NVG UOR
a quick carrier conversion

When the UK's Royal Navy urgently needed NVG-compatible lighting for the flight deck and other areas of its baby aircraft carriers, it turned to Consolite Technology.

Without a doubt, NVG are the safest, most effective aid to visual flight in darkness, and should now be regarded as basic and central to full operational capability for all tactical military aircraft (and law enforcement and air ambulance operations, too, but that's another story).

An essential element of that capability is the provision of lighting in aircraft operating areas that is either compatible with or 'friendly' towards the goggles – that is, it won't swamp them with light, blinding the pilot or forcing him/her to lift the goggles at a critical phase in an approach. This is particularly vital aboard aviation-capable warships, which are demanding enough to land on in daylight.

As the UK's Royal Navy (RN) is a very accomplished long-time exponent of NVG ops (it used them during the Falklands war in 1982), it might come as a surprise to learn that it took an Iraq War-related urgent operational requirement (UOR) to bring the lighting aboard the *Invincible*-class aircraft carrier *Ark Royal* up to standard. To those familiar with the UK military budgetary environment, it probably won't be a surprise at all.

In 2003, the Warship Support Agency (WSA) approached Consolite Technology with a UOR to assist in the modification of HMS *Ark Royal's* lighting. Consolite is a UK-based company that supplies a broad range of night vision-related products and services from goggles and compatible lighting systems to NVG flight training, aircraft and ship modification for compatibility, plus consultancy and testing. According to Consolite's Nick Rice, "The benefits of fitting NVG-friendly lighting to aviation-capable warships had previously been demonstrated by a trial installation on HMS *Fearless*. Some baseline compatibility levels generated by that fit were incorporated in a NATO standard."

The rationale behind the concept is straightforward, explains Rice. "Naval aircrew want to use NVG. A ship such as *Ark Royal* has many lights in positions where they can interfere with pilots' NVG, whether during take-off, taxiing or recovery. Whilst many lights are unnecessary and can be extinguished, turning off all the ship's lights is not an option."

He cites a number of reasons for this – firstly, that some, such as navigation lights, are a legal requirement when sailing in international waters in peacetime. Also, many are needed by the ship's crew to allow them to perform their duties, such as maintenance activities or control of flight operations.

HMS *Illustrious* seen here at sea in a partially converted state through an image intensifier. Her NVG floodlighting is on, but she is showing an unconverted navigation light up high, and there's an incompatible aircraft light on at the other end of the ship.

The view from an aircraft on *Ark Royal's* deck at sea, post-conversion, with the marshal giving the signal to take off.

Aircrew on final approach prefer to be able to see visual landing aids (VLAs) through their NVG to provide visual cues, so they must be clearly visible but not dazzlingly bright – 'NVG-friendly', in other words. "Flipping up the goggles to revert to the human eye during approach is hazardous because the eye must adapt at a critical part of the mission. NVG cause a loss of dark adaptation due to the green emissions from the eyepiece phosphor," Rice explains. "The same VLAs may also need to be used by aviators not wearing goggles."

Thorough survey

Initially, Consolite conducted a detailed survey of the ship, working with her officers and WSA staff to identify all the lights that could not be switched off and that would be visible to aircrew on NVG – and there are many. The list includes all of the lighting that

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Looking at *Ark Royal's* ramp with Gen III, Omni IV goggles with the deck end/centreline light on. Stray light on the deck comes from Portsmouth harbour, as the ship is in dock in this picture.

illuminates the flight deck: runway lights, edge lights, helicopter approach lights, floodlights, status lights, instruments and indicators, plus vehicle lights. There are also hangar lights (the doors can't be kept closed all the time during night flying), plus accommodation and hatch lighting close to the flight deck. All the lighting within FLYCO (the flight control office overlooking the flight deck), including the instruments, displays and indicators, as well as general area lighting, was also on the list, as were all the lights within the air control room (directly adjacent to the flight deck), the navigation lights and, finally, the VLAs: the deck approach positioning system (DAPS), the carrier line-up beacon system (CLUBS) and the glide path indicator (GPI).

The bridge was also identified as a potential issue, but, Rice says, "due to its limited visibility from most of the flight deck and the scale of the work required, it was decided not to include it in the modification". The UOR eventually went ahead on the basis of the list above, with the exception of the navigation lights and the VLAs, he notes. These were left out because several complex issues, such as the need to stick to international colour regulations for navigation lights, for example, meant that the work would have taken too long.

However, the WSA has let contracts to modify these systems on both *Ark Royal* and *Illustrious*. Both Consolite and Oxley Avionics bid on this area, and Oxley was chosen for the navigation lights. The contract for the VLAs, however, went to Aeronautical and General Instruments, which has supplied its new GLIS and HIHAT systems.

Consolite worked in close consultation with the ship's staff to understand the operational requirements for each light type and then developed a range of modification techniques to achieve the desired result.

Rice continues, "The work previously carried out on *Fearless* and elsewhere had generated the rationale that lights intended to be seen by aviators on NVG should be 'NVG-friendly', while any lights not needing to be visible should be 'NVG-compatible'. Consolite was able to combine past experience with field and laboratory trials to arrive at suitable levels of compatibility for each light type."

NVG-compatible lights are completely invisible through the goggles but clearly visible to the naked eye, according to rules clearly laid out in MIL-STD-3009, which is aimed primarily at cockpit lighting. NVG-friendly lights, on the other hand, are clearly visible both through NVG and with the naked eye, but the standards are, as yet, not so well defined. ('Black' lights are visible *only* through NVG.)

Minimal disruption

Wherever possible, the aim was to cause as little disruption as possible to the existing light fitting, Rice explains. "This was usually accomplished by replacing an element of the light assembly with an NVG filter glass. For example, all of the visually secure deck floodlights had their clear-glass exit window replaced by a piece of filter glass. In some cases, it was deemed to be preferable to replace the light unit completely with an LED-based alternative."

Many of the exterior lights presented what Rice describes as "unique challenges", requiring capabilities quite different from Consolite's existing expertise in aircraft cockpit lighting conversion. "They can be very much brighter, designed to be seen at long range, rather than close up. They get very hot, so special techniques are needed to ensure that the filters can cope with extreme thermal shock. They are permanently in a salt-laden atmosphere, so must be able to survive without degradation. Some are rather large."

Rather than work alone, Consolite picked key suppliers to produce a range of filters, of both the absorption and interference types. Where thermal shock was a potential issue, says Rice, all filters were proof-tested before installation.

Interference filters use a series of thin film layers to reflect selectively the unwanted (near-IR) wavelengths back towards the source. Advantages include a very sharp wavelength cut-off that provides very good transmission and colour retention, and the fact that they can be used with a heat-resistant substrate. Their disadvantages are that they can only be used in flat form and that the colours can shift when the lights are seen from off axis.

Absorption filters have an IR-absorbing dye within the glass. These are easy to shape, but offer lower light transmission and poorer colour retention.

Many of the interior lights were fluorescent tubes, which meant that

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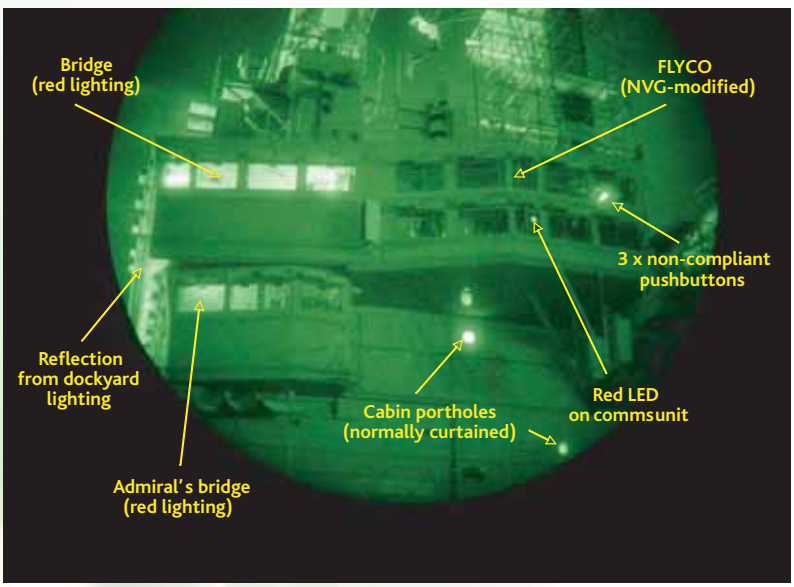

The bridge remained unconverted because the incompatible light from it is not very visible from most of the flight deck and conversion would have been a very big job.

***Illustrious's* sister ship, HMS *Ark Royal*, alongside in daylight. 'The Ark' was the subject of the 2003 UOR that started the RN's carriers off on the road to full NVG compatibility.**

Consolite had to develop a novel polymer solution, replacing the existing red sleeving with an NVG-compatible filter sleeve and light-proof end caps.

The company's aircraft lighting experience did come in handy, despite the differences involved in a ship fit. Rice elaborates: "FLYCO and the air control room were treated in the same way as an aircraft cockpit conversion. The reasoning was that not only does the light spilling out of the windows create interference for approaching aviators, but the flight operations control personnel inside could also use NVG to look outside for a clearer view. Therefore, all lighting in these locations was made fully NVG-compatible. There are a number of large CRT and LCD screens in these areas, so of particular value here was the Korry Nightshield polymeric filter material. It would be difficult to obtain glass filters in large enough pieces, and there would be an ever-present risk of glass breaking. Polymer filters, on the other hand, can be had in large sheets, present no shattering threat and can very easily be added to the front of a display, with a quick removal mechanism, if required."

Fast fit

Being a UOR, speed was vital. "The full kit of parts was developed and manufactured in just eight weeks, and installed on the ship over two weeks," Rice recalls, proudly pointing to subsequent flight trials that "showed the installations to be fully acceptable to aircrew and ship personnel alike".

HMS *Illustrious* was modified with a similar but more complete fit, and *Ark Royal* later brought up to the same standard. "For example, the deck status lights ['traffic lights'] were replaced by LED arrays supplied by LFD Ltd. A number of flight trials have now been made on both ships, and after a few tweaks, the conversions are accepted and well liked by aircrew. Just as importantly, the availability of plenty of light on the deck, even during NVG operations, means that the deck crew can perform their duties without the constraints or danger of having to work, literally, in the dark."

Consolite has gone on to modify a number of other ships for both the RN and other nations, including frigates, destroyers and LPDs, as well as landing craft so that the Marines can navigate them while using NVG, Rice reports. The company is now engaged in drafting a new specification for NVG lighting on warships, with particular reference to the new CVF class.

Consolite's Tony Worsdell says, "The approach is to consult with all interested parties – aircrew, ship staff, designers, lighting manufacturers, and so on – to arrive at a consensus on the requirements for the lights with respect to NVG use. The installed equipment on *Ark Royal* and *Illustrious* provides a baseline of what is known to work, and this, coupled with laboratory measurements of modified light sources, will permit the establishment of a robust set of standards for future use." ***DH***