The International Maritime Transport and Logistics Conference

"Marlog 10"

Digitalization in Ports & Maritime Industry

10 2021 Marlog

The Performance Evaluation of Smart Communication System for Ports across Different Seasons.

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Outline

- ***Introduction***
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Introduction

Visible Light Communication in smart ports

*The Visible light communication **(VLC)** system can provide fast, secure and cost-effective solutions by unitizing the LED blub light for communication among different stages at indoor and outdoor environments.*

Utilization of communication technologies in ports operation can be considered as enabler for port system automations (smart ports) where the communication links (VLC system link) can be applied at :

- container ship,
- ship-to-shore handling,
- carriers,
- yard storage,
- terminal management

Introduction

Visible Light Communication in smart ports

more than 45% of sunlight spectrum locates in the visible light band,

The VLC is still able to promise high speed solutions even in environments and areas that are vulnerable to electrometric wave ***radiations***

System Model

The visible light communication impulse response has been analysed through taking into consideration multiple reflection also for both non line of sight (NLOS) to third reflection and line-of-sight (LOS) components was considered

The evaluation considers the sunlight intensity variation over the year.

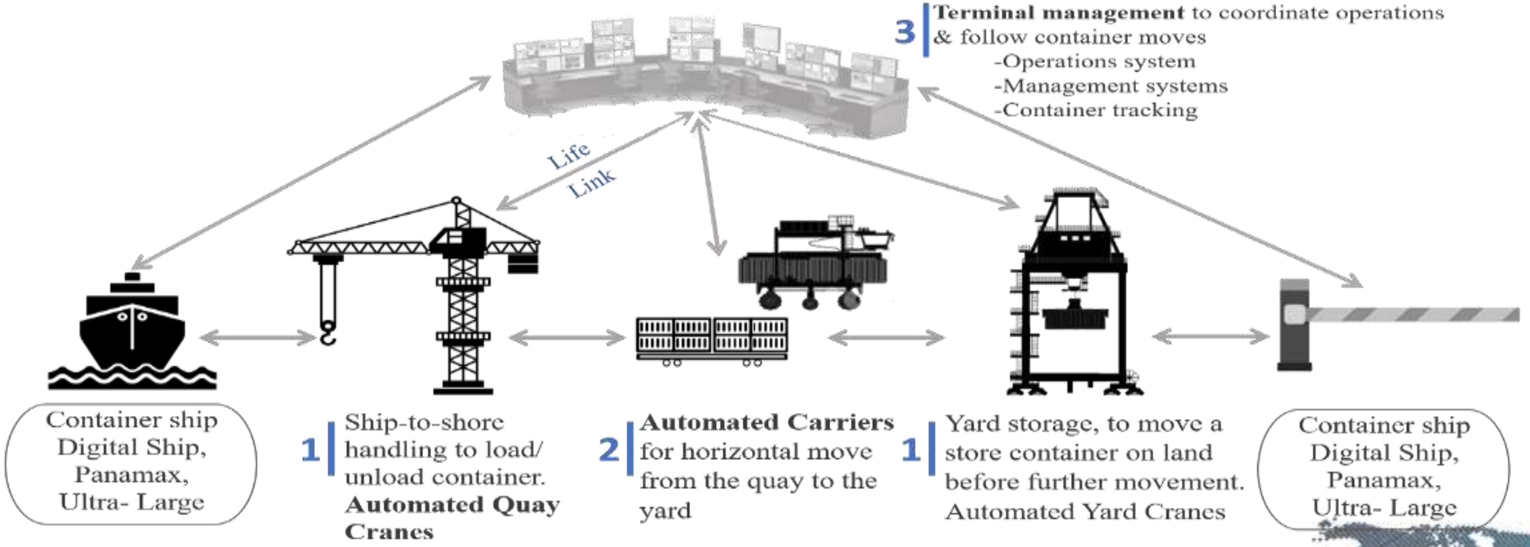
System Model

Egypt and Germany are used as two representative locations in order to capture the hourly sunlight irradiance as a function of latitude and longitude of locations, day of the year, time of the day and level of cloud cover.

At terminal management offices, it is assumed that LED light illumination is unitized for communication within the office and also outdoor light bulbs had been considered for external communications

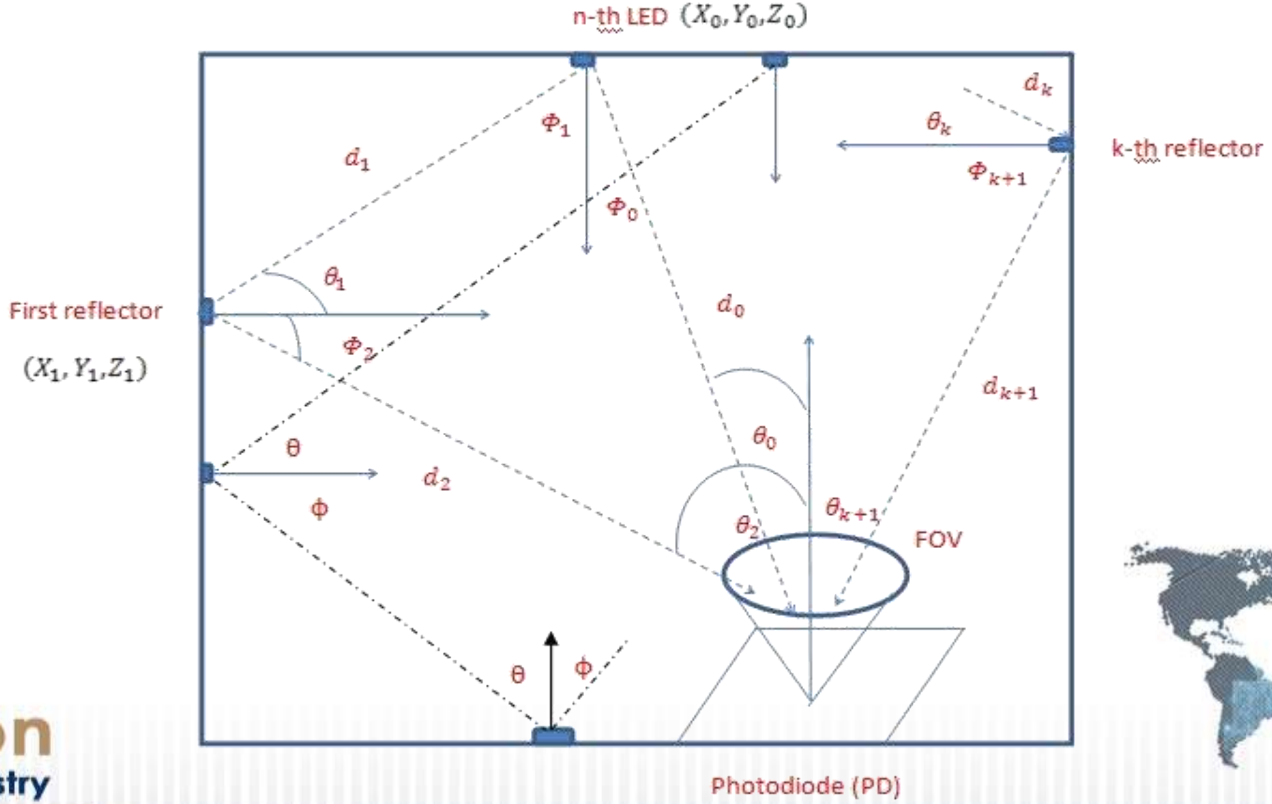
Terminal Automation

Terminal Automation using VLC System Links



Terminal Automation

Visible Light Communication



Mathematical Model

- $h(t) = \sum_{n=1}^{N_{LED}} \sum_{k=0}^{\infty} h^{(k)}\,(t;\Phi_n)$ **(1)**

- $h^{(k)}(t;\Phi_n) = \int_S \left[L_1 L_2 \ldots\ldots.. L_{K+1} {\Gamma_n}^{(k)} rect(\frac{\theta_{k+1}}{FOV}) \times \delta(t - \frac{d_1+d_2+\cdots d_{k+1}}{c}\right] dA_{ref},\ k \geq 1$ **(2)**

Where:

$$L_1 = \frac{A_{ref}(m+1)cos^m\Phi_1 cos\theta_1}{2\pi {d_1}^2}$$

$$L_2 = \frac{A_{ref}\,cos\,\Phi_2 cos\theta_2}{\pi {d_2}^2}$$

$$L_{k+1} = \frac{A_{PD}\,cos\,\Phi_{k+1}\,cos\,\theta_{k+1}}{\pi {d_{k+1}}^2}$$

Sunlight Irradiance

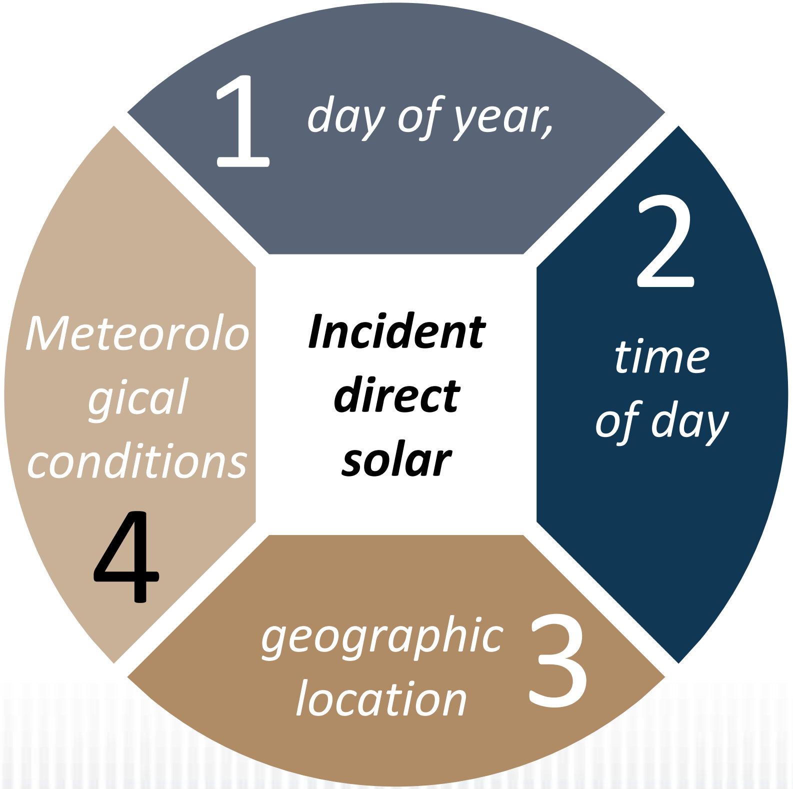
$$\sigma_{total}{}^{2} = \sigma_{shot}{}^{2} + \sigma_{thermal}{}^{2}$$

$$q_{sum}=1350.3\times 1.0+0.033\cos 360n365\times[\sin\varphi\ \sin\delta+\cos\varphi\ \cos\delta\ \cos\omega]$$

Here, solar declination is δ, angular displacement is and location longitude is φ.

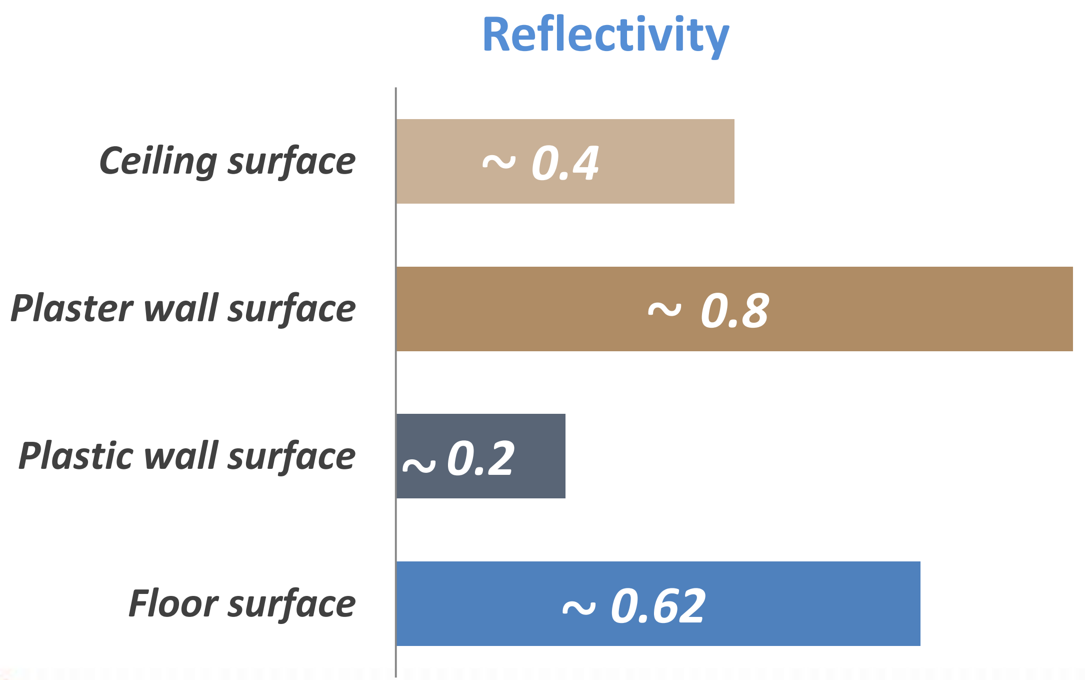
Sunlight Irradiance

Sunlight Radiance



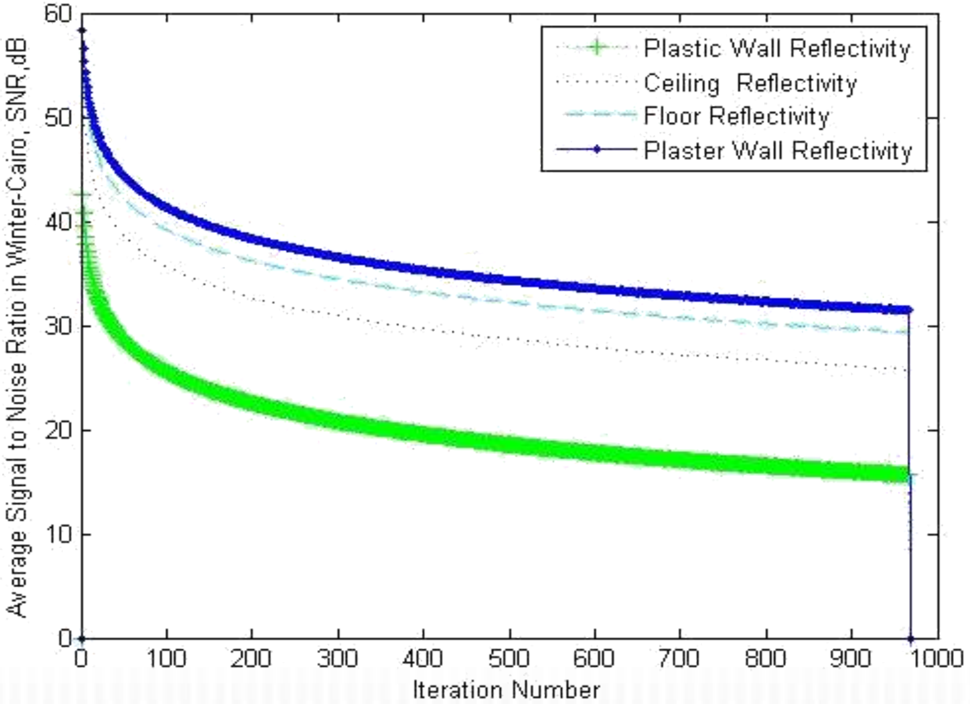
Sunlight Irradiance

Surface Reflectivity



System Performance

Winter season (Cairo)

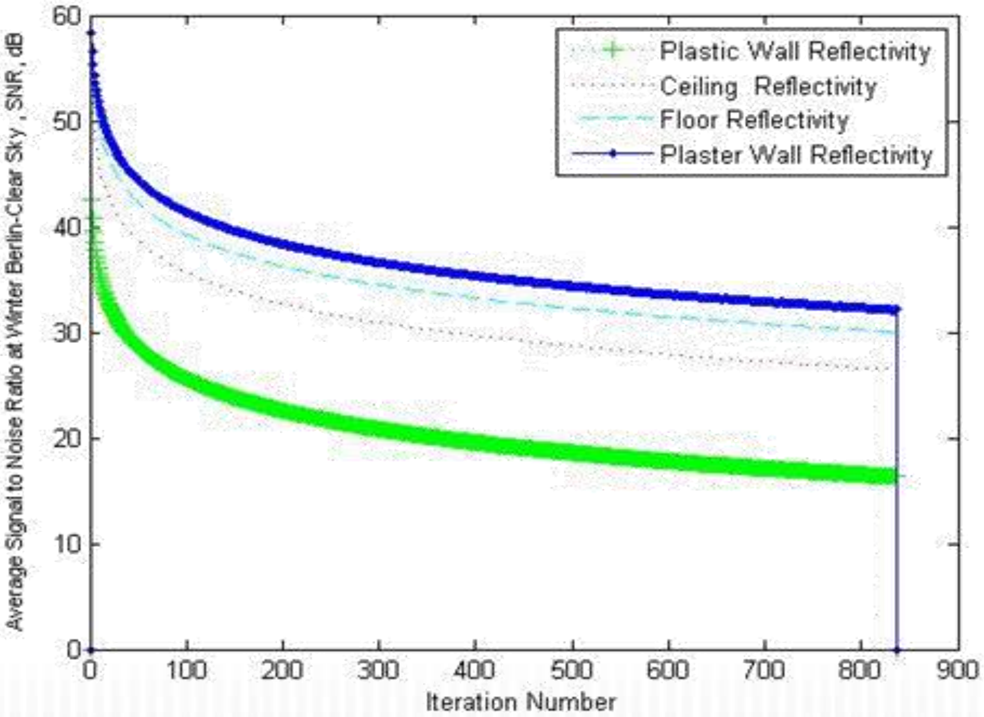


Performance over the year

Plastic wall (Db)	~17
Ceiling surface (dB)	~29.5
Floor surface (dB)	~34
Plaster wall (Db)	~36

System Performance

Winter season (Berlin-Germany)



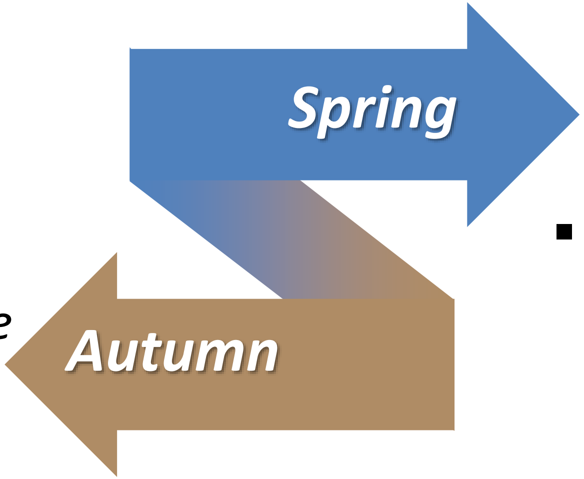
Performance over the year

Plastic wall (Db)	~20
Ceiling surface (dB)	~31
Floor surface (dB)	~36
Plaster wall (Db)	~37.5

System Performance

Performance over autumn and spring

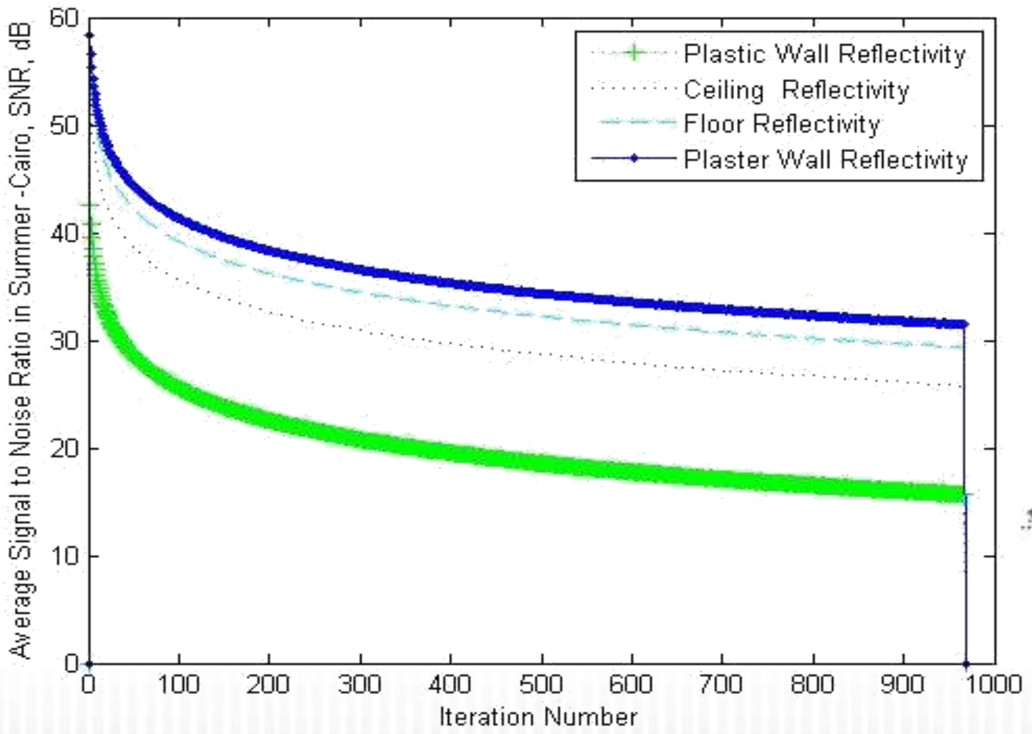
- *In Cairo, sunlight irradiance reaches 1175.087 W/m2*
- *In Berlin, sunlight irradiance is 822.627 and 368 W/m2 for the clear and cloudy sky, respectively.*



- *In Cairo, the average SNR was 14 dB and 17 dB for plastic wall surfaces, and 30 dB and 37 dB for plaster wall surfaces.*
- *In Berlin, the average SNR is 18.5 dB/16 dB, 37 dB/32.5 dB for plastic and plaster surfaces for clear and cloudy skies.*

System Performance

Summer season (Cairo)

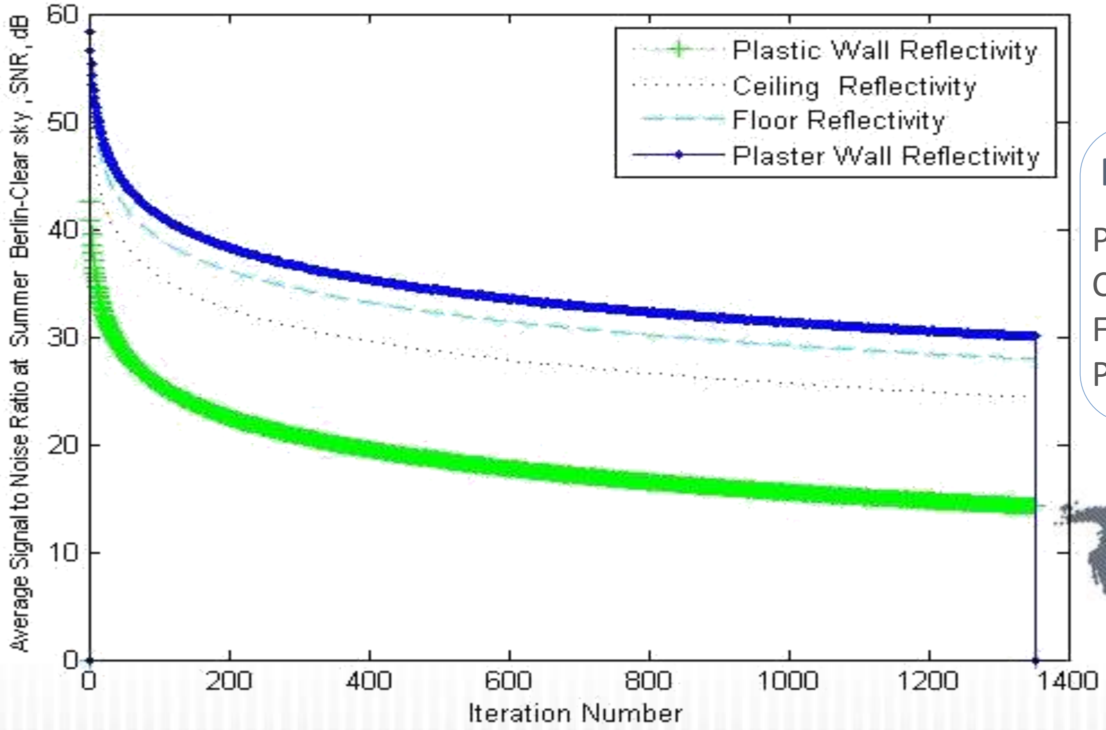


Performance over the year

Plastic wall (Db)	~13.5
Ceiling surface (dB)	~25.5
Floor surface (dB)	~30
Plaster wall (Db)	~33

System Performance

Summer season (Berlin)



Performance over the year

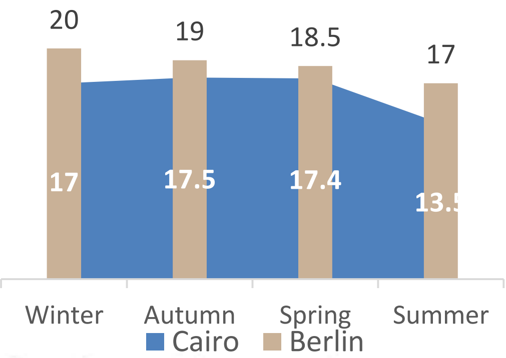
Plastic wall (Db)	~17
Ceiling surface (dB)	~27
Floor surface (dB)	~32.5
Plaster wall (Db)	~35.5

Conclusion

Performance over the year

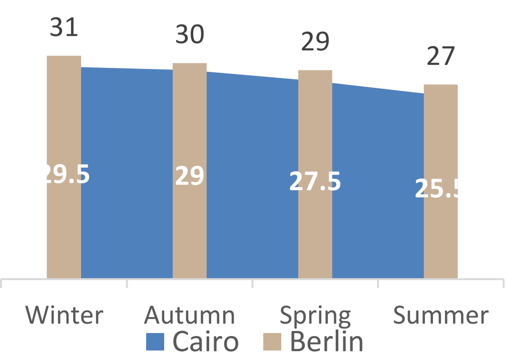
● Plastic wall (Db)

season	Cairo	Berlin
Winter	~17	~20
Autumn	~17.5	~19
Spring	~17.4	~18.5
Summer	~13.5	~17



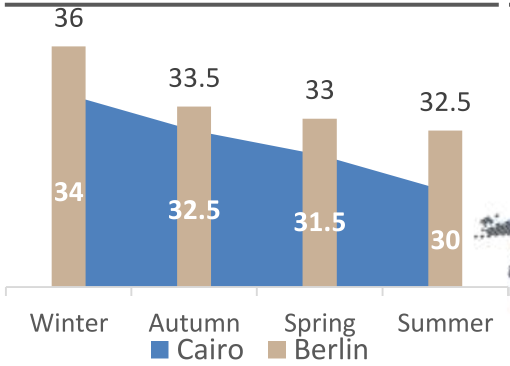
● Ceiling surface (dB)

season	Cairo	Berlin
Winter	~29.5	~31
Autumn	~29	~30
Spring	~27.5	~29
Summer	~25.5	~27



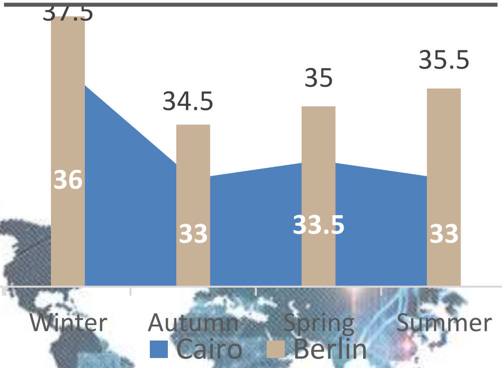
● Floor surface (dB)

season	Cairo	Berlin
Winter	~34	~36
Autumn	~32.5	~33.5
Spring	~31.5	~33
Summer	~30	~32.5



● Plaster wall (Db)

season	Cairo	Berlin
Winter	~36	~37.5
Autumn	~33	~34.5
Spring	~33.5	~35
Summer	~33	~35.5



Conclusion

01 *The impact of irradiance of sunlight on a VLC system performance is evaluated for Cairo and Berlin, as representatives of significant differences in metrological conditions.*

02 *A comparative performance of attainable BER and average SNR is performed on an hourly basis over the year for clear skies.*

03 *The minimum SNR is obtained in Cairo, summer clear skies (~13.5 dB) and maximum SNR is achieved in Berlin, winter/cloudy sky (~39.5 dB).*

Conclusion

04 *Plaster wall surfaces are recommended for locations with high sunlight irradiance due to high reflectivity but plastic walls should be avoided in such environments.*

05 *The BER range from 10-13 to 10-10, for plaster and plastic wall surfaces, respectively*

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Thank you

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