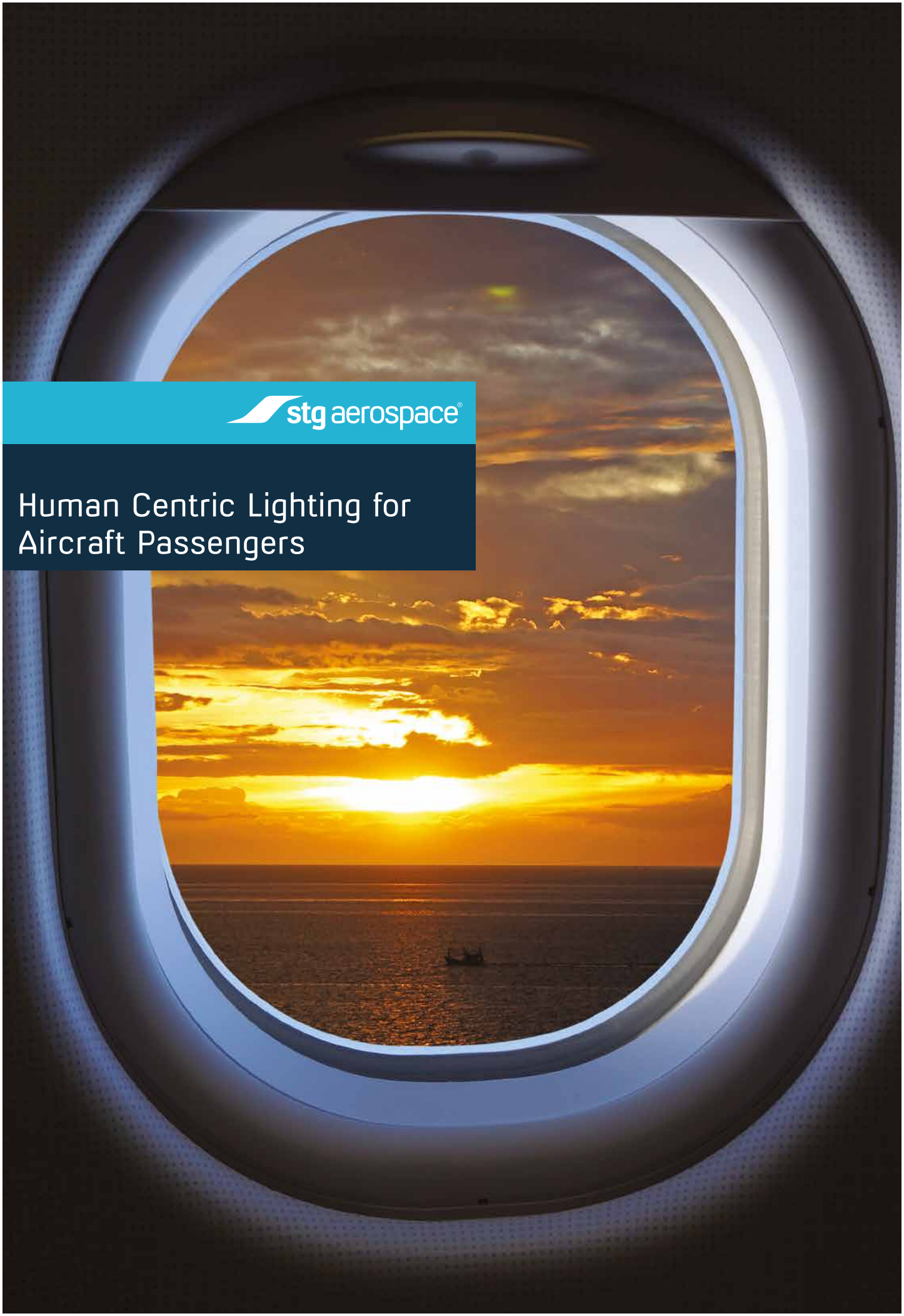

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Human Centric Lighting for Aircraft Passengers

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Dr Sean O'Kell
Director of Innovation

Dear Reader,

Human centric lighting is a new term used to discuss lighting purposely designed to help us feel and perform better. It relies on a combination of intensity and colour spectrum to produce a photo-biological response. In plain English, information from light is how our brain determines what time of day it is and acts as a signal to produce the appropriate amount of energy; more through the day, less at night.

So far, little of these findings have filtered into the aerospace industry and there is much confusion over how human centric lighting can be implemented within the cabin. We will discuss research into how humans interact with light and how this can be used to improve the passenger experience.

"Human centric lighting is providing the right light, at the right time, making people's lives better."

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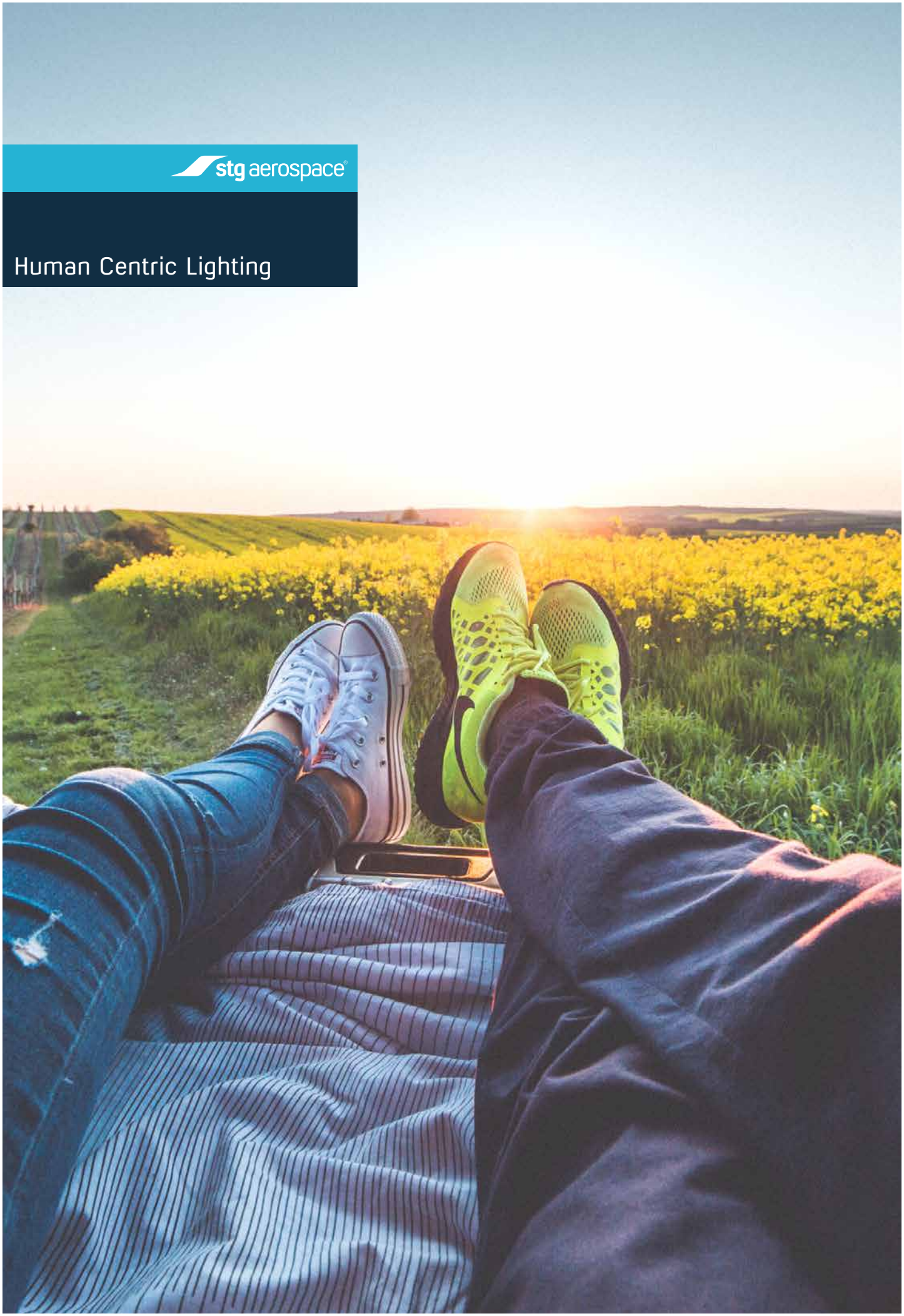
Human Centric Lighting



LIGHTING FOR PEOPLE

Light is how our eyes see the world around us but it also helps our brain to determine what time of day it is and what we need to be doing. Our brain uses this information to produce the appropriate response whether that's to energise, relax, to be on alert or even what mood we need to be in. As lighting obviously plays such a big role in how we feel and interact with the world around us, it is fundamental that we take these non-visual effects into consideration when designing, choosing and using lighting.

Up until recently, trends in the legislation and practice of lighting have been concerned with high intensity illumination and increasing energy efficiency. However, more information is emerging on how we interact with light and it turns out that we get a lot more information from light than just what we can see. Lighting has also been shown to provide biological and emotional benefits demanding an entire new branch of lighting design - Human Centric Lighting.

Human centric lighting is intended to promote a person's wellbeing, mood and health. It can improve concentration, increase safety and efficiency in workplaces and even change the perception of our environment. In short, lighting is not just about the visual.

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Applying Light

THE FUNDAMENTALS OF LIGHT FOR HUMANS

Originally, artificial lighting was used to extend the productive hours of the day and has helped massively in the advance of our society and culture. For years, lighting design has centred on producing as much illumination as possible, as energy efficiently as possible, with little to no thought of the non-visual effects of lighting on humans.

Starting out with fire and candles, now we have LEDs: lighting has evolved to be more adaptive, safer and now meets more of our needs than ever. With such a range of lighting available to us, we are in a position where we can choose not only how we illuminate our space but also how to get the most out of lighting to improve our wellbeing.

When designing, choosing and using lighting there are four factors that we must consider;

SETTING

A light fitting and the light it produces is a part of the aesthetics of the space, to create the best space possible the aspects of the light must complement its setting.

TASK

Light can help or hinder us with our tasks. While certain light can increase concentration and cognitive performance, other light will make us drift off and feel sleepy.

PEOPLE

Light synchronises our internal body clock and helps to maintain our health and wellbeing. Without daily adjustments our circadian rhythm will exceed 24-hours.

AMBIENCE

Light makes the environment; whether it's achieving a comfortable, cosy atmosphere or emphasising safety, lighting can make or break the perception of the space.

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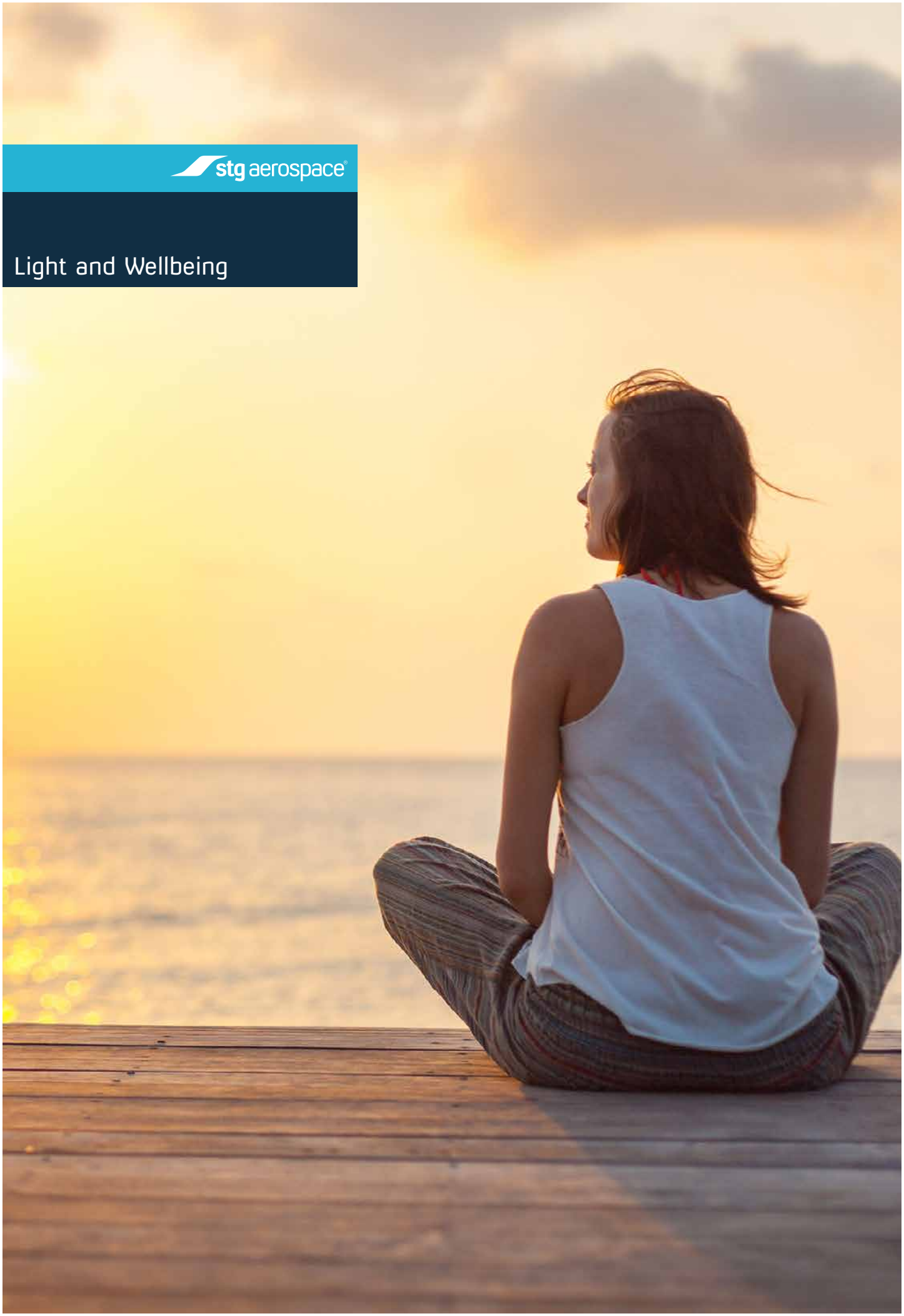
Light and Wellbeing



BIOLOGICAL RESPONSE TO LIGHT

Light is what stimulates sight and makes things visible. As humans, we see light from the visible spectrum; light with a wavelength typically within the range 380 nm to 750 nm. When we see, visible light enters our eyes and interacts with cells at the rear of the eyeball (the retina). The information from these cells travels to our brain where it determines the intensity and colour of the incoming light and uses it to build up the image that we see.

However, our brain does a lot more with information from light; it uses light to determine the time of day and season of the year. Our brain then uses this information to determine what sort of response is needed such as activating or relaxing. These non-visual effects don't help us to physically see the world but do help to enhance our connection to what is going on around us.

The non-visual information from light is gathered through a particular subset of cells in the eye called intrinsically photosensitive retinal ganglion cells (ipRGCs). The function of these cells (only recently verified in 2002) is to relate information from the eye to the brain, specifically the hypothalamus. The hypothalamus uses this information to synchronise our internal body clock and determine the appropriate response according to the time of day. Without daily synchronisation, our body clock will naturally drift and exceed a 24-hour cycle.

How well our bodies respond to this non-visual information depends on the colour (spectral qualities) and brightness (intensity) of the applied light.

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Functionality of the Eye

VISION AND THE TRADITIONAL PHOTORECEPTORS

Our eyes use light to see and our brain uses information from our eyes to build up an image of the world around us. In our eyes there are many millions of photoreceptors of different types. Rods and cones are the main photoreceptors responsible for creating our vision.

CONES

Provide information under bright conditions (photopic vision). There are three types of cones, which have a peak responsivity to red, green and blue light respectively. Our brain uses the information from these cones to establish colour vision.

RODS

Help us to see in low light conditions (scotopic vision). Rods are incredibly sensitive and give us the ability to see when there is almost no light. However, as there is only one type of rod they are only sensitive at short wavelengths – the blue-green end of the visible spectrum.

The traditional photoreceptors relay information from the retina to the visual cortex at the rear of our brain.

Intrinsically photosensitive retinal ganglion cells (ipRGCs)

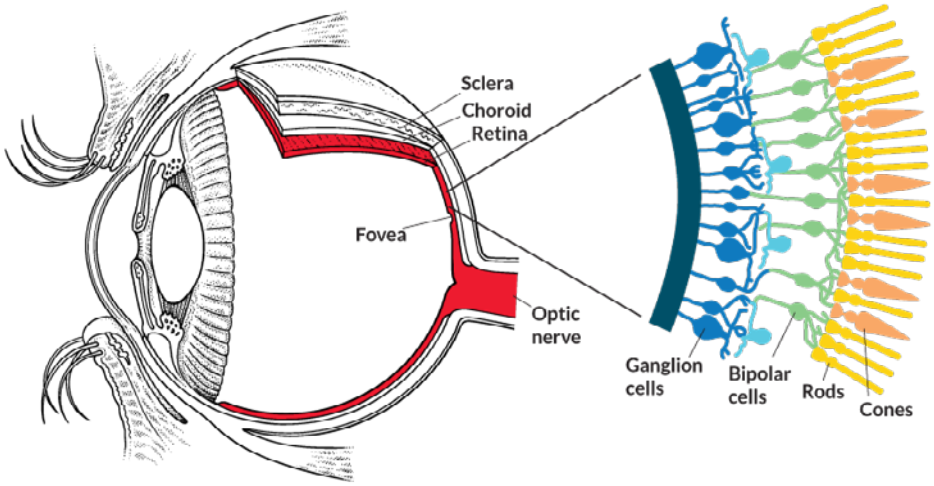
While rods and cones take care of our picture of the world, our brain relies on a third photoreceptor for crucial non-visual information.

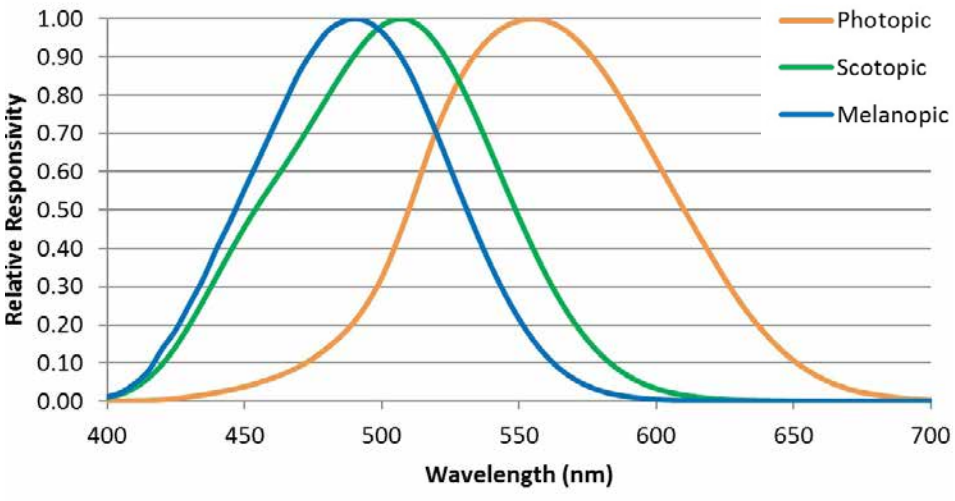
Intrinsically photosensitive retinal ganglion cells are a newly discovered subset of ganglion cells that reside in the retina of our eyes.

These cells take in information on the colour and intensity of the light around us and relay it to the hypothalamus where the main functions are;

Regulation of the internal body clock

Production of arousal





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Innovation

ONGOING RESEARCH

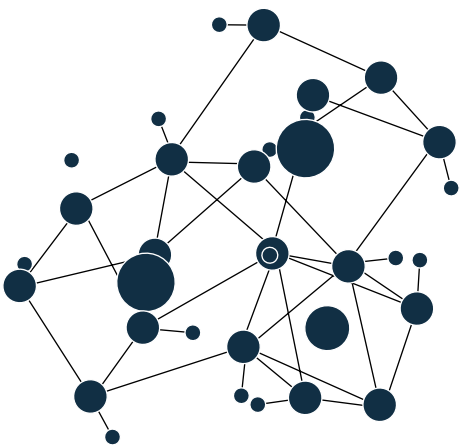
The full effects of lighting are still being determined. Although we now know how our circadian rhythm is regulated using light, the impact of lighting on our mood, wellbeing and physiology are not yet completely understood.

There is currently no agreement on how circadian and human centric lighting systems should be used and indeed, when it comes to schools and work places the discussion is still open as to whether they should be used at all, considering our little knowledge of long-term effects.

At STG Aerospace, we are contributing to the research pool by investigating stress and relaxation at all stages of the flight and assessing how these physiological responses relate to light. This research will help us to deduce how to best use lighting to enhance the air-travel experience for the passenger.

At STG Aerospace, we are performing research in collaboration with the Delft University of Technology, who are one of the world leaders in investigating passenger comfort, perceptions and wellbeing.

We are also working on passenger perception of emergency lighting systems with Cardiff University. We are looking at ways of introducing branding and aesthetics, and passenger interaction with these systems: both in emergency and non-emergency scenarios.



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HCL and Air Travel

CAN YOU BEAT JETLAG?

The reality is that your body will take some time to get used to a different time zone but there are ways that you cheat jetlag and minimise it's effects;

JETLAG CALCULATOR

Using information about your destination and place of origin, online jetlag calculators advise you on adjusting your sleep cycle over a few a few days before and after you travel.
This will help to reduce the shock to your system.

SLEEP

When going easterly jetlag is at its worse but when traveling westerly your day will be longer. Having a snooze on the plane will help you stay awake until an appropriate bed time when you arrive. Limit your exposure to light and noise, kick back and relax.

GO OUTSIDE

Getting plenty of daylight will help to re-adjust your internal body clock to the new time zone. When travelling east get plenty of light in the morning and when going west going out in the afternoon really helps to kick start your circadian rhythm.

WATER

It is important to stay hydrated by drinking plenty of water, but it is also important to avoid alcohol and caffeine.
It may not sound like the perfect start to your holidays but you will feel the benefit when you arrive at your destination.

How to limit your exposure to light in an environment you have little control over?

Studies have shown that anxiety related to a fear of flying can be exasperated by the feeling of losing aspects of control. When traveling by air we have very little control over our environment which can make us uncomfortable.

In the aircraft cabin, we have control over only one light; the reading light. At STG Aerospace we have taken advantage of this and used our reading light to define the personal space of the user, helping to enhance the perception of control over our own space. This has been achieved by using a specially designed square light footprint with little light spill onto neighbouring passengers; illuminating your space, for your needs.

Design Ethos

QUALITY AND SIMPLICITY

The STG Aerospace design ethos is to design high quality, simple lighting solutions. As part of this, our retrofit cabin lighting uses the existing light controls and requires no retraining for the cabin crew. We have also taken on board feedback from cabin crew already using LED lighting systems; the predominant response was that while LED lighting systems can offer up to many millions of colour options, when it comes down to it they are just not used to anything close to their full extent.

Typically, an airline will choose four light settings – three of which are a 'white' light and the fourth is usually a shade of blue. Blue light is found to be relaxing and refreshing, helping to make passengers feel energised when they arrive at their destination. For these reasons, the STG Aerospace cabin lighting system liTeMood® comes with a specially designed liTeMood® blue setting, enhancing the passenger experience with high quality, simple lighting.

Benefits of an LED system

While we may be aware of the benefits to using LED lighting in our homes, within the cabin, LED lighting can help with more than keeping the energy bills down;

MAINTENANCE

LED lamps can have lifespans exceeding 50 times that of their counterpart and are more than 10 times as reliable, requiring less maintenance and reducing aircraft ground-time.

WEIGHT

An important factor to consider for aircraft, weight is directly related to fuel cost. liTeMood® is over a third lighter than incumbent systems helping to reduce fuel burn.

ENVIRONMENT

Fluorescent lamps contain mercury, which is toxic and must be disposed of safely. LED systems do not contain harmful substances and are safer to dispose of.

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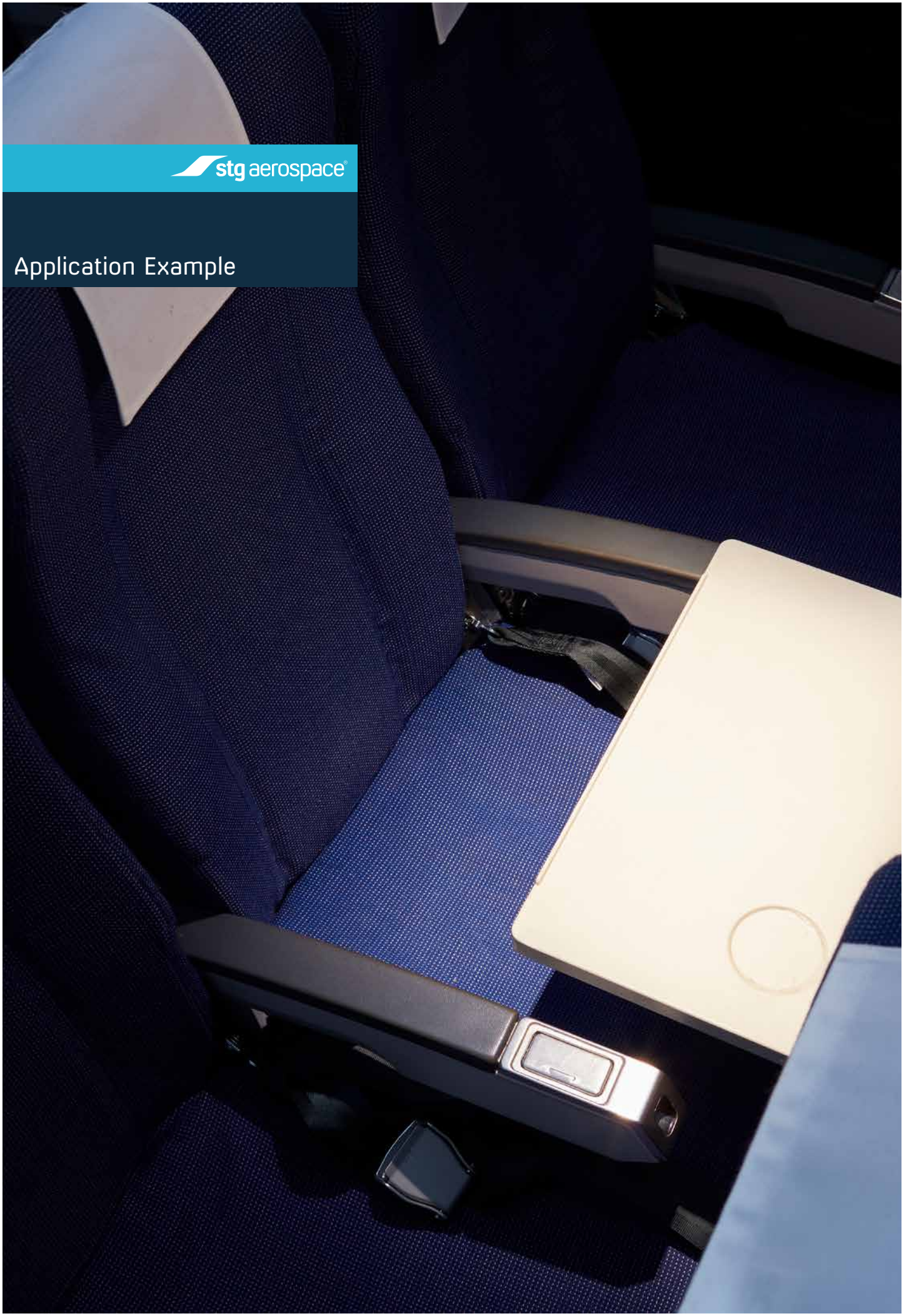
Application Example



liTeMood® LED READING LIGHT

Human centric lighting used sensibly.

BALANCE

Colour is balanced with intensity to provide a light which does not impact on other passengers trying to sleep.

HIGH COLOUR RENDERING INDEX (CRI)

Colours are more vivid and ‘true’. Important for environments serving food as this helps to make food look fresher and healthier. Also important for magazines and books with colour images as this helps to make images pop off the page.

UNIQUE SQUARE LIGHT FOOTPRINT

Helps to define passenger space, reinforcing boundaries, improving sense of control.

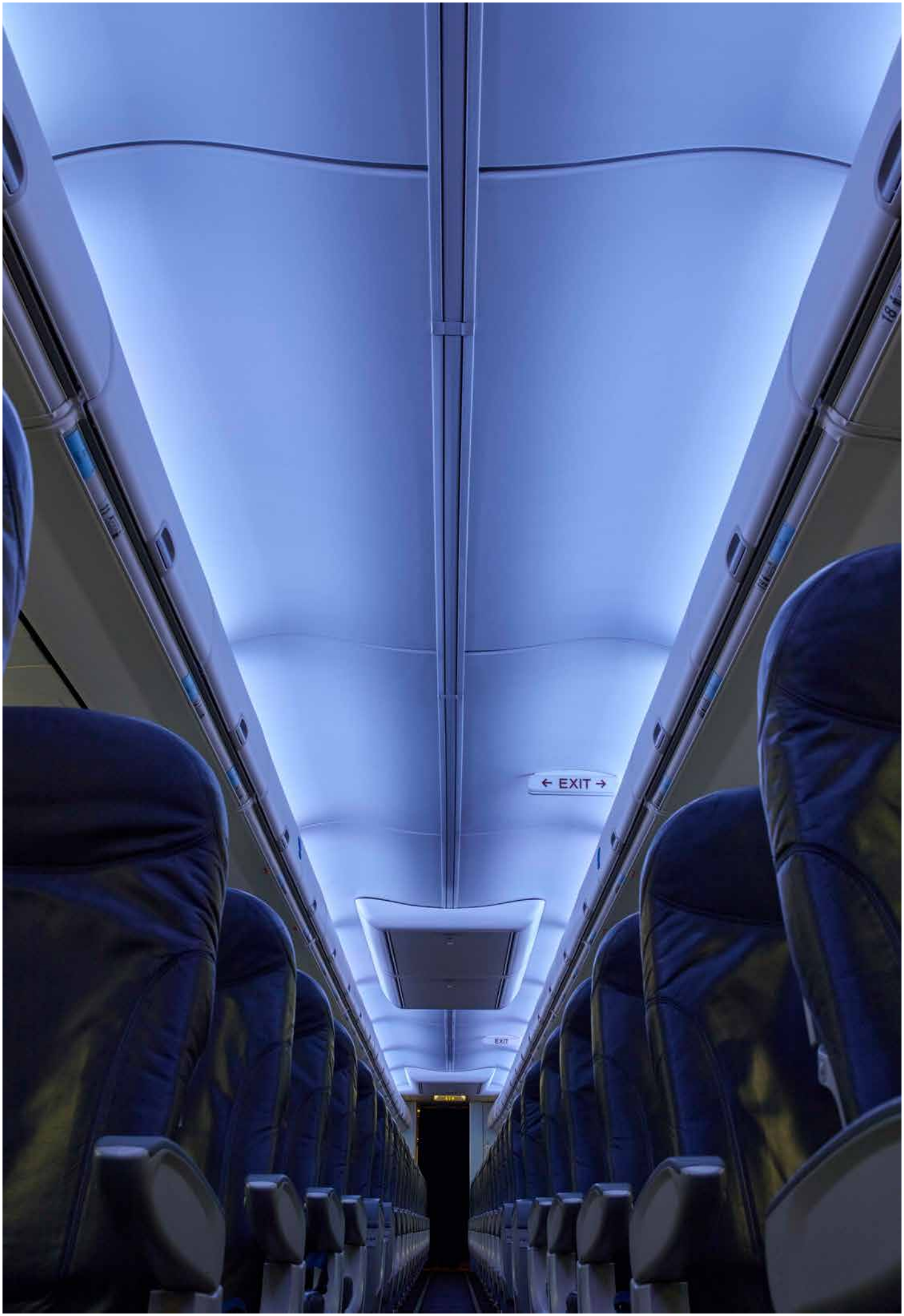
Uniformity

The LED Reading Light, from STG Aerospace, has been specially designed to provide a uniform, square light footprint. The light is limited over the users own personal space, with little to no light interrupting those in the neighbouring seats. Importantly uniform lighting has been found to;

DECREASE ANXIETY

INCREASE ANCILLARY SPENDING

BEST READING ENVIRONMENT



liTeMood® CABIN LIGHTING

Aesthetically pleasing lighting made for people, and we haven't forgotten about the cabin crew.

PROVIDE SUFFICIENT LIGHTING FOR CABIN CREW AND PASSENGERS

STG Aerospace is concerned with creating lighting which enhances the passenger experience but we haven't forgotten that for the cabin crew it is also a work place. Studies have shown that negative ambient conditions, such as noise, smells and lighting, can have a subconscious impact on our health. Researchers found that while cabin crew didn't notice an increase in noise within the cabin, staff did mention more aches and pains, complaining of sore feet and neck.

USES EXISTING CONTROL SYSTEM

Quicker and easier installation compared to systems that require an interface overhaul while providing the extra benefit that no training is required for the cabin crew.

CABIN IS PERCEIVED AS BEING MORE MODERN, CLEANER AND SAFER

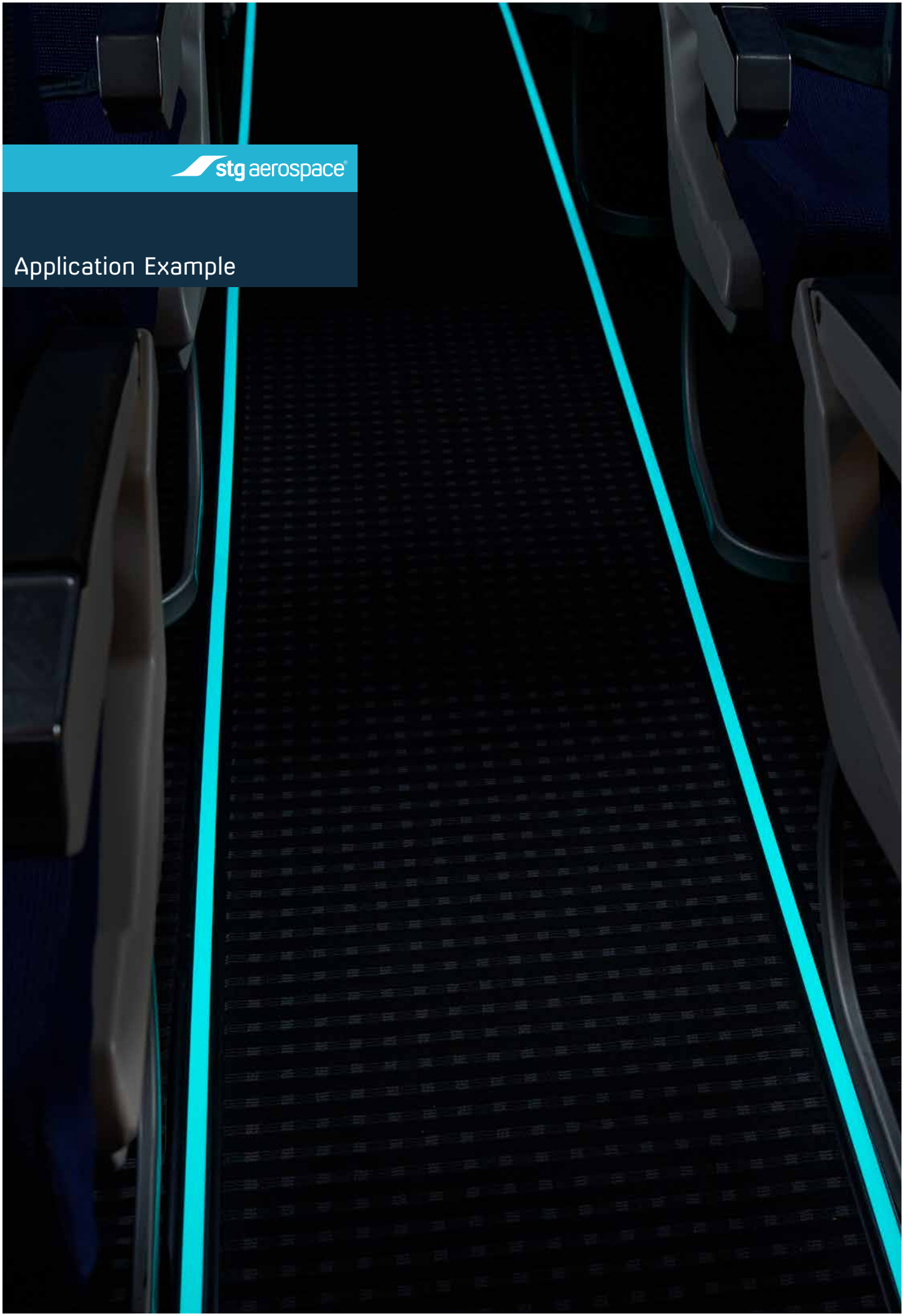
A study at Deflt University of Technology gauged passenger perceptions of an aircraft cabin illuminated with fluorescent lighting and compared this to the perceptions of the exact same cabin retrofitted with LED lighting. The results showed significant increase in the positive perception of the cabin from seat comfort to cabin cleanliness.

Balance

liTeMood® includes a carefully considered night light setting designed to encourage passengers to relax, rest and sleep. This has been done by achieving a balance between light colour and intensity.

The best conditions for sleeping are little to no light; any light of significant intensity will discourage sleep. But even in conditions where most of the passengers are snoozing the cabin must remain at all times a safe environment for passengers and crew to walk around.

To achieve this we have been able to reduce the intensity as safely possible by targeting the cells in our eyes that help us to see in low light conditions, rod cells. Rod cells are most sensitive to short wavelength light so by opting for an LED that incorporates this we can help to make the cabin as dim as possible without compromising on safety.



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Application Example

saf-Tglo® blu

Bringing aesthetics and non-visual benefits to the latest evolution in safety lighting.

PASSENGER PERCEPTION

The traditional green glow of photoluminescent products is seen perceptually as a regulatory safety measure, even in non-emergency scenarios. saf-Tglo® blu is new and refreshing, complementing the cabin aesthetics without comprising on passenger safety.

BRANDING

saf-Tglo® blu can be used to enhance the cabin aesthetic with ambient colours which better match that of the airline brand. The blue glowing base is whiter in colour than the traditional green glow (which has an ambient yellow tint) meaning that, when used with a film, the base colour has less of an impact on the overall colour; allowing for more attainable brand colour matching.

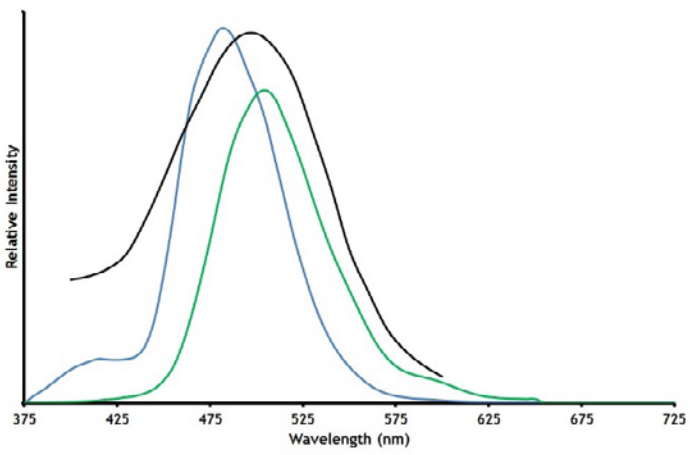
SAFETY

EASA and FAA approved, guaranteeing that the cabin meets the necessary safety requirements. saf-Tglo® is a self-illuminating system requiring no electrical power – if it's there, it works.

Scotopic Vision

In low-level light conditions, our eyes use the more sensitive rod cones in order to see. Rod cones have a peak sensitivity in the blue green region of the visible spectrum. While traditional green glowing photoluminescent products fall comfortably within the scotopic vision range (see graph below), saf-Tglo® blu has greater intensity within this responsive region.

So, while both photoluminescent systems perform their desired safety functions as required, saf-Tglo® blu provides a more calming, professional and aesthetically pleasing safety solution.



Glossary

This glossary and list of abbreviations are intended as aids to understanding specific terms, the explanations are not intended as exact definitions and do not claim to be complete.

Circadian Rhythm	A roughly 24-hour cycle in the physiological processes of living beings.
Correlated Colour Temperature (CCT)	Compares the colour of the emitted light from the measured light source to that of a black body light radiator at a known temperature. The temperature of the black body at the point where the colour of the light from both emitters is the same is the correlated colour temperature, measured in degrees Kelvin, K.
Colour Rendering Index (CRI)	A quantitative measure of the ability of a light source to reveal the colours of various objects faithfully in comparison with an ideal or natural light source. The more faithfully the colours appear the closer the CRI is to 100, the maximum.

Intrinsically Photosensitive Retinal Ganglion Cells (ipRGCs)	A photoreceptor in the eye, which takes in non-visual information from light. This information is processed in the hypothalamus region of the brain.
Illuminance	A measure of how much the incident light illuminates the measurement surface.
Jetlag	A physiological condition which results from alterations to the body's circadian rhythms resulting from rapid long-distance trans-meridian (east–west or west–east) travel on high-speed aircraft.
Lumen (lm)	The SI derived unit of luminous flux.
Luminous Flux (Φ)	A measure of the total quantity of visible light emitted by a source.
Lux (lx)	The SI unit of illuminance and luminous emittance, measuring luminous flux per unit area.
Melanopsin	The photopigment responsible for the light sensitivity of the retinal ganglion cells.
Melatonin	A hormone released by the pineal gland which regulates sleep and wakefulness. The hormone can be inhibited by light and initiates tiredness.
Photobiological Effects	The non-visual effects of the interaction between light and humans.
Photoluminescence	Light emission from any form of matter after the absorption of photons. It is initiated by photoexcitation following which various relaxation processes typically occur in which other photons are re-radiated.
Photons	The fundamental particles of light.
Photopic Vision	The vision of the eye under well-lit conditions. In humans and many other animals, photopic vision allows colour perception, mediated by cone cells, and a significantly higher visual acuity and temporal resolution than available with scotopic vision.
Photoreceptors	A photoreceptor cell is a specialized type of cell found in the retina that is capable of photo-transduction; converting light into signals that can stimulate biological processes.
Retina	The third and inner coat of the eye, which is comprised of a light-sensitive layer of tissue.
Scotopic Vision	Scotopic vision is the vision of the eye under low light conditions. In the human eye, cone cells are non-functional in low light; scotopic vision is produced exclusively through rod cells that are most sensitive to wavelengths of light around 498 nm (green-blue) and are insensitive to wavelengths longer than about 640 nm (red).
Visible Light	Light composing of wavelengths within the visible spectrum range.
Visible Spectrum	The visible spectrum is the portion of the electromagnetic spectrum that is visible to the human eye. A typical human eye will respond to wavelengths from about 380 to 750 nm.
Wavelength	The distance over which the wave's shape repeats.

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STG Aerospace is the leading Innovator of Light in commercial aviation.

We understand the challenges airlines and their passengers face —we've talked with flight crews, mechanics, marketing teams and more. We've surveyed hundreds of aircraft and now know that simple and standardised lighting solutions provide the best results for our customers.

We've spent decades developing our range of products that will have real impact on your interior while staying true to your brand, remaining fully compliant and always in line with safety regulations.

Our range of products delivers a harmonious view of what can be achieved using light within a cabin space. They integrate seamlessly to deliver an optimal environment that provides safety, comfort and ambience for passengers plus enhanced retail metrics for airlines.

Our lighting systems are simple, reliable, easy to install and created with ease and comfort in mind. Over 300 airlines use our products operating more than 11,000 airplanes today.

"We're STG Aerospace, the expert in cabin lighting"

liteMood® saf-tglo® saf-tsign®

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