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In the Blink of an Eye

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Helmet-Mounted Display Development

BAE Systems

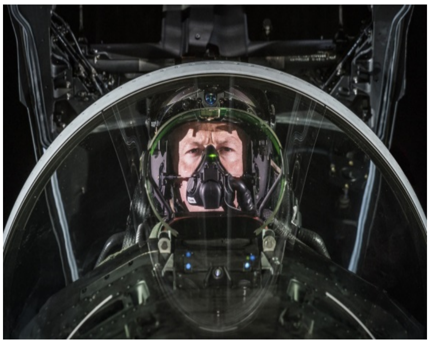
This was a remarkably fast-moving tour that embraced all phases of development of helmet-mounted displays and sights (HMD/SS) in a detail that only a front-line participant could have provided. Alex's presentation looked back over the 40 years throughout which HMD/S concepts have been tested and proven, and how head worn systems have evolved to meet the needs of today's aviators. The talk also presented an overview of the rapid pace of the technology development needed to provide the required increased levels of capability over the time frame.

The HMD/S has been used primarily in high-performance fixed and rotary-wing aircraft. Development has therefore focussed largely on military requirements. While he kept to this stream, there was acknowledgement that we are seeing increased access to the technology in lower-cost, higher production rate devices to assist a wide range of applications, from vehicle drivers to specialist professional applications. In their core aviation guise the HMD/S is a support system that can be appropriately integrated with associated sensor and information systems to provide guidance and information, on-demand and in an intuitive manner.

Mid 1970s

This was the period when cockpit designers reviewed military cockpit ergonomics and identified the limitation of head-up display (HUD) - introduced in the late-60s – in high performance aircraft. The necessity to re-focus the eyes when looking down from the collimated (infinity focus) optics of the HUD, to use and survey the controls and electro-mechanical displays in a cockpit, had a high impact on the pilot's 'situation awareness' – a term that refers to the assimilation of extensive sources of data. Maintaining such awareness is often survival-critical in military operations.

Initial LED-based HMS 1976



The desire was that a device like a HUD, but that projected a collimated image on the helmet visor, would be developed. It was expected to be easier to adjust to the change of being head-up or head-down in the cockpit. At that time, light-emitting diode (LED) technology was in its infancy and the availability of bright high resolution LED arrays in the compact space available limited the amount of information that could be presented. These early LED arrays had benefits over the miniature cathode-ray tube (CRT) as they were robust and compact. In use, brightness was automatically controlled to maintain display visibility according to ambient conditions. It was seen to be light and compact enough to be installed in a helmet and used in flight testing. It evolved into an effective helmet cueing system, using simple LED symbols such as arrows and cross hairs, to cue the pilot to a desired line of sight as an aid for targeting. This system later saw operational service on RAF Jaguar, Harrier and Tornado aircraft. It was a useful new guidance display, but already there were concerns over the impact the weight of even a small system could have on a pilot's ability to move their head during high-G force periods.

CRT display 1979
This was for helicopter applications (e.g.: Apache) and offered more HUD-like information capacity. It was only possible because helmet weight limitations were not as severe as in a fast-jet, but the functionality was limited – until such time as better quality sensor data was available to be displayed.

F-16 Falcon Eye 1987
This was developed for the US F-16 fighter and was a HMD/S with a 1-inch CRT. It could be used to assist the pilot to attain optimal release of a weapon, and was useable with 90º off-axis release of AIM-9 (Sidewinder) missiles.

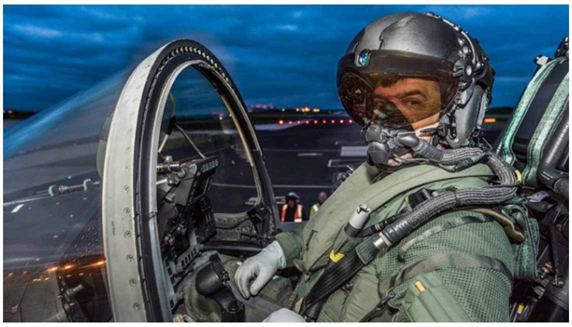
Night-Vision Goggles (NVG) and Integrated Helmets
NVG's had been available for ground troop operations from the mid-70s but were incompatible with the head-wear of military pilots, and this led to the development of several types of Night Vision Goggles including Cats Eyes (used by the US Navy), Night OP (UK Fast Jet) and Night Bird (UK Army Helicopters). The desire to reduce mass and bulk led to the development of an Integrated Night Vision Helmet (INVH).

Integrated Night Vision Helmet (INVH).
Initial trials on both fast jet and helicopters demonstrated the concept, but this product was optimised to become a dedicated rotary wing Integrated HMD called Knighthelm selected for the Germany Army 'Tiger' (an Apache-like attack aircraft) which has been in-service since the late 1990's .

Viper - Visor projected HMD
Introduced in the early 90s, the Viper 1 HMD used a ½" CRT in the upper part of the helmet, and reflected an image through lens to the wearer's eye line. It was designed for military use, and the design was modified in several stages that led to the Viper 4 HMD that was capable of supporting effective use of air-to-air and air-to ground munitions, and could enhance the success rate of high angle off-boresight missile launches. This became a very successful design configuration and was used on a variety of international flight trials programs on many different aircraft types to validate and prove next generation operational concepts.

Crusader HM
This was a technology demonstrator introduced in the late 90s, and was the first HMD to use holographic technology with integrated digital night vision (replacing NVGs) in a new type of modular aircrew helmet design specifically for HMD applications.

Striker® HMD



This HMD system was a combination of the visor projected optical system developed for Viper with the modular aircrew helmet from Crusader. It provides todays Typhoon aircrew with a dedicated high capability HMD and was the first high speed ejection cleared binocular HMD to enter service. It was developed by GEC Marconi Avionics in Rochester and Edinburgh who, following the merger with British

Aerospace, are now part of the BAE Systems organisation. This cutting edge product is used in Typhoon and Gripen fixed-wing and also on several rotary-wing aircraft. It has a 40-degree field of view, and is usable with a large-range of ordnance, including those using FLIR and laser designation sensors. The terrain is reproduced as a grid and can present terrain warnings, provide cable and obstacle awareness data in real-time and, using medium-wave infra-red and local area processing (LAP) algorithms, the outside world is viewable by the pilot almost irrespective of day/night or weather conditions.

A film of the imagery displayed on Striker®, overlaid on the outside-world view showed the correlation of HMS and real-world imagery. This imagery was taken in relatively clear conditions. There were obstacle warnings, and very clear cable awareness graphics that revealed this potential hazard even before it could be seen in the outside world.

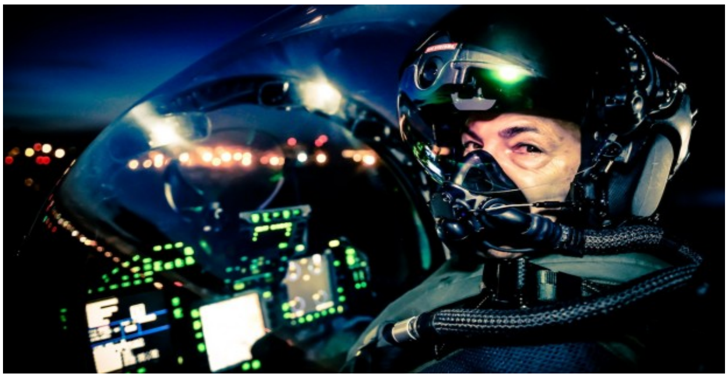
Current day – Farside™ – 3D-Conformal Symbology
There is more to come – and a development currently in implementation is a technique for placing ground anchored conformal symbology at the apparent range of the related object. This is being developed to enhance spatial awareness during approach and landing in degraded visual environments – especially relevant for helicopters - and near to any hazardous obstacles.

Holographic optical waveguide
This was cited as the most promising new stage of development, and that will combine 3D-imagery with an even larger field of view. This new optical concept uses basic optical/physics concepts such as total internal reflection and diffraction (a hologram is just a complex diffraction grating) to present a wide field of view, high quality full colour image over a large eye motion box in a flat optical component enabling a glasses like display. (Note: Microsoft HoloLens also uses the concept albeit less advanced).

Next generation
An objective of research is a 'wearable' display – basically like a pair of glasses. This might be best for other applications, and it could complement the crew's visualisation of the outside world by providing similar wider-range awareness for operations that collaborate with the aircraft.

Other potential users in the military could be followed by users in civil aviation, the automotive industry, security, first responder (emergency services – medical, police and fire fighters), medical procedures of any description - related to hospital wards or operating theatres - and on the consumer market there will be many future application possibility, for example in supporting Microsoft, Apple and Google service-related products.

Striker® II



The speaker concluded with a revue of the current Striker® II HMD, that is being developed for front-line system applications. He promoted the HMD as having become a key component of the pilot avionic and life-support system offering support with regard to primary mission requirements and also supplying protection and comfort. He believes the point has been reached where many of the cockpit display and some control functions can be done through the HMD, giving the designers of future cockpits the capability to choose the optimum path to achieving a solution that enables aircrew to do their job more effectively .

This was a very unique lecture, presented by a devoted specialist whose pleasure gleaned from the work in which he is involved was plain to see. The audience of around 80 people expressed their pleasure, and especially regarding the considerable depths to which he probed the technology involved, and described eloquently.

Lecture notes by Mike Hirst