AN INTERRUPTION TO ONE OF OUR ONGOING FEATURES TO PUBLISH THIS WELCOME ARTICLE SERIES FROM THE PAPERS AND ARCHIVE OF FORMER V.A. MEMBER THE LATE W/C BOB PROTHERO MRAES, MIMGT, MBIM, RAF RETD – MORE INFO NEXT ISSUE. ED

AIR TO AIR REFUELLING SIMULATION – RAPID PROGRESS REVEALS NOVEL PROBLEMS

Presentation to Royal Aeronautical Society Flight Simulation Group by the late Wing Commander R. M. Prothero MRAES, MIMGT, MBIM RAF, Headquarters 1 Group, Royal Air Force Upavon. Made during his time at the RAF Staff College No.66 Advanced Staff Course.

1. Before I begin perhaps I can qualify my credentials somewhat. I am here very much as an aircraft operator and training specialist, and not an expert on flight simulation in a technical sense. Also, the views I will express are my own, and do not necessarily reflect current Ministry of Defence policy.

2. My aim is to discuss Air to Air Refuelling simulation, and the problems that have arisen as we have developed the necessary CGI software. That said, I intend to outline very briefly the RAF procedure for Air to Air Refuelling, illustrated with a short video tape of an actual training sortie, so you will have some idea of exactly what it is we have been trying to simulate to date. Then I will cover in general terms the systems we are using, and are being developed for air to air simulation, before discussing the problems we have encountered in our efforts. I will then round off with a few words on my view of the future. I may occasionally lapse into Air to Air Refuelling jargon, but I hope that you will find the terms broadly self-explanatory.

3. As I indicated, my first objective is to conduct a potted course in Air to Air Refuelling. As I am sure most of you know, the RAF uses the probe and drogue method of in-flight refuelling shown here. It is by nature totally different in concept and employment to the 'boom' system employed by the American Air Force, of which we will hear more of later. Both systems have their advantages and limitations, but suffice to say that in pure flying terms, the probe and drogue system is perhaps the more demanding in achieving an airborne link up, but once the necessary tanker to receiver contact is made, the system gives more freedom of movement and absorbs turbulence or upset more readily. Moreover, the system does not require a dedicated crew member to operate the system.

4. But in all air to air refuelling, there are 2 participants: a tanker to dispense fuel, and another aircraft to receive fuel. Dispensing is a comparatively routine activity, and although the systems used are complex, progress has been made in developing sophisticated CGI systems and ground training aids which will allow crews to be trained in every aspect of receiving fuel without the need for expensive tanker or receiver flying. However, any savings to be made in this area are limited to flying hours alone, and both now and in the future I see little difficulty in providing good tanker training. Simulation of the receiving activity on the other hand, although it appears simpler as a one-on-one activity, is in fact far more complex and requires a high degree of machine sub-system integration, and sophistication in the CGI systems, than has been available in the past.

5. Now the RAF employs air to air refuelling to enhance the capability of nearly all its front line aircraft, a great deal of air to air refuelling receiver flying is undertaken training our crews, and this is of course extremely expensive. Without teaching grandmother how to suck eggs, it is particularly expensive in airframe and engine fatigue. In fact in our tanker fleet, time spent in the air to air receiver role is the single most important factor in determining the remaining fatigue life of our aircraft, after perhaps only aircraft gross weight on take-off. Consequently, as

Above: The long-running Nimrod AEW 3 saga was also one of the aircraft that Bob dealt with in the AAR simulation field before its cancellation. Bob was at the time of this AAR sim presentation a Squadron Leader. (Airline.net)

it is mainly in the successful simulation of receiver activity that major savings are to be made, I am going to concentrate on this aspect from here on.

6. Firstly, it is important to understand that an aircraft receiver requiring fuel in the air undertakes 6 distinct sequential activities: a rendezvous; a formation join; pre-contact preparation; making refuelling contact; holding in contact, and disengagement. If we are to train our crews effectively in a simulator and achieve maximum savings, all these elements must be simulated effectively for the whole to have training value. And I will just say a little bit more about each of these particular elements.

7. The rendezvous is a critical activity in air to air refuelling. We can employ radar guidance from a ground station to get a tanker and receiver together, or we can use strictly procedural methods. For example, by flying the tanker head on to the receiver aircraft, obviously with height separation, and then turning the tanker onto a reciprocal heading at a given split range, we can usually achieve a satisfactory link up. In the end however, any procedure relies on visual contact being established at some stage to enable the tanker aircraft and receiver aircraft to achieve close formation.

Needless to say the human eye is fallible, and although in day VMC there is normally little difficulty in achieving a rendezvous, at night or in cloud it is a different matter. The formation join requires special procedures to ensure that any misjudgement does not jeopardize either the tanker or receiver, and as most air to air refuelling is conducted without a face-to-face briefing between the pilots involved, there are standard operating procedures that must be complied with. Pre-contact actions are purely concerned with extending the probe of the aircraft if applicable, trailing the tanker hose, and making the necessary switching.

The pre-contact actions are pretty straightforward and are extremely easy to simulate and therefore I will say little more about this particular phase. The process of air to air refuelling however is dependent upon achieving a successful contact between the receiver's probe and the tanker's hose, and holding long enough to achieve the necessary fuel transfer. This is the area in which we spend a great deal of training time. The process itself is best illustrated by a video rather than me describing it, but just a few words about it. Before we start the sequence I should explain that you will hear mention of crosses in the film together with hose markings and 'HDUs'.

TBC

AN INTERRUPTION TO ONE OF OUR ONGOING FEATURES TO PUBLISH PART 2 FROM THE PAPERS AND ARCHIVE OF FORMER V.A. MEMBER THE LATE W/C BOB PROTHERO MRAES, MIMGT, MBIM, RAF RETD.

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On making a successful contact between the receiver's probe and the tanker's hose, and holding long enough to achieve the necessary fuel transfer: (Before this film sequence began, Bob explained that the audience would hear mention of crosses in the film together with hose markings and 'HDUs).

"The crosses are marks on the tanker fuselage and refuelling housing, that, through changes of perspective, provide a receiver pilot with a line defined astern of the tanker which will enable him to position the aircraft correctly to achieve a contact between the probe and the drogue. (An illustration was shown here as to what the crosses look like in a good position). The vertical bars would be split if the aircraft was too far to the left or right, and the horizontal bars split if the aircraft were too high or too low. The hose markings mentioned are the bands of colour on the hose that make movement forward and aft between the receiver and tanker more obvious."

"HDU' is short for Hose Drum Unit and you will note in the film that the hose moves from left to right as it winds into the tanker, and the reverse as it pays out - thus providing a means of measuring range, or movement forward and aft from the tanker - a motion cue. When looking at it in real time, you will first see the VC10 tanker trailing its hose, accompanied by some crew chat, before the VC10 receiver moves astern to commence AAR training. That is the part we want to simulate."

(At this point Bob looked at the equipment available at that time and where they had got to so far in that area, while with apology to any manufacturers present he talked generally about aircraft type, rather than proprietory systems).

"For some time we have been using an experimental simulator at Hatfield that is not specifically modelled on any aircraft type. It can be configured at will to simulate probe positions for Hercules, VC10s, Nimrod, Victor and so on, but the CGI is very basic and handling matching to type is done very subjectively on the day. It gives a night picture with only the most simple outline for the tanker, and the refuelling equipment hose etc."

(A series of slides then showed a distant view of the simulation with a close-up, in contact, and refuelling).

"I think you will agree this is quite a contrast in quality to the video that you have just seen. Nevertheless the machine although not designed for training, has achieved a great deal in starting some of our pilots in the basics of Air to Air Refuelling, and a trial to determine the exact value of the machine is still proceeding."

"The first of our operational simulators with an AAR mode is the Nimrod AEW. This has a dusk night CGI system that has a tanker model, a fully dynamic hose and drogue representation, and all the visual cue points that we thought we needed to achieve AAR training. The next machine is a

Above: A de-fuelling "tail-heavy" incident at Brize Norton in December 2007 which wrote off the VC10 aircraft XV806. One of 2 people was said to have been hurled from the cockpit to the tail end of the aircraft and badly injured. (HMVF)

VC10 tanker simulator, with both tanker and receiver modes in the CGI system. Preliminary modelling is still underway, but it is clear that the final capability will be in the same order as for the Nimrod AEW. In the longer term we hope to have the AAR modes added to our VC10 transport and Hercules simulators, but this is probably some way off and is not my area of responsibility."

"When you consider that it was in this hall only 2 years ago, that I first saw a slide of a CGI model of a Vulcan tanker in early development, then we have come a long way quickly, and even as I speak we have some pilots flying who conducted their early AAR training in the Hatfield machine. So much for the rapid progress, what have learnt as we have gone forward?"

"In any assessment of an AAR moded simulator, we obviously have to start off with a simulated rendezvous. At present much depends on the setting-up of the machine operator, and therefore, until the set-up is canned, or fully automatic, the 'op' needs some knowledge of Air-to-Air Refuelling Standard Operating Procedures (SOPs). This is of course a bit easier said then done. Even after a good set-up, a great deal of the training value of the machine depends on a full tie-up between many of the simulator sub-systems and the CGI."

"Here I include integration of the spacial position indications shown on navigation aids, Air-to-Air TACAN, UHF or other Direction Finding (DF) aids, CCWR (Connected Components Workbench Rendition?) picture, and Electronic Support Measures (ESM) sensors as well. All are important, and in turn, crews must access which is the best information available when conducting a RV. Thus all must be integrated accurately in a simulation if we are to generate a training environment, So far not all sub-systems in our machines are fully integrated, but I believe it is important for the future."

A CGI of a Vulcan K2 was an early devcelopment, its rear HDU seen here. (Flickr)