20160929_Presentation

Laser Eye Dazzling Research

Joint AFRL – Dstl (UK) Project

Principal Investigators:

Dr Leon N. McLin

[USAF 711 HPW/RHDO]

Dr Craig A. Williamson

[Dstl Cyber and Information Systems Division]

Maj Ed Kelly

711th Human Performance Wing

Airman Systems Directorate

Bioeffects Division

Optical Radiation Bioeffects Branch

Outline

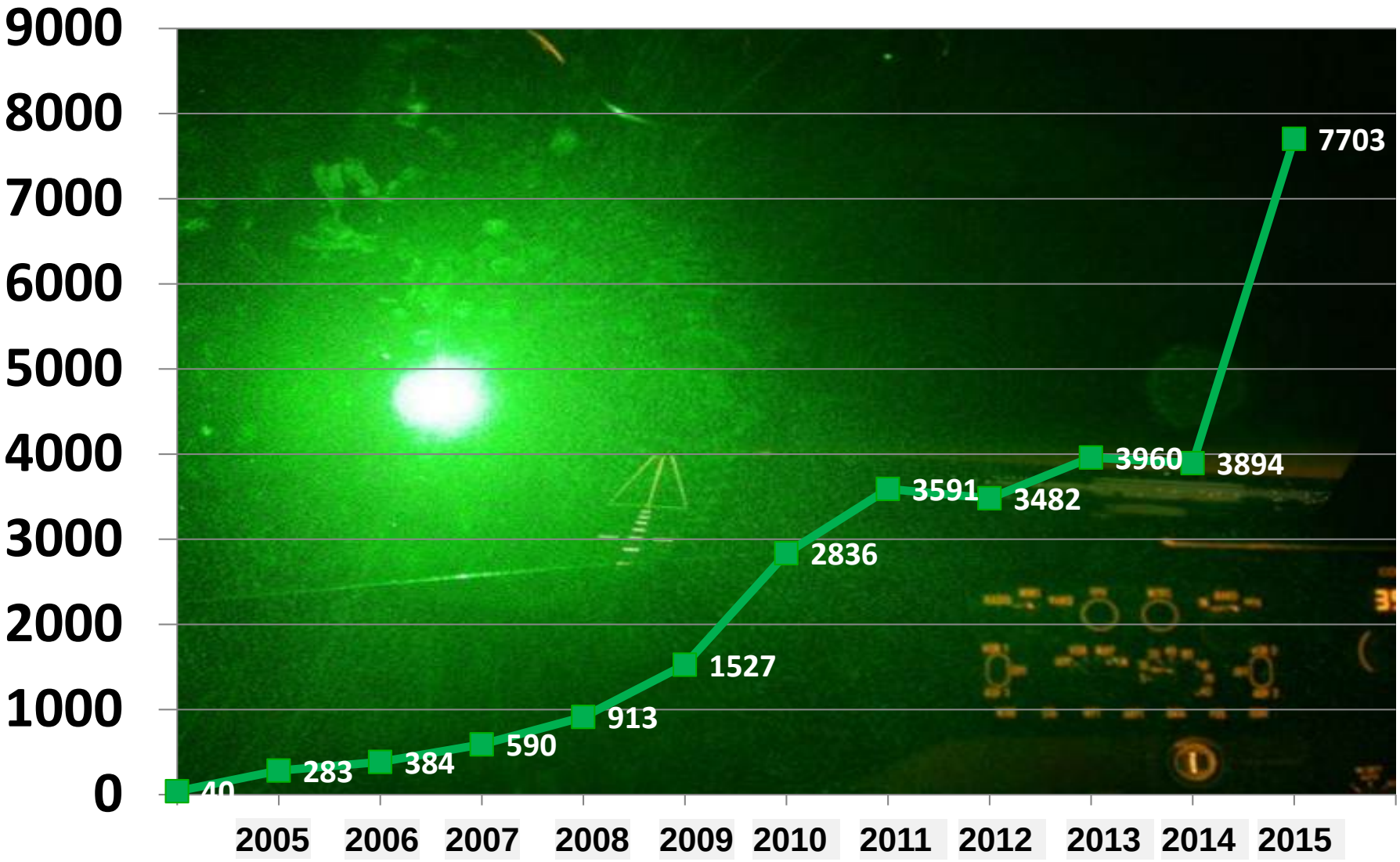
- **Overview of Laser Dazzle Effects**
  - **What is it?**
  - **Why is it important?**
- **Effects**
- **Mitigation**
- **Calculations**
- **Summary & Questions**

What is Laser Dazzling?

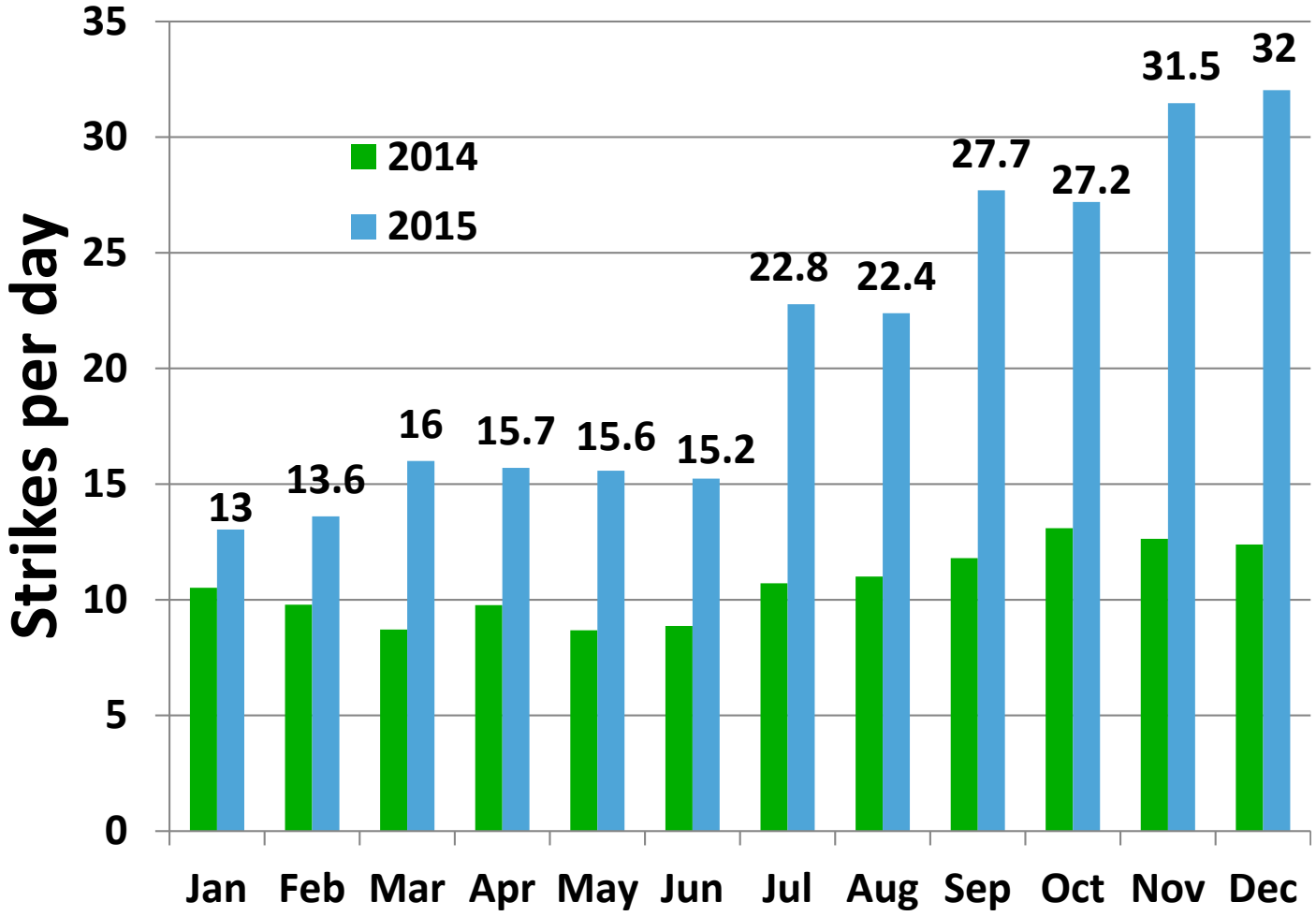
Why is Laser Dazzling Important?

- **Laser Striking Aircraft**
  - **1000s of airline pilots are experiencing laser eye dazzle during fight every year**
  - **In the US alone over 10 incidents occur each day against commercial aviation**
- **Military security & police forces increasingly deploy laser dazzle as a non-lethal option to warn and determine intent**
  - **Applications include checkpoint control, crowd suppression, and anti-piracy**

Laser Strikes (FAA)



Laser Strikes (FAA)

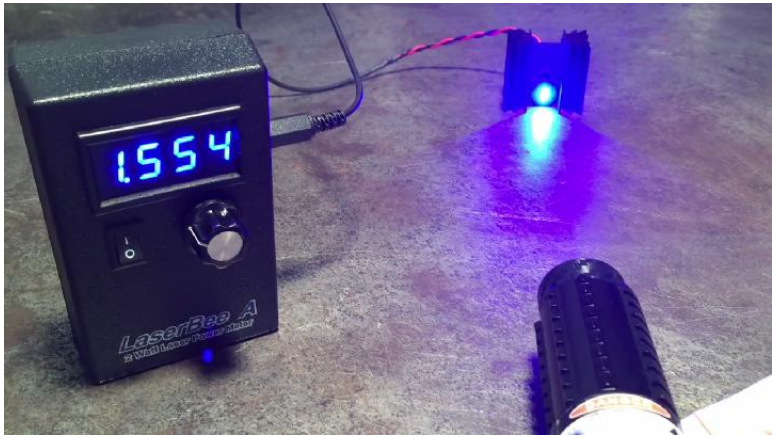


On-line Laser Videos by Laser Enthusiasts

My homemade 40 W laser shotgun

“It’s kind of like owning a gun”

“These babies are **not** your average laser pointer”



Power measured at over 1.5W

Online “Professional Laser Pointers”

Follow Us

laserpointerpro

Newsletter
Enter email address ... Submit

5000mW 450nm 2*16340 Batteries Single-point Blue Beam Light Laser Pointer Pen Silver

SKU: HK-32002531
Color: Blue-violet Laser Pointers
Power: 5000mW Lasers
Rating: Write a Review

FREE DELIVERY Worldwide Free Shipping

~~$725.99~~ $119.99 Save 83%

Qty: 1 Add To Cart

Share 0 Tweet

Like Share 2.2m

Description Shipping & Payments Product Reviews

Attach close importance to our 5000mW 450nm 2*16340 Batteries Single-point Blue Beam Light Laser Pointer Pen Silver! Adopting fine aluminum alloy material, the outer shell is solid and sturdy to resist daily scratch, bump and shock etc. It supports single-point style, directly pointing at whatever desired target. Powered by 2pcs 16340 batteries, and with stable performance, it has low power consumption and long service life. Furthermore, it sends out harmless light, quite environmentally friendly. You can trustingly apply this laser pointer pen into daily life!

Others listed:

- **6000 mW Laser Pointers 450 nm, $299.02**
- **5000 mW green, $478.44, Save 61%**
- **3000 mW red 650 nm, $129.99**
- **3000 mW, violet 405 nm, $139.99**
- **1500 mW blue 473 nm, $99.99**
- **1500 mW, multifunctional red 650 nm, blue and green 532 nm,$159.99**

Safety Standards

> 1,000 pages of international advice on laser safety includes only 1 page to address laser eye dazzle

There is no established safety advice to describe, mitigate or quantify the visual effects of laser eye dazzle within existing standards such as ANSI Z136 and BS EN 60825

Safety guidance is urgently needed to:

1. Allow the impacts of laser eye dazzle to be understood and quantified
2. Inform the protection measures required for those at risk
3. Optimize the safety and effectiveness of laser dazzle devices

Laser eye dazzle

Safety Framework

Effects *

Mitigation

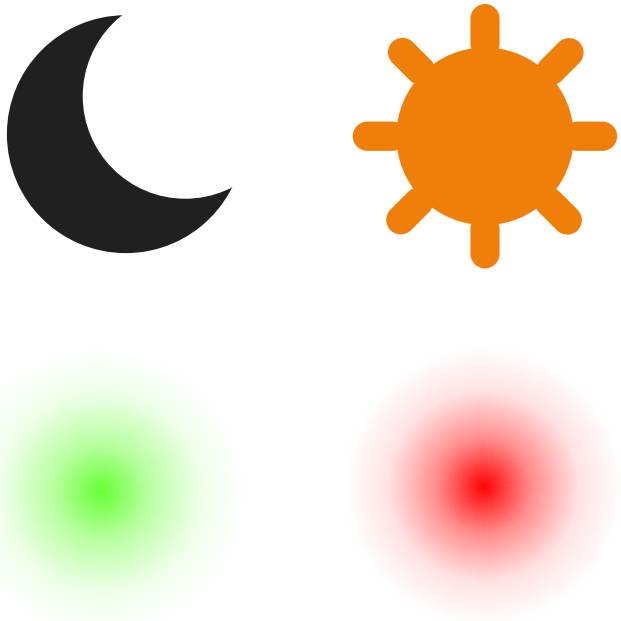
Calculations

Effects

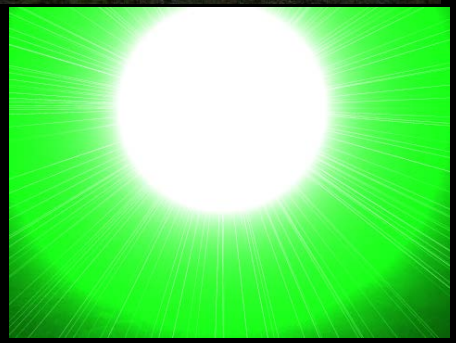
- **Visual**
  - **During exposure**
    Dazzle field
  - **After exposure**
    Afterimages
- **Non-Visual**
  - **Upon exposure**
    Aversion
  - **During exposure**
    Distraction

Contributors

- **Dazzle field**
  - **Ambient light**
  - **Irradiance**
  - **Wavelength**



How Much Irradiance Impedes Vision

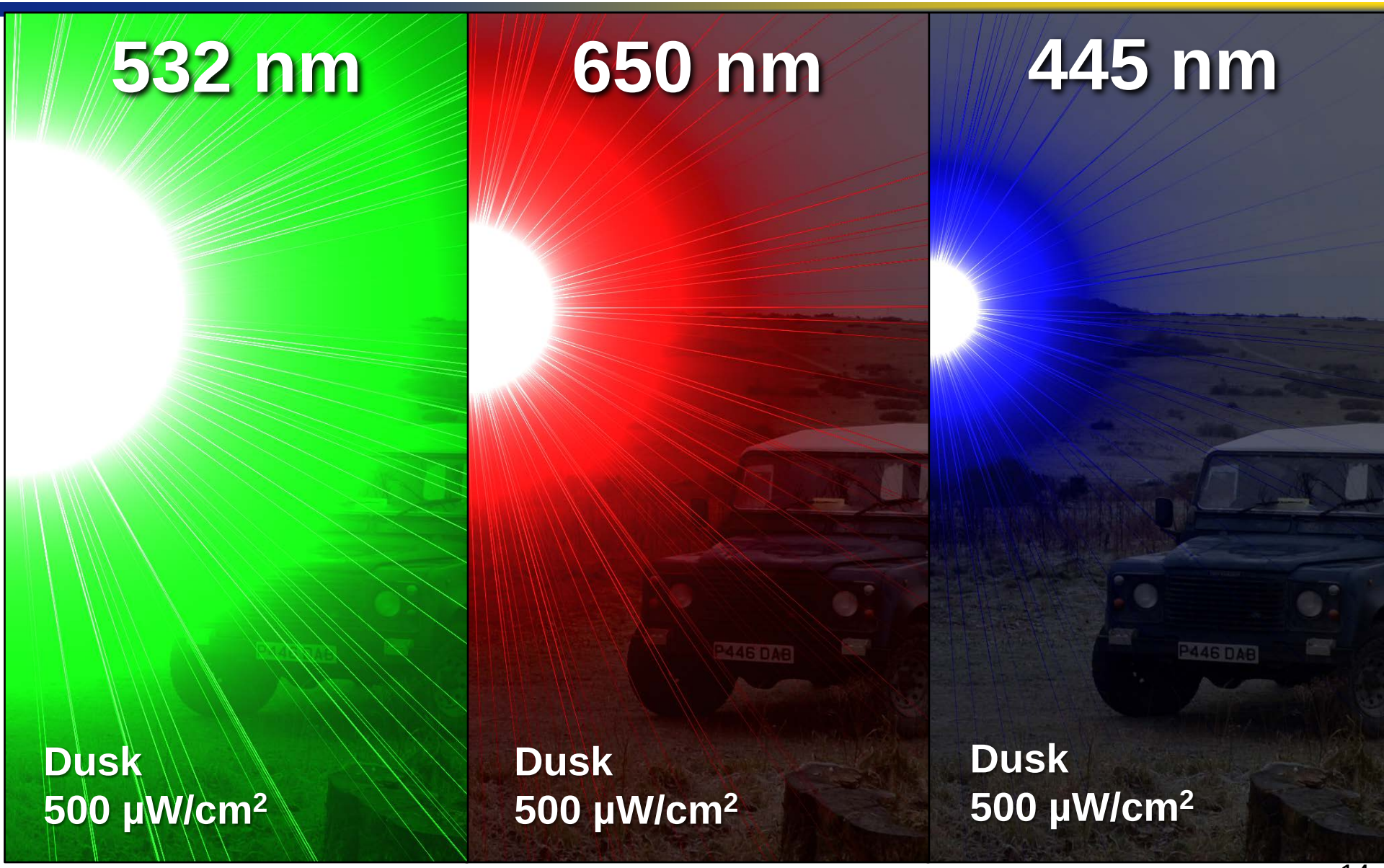
0.5 μW/cm²	5 μW/cm²	50 μW/cm²	500 μW/cm²
			
			
			

Night

Dusk

Day

Wavelength Effects



Contributors

- **Task difficulty**
  - **Location**
  - **Size/contrast**
  - **Complexity**

Laser eye dazzle
safety framework

Effects

Mitigation *

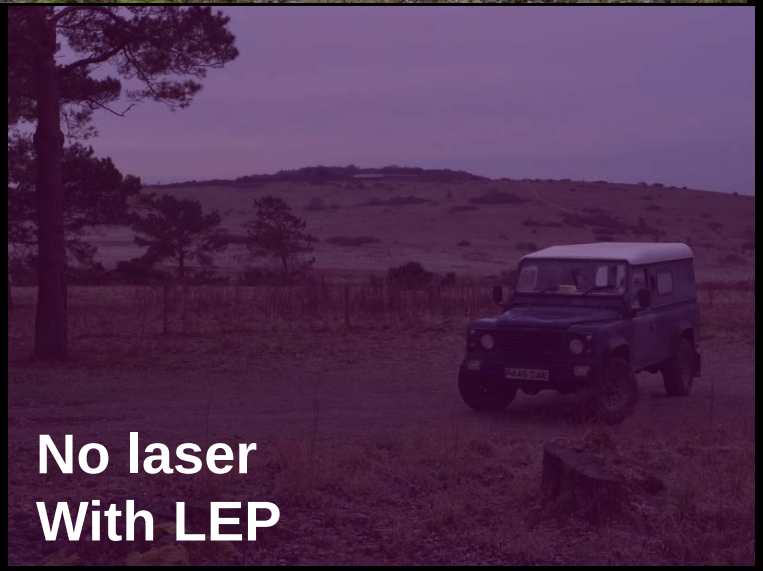
Calculations

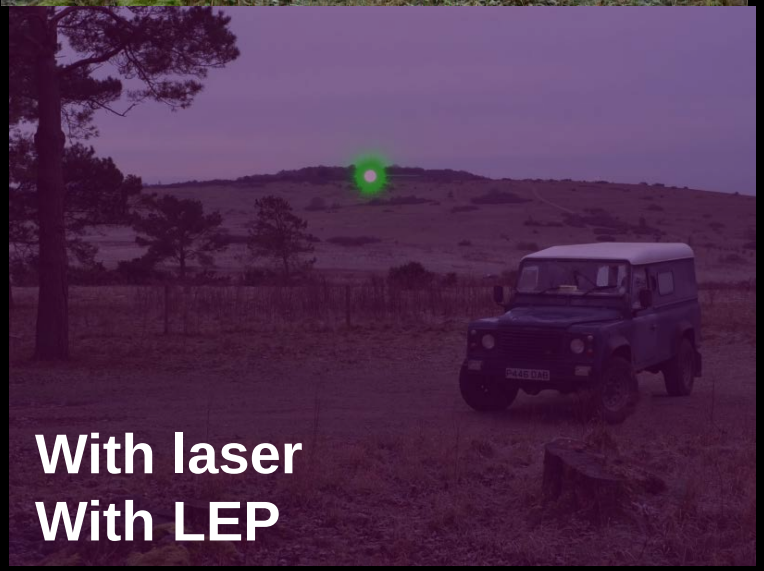
Mitigation

- **Pre-exposure**
  - **Training**
  - **LEP**
- **Post-exposure**
  - **Visual check**
  - **Reporting**

- **During exposure**
  - **Wear LEP**
  - **Manoeuvre**
  - **Shield eyes**
  - **Don’t rub**
  - **Warn others**

Laser Eye Protection (LEP) Impacts





Laser eye dazzle
safety framework

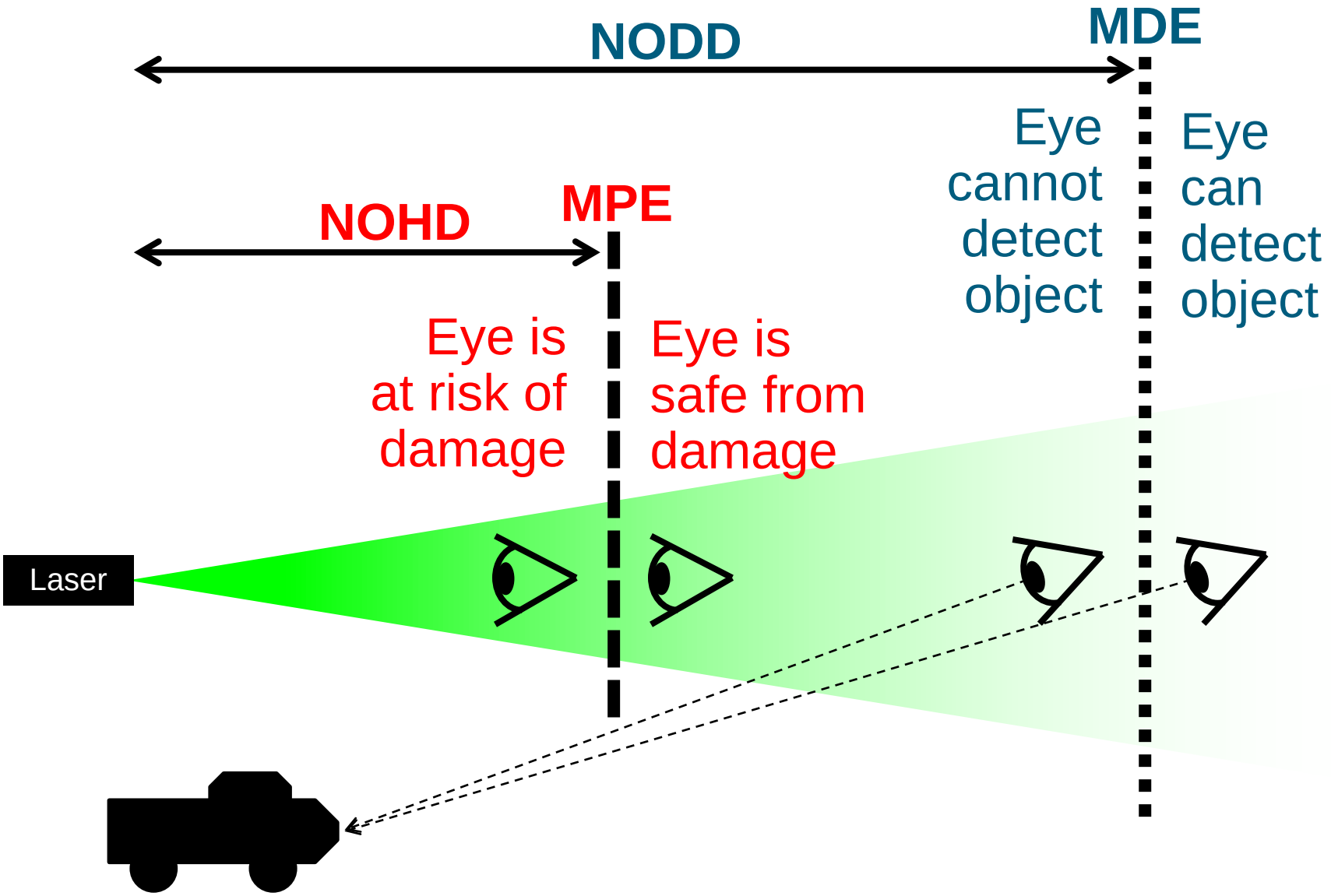
Effects

Mitigation

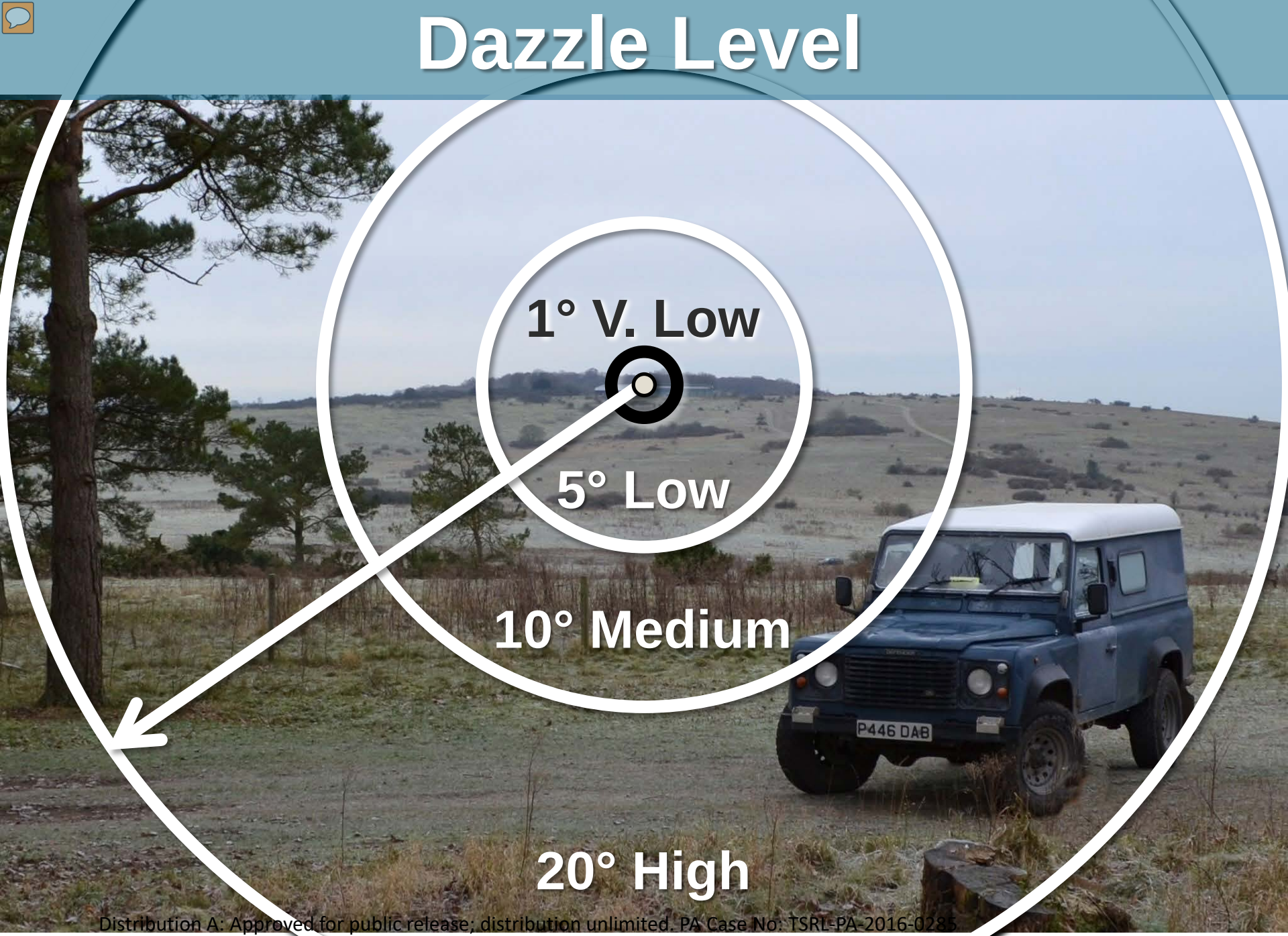
Calculations *

Comparing Damage to Dazzle

NOHD/MPE v. NODD/MDE



Dazzle Level



Defining New Terms

DL Describing the size of the dazzle field

Dazzle Level

MDE Laser irradiance above which an object cannot be detected

Maximum Dazzle Exposure

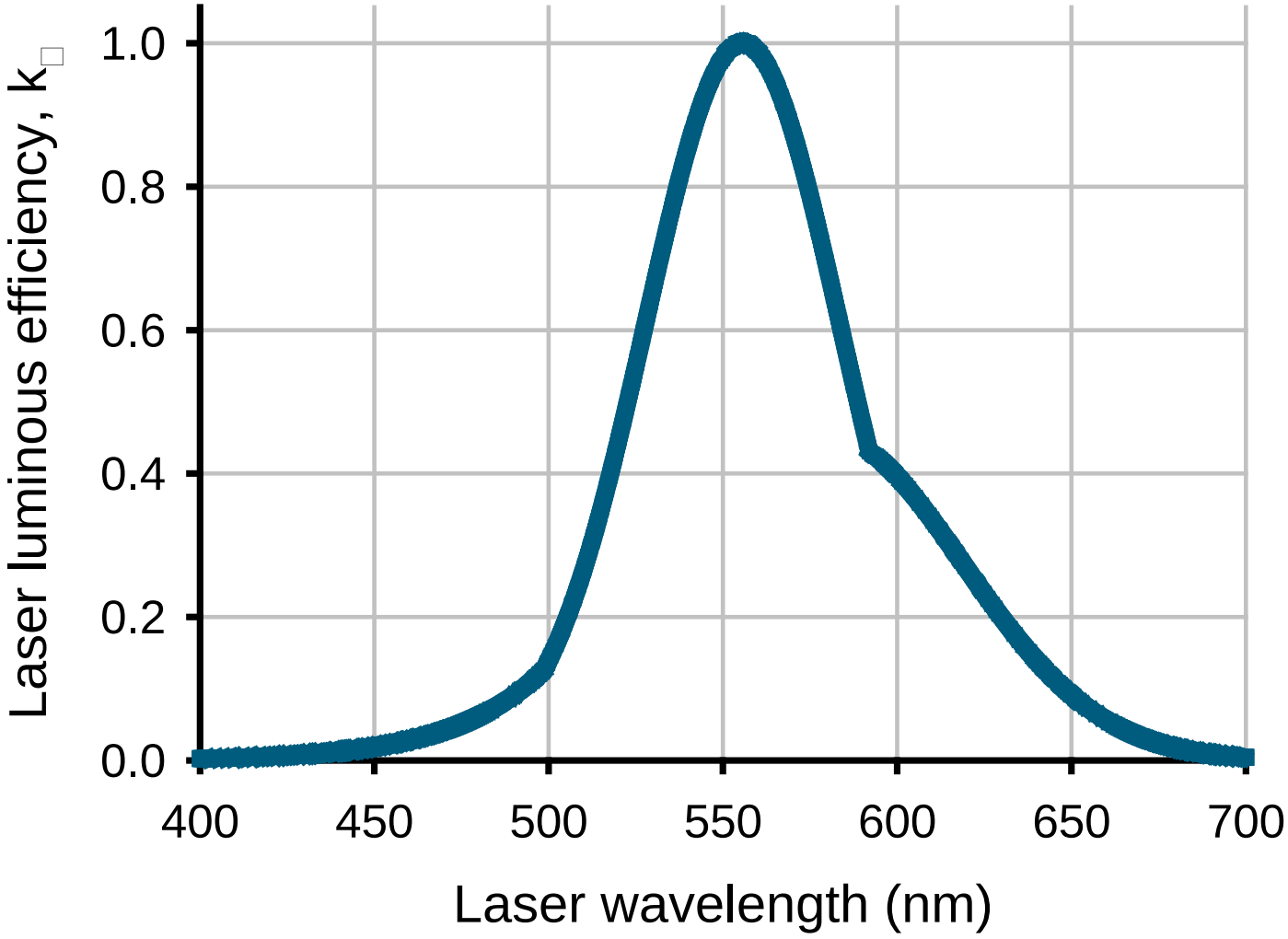
NODD Distance beyond which the laser irradiance is below the MDE

Nominal Ocular Dazzle Distance

MDE $\mu W/cm^2$
Maximum Dazzle Exposure

Dazzle Level	MDE ($\mu W/cm^2$) at Night	Dusk	Day	
V. Low	0.002	0.3	20	$\div k_\lambda$
Low	0.1	15	1,000	
Medium	0.3	60	4,000	
High	1.0	250	16,000	

Human Eye Response



Calculating the NODD

$$NODD = \sqrt{\frac{4P}{\pi d^2 MDE}}$$

- P = laser power (W)
- d = laser divergence (mrad)
- MDE (W/m^2)
- NODD (km)

LEP Optical Density (OD)

$$OD = -\log\left(\frac{MDE}{U}\right) \qquad U = \frac{P}{\pi\left(R\frac{d}{2}\right)^2}$$

- MDE (W/m^2)
- U = laser irradiance at range R (W/m^2)
- P = laser power (W)
- R = range to laser (km)
- d = laser divergence (mrad)

Example Application

MDE for 532 nm $k_\lambda = 0.6998$

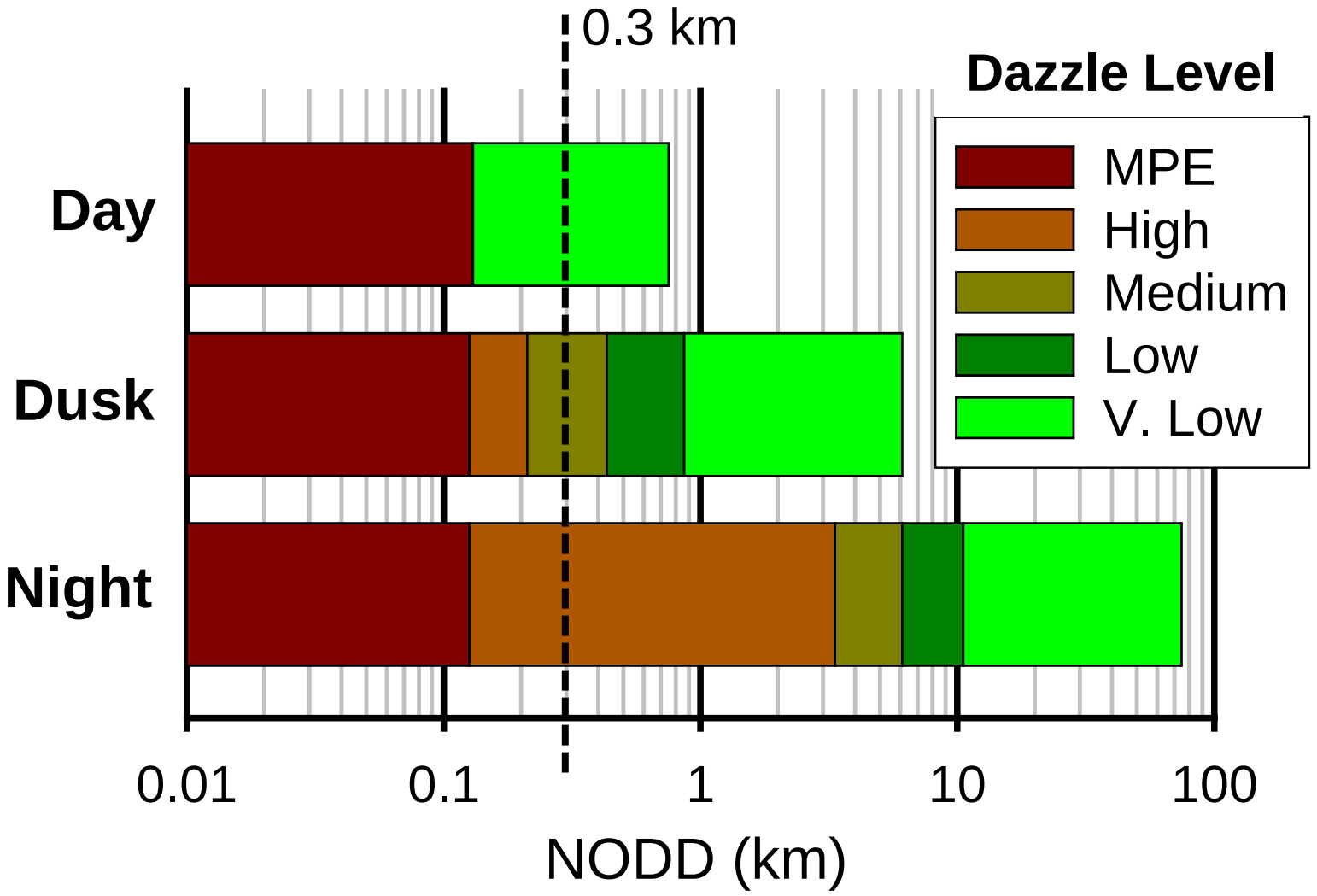
Dazzle Level	MDE (μW/cm²) for 532 nm at		
	Night	Dusk	Day
V. Low	0.0029	0.43	29
Low	0.14	21	1,429*
Medium	0.43	86	5,716*
High	1.43	357	22,864*

Example Application

NODD for 500 mW, 2 mrad

Example laser: **532 nm, 500 mW, 2 mrad**			
Dazzle Level	**NODD (km) at**		
	Night	**Dusk**	**Day**
V. Low	74.6	6.1	0.75
Low	10.6	0.86	0.11*
Medium	6.1	0.43	0.05*
High	3.3	0.21	0.03*

Visualizing NODD Effects



Example Application

LEP for viewing at 0.3 km

Example: **532 nm, 500 mW, 2 mrad, at 0.3 km**			
Dazzle Level	**LEP requirement (OD) at**		
	Night	**Dusk**	**Day**
V. Low	4.8	2.6	0.8
Low	3.1	0.9	–
Medium	2.6	0.3	–
High	2.1	–	–

Summary

DL Describing the size of the dazzle field

Dazzle Level

MDE Laser irradiance above which an object cannot be detected

Maximum Dazzle Exposure

NODD Distance beyond which the laser irradiance is below the MDE

Nominal Ocular Dazzle Distance

Questions?