The A-7 Corsair TRAM Head Up Display

by

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14th July 2020

The A-7 Target Recognition Attack Multisensor (TRAM) Head Up Display system

The world's first raster HUD system was commenced in 1971 by the Company as a private venture project and a system to combine the traditional cursive flight symbology with a raster scene of the outside world was developed by George C. Bull. This design was patent filed in 1973 (GB1,439,943 'Improvements in or relating to display devices') LTV and the Company had been collaborating on TRAM since 1972 and a contract was awarded in 1973 for equipment on the A-7 Corsair.

It was recognised at an early stage that benefits were to be gained from using a development of the existing A-7 HUD for night operations. Over l00hr of flight-testing on the new HUD design had already been completed, in addition to a large amount of bench work, by the end of 1975. Eight prototype raster HUDs were delivered in January 1976 **[1]** for evaluation at the U.S. Naval Air Centre, Patuxent River, as part of the Target Recognition and Attack Multisensor (TRAM) system of which the Hughes AN/AAS-73 Forward Looking Infrared sensor pod (FLIR) was the other major component. This system electronically combined the display of a low light level or infra-red sensor in the HUD system with the HUD symbols such that the pilot was given night vision. Another application was to display a radar display. TRAM was expected to provide the A-7 with a 24hr ground-attack capability and to improve aiming accuracies during daylight operations.

The HUD operated in a normal high brightness symbology mode in daylight with a raster display at night thus providing a 24-hour capability. The PDU already installed in the A-7 needed relatively minor modification to accept and process the FLIR video input**.(Fig.1)** However, a Video Mixer Unit **(Fig.2)** was added to the digital electronic unit within which symbology was added to the raster by means of a complex dual Vidicon, CRT scan converter which required a large number of preset adjustments **[2]**. The outline scheme from the Patent is shown in **(Fig. 3).**

The normal Waveform Generator produces cursive symbology in accordance with the input signals from the aircraft sensors such as speed, altitude, position and orientation derived from gyros, accelerometers and air data sensors. In a normal HUD this is the display presented on the CRT screen and the TRAM systems could still operate in this mode. However, the aircraft is also fitted with the TRAM imaging sensor which may be sensing in the Infra-red or low-light television spectrum. The output from the TRAM sensor is a raster display as in a television scan.

The cursive symbology is written onto a miniature Cathode Ray Tube which is optically coupled to a storage tube which cyclically scans the CRT to produce a raster output- in other words the combination is converting cursive to raster format. The output is a composite display of the outside world from the sensor with symbology overlaid. The Video Mixer box contained two single ended storage tubes coupled to miniature CRTs and the pair operate sequentially. During each field period one of the tubes operates in storage mode to store on its target the stroke writing mode signal applied to it from the Waveform Generator while the other operates in a reading mode to read out from its target, in a raster scan format, the signal applied to it from the Waveform Generator during the previous field period..

The HUD CRT is able to operate in raster or Cursive mode but in the raster mode the luminance was poor, and it was proposed that a blind could be fitted, between the Combiner and the Windshield, if the system was used in daylight but of course at night the blind is unnecessary.

The most difficult part of the system was the alignment of the outside world image accurately to the aircraft boresight and then aligning the symbology in a like manner; hence the plethora of adjustments. Even so, the system was never accurate enough for use at low-level.

The TRAM Head Up Display had a fairly small field of view by today's standards. The instantaneous view, without moving the head was just over 12 degrees, with a total field of view of 20 degrees. in spite of this small field of view, the fact that the display was collimated gave

the impression of looking through a port hole on the outside world **[3]. (Fig. 4)** Add the "normal Head Up Display symbology to the picture, and you have effectively duplicated the daytime conditions - as long as you only look at the display and not through the canopy sides. Even so, the pilots found they were quite able to fly and manoeuvre the aircraft at low level, and to pick up targets - as long as they were flying towards them. The integration of an 'off-track' view was eventually resolved with a gimballed FLIR, Night Vision Goggles and of course a HUD with a significantly improved azimuth field of view.

This order was expected to be the first of several, as, at the time, all Corsair HUDs were expected to incorporate raster displays in future. Since the Company had by then supplied about 1,500 HUDs for A-7D and A-7E Corsairs already this was hoped to provide significant business, but this did not happen. A derivative of the F-16C/D HUD, which had cursive in raster capability, was fitted to the A-7D/K much later.

In March 1977 the Company received a production order worth $1.25 million for these raster Head-Up Displays for the US Navy A-7E Corsairs. The Corsair order was the first production commitment for a raster HUD.

The FLIR in the A-7 system had a zoom capability of about 11:1 and was used in identification of target ships from medium altitude. The pilot was not concerned with really low level 'nap of the earth' flying so the existing field of view was quite adequate. Around 65 of these TRAM systems were made and they saw service in Vietnam; it was the only such system in service until early 1985.

On March 1st, 1973 this system and many other company products were shown to Michael Heseltine then Minister for Aerospace and Shipping when he made a visit to the Rochester establishment. He met Dr B. J. O'Kane the Chairman and Mr J. E. Pateman, CBE the Managing Director and were photographed for the 'Avionics News' showing him the four Queen's Awards for Export Achievement

awarded to date **[4]**. Afterwards Mr Heseltine commented to the Press '*Marconi-Elliott Avionics is a very impressive company. What I have seen today very much confirms the impression I already had'*

There is an amusing tale about a test flight at night with the A-7 TRAM system. Six trucks disguised for some reason with brown paper were sent into the Texas scrub to see if the FLIR system could find them. Unfortunately, the local sheriff had a team nearby on the watch for cattle rustlers. They were not amused when out of the pitch black came an A-7 at frighteningly low level!

In 1979 Rochester was treated to a flypast of two A-7 Corsairs which were purportedly fitted with the TRAM system, but it is more likely that they were fitted with the standard HUD. In early 1985 this TRAM HUD system was still the only such system in service in the world.

1. 'FLIGHT INTERNATIONAL' 26th March 1977. Also '*FLIGHT* INTERNATIONAL' 31st January 1976

2. The Author was part of the team working with George C. Bull on this project

3. 'Night Vision By NVG With FLIR' by G C Bull. AGARD Conference Proceedings No.379 Visual Protection And Enhancement. Papers presented at the Aerospace Medical Panel Symposium held in Athens, Greece, 22-24 April 1985.

4. See 'Avionics News' Issue No. 2 April 1973

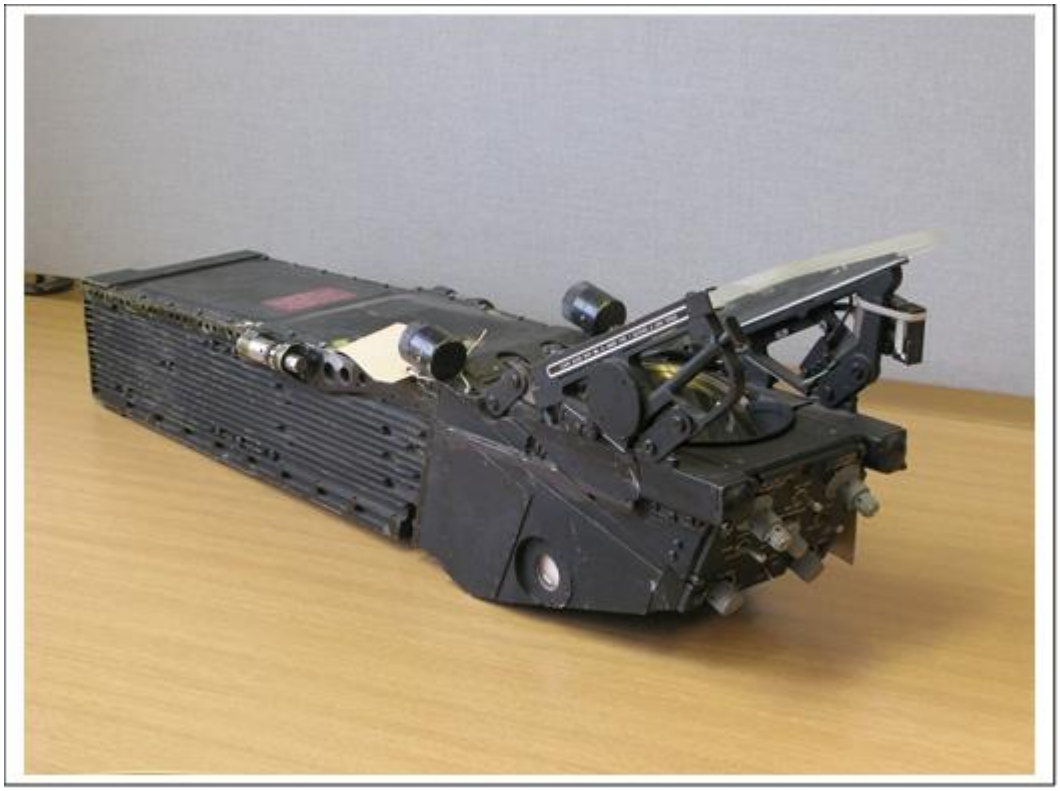

Fig 1 The A-7 TRAM Pilot's Display Unit.
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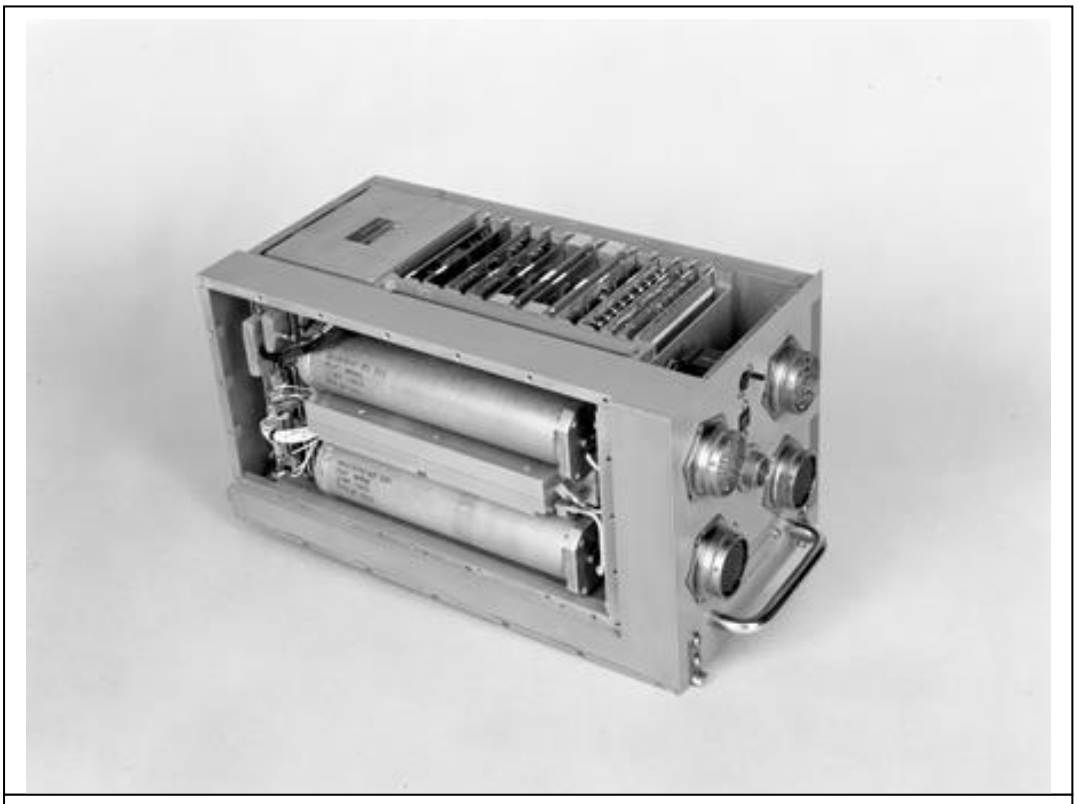

Fig 2 The A-7 TRAM Video Mixer Unit.
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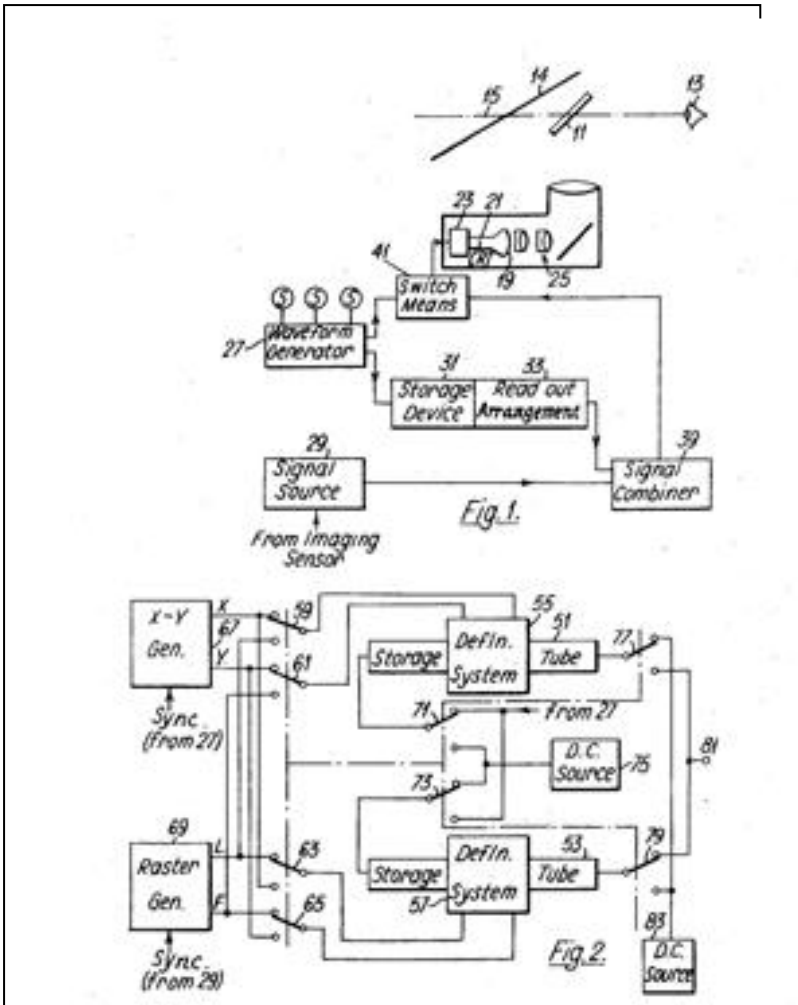

Fig 3 The A-7 TRAM system from Patent US3,932,861.
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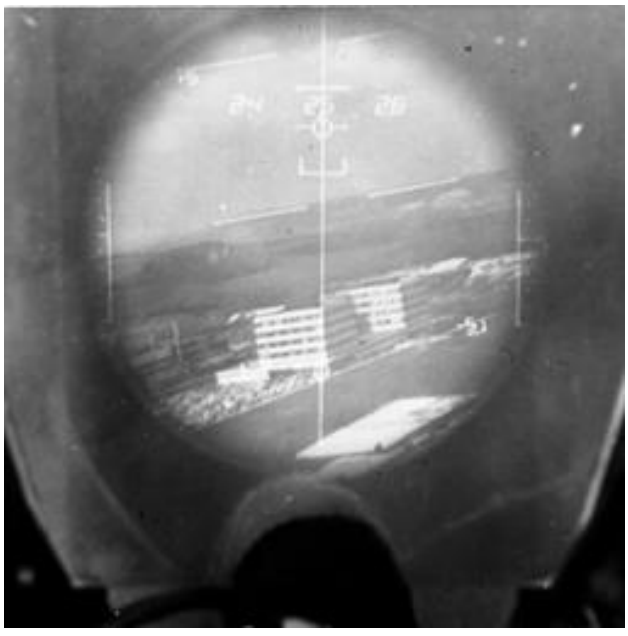

Fig 4 A pilot's view on the the A-7 TRAM system.
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