meg – Augmented Photobiology

Studio Roosegaarde
Urban Sun
Phase 1 – Technological assessment

Milan, September 10 – 2020
Urban Sun

Introduction

The **Product Architecture** is a concentrated array of UVC Sources installed on an Aerostat.

The **excimer-based UVC Source** has been defined by meg, due to lack of reliable information.

Third-party technology providers will develop such source based on meg’s briefing.

The **Visual Task** is a relevant air volume below the Aerostat. Control Surfaces A and B have been analyzed to understand the system’s behavior.

**Reference Scientific Literature** and **Important Notes** are in the Appendix, containing useful information for the best understanding possible of our work and for general public/press communications.
Urban Sun
Target air volume and Control Surfaces

TARGET: VIRTUAL SURFACE «A»
H = 220 cm
Droplets outburst max height³
Droplets and aerosol might reach this height during Sneezing and Coughing³

99 U.S. Percentile man height 1920 cm

TARGET: VIRTUAL SURFACE «B»
H = 70 cm
Safe height for children/baby carriage
Urban Sun
Source provider briefing

Source / Fixture
Source type: Excimer KrCl, 222nm peak, filtered
Optical power: 120'000 mW (net Irradiance @ 222nm)
Electrical power: 1200 W (estimated @ UVC E=10%)
FWHM: 60°, roto-symmetric
Optical system rendition: > 75%
Emitter overall dimensions: 600 x 150 x 150 mm (approx., excluding secondary optics)

Application
Number of Fixtures: 8 per Aerostat
Array: 360° full-round, 45° each
Height: 35 mt
Tilt angle: 33° (adjustable +/-90°)
Total electrical power: ~10'000 W (estimated @ UV E=10%, R=75%)

Performance / KPI @ Surface A
Irradiance uniformity: > 80%
Eave: 0.012 mW/cm²
Emin: 0.010 mW/cm²

Performance / KPI @ Surface B
Irradiance uniformity: > 80%
Eave: MAX ±5% of Eave @ Surface A
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Urban Sun
Reference spectrum data [222nm peak, filtered]
Urban Sun
Application
Urban Sun
Radiometric distribution
Urban Sun

Time Function\(^1\) and Pathogen Reduction\(^1\) estimates %
Urban Sun

Time Function¹,² focus: Sneezing/Coughing vs Breathing³

SNEEZING / COUGHING
Droplets reach 1,5 mt in ~0,3 sec
D = 2 %

BREATHING
Droplets reach 1,5 mt in ~1 sec
D = 5 %

¹² meg / Urban Sun - Phase 1
³ meg / megscience.com
Urban Sun
From Numbers to Messages

Floor Round Area
Ø 38  mt
1’133  m²

20% reduction  4  seconds¹,²
50% reduction  13  seconds¹,²
99,9% reduction  3  minutes¹,²
Important considerations: UVC design process

meg simulations are to be intended as design guidelines, and all calculations and assumptions must be tested and verified on a physical, full-scale, working Proof-of-Concept prototype.

Where possible, meg utilized data available from relevant technology suppliers. Where not, meg hypothesized a feasible but custom-made UVC fixture.

**Maximum Exposure Time** calculations are according to:


meg estimated Maximum Exposure Time considering an ideal single-emission source peaked at 220nm, thus setting $EL = 25 \text{ mJ/cm}^2$.

Where Irradiance Uniformity of a Visual Task is $\geq 80\%$, meg used the minimum maintained average irradiance value ($E_{ave}$: $E_{min}/E_{med}$) for further calculations.

Where Irradiance Uniformity of a Visual Task is $< 80\%$, meg used the minimum irradiance value ($E_{min}$) for further calculations, thus potentially leading to conservative results and due to evident lower values/risk areas.
Important considerations: on «COVID-19»

1 The reference scientific paper which constitutes the base for meg’s simulations is:


Standard Rate Constants and UV Doses reported are relating to:
- HCoV-229E $k=4,1$ cm$^2$/mJ $D_{90} = 0,56$
- HCoV-OC43 $k=5,9$ cm$^2$/mJ $D_{90} = 0,39$

Although no specific value is given in strict relation to SARS-CoV-2, the pathogen related to COVID-19 disease, the study clearly states that «...all coronaviruses will respond similarly».

meg virtually simulated using data from the worst-case of HCoV-229E, thus potentially leading to conservative results.

meg simulation process and data analysis follow the intent, assumptions and conclusions of such scientific research.
Important considerations: impact on Time Functions

2 All of the simulated scenarios are in an open-air environment. Airflow speed rate has to be considered set at per Reference Paper. meg estimated it at 0.02 mt/s at the noted UVC-exposed volume, according to available data and volumetric/cross section approximations. This estimated speed is 0 (zero) on the Beaufort Scale – «calm/no wind». Relative Humidity and air Temperature time-impacting factors have not been taken into account, in absence of relevant scientific literature. However, the reference paper’s environmental parameters are $RH_{ave} = 66\%$ (from 50% to 70%) and $T = 24^\circ C$. Meg depreciated by 10% the simulation outcomes for $H = 35mt$.

3 Breathing (nose, mouth), Sneezing and Coughing droplets velocities have been sourced from the reference paper: «Airflow Dynamics of Human Jets: Sneezing and Brething – Potential Sources of Infectious Aerosols» – PLoS ONE 8(4) e59970; 2013 and Ref. 15, 17.

Talking droplets velocity is proven to be too language-dipendent, and finds an extremely limited use in this case scenario. meg virtually simulated using data from the worst-case speeds of 4.5 m/s for sneezing/coughing and 1.4 m/s for breathing, thus leading to conservative results.
1) Supplier Briefing
Freeze presentation for Supplier, alignment with Roosegaarde Studio.
meg+RS to send/brief companies.
Tech Companies to commit to meg’s tailor-made briefing,
and counter-verify simulations.

2) Maximum exposure time
Source Supplier to verify final MET/EL.

3) Virologist onboarding
“Virtual simulations indicate a positive impact of the Urban Sun in reduction of airborne coronaviruses in public spaces.”

Carlo D'Alesio from MEG – augmented photobiology – and Professor at Politecnico di Milano.
meg – Augmented Photobiology

Studio Roosegaarde
Urban Sun
Phase 2 – Urban Sun Pilot Simulation Rotterdam

Milan, March 02 – 2021
The **Product Architecture** is a UVC Source installed on an Aerostat.

The **excimer-based UVC Sterilray Source** has been simulated by meg, assuming technical data as optical power and radiometric spatial distribution, based on the single point irradiance measurement and rough* spectral power distribution provided by VSL.

The **Visual Task** is a surface of Ø11 mt and height of 2.2 mt above floor. It has been analyzed to understand the system’s behavior.

**Reference Scientific Literature** and **Important Notes** are in the Appendix, containing useful information for the best understanding possible of our work and for general public/press communications.

*See slide 16
Urban Sun
SYSTEM ARCHITECTURE & APPLICATION

Source / Fixture
Source type
Estimated Optical power
Electrical power
Estimated FWHM
Optical system rendition
Emitter overall dimensions
Sterilray Excimer KrCl, 222nm peak, not filtered
2'750 mW* (low setting)
Unknown
120°, lambertian
Unknown
220x575x190mm

Application
Number of Fixtures
Height
Tilt angle
Total electrical power
1 per Aerostat
10 mt
0°- not adjustable
Unknown

Performance / KPI @ Target Surface
Irradiance uniformity
Eave (unweighted)
Emin (unweighted)
68%
0,00073 mW/cm²
0,00050 mW/cm²

* meg-estimated value. See process details in slide 12
**Droplets and aerosol might reach this height during Sneezing and Coughing, see slide 15

meg / Urban Sun - Phase 2
March 2, 2021
Urban Sun
Radiometric distribution - Low setting
Urban Sun

Time Function$^{1,2}$ and Pathogen Reduction$^1$ estimates % - Low setting
# Urban Sun

From Numbers to Messages - Low setting

## Target Round Area

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</tr>
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</table>

1,2
Urban Sun

Permissible eye exposure time per day\(^4\) - Low setting

\[ EL = 19.47 \text{ mJ/cm}^2 \text{ as per current ICNIRP Guidelines based on VSL spectral measurements and integrated values of } S(\lambda). \]

Eyesight parallel to ground > 15hr\(^4\)

Direct stare into beam \((A)\) 5hr 40mins

Direct stare into beam \((B)\) 9hr 50mins

Direct stare into beam \((C)\) 49hr 10mins
Urban Sun

Permissible eye exposure time per day$^4$ – Evaluation Method

EL = 19.47 mj/cm² as per current ICNIRP Guidelines based on VSL spectral measurements. and integrated values of S(λ)
Important considerations: data verification process for simulation

Studio Roosegaarde provided meg with these data regarding VSL measurements:

- Setting = High
- Weighted Irradiance = 0,0094 W/m² (0,00094 mW/cm²)
- Calculation point distance from light source = 4,67mt

Meg derived an educated guess on the Radiometric emitting flux of the light source based on the aforementioned data, simulating the same conditions and adjusting the flux in the software until a similar (unweighted) irradiance was obtained.

On a second instance Studio Roosegaarde provided meg with these data regarding VSL measurements:

- Setting = Low
- Weighted Irradiance = 0,00138 W/m² (0,000138 mW/cm²)
- Calculation point distance from light source = 8,00 mt

Meg derived an educated guess on the Radiometric emitting flux of the light source based on the aforementioned data, simulating the same conditions and adjusting the flux in the software until a similar (unweighted) irradiance was obtained.

These data were used as a benchmark to simulate the requested conditions of:

- Setting = Low
- Height of the Urban Sun = 10mt
- Height of the target area = 2,20mt
- Diameter of the target area = 11mt

Obtaining the values which have previously been displayed in this presentation.
Important considerations: system architecture & application

meg simulations are to be intended as design guidelines, and all calculations and assumptions must be tested and verified on a physical, full-scale, working Proof-of-Concept pilot.

Maximum Exposure Time calculations are according to:


meg estimated Maximum Exposure Time considering a spectral integrated source peaked at 222nm not filtered, thus setting \( EL = 19.47 \text{ mJ/cm}^2 \) based on VSL spectral measurements and integrated values of \( S(\lambda) \).

Where Irradiance Uniformity of a Visual Task is \( \geq 80\% \), meg used the minimum maintained average irradiance value (\( E_{\text{ave}}: E_{\text{min}}/E_{\text{med}} \)) for further calculations.

Where Irradiance Uniformity of a Visual Task is \( < 80\% \), meg used the minimum irradiance value (\( E_{\text{min}} \)) for further calculations, thus potentially leading to conservative results and due to evident lower values/risk areas.
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Urban Sun

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Thank You for your attention.