

Compatibility between Night Vision Goggles and Light Emitting Diodes in ground obstruction lighting

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Background

- Night Vision Goggles (NVGs) have been used by low flying military pilots for many years and increasingly by airborne police and air ambulance personnel
- Legacy incandescent lighting on aircraft and ground obstructions has always been highly visible through NVGs
- Modern Light Emitting Diode (LED) lighting technology provides many advantages over legacy lighting
- Unless you are an NVG user.....



Royal Navy air safety report highlights issues detecting other aircraft through NVGs

- In 2013 a Royal Navy Lynx helicopter crew was operating at night using NVGs
 - The crew were advised of another Lynx, 6 miles away
 - The other aircraft's anti-collision lighting was not visible through NVGs, although the red anti-collision beacon was clearly visible when viewed directly by the unaided eye
 - During the next 10 minutes, the aircraft closed to 3 miles separation, but the anti-collision lighting remained invisible through the NVG



Royal Navy air safety report highlights issues detecting other aircraft through NVGs

- It was determined afterwards that the external lighting of the Lynx used LED technology
 - Only the red 'NVG friendly' lighting was operating at the time
 - Infra-Red 'covert' LED lighting (only visible to NVGs) was OFF
- Recommendations from air safety occurrence report
 - Lynx pilots were advised to always select both Red and IR lighting during training flights to improve visibility to NVG users
 - Recognition that the problem is potentially more general, covering all 'visible' LED light sources on aircraft and ground obstructions
 - Advice issued to all UK military aircrew pilots that red obstruction / anti-collision lighting may not be visible through NVGs, due to possible use of LED, and to modify their visual scan pattern and assess low level routes for possible obstructions accordingly

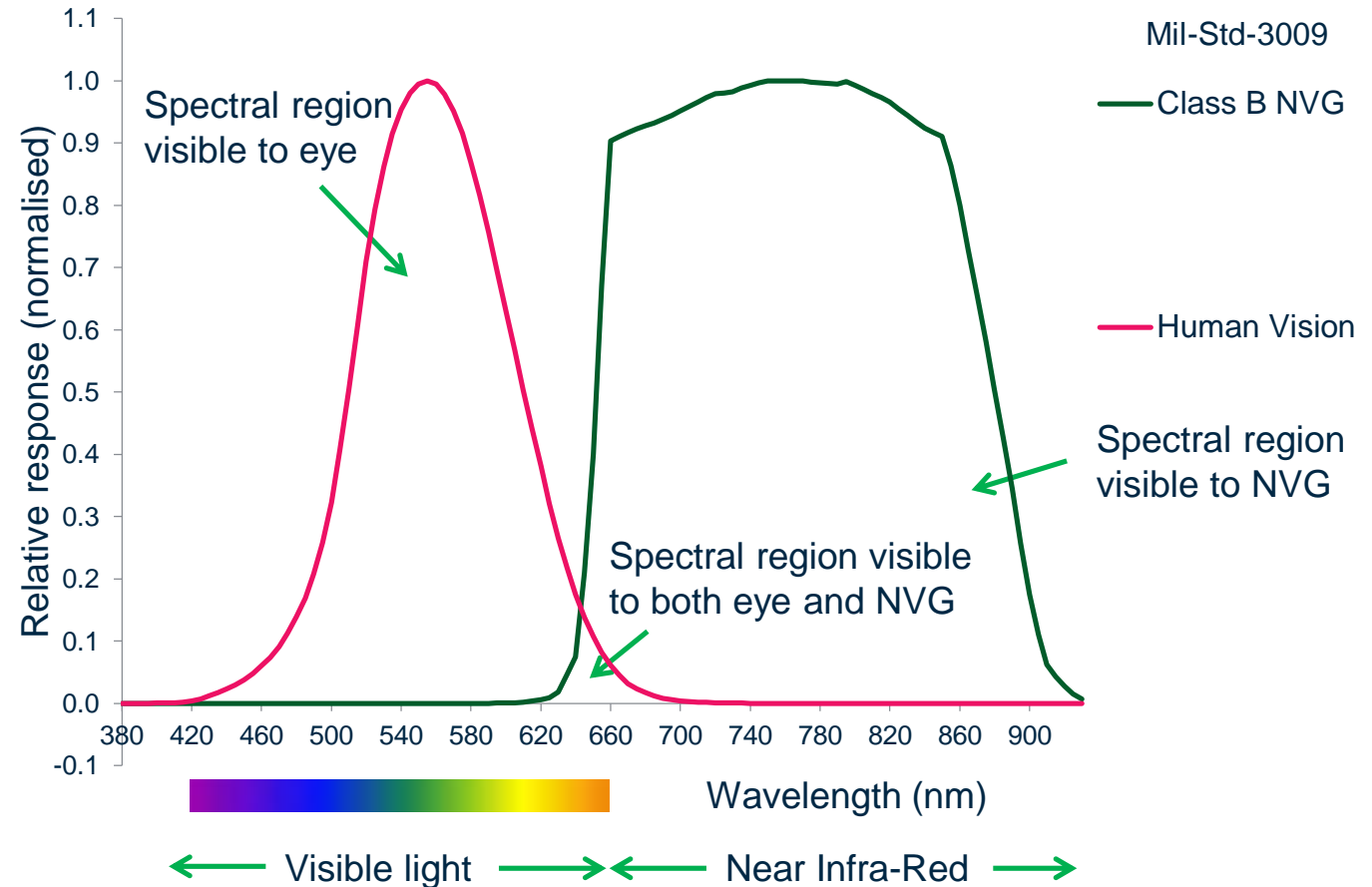


QinetiQ study into NVGs, LEDs and ground obstruction lighting

- QinetiQ tasked to investigate NVG/LED compatibility issues for ground obstruction lighting (focussing on wind turbines), which included the following tasks:
 - Quantify differences in NVG sensitivity to incandescent and LED lighting
 - Review regulations for ground obstruction lighting to determine applicability to NVGs (particular emphasis on wind turbines)
 - Consider possible mitigations to issues identified

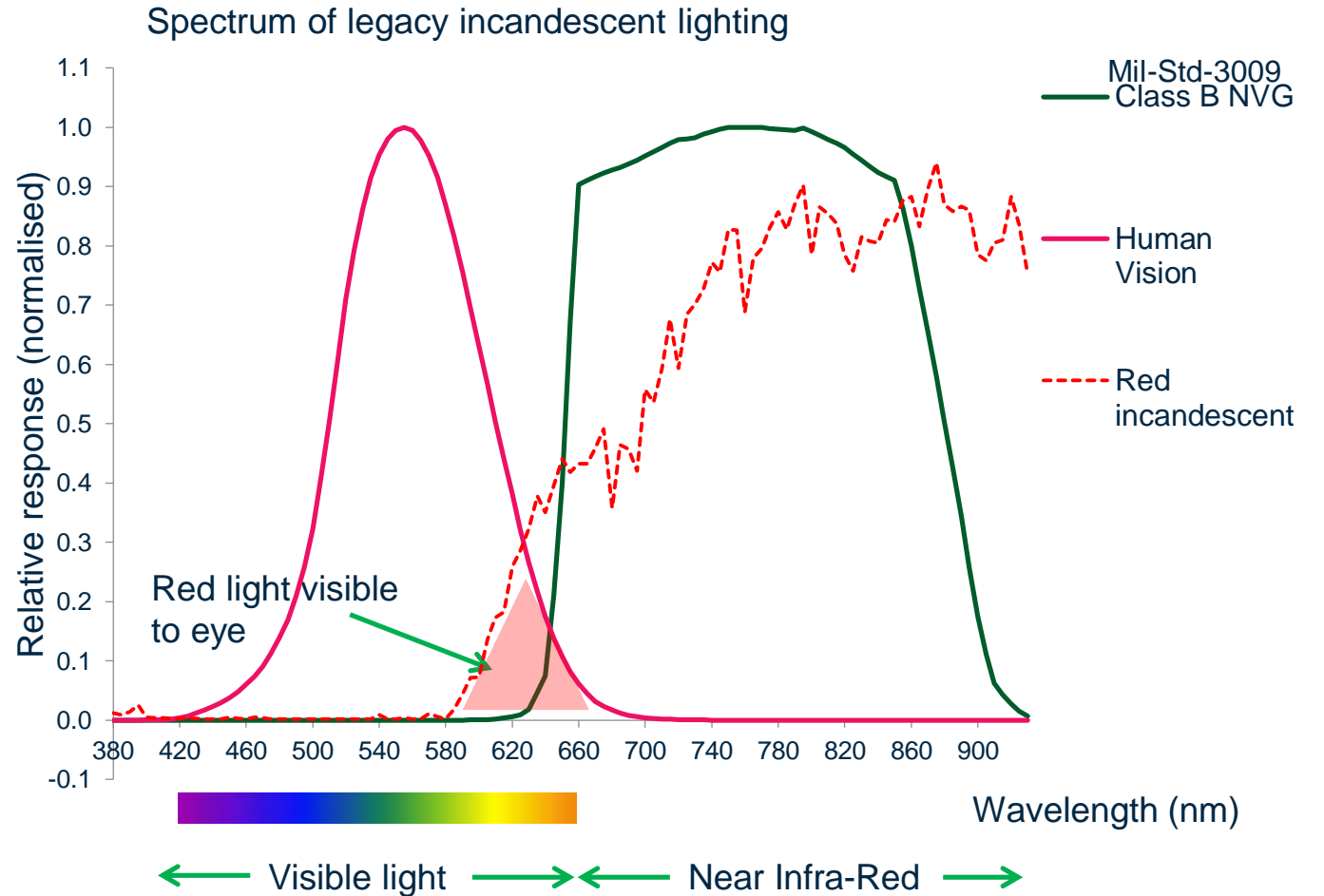
NVG spectral response - cockpit lighting compatibility filtering

- Aircrew NVGs detect very little of the spectrum visible to the human eye – deliberately
 - Unfiltered image intensifiers are sensitive across the visible waveband and into the near IR
 - Aircrew NVGs are spectrally filtered to provide compatibility with complementary filtered cockpit lighting and to eliminate reflections visible to NVGs in cockpit transparencies – generally according to Mil-Std-3009



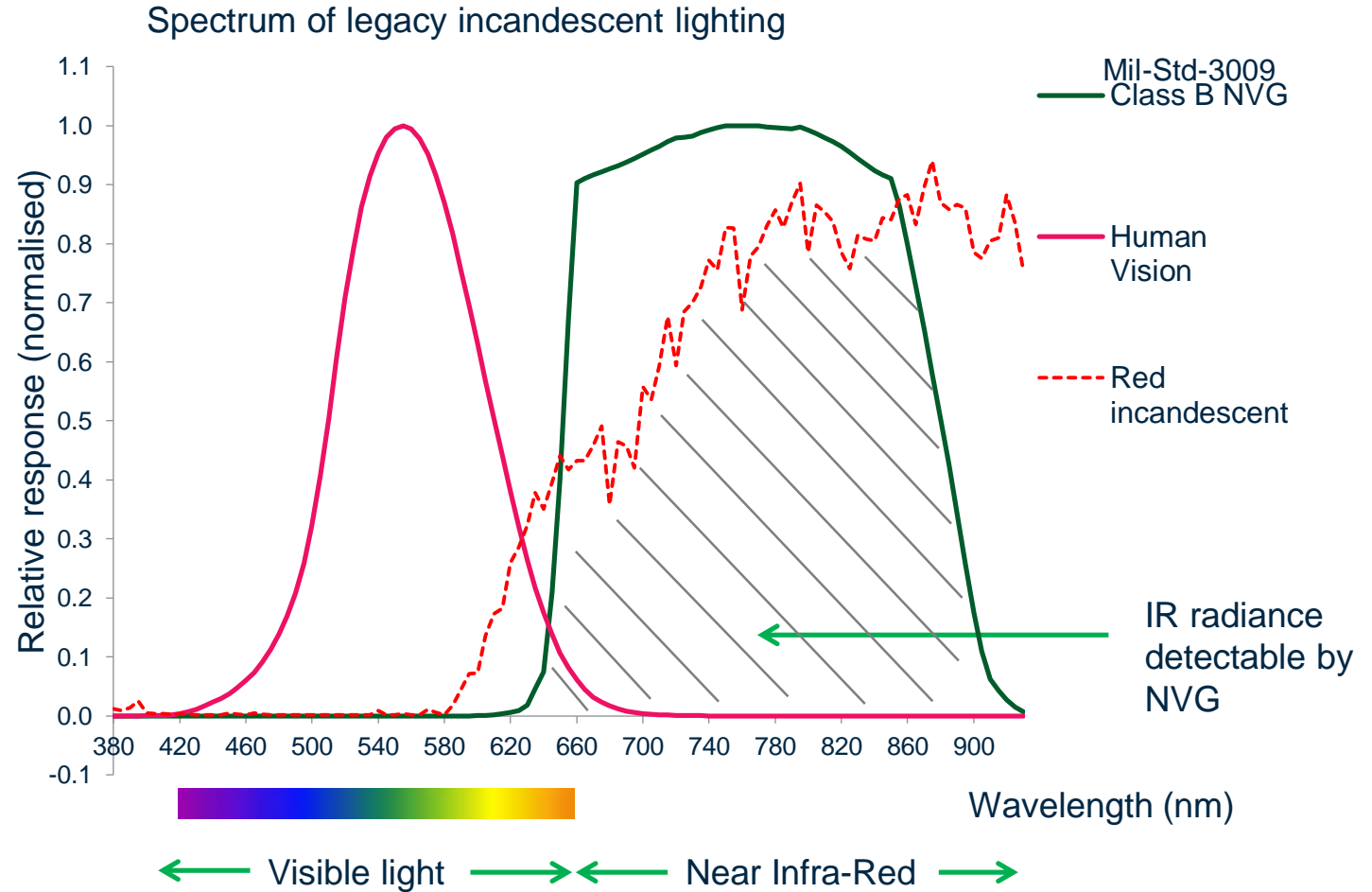
NVG compatibility with incandescent lighting

- Filtering of NVGs previously not an issue with incandescent obstruction / anti-collision lighting
 - Incandescent lighting is a broadband spectral emitter, emits IR in the NVG sensitive region



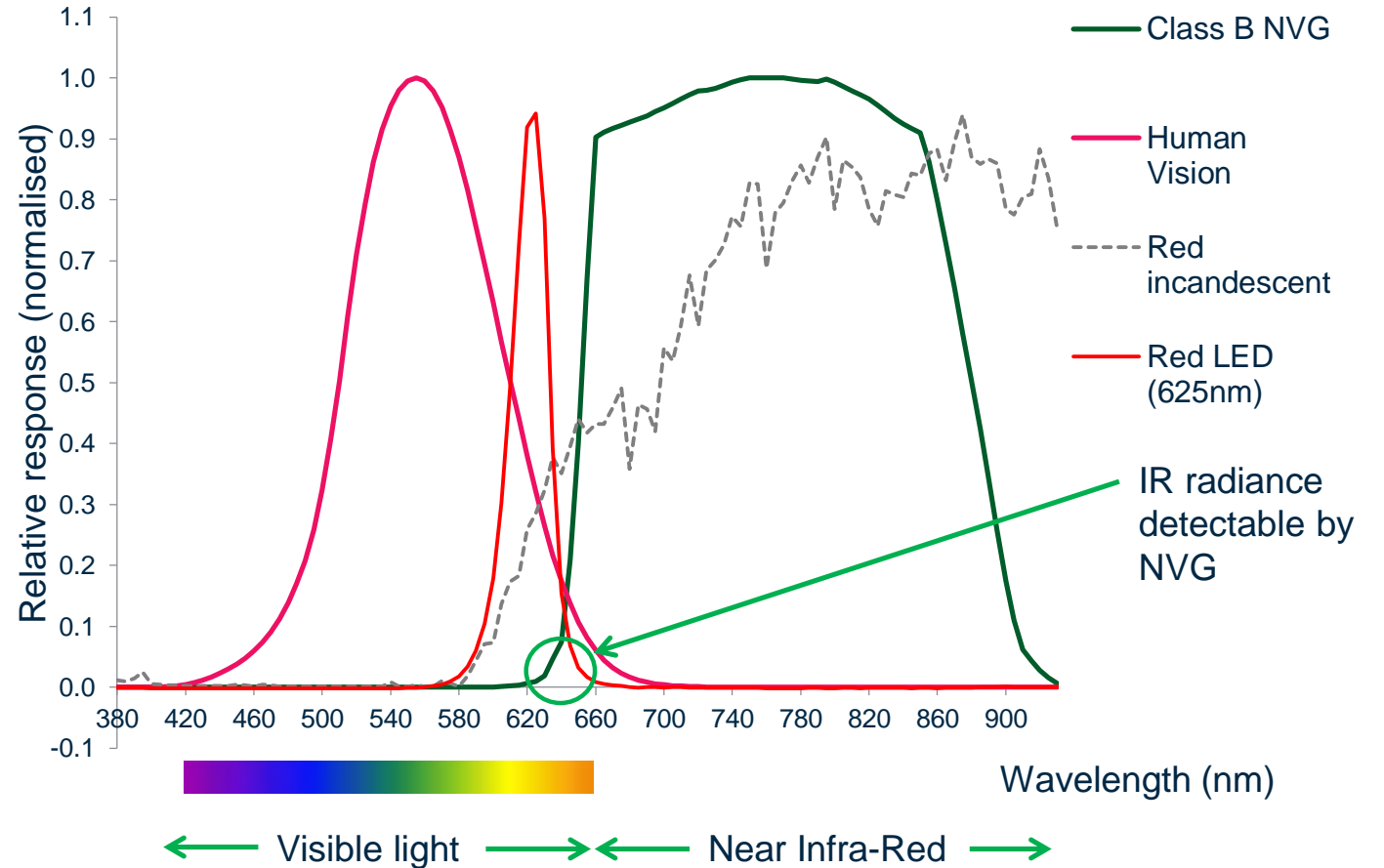
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NVG compatibility with red LED

- With LED lighting there is very little emission in the NVG spectral region
 - NVG weighted radiance of the LED calculated as 369 times lower than incandescent lamp of equal visual luminance
 - Theoretical difference in detection distance of 19 times, ignoring atmospheric effects
 - Minimum detection ranges for both technologies unknown, depend on factors such as illumination and background

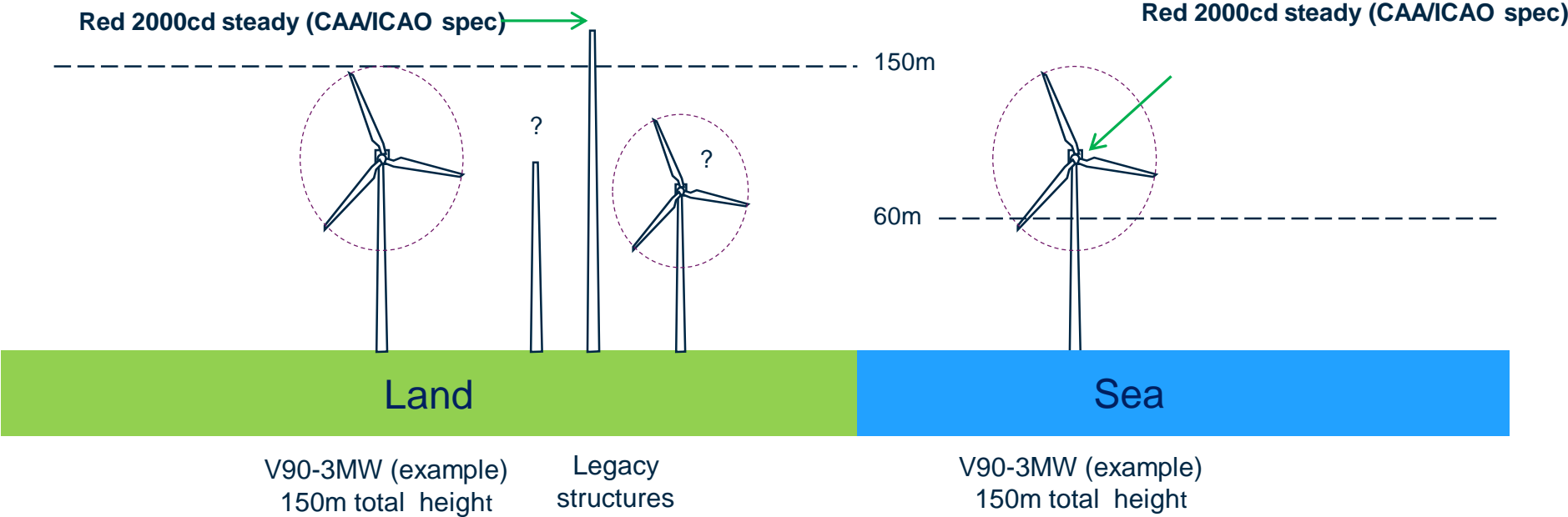


ICAO lighting requirements for wind turbines/large structures

- ICAO lighting specification for red lighting only specifies visible luminance – no requirement for infra-red / NVG visibility
- International Civil Aviation Organisation (ICAO) regulations require illumination of many obstructions close to airfields but do not require obstructions away from airfields to be illuminated at night, unless over 60m (offshore) or 150m (onshore)
- Most land based wind turbines, and other obstructions, away from airfields, are not tall enough to require illumination, but still present a hazard to military aviation
- Circa 9700 wind turbines now installed on UK mainland or in coastal waters (2019)

ICAO lighting requirements for wind turbines/large structures

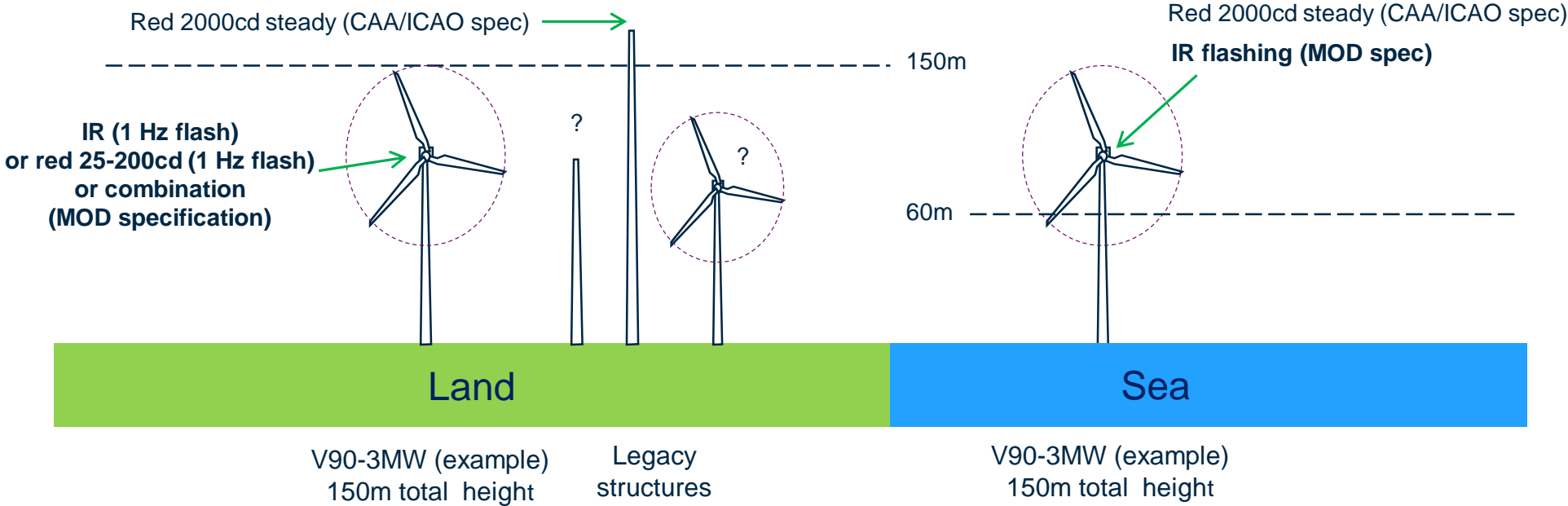
CAA/ICAO requirement - Red lighting required above 150m overland, 60m offshore,



UK MOD guidance on illuminating obstructions for NVG users

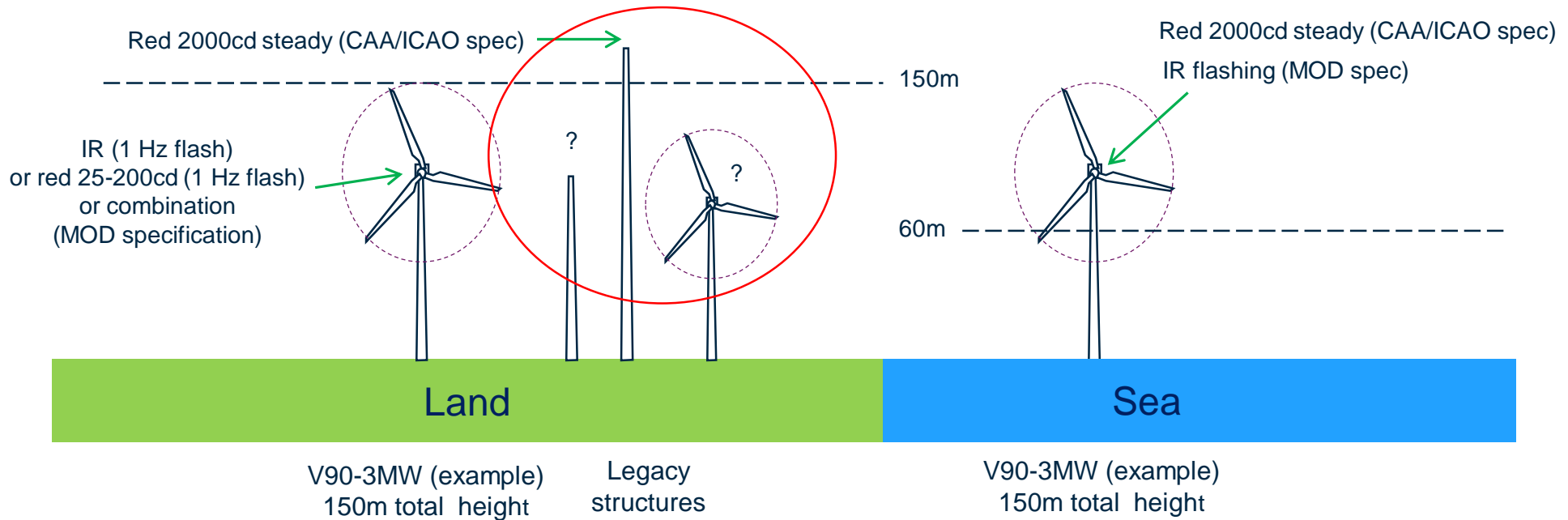
- UK MOD do provide recommendations for illuminating wind turbines for NVG users
 - Overland wind turbines are generally below the 150m (500ft) height requiring mandatory red obstruction lighting but are tall / numerous enough to hazard low flying aircraft
 - Wind 'farms' often close to rural towns and villages and local communities object to red lighting on windfarms, as this can cause significant visual disturbance to the rural environment at night
 - In 2009, MOD and QinetiQ evaluated Infra-Red Light Emitting Diode obstruction lighting and determined it was visible to NVGs at the required range, but invisible to the unaided eye
 - MOD developed a specification for IR obstruction lighting, which is recommended but not mandatory for UK windfarms
 - QinetiQ were unable to determine what proportion of wind turbines were illuminated with IR LEDs

UK MOD guidance on illuminating obstructions for NVG users



Legacy structure illumination

- Potentially many legacy structures with incompatible / no lighting
 - Many wind turbines erected before MOD guidance issued
 - Structures where previously visible red incandescent lighting has been replaced by red LED lighting
 - Problem growing as red incandescent progressively replaced by LED



Further Implications

- Situation outside UK is unknown but ICAO regulations are applicable worldwide
 - UK MOD specification was only specification quoted worldwide for IR LED obstruction lighting products, believed other countries do not have a similar standard
- Findings applicable to illumination at / near to airfields
- Findings could apply equally to aircraft anti-collision lighting
 - Study was not required to examine civil and military aircraft anti-collision lighting standards, but findings are believed to be applicable
- It is not known how well NVG users appreciate these issues
 - UK MOD has issued advice to UK military pilots concerning issues with red LED lighting and NVGs but QinetiQ have spoken to aircrew who are not aware of this

No easy solutions

- Changing NVG filter characteristic would make red LED more visible - but
 - Would negatively impact cockpit compatibility
 - Cockpit instrument filter modifications likely to be expensive
- Change aviation regulations
 - Aviation regulations need to be amended to mandate requirement for IR content in ground obstruction lighting
 - A specification would need to be agreed, but the UK MOD specification could be considered
 - Potentially effective solution, but long term (how often are light units replaced?)
- Improve awareness with aircrew and lighting manufacturers
 - Not all aircrew are aware of NVG / LED compatibility issues
 - Lighting manufacturers could be encouraged to include IR as standard in their Red LED products
- Emphasises the need for good low level route planning and in-flight lookout

Acknowledgment

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