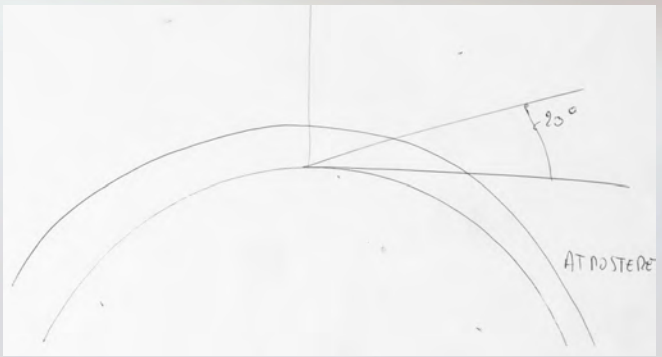
Urban conditions

- One reflection rays
- Two or more reflection rays

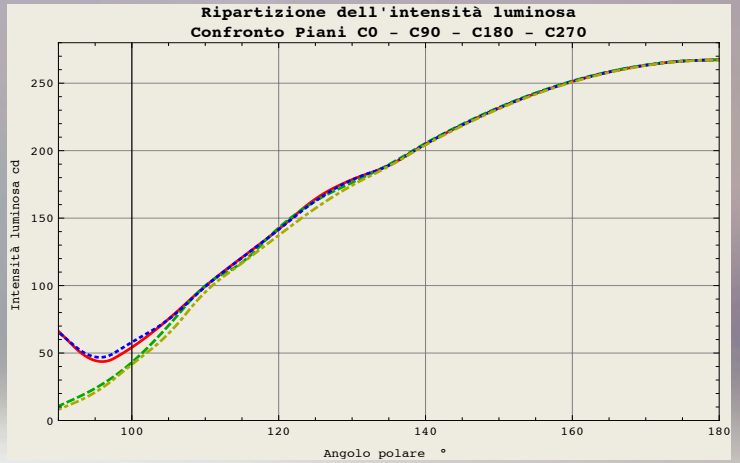


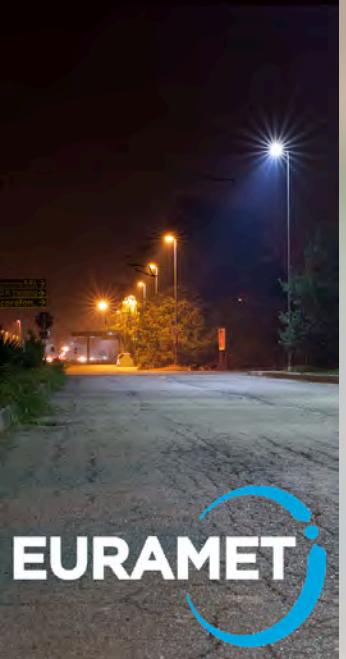
Rural condition

- Direct emission of the luminaire > 0
- Road reflection



Lighting pollution



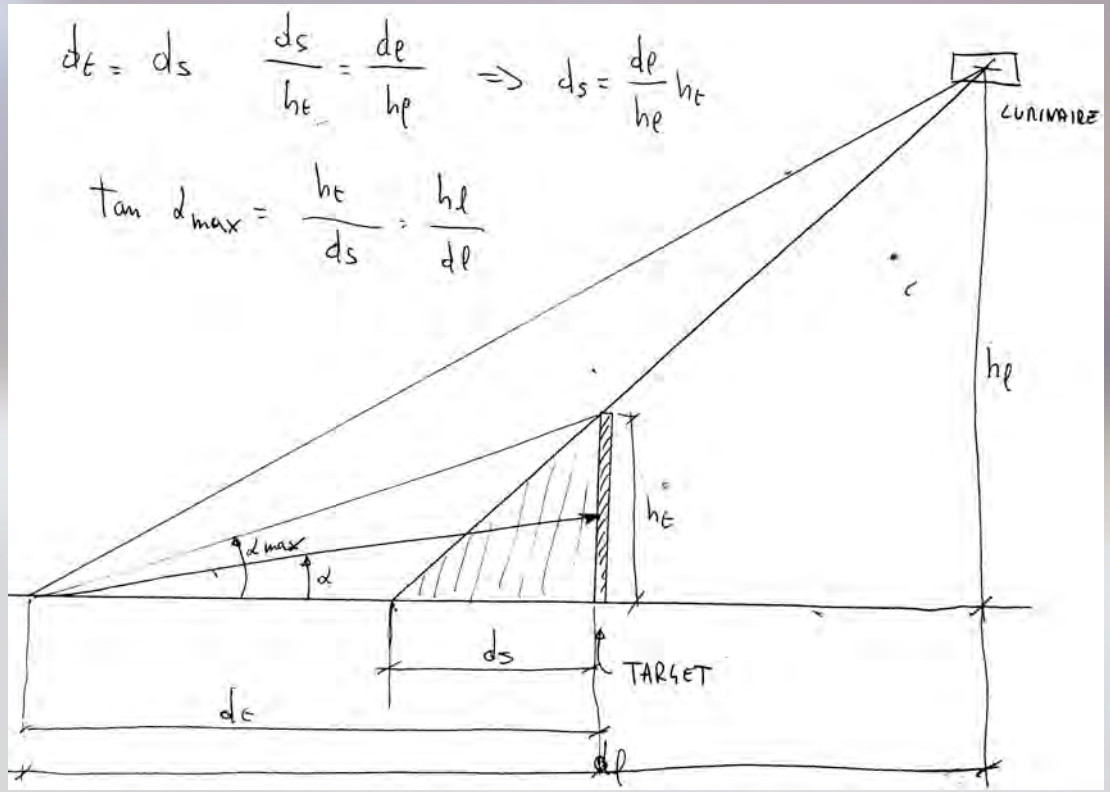


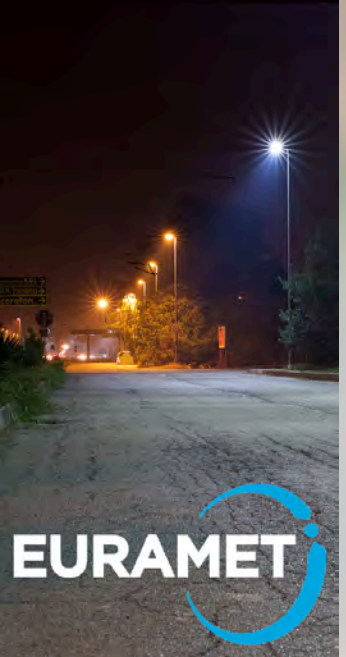
Measurement of an installation with a single column

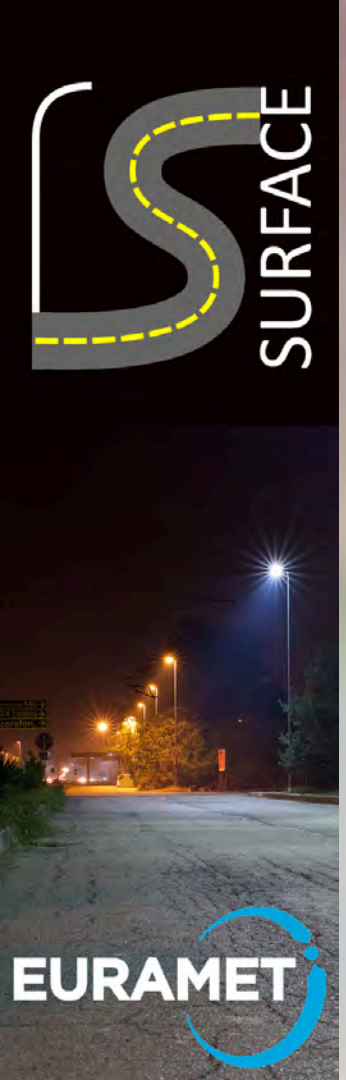
- Near field photometry
- Specular contribution up to 10 °

STV – Small Target Visibility

- ✓ **Luminaires before the target**
  - ➢ **Only forward-scattering**
- ✓ **Luminaires after the target**
  - ➢ **Presence of shadow**
  - ➢ **Only backscattering**



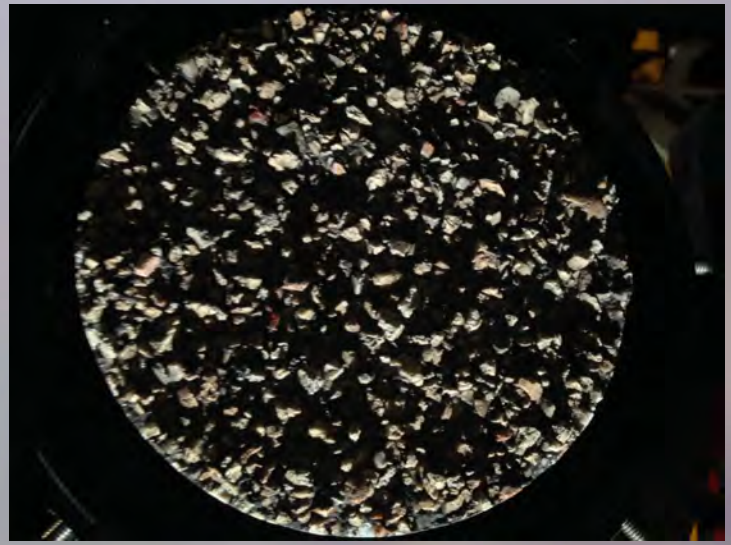




Part 2 INTERCOMPARISON

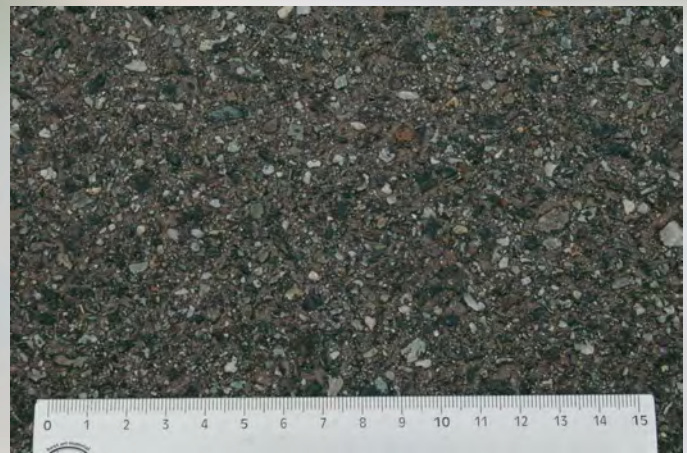
INTERCOMPARISON

SURFACE

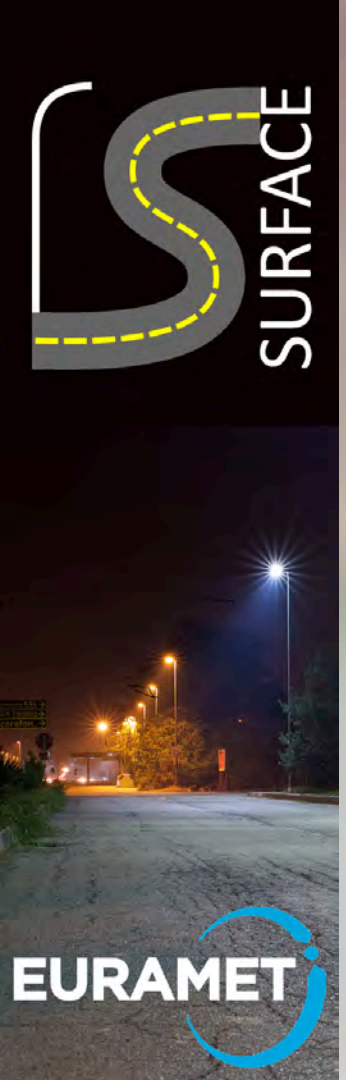


EURAMET

SURFACE

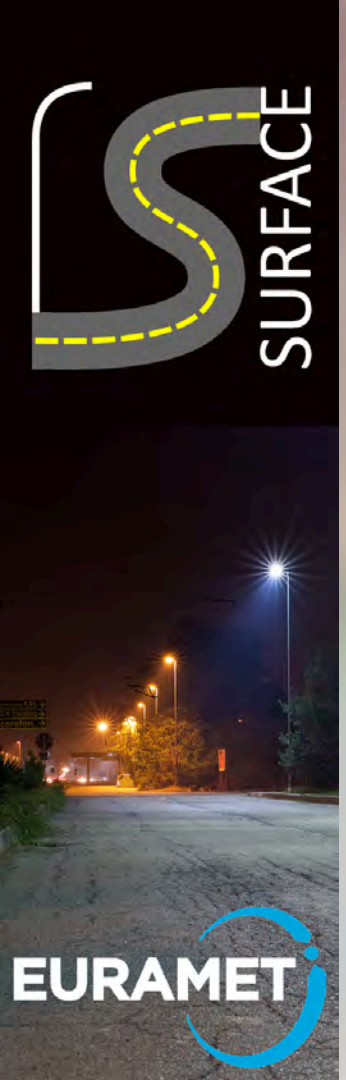


EURAMET



CERTIFIED REFERENCE MATERIALS

	0,00	2,00	5,00	10,00	15,00
45,00	0,02	0,02	0,02	0,02	0,01
56,31	0,03	0,03	0,03	0,02	0,02
63,43	0,05	0,05	0,04	0,03	0,02
71,57	0,11	0,10	0,07	0,04	0,02
75,96	0,18	0,14	0,08	0,04	0,02
78,69	0,25	0,18	0,09	0,03	0,02
81,25	0,37	0,24	0,09	0,03	0,03
82,87	0,50	0,29	0,09	0,04	0,03
83,99	0,70	0,37	0,12	0,05	0,05
85,03	1,00	0,51	0,16	0,07	0,07



Creating impact (WP4)

- Involvement of road authorities
  - Which reference table values are used
- Dissemination of results
  - Workshops
  - Training courses
  - Written material