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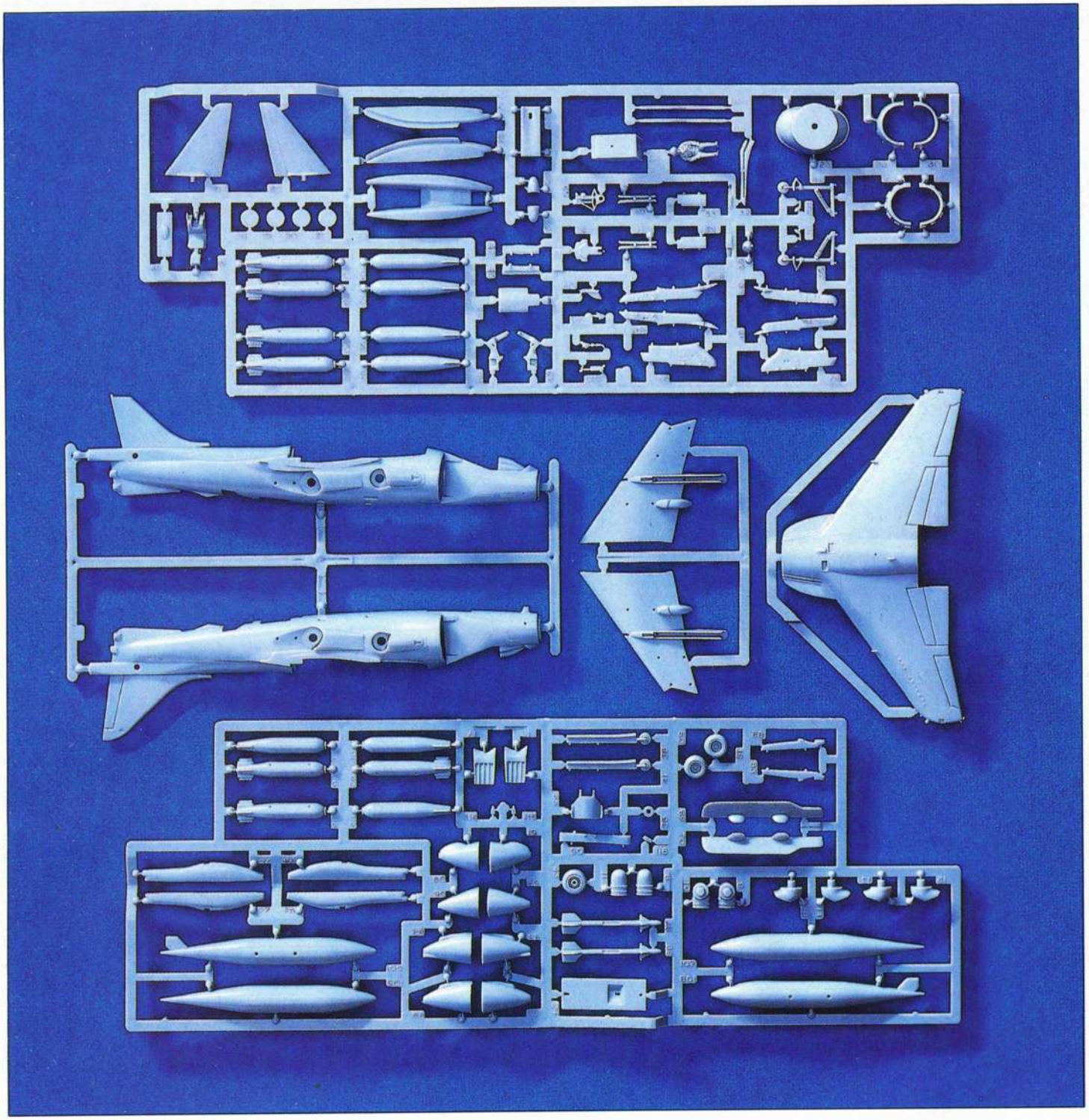

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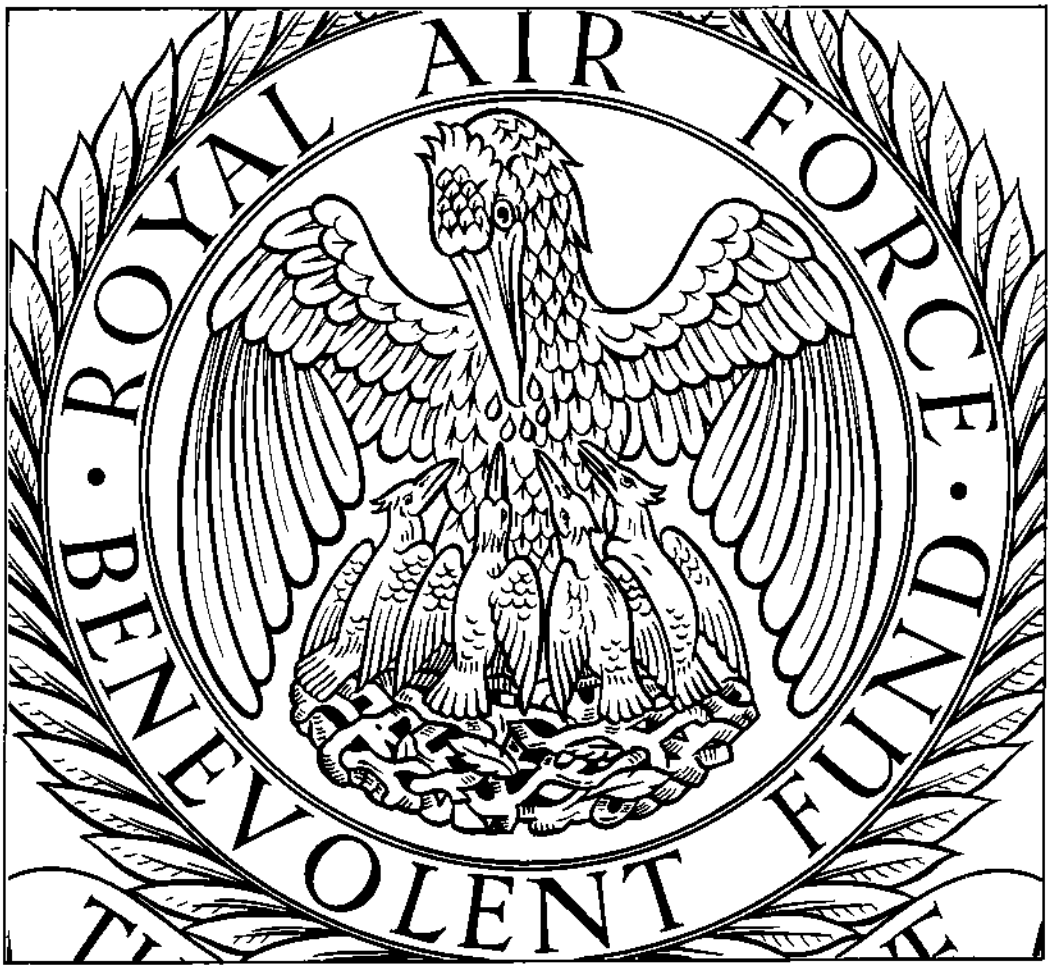

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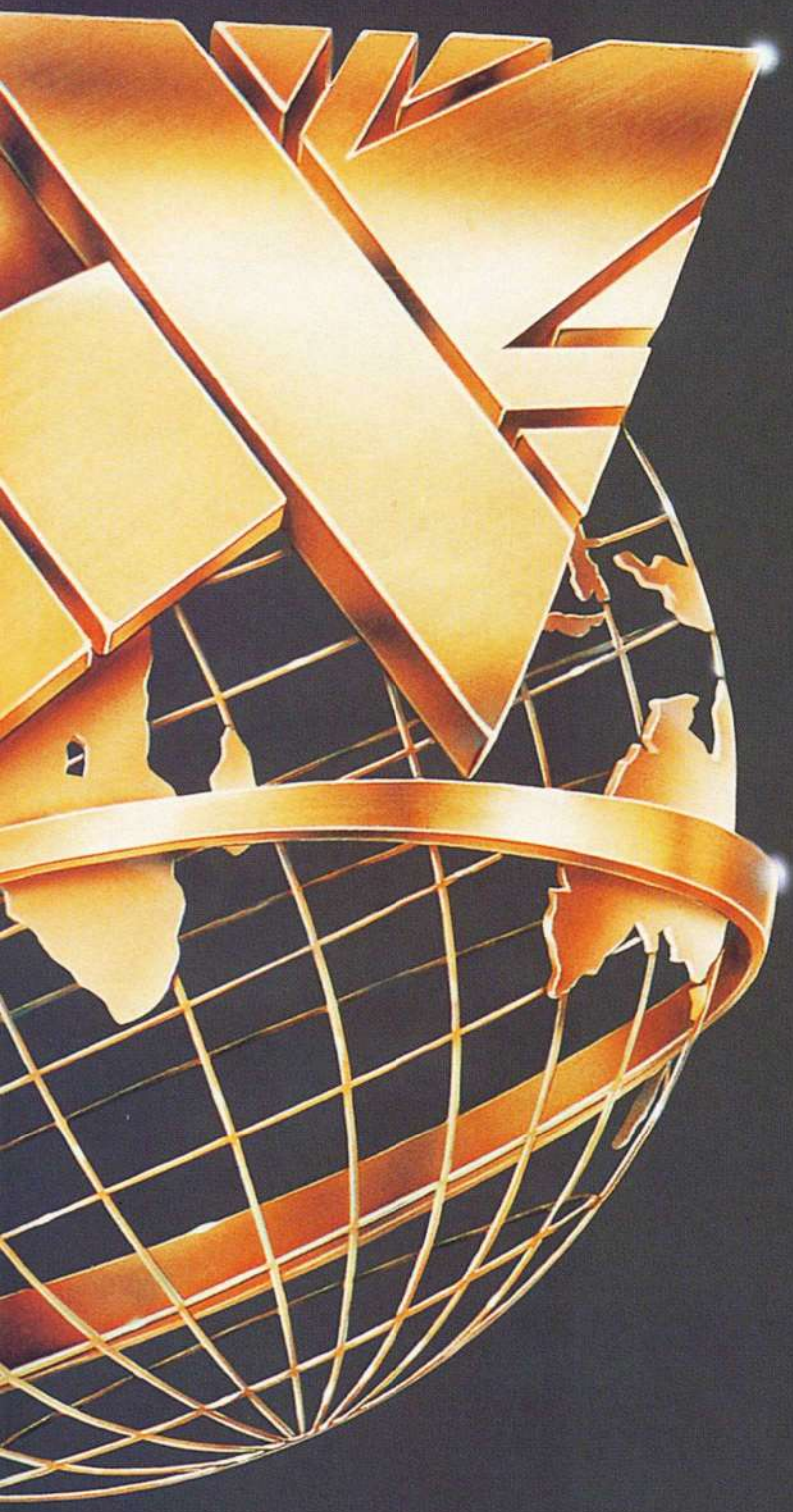

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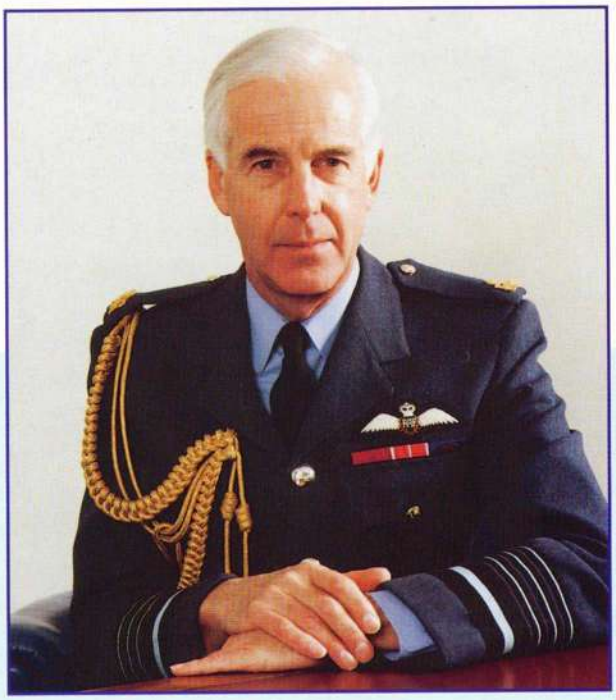


INTRODUCTION

Air Chief Marshal Sir Michael Graydon

GCB CBE ADC FRAeS RAF

Chief of the Air Staff

This year marks the 25th Anniversary of the International Air Tattoo, an event that has grown to become one of the foremost air shows in the world. Whilst bringing the excitement of spectacular flying to millions of spectators it has also raised substantial sums of money for the Royal Air Force Benevolent Fund.

Although the RAF of today is smaller than 25 years ago it is more efficient and operationally focused than ever before. Every front-line aircraft type in our inventory is involved in operations around the globe, such as the Falkland Islands, Saudi Arabia, Turkey and the former Yugoslavia. Last year, in a vivid demonstration of the effectiveness of airpower, the carefully controlled bombing campaigns in Bosnia, in conjunction with the diplomatic and land forces' activities, brought the warring factions to the negotiating table.

RAF Jaguar aircraft, equipped with the Thermal Imaging Airborne Laser Designator (TIALD) pod, worked with the Harriers, carrying laser-guided bombs, and together they made a significant contribution to the NATO campaign. This capacity remains at the call of NATO Commanders. Our Tornado F3 aircraft also played their part in keeping the skies clear, as too did the E-3D Sentry AEW aircraft. Our Nimrod maritime patrol aircraft, air-to-air refuelling tankers, air transport aircraft and support helicopter forces all play vital roles in UN and NATO efforts to bring peace to that troubled part of the world.

Such commitment to peace keeping and peace support operations is not without cost. Many of our people continue to spend a large part of each year away from home, which is hard on the families left behind.

Against a background of change, the RAF is reshaping to meet the future. In this publication you will read for yourself of the new aircraft systems that will be entering service: aircraft such as the EH101, the C-130J and of course Eurofighter 2000. In conjunction with our emerging weapons programme, and the many improvements we have been able to make to our operational capability, the Royal Air Force is well placed to contribute modern and effective air power to our national and international security needs.

In all of this our men and women continue to play an important role as ambassadors for the United Kingdom. The *Red Arrows* have enjoyed two outstanding winter tours that included, last year, South Africa and the Middle East and, earlier this year, Australia and the Far East. The performance of our air and ground crews and of their British equipment has shown the world the 'Best of British' in a manner that has brought the greatest credit to the United Kingdom, to its industry and to the Royal Air Force.

Over the next year, the Royal Air Force faces a major reduction in manpower with some 8,500 leaving the service on redundancy and another 4,000 leaving on their planned retirement date. Such turbulence will not be without significant family upheaval and, in some cases, hardship. The RAF Benevolent Fund will be to the fore in helping those in need.

The International Air Tattoo is an opportunity for you to see some of the best aircraft and pilots in the world demonstrating their capabilities and skills. These skills, in many cases, have been used in operations in the last year. Sadly, such demands can have a personal cost and the RAF Benevolent Fund stands ready to help in any way possible. Your support to the Fund will be the clearest mark of your appreciation of the Royal Air Force and its contribution to our nation and our way of life.

Michael Graydon

A Year to remember

Sqn Ldr Tony Cunnane

A Press Release issued by the Ministry of Defence in August 1995 marked the *end of the beginning* as far as the *Red Arrows* were concerned. At the time of year when the Team members usually start looking forward to the end of season parties and a spot of well-earned leave, they had to start thinking about inoculations, passports and visas and what to do with the wife and children. When the two pilots reaching the end of their three-year stint with the team should have been contemplating their posting to pastures new, they could instead dream about six extra months in the best flying job in the world. But no-one realised, or even thought it really likely, that before Spring 1996 the team would have travelled to and displayed in Africa, Malaysia and Australia.

In that Press Release Chief of the Air Staff, Air Chief Marshal Sir Michael Graydon, commented: "*Since 1965, the* Red Arrows *have demonstrated a standard of excellence which the public in the UK has come to recognise as the hallmark of the Royal Air Force. Moreover, during their many displays abroad they have been outstanding ambassadors for their Service, for British Industry whose technical capability is epitomised in the Hawk aircraft which they fly, and for the UK. I am thus delighted that they have been chosen to represent the best of British Industry by undertaking this tour.*"

The Beginning

The beginning of 'The Beginning' was at least nine months earlier when, back in December 1994, the first hints of an extended overseas tour, perhaps to South Africa, started to filter through to Rumour Control at the *Red Arrows*' HQ at RAF Scampton. However, it is difficult for the MoD to justify the cost of sending the team to far off places unless tangible benefits, for either the RAF or what is known as 'UK plc', can be identified.

As 1995 dawned there were other, more pressing, issues to be resolved. The future of Scampton, and with it the future of the Royal Air Force Aerobatic Team, seemed to be in the balance. Would Scampton close as part of Defence Costs Studies and, if so, where would the *Red Arrows* go? Was there even a future for the team?

It became clear as the year progressed that although the future of the *Red Arrows* was secure, Scampton was doomed to close. Wildly inaccurate stories about possible new homes for the team appeared in the media and elsewhere, while the team embarked on what was to become their busiest ever season.

Formal approval to go ahead with the first tour, to South Africa, was not received at Scampton until just six weeks before the date set for departure. Already much of the detailed planning had, necessarily, been completed. The staff of British Airways' Operations Division at Heathrow gave considerable help to the team during the planning of the long legs over the vast tracts of Africa. The airline even provided two complimentary tickets to take the team's

Above: *The* Red Arrows, *together with BAe's blue Hawk 100 and support RAF Hercules, lined up at Langkawi, Malaysia.* BAe

Above: *On display over the Hotel Sheraton on the sea front at Doha, the capital of Qatar.* Peter Mobbs

Manager and Engineering Officer to South Africa for on-site surveys.

The Head of the Defence Export Services Organisation (DESO), Charles Masefield, who conceived the whole idea of commercial 'sponsorship' for the team, emphasised the significance of the tours. "Over the last 30 years the RAF Aerobatic Team has established a world-wide reputation for precision and excellence. These *Red Arrows* tours, which are sponsored by British companies, provide a clear demonstration of the determination of British Industry to step up its activities and presence in key countries around the world."

Critical 'gates'

British Embassies and High Commissions along the route played their part by booking hotels and arranging the complicated diplomatic clearances. There were two critical 'gates' that constrained the planning: a display

Spectacular photographs as the team flies over the Victoria Falls. Peter Mobbs/Air Cdre Bostock

in Oman on 2 October at which HRH The Prince of Wales would be the guest of honour and the need to arrive at Waterkloof, 4,300 nautical miles to the south of Oman only 48 hours later, in time to practice a 'hot and high' display before the VIP opening of the South African Air Force's 75th Birthday Celebrations.

The Hawks deployed with their standard navigation equipment: all were fitted with TACAN but only seven with VOR and none with HF radios. Eight of the aircraft also carried 'hand-held' Garmin 100 GPS satellite navigation receivers that were perched on the cockpit coaming. One additional pilot had a Garmin 95 strapped to his knee pad.

Middle East

The original 1995 Display Season ended with displays in late September in Turkey and Greece and it was opportune to continue from Athens through the Middle East without re-starting from Scampton.

A wave of tummy troubles, caused by unscrupulous hotel staffs in Ankara filling mineral water bottles from the ordinary taps and then sealing the bottles to make them look authentic, made life unpleasant for several days. First stop was Doha, the capital of Qatar. The display was centred on the splendid Hotel Sheraton on the beach but all six lanes of the entire 10 km stretch of the Corniche through the centre of the capital became one huge parking lot.

A very late change of plan, caused by the imminent arrival of a detachment of USAF aircraft that needed the apron parking slots, meant that the *Red Arrows* had to leave Doha earlier than planned. They could not fly direct to Oman because all the hotels there were fully booked for a Gulf Co-operation Council meeting. Instead the team had two unscheduled nights in Bahrain.

There were far fewer spectators at Seeb International Airport because it was a VIP event and not open to the general public. The Prince of Wales took time out to talk with the team after the display before departing, with his entourage, in a fleet of helicopters that literally blasted the 11 Hawks with sand, dust and flying debris. The *Red Arrows*' groundcrew were not amused but it was not the Prince of Wales' fault.

The Grass People

After the Seeb display the team headed off at dusk to Riyadh for a night landing and night stop. Next day was a very tiring three-hop day. The first two legs, from Riyadh to Jeddah and on to Addis Ababa, took the formation over isolated terrain with few navigation aids. The Garmin equipment proved to be worth its weight in gold.

The facilities on the ground at Addis Ababa were poor. The parking ramp in particular was littered with all kinds of rubbish, a real FOD hazard. The Air Traffic authorities would not accept the departure flight plan until the landing fees had been paid in full in cash! Fortunately, a representative of the British Embassy was on hand to fork out. But Addis had one final surprise for the pilots. As the 11 aircraft accelerated down the runway for take off, dozens of people suddenly and alarmingly appeared from the long grass at the edges of the runway. Apparently they lived in the grass and had stood up to wave goodbye to the British fliers.

The flight to Nairobi took the formation through the ITCZ (Inter-Tropical Convergence Zone) and across the Equator. The weather progressively worsened. Approaching Nairobi, the team climbed to 43,000 feet to keep above the frontal cloud but the let down into Jomo Kenyatta International Airport was

A Year to remember

In transit to Cape Town with the essential support Hercules, off the South African coast. Peter Mobbs

something of a nightmare. The Leader split his formation into two sections for the penetration to the airfield. This was a wise decision because the weather was much worse than forecast. The aircraft were continuously in thick cloud until they broke out in torrential rain just 400 feet, about one nautical mile, on the final approach. A fine piece of precision close formation flying by all the pilots.

Intercept

The following day, as the formation approached the border between Malawi and the Republic of South Africa, in anticipation of an interception by SAAF fighters at the border, Squadron Leader Rands mischievously obtained ATC clearance for a cruise climb to 47,000 feet. The SAAF Cheetahs that came up to meet the *Red Arrows* could not reach that height and so the Hawks obligingly descended to a more suitable level to be escorted to the Waterkloof Air Base on the outskirts of Pretoria. One up to the RAF!

Hot and High

Later that same afternoon, having barely had time to meet their hosts, the team was airborne to practice. This was essential for two reasons. Firstly, it was required by the Display Regulations which called for all participants to demonstrate their routine so that the flight safety officers could be satisfied that no display contravened the rules.

Secondly, the airfield at Waterkloof is what is known as 'hot and high' – an altitude of over 5,000 feet above sea level with ground temperatures well into the 30°s Centigrade. In those conditions the Hawk's Rolls-Royce Adour engine gives considerably less thrust than at sea level in temperate climates. Turning circles get physically larger and looping manoeuvres use up more height and are more difficult to fly.

The practice showed that the 20 minute UK display would take 23 minutes at Waterkloof and the flying programme timings would have to be adjusted to take that into account. Other performers had to make similar adjustments to their own displays and timings, even the Russian's mighty Su-27 *Flankers*.

In the following three days the team displayed five more times. John Rands said afterwards, "I have never displayed in front of such enthusiastic and friendly people as those we found at Waterkloof. Displaying hot and high was a new and fascinating experience."

According to official estimates, over half a million people attended the air days at Waterkloof and countless thousands throughout the Republic watched the extensive live TV coverage. One of the little things that kept the detachment personnel amused was estimating how long it would take any South African citizen to introduce the subject of the Rugby World Cup into a conversation. 75 seconds was about average!

Whilst the official reason for the *Red Arrows*' presence at Waterkloof was to help the SAAF celebrate its 75th birthday, high level representatives of the British companies funding the tour were much in evidence in their companies' display areas. They all expressed themselves delighted with the *Red Arrows*' presence and performances.

Homeward Bound

From Pretoria the detachment moved south west for a few days in Cape Town and everyone immediately fell in love with this delightful city and its friendly people. A display over the historic waterfront area with Table Mountain looming dramatically in the background was received ecstatically and traffic in large parts of the city came to a complete standstill.

After Cape Town everyone started to relax knowing that they were, in effect, starting the long journey home. First there was a low level transit around the Cape of Good Hope and Cape Agulhas, the southernmost point of Africa, to Durban.

The display at Durban was centred on the splendid beach and watched by an enormous crowd. The team Manager's commentary, relayed over a public address system, was heard by tens of thousands of people along several miles of the promenade. The following day was a rare day off, spoilt somewhat because of a 42°C temperature, a 40mph wind blowing like a furnace, and humidity of almost 100%.

After leaving Durban the team spent a few days in the dry north of the Republic at Hoedspruit, home of the SAAF's own aerobatic team, the *Silver Falcons*. Then it was on to Harare, capital of Zimbabwe, to take part in an air day specially arranged by the Air Force of Zimbabwe. The following day a side trip was made to the Victoria Falls for a photo-shoot.

"The journey north from Zimbabwe was relatively uneventful with light winds and stunning scenery" said Squadron Leader Rands. "I was mesmerised by the greenness and beauty of Kenya and Ethiopia. In the many trips I have flown over the Mediterranean and the Alps I have never seen them so clearly. It was a little compensation for the stiff legs and numb bum after 15 hours in the cockpit over three consecutive days!"

Passing Through

The detachment arrived back home on 19 October and remained there for just 35 days before taking off from Scampton for the very last time on 23 November. The final departure from Scampton was an emotional occasion, more so perhaps for those left behind. The media were there in force to film the events for posterity and John Rands led his pilots on one final flypast over No 4 Hangar, the team's home since 1983. The Hercules support aircraft took off just a few minutes after the Hawks had disappeared from sight and sound. The very last aircraft to leave Scampton, shortly after the Hercules, was a Chipmunk flown by Station Commander, Group Captain Chris Burwell, on his final day in command.

Far East

The 7,500 mile route to Langkawi Island took the team through Saudi Arabia (where the *Red Arrows* gave their first ever display in the Kingdom), the United Arab Emirates, Pakistan, India and Thailand. This time the transit was rather more leisurely and relatively uneventful. The detachment had two days off in Langkawi

before the first public display at LIMA95, Langkawi International Maritime and Aeronautical Expo, on 5 December.

Britain's Minister for Defence Procurement, James Arbuthnot, was at Langkawi. At a press conference he was asked by a local reporter why British pilots were demonstrating the Hawk. The Royal Malaysian Air Force operates the advanced Hawk 100 two-seat trainer and the Hawk 200 single-seat fighter variant. Why were the Malaysian pilots not flying the Hawks? "The *Red Arrows* are probably the best in the world", said the Minister. "Everyone is keen to see them. Their aerobatics show what the Hawk aircraft can do when operated to the limits. LIMA95 is one of the world's finest international aviation exhibitions, an excellent shop window for British industry. One of the highlights, if not *the* highlight, is the *Red Arrows*, sponsored by 16 British companies and showing what is the very best in Britain."

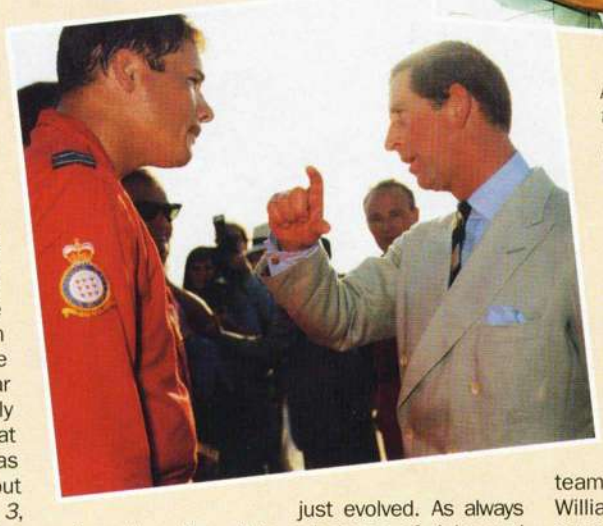
Accident

An unfortunate road accident on the island put an end to the tour for one of the pilots and created a precedent for the *Red Arrows*. Three of the pilots were in a stationary hire car waiting for a gap in the traffic to turn right when they were struck from behind by a lorry. The rear offside corner of the car was so badly damaged that any passenger in that seat would probably have been killed. As it was all three suffered cuts and abrasions but Flight Lieutenant Sean Perrett, *Red 3*, suffered a complicated collar bone fracture as well. He spent several days in the brand new Langkawi Hospital before being flown home to England. During the Christmas holidays Sean was operated on and a titanium plate was bolted in to hold the two ends of bone together.

That accident should have reduced the *Red Arrows* to eight aircraft which would have been most unfortunate at such a prestigious event. However, travelling with the detachment were the two replacement pilots for the 1996 season. Since joining at Scampton in September they had been getting in a little practice as and when it could be programmed. The new *Red 3* for 1996, Flight Lieutenant Dave *Stobes* Stobie, is both a Qualified Flying Instructor and a Qualified Weapons Instructor. More importantly in this context, he is a former Hawk solo display pilot and he had performed at over 30 displays all round the UK during the summer months of 1994.

It was decided it would be possible to modify the first half of the display to allow Flight Lieutenant Stobie to fly in the '3' slot. Ultimately the decision was made by the team Leader. "It was not an instant solution; it just evolved. As always in such matters, it is a balance of risks and possibilities. If I thought I was flying a pilot who was a danger to himself, or more importantly to the other pilots, it would be a non-starter. But I was clear in my own mind that what we were doing was safe and sensible and the best decision available to me. In the event *Stobes'* flying as *Green 3* was immaculate".

Thus, Flight Lieutenant Dave Stobie became the first ever 'green-suited' pilot to display in public with the *Red Arrows*. Since there was no time to integrate Stobes into the intricate, high energy manoeuvres which form the second half of the display, that was flown by the remaining eight pilots.



Above: *John Rands makes a presentation to the Malaysian Prime Minister at Lima.*

Left: *HRH Prince of Wales in conversation with team members at Seeb Inernational Airport.* Photos Peter Mobbs

Royal Command Performance

About 1030 one morning, as the pilots were chatting to delegates at the various British exhibitions on Langkawi airfield, there was an announcement over the public address system stating that the *Red Arrows* would open the flying display shortly. The team Manager, Squadron Leader Mike Williams, was dispatched to have the announcement corrected only to be told by the organisers that the King of Malaysia was coming at 1130 to watch the *Red Arrows* and that was that! The display had originally been scheduled for late afternoon and the ground crew were some miles away relaxing in their hotel. Needless to say the team did take off within the hour and gave a superb performance for the King.

Australia

On 12 January 1996 the team members flew out from Heathrow to rejoin their aircraft that had been left at Butterworth, Malaya during the holiday period. They were then scheduled to fly on to Australia to help the RAAF celebrate its 75th birthday and give displays at Canberra and Sydney.

After leaving Australia the *Red Arrows* were returning to the Far East for displays in Brunei and Manila before arriving in Singapore on 2 February to appear at the major Asian Aerospace exhibition at Changi. If all goes to plan the team will arrive back at RAF Cranwell, their new home, on 20 February. Only then will the 1995 season finally draw to a conclusion.

Almost the End

The Commandant of the RAF's Central Flying School, Air Commodore Simon Bostock, who has overall responsibility for the operations of the *Red Arrows*, accompanied the team on the tours of the Middle East, Africa and Malaysia. Speaking just before Christmas, the Air Commodore said: "Few would disagree that the 1995 season, although still not officially ended, has been one of the finest ever, and the manner in which all members of the squadron have faced daunting challenges has been nothing short of superb. The highly successful tours just completed are a fitting reflection of their worth and all members of the *Red Arrows*, but above all the Leader, deserve great credit."

The Red Arrows' *First and Second Line groundcrew with their counterparts from the South African Air Force aerobatic team, the* Silver Falcons, *at Waterkloof.* Peter Mobbs

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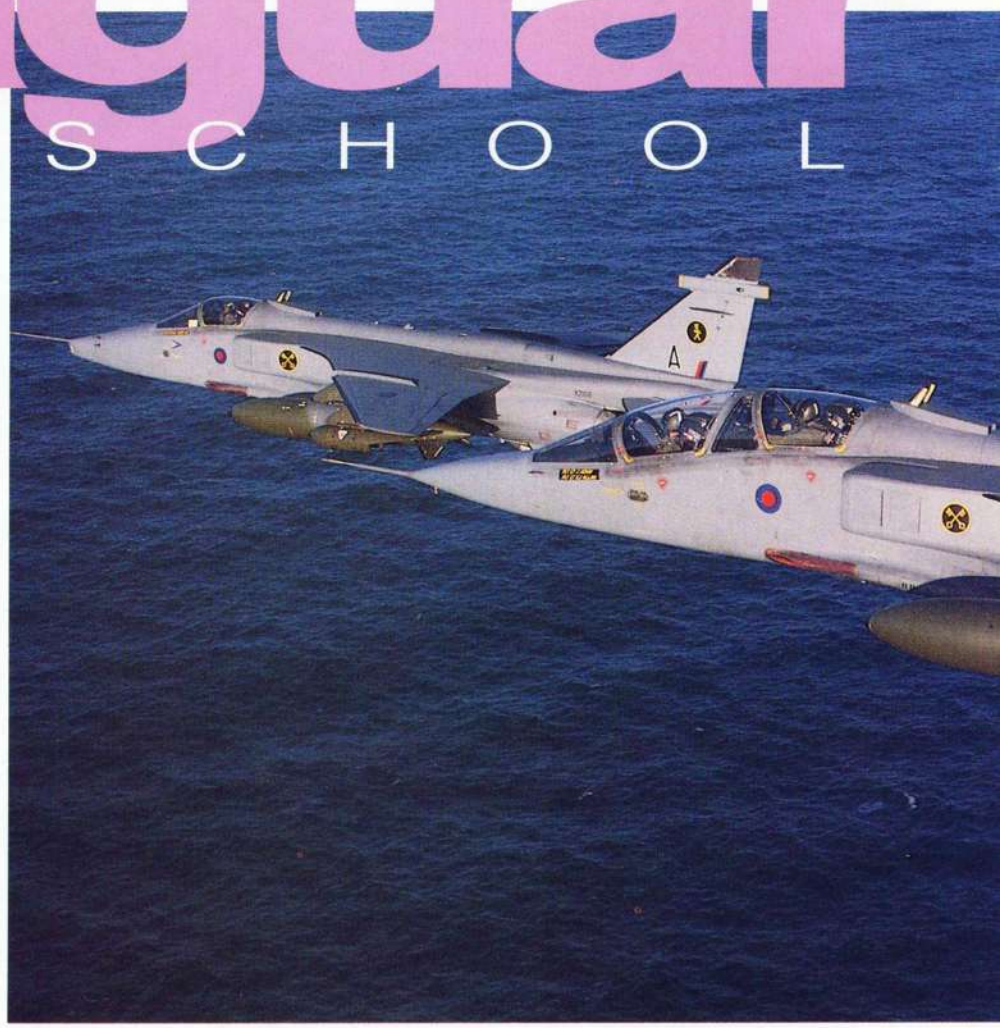

Peter R Foster

When the Royal Air Force despatched 12 Jaguar GR1A aircraft and their crews to the Gulf in August 1990 in response to Iraq's unprovoked attack on Kuwait they were to be the spearhead of the RAF's involvement of what became Operation *Desert Storm*. Although this was ultimately a triumph in the application of air power, little were the pilots, or the public, to realise that the Jaguar was to bear the brunt of peace keeping duties in a number of 'hot spots' almost continuously for the next five years.

Such tales of daring deeds where crews 'go to war', then home for tea and medals, perhaps obscures the fact that none of this would have been possible had it not been for the dedication and professionalism of the Jaguar Operational Conversion Unit (JOCU). No 16 (Reserve) Squadron, as the unit is known today, is still located at RAF Lossiemouth in the far north of Scotland, a base it first moved to some 23 years previously, when the Jaguar was just entering the RAF's inventory.

At that time the unit took on the mantle of No 226 Operational Conversion Unit, a title it received from the previous Lightning Conversion Unit at RAF Coltishall – an appropriate association as this was to be the Jaguar's first operational front line base. With the need to work-up some eight front line squadrons on the type in a four-year period, as well as produce the right training package to meet all the requirements of this new strike/attack aircraft, pilots involved in the programme in those early years were to set the very high standard that is maintained today.

At that time, when the main threat was still seen as coming from the Warsaw Pact, the Jaguar had a predominantly strike role. Today this has passed onto the much more sophisticated two-man Tornado GR1 leaving the Jaguar to concentrate on roles that are more in keeping with the present day threat scenario of attack and armed reconnaissance.

An aircraft that has, on more than one occasion, been seen as an easy option for politicians attempting to make defence savings but survived due to its ability to be such an influential tool of the political will. When many thought it would succumb to inevitable cuts the aircraft and crews have answered by proving just how useful they can be. This has seen the Jaguar continuously upgraded to meet changing roles, increased threats and the introduction of new technology. This has kept the Jaguar in a position where it would be very difficult to be without it, at least until it can be replaced by something better.

Below: *Line-up of No 2 Sqn/226 OCU Jaguars at RAF Lossiemouth in August 1975.* Peter R Foster

Since the early 1970s when No 226 OCU was equipped with as many as 23 twin-seat Jaguar T2s and 27 single-seat Jaguar GR1s, No 16 (Reserve) Squadron undertakes the same task today, albeit much reduced, with just 12 aircraft. In these 23 years there have been 110 long courses, providing initial conversion for those new to the Jaguar to a level where they are considered at a limited combat ready state; 121 short courses for those re-entering the Jaguar world or into positions not requiring the same level of training and 28 Qualified Weapon Instructor (QWI) courses. On top of this the unit runs its own instructor pilot courses, where experienced pilots are taught how to pass on their knowledge of handling, instrument flying, low-level navigation, weapon delivery, attack profiles and evasion training as detailed in the course syllabus, lasting some 70 hours. A number of other specially tailored courses are provided to meet specific needs, such as the Instrument Rating Examiners Course, running as and when required.

At RAF Lossiemouth the unit has been instrumental in the training of all Jaguar personnel from four countries that currently operate the BAe produced aircraft – Oman, Ecuador, Nigeria as well as the RAF and sees former pupils from these air forces returning to take advantage of QWI course, experience that cannot be gained elsewhere.

Under the expert guidance of its present commanding officer, Wing Commander Brian Newby, No 16 (Reserve) Squadron continues to uphold the long established and respected traditions of the Jaguar Force. In being bestowed the No 16 Squadron mantle, the OCU/reserve squadron continues to maintain the history that goes back to the dark days of February 1915 on the Western Front, when it was first formed at St Omer in France, to provide close support for the army – a role not too distant from that today.

No 16 Squadron operated such famous types as the Armstrong Whitworth Atlas, Hawker Audax and Hector between the wars; it then took the Westland Lysander to France in 1939 before a change of role saw the squadron undertake tactical reconnaissance with various marks of P-40 Tomahawk, P-51 Mustang and Spitfire. After World War 2 the squadron was assigned the role of ground attack, close air support and interdiction, using such famous types as Tempest, Vampire, Venom, Canberra, Buccaneer and Tornado before it became the first of the RAF Germany Tornado squadrons to be inactivated under the 'Options for Change' on 11 September 1991.

Having provided aircraft and crews for both Operation *Desert Shield* and later *Desert Storm*, No 16 Squadron has quite rightly made a place for itself in the history books. Its role today is, however, of no less importance as it continues to supply the Jaguar force with new (and refreshed) aircrew, for the exacting tasks that the three Coltishall-based squadrons (Nos 6, 41 and 54) face.

Although a non-operational squadron in peace-time, the JOCU sent crews and aircraft to serve during the Gulf War, as it would do

Above: *All RAF tactical aircraft, including the Jaguars of No 16(R) Sqn, are progressively being painted in an overall grey scheme.* Peter R Foster

Left and below: *No 16(R) Sqn Jaguar GR1A XZ108 and T2A XX832 in close formation during a low-level sortie over the Scottish coastline.* Peter R Foster

under any national emergency. Equally the 'staff' or instructors have to maintain their operational expertise, just in case a situation arises whereby the squadron is released from its reserve commitment and becomes integrated once again into the RAF's front line structure. However, with such stress being placed upon the RAF's now very limited assets with continual detachments in support of UN Peace Keeping initiatives, UK Foreign Policy directives and normal deployed training packages, a posting to Lossiemouth for Jaguar pilots does at least return to some sort of semblance of family life.

The squadron has also been tasked for many years with providing an aircraft and pilot to provide a Jaguar display at UK and overseas airshows through the summer season. For the past two years this has fallen into the very capable hands of Flight Lieutenant Andy Cubin, who with his specially gloss painted black Jaguar GR1A, XX116, has thrilled many an air show audience with the aircraft's performance and his personal flying expertise.

The staff pilots with No 16 (Reserve) Squadron number just nine, along with two flight commanders and Brian Newby. There are generally four students undertaking the long course. This begins with two and a half weeks of ground school followed by three dual-handling and one solo handling sortie. Five instrument flights, of which four are dual with an instructor and one solo, three sorties involving formation flying, of which two are with the instructor in a Jaguar T2A, and a package of five trips of low-level flying brings the general aircraft handling stage to its conclusion.

The weapons phase is built around 15 sorties, five of which are flown dual, which then lead to simulated attack profiles (SAPS) that are divided into three trips flown as a single ship, the first being dual, and five as part of a formation which again sees just one flown with an instructor.

Before the students are introduced into the world of air combat (three sorties), and evasion tactics (nine dual sorties), they undergo a number of 'check rides' carried out by a flight commander or the squadron boss. In these they will be assessed on their instrument flying which leads to them achieving an instrument rating and their general handling abilities.

Running parallel to the long course are short courses of anything from one to five pilots generally tailored to the individual needs of those concerned. Most of the students on a short course are pilots either returning to operational flying or taking over supervisory positions within the squadron structure, for example Flight Commanders.

One of the most important, and quite possibly most demanding, courses run by the squadron are those for Qualified Weapon Instructors. Here pilots selected for the QWI course, which generally caters for up to four students at any one time, learn the intricacies of retard bombing, strafing, 'toss and loft' deliveries, air-to-air firing of both gun and missiles, air combat training (ACT) and tactical management. The course deals in depth with how the ordnance operates, how best to deliver and its practical application.

Above and right: *Low level navigation and simulated attack profiles are amongst the tasks undertaken by students with No 16(R) Squadron.* Peter R Foster

Pilots undertaking this course do so at the behest of either their own squadrons, where they then move or are promoted into an executive position or become instructors in weaponry in their own right. The instructors of No 16 Squadron are, with one exception, either QFIs of QWIs. The one remaining pilot is a tactics instructor (TI) who though 'certified to instruct' does not have a formal 'Q' qualification.

The QFIs deal with the conversion sorties and the early instrument flying and the QWIs deal with all of the weaponry skills. All other phases including formation, low level navigation, air combat, simulated attack profiles, evasion training and some of the instrument flying is shared by all the instructors including the tactics instructor (TI).

The planning of the courses is undertaken at No 1 Group, Strike Command and are dove-tailed to maximise the time and resources available. The QWI course, of which there is one each year, is open to other Jaguar users, time being bought from the unit by the country concerned, although with the limited assets currently available this could be at the expense of an RAF slot.

The future for the squadron looks secure with RAF front line assets, particularly in the tactical areas, having been cut back as far as things can go. The Jaguar itself is scheduled to be replaced by the Eurofighter 2000 in a timeframe of around 2006, always assuming that current plans are maintained. It was originally to have been replaced by the mid-1990s but this has slipped through delays in aircraft development and political wrangling.

To maintain both its lead in the tactical field, and to help ensure its survivability, RAF Jaguars have received a number of upgrades. Initially the NAVWASS system of the early Jaguar was replaced by the Ferranti FIN 1064 which incorporated a new Inertial Navigation System (INS), computer and power supply linked to the existing radar altimeter, air data computer, Head Up Display (HUD), moving map display and laser ranger. Also on the plus side, apart from being greatly more reliable and accurate, the FIN 1064 was some 110lb lighter than the original NAVWASS and occupied only one third of the space.

The system offered the Jaguar a 99% serviceability and a maximum drift of one mile per flight hour without any form of updating, thereby improving the aircraft operating capability greatly. The modification came in the mid-1980s when the Jaguar force had been reduced to just four front-line units. Initially 75 single seat GR1 and 16 two-seat T2 aircraft received the modification and were in the process re-designated GR1A and T2A respectively.

Defensive aids added during the same period included the Philips-MATRA Phimat chaff pod, Tracor AN/ALE-40 flare dispensers, Westinghouse AN/ALQ-101(V) jamming pods and provision for the conveyance of AIM-9L Sidewinder air-to-air missiles, carried on the port outer pylon until overwing rails developed for the Jaguar International were added late in 1990 in response to the Gulf crisis.

For the same reason 1990 saw the programme for upgrading the fin-mounted Marconi ARI 18223 radar warning receiver (RWR) to Sky Guardian 200 standard, with improved processing and threat reception accelerated. Notwithstanding the weight savings made by the introduction of FIN 1064, the empty weight of the Jaguar, less pilot and fuel, had by 1992 grown from 16,300lb to 16,975lb. Although during 1978 the RAF had begun replacing the Mark 102 engines with RT172-26 Adours, known locally as the Mark 104, during the Gulf War turbine temperatures were allowed to rise from 700° to 725°C boosting the dry thrust from 5,270lb (23kN) to 5,350lb (24kN) and with reheat from 7,900lb st (35kN) to 8,100lb st (36kN). The Gulf War also saw those aircraft deployed fitted with 'Have-Quick' radios. The only indication of this fitment being the addition of a single large blade aerial surmounted by a dipole behind the cockpit, replacing two smaller antennas.

Experience gained during the Gulf conflict in the use of smart weapons, and the need in subsequent UN peace keeping actions for precision bombing, has seen the Jaguar adapted for the operation of the GEC-Ferranti Thermal Imaging Airborne Laser Designator (TIALD). Ten single-seat and two twin-seat aircraft have been modified and re-designated GR1B and T2B respectively with the system, both having seen action in Bosnia during August 1995.

In parallel the RAF has purchased Paveway III bomb guidance units and nine TIALD pods for the Jaguar. These aircraft will also gain a GEC-Marconi A4 wide-angle head-up display, global positioning system (GPS), digital database, multi-purpose colour display replacing the original projected map display, video recorder for TIALD imagery and a HOTAS control column.

In a separate programme all RAF tactical aircraft are now beginning to receive a new grey paint scheme. This new scheme of dark sea grey upper sides and medium sea grey lower sides, plus fin, will remove the necessity of painting aircraft in the temporary washable ARTF and reduce the man hours to maintain and remove it. A number of aircraft have now received this new scheme, but with the RAF adopting a policy of sanitising aircraft involved in Peace Keeping roles, by the end of 1995 the grey Jaguars were being operated devoid of individual squadron insignia.

With investment in this 25 year old aeroplane still at a premium the role of No 16 (Reserve) squadron is as important now, as ever, in providing the RAF with pilots to maintain a credible Jaguar Force into the next century.

Below: *Andy Cubin displaying No 16(R) Squadron's gloss black-painted Jaguar GR1A XX116.* PRM

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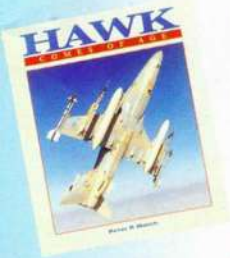

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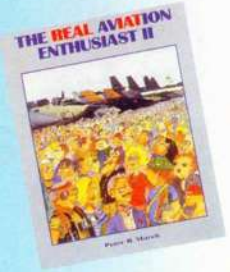

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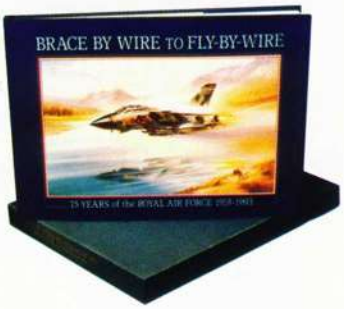

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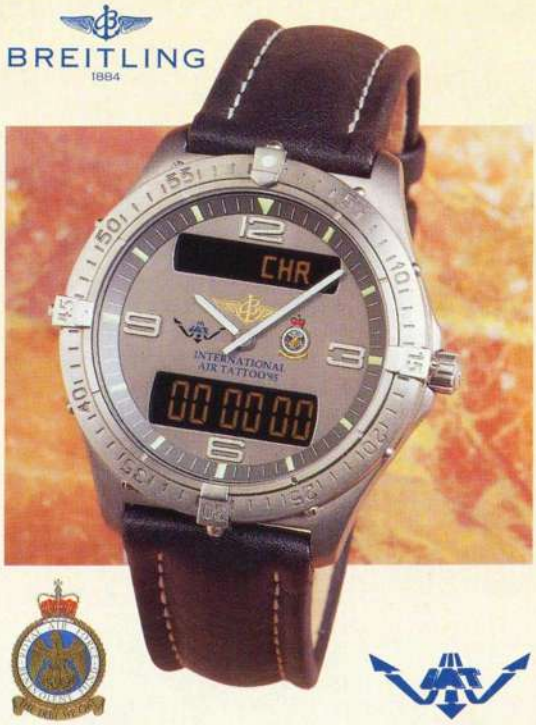

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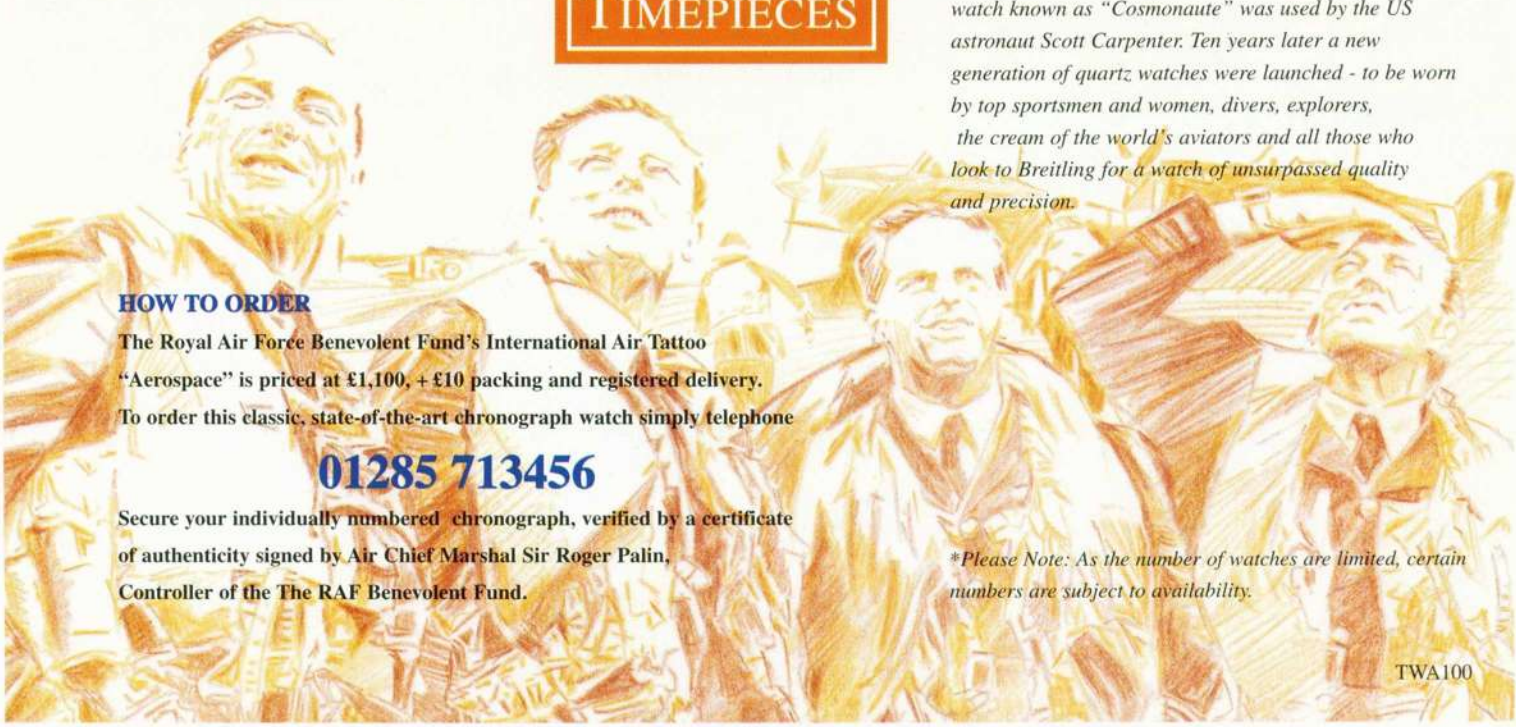

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TWA100

Tim Ripley reviews the RAF's contribution to NATO and UN peacekeeping efforts in the former Yugoslavia over the past twelve months.

THE RAF IN BOSNIA 1995

Six Chinook HC2s formed part of the RAF Support Helicopter Force that was deployed to Ploce in southern Croatia to provide support for the Rapid Reaction Force. Patrick Allen

The Harrier GR7 crews of No 4 Squadron who took part in NATO's Operation *Deliberate Force* bombing effort against Bosnian Serb military targets last August and September have prepared a bomb damage video. Images of one 1,000lb laser guided bomb after another blasting bunkers and other targets are presented. Group Captain Richard Thomas, who was the RAF representative at the headquarters of NATO's 5th Allied Tactical Air Force (5 ATAF), described the NATO air effort as 'a precise use of airpower'. The Bosnian Serbs certainly got the message. After eleven days of NATO bombing they started to withdraw their heavy weapons from around Sarajevo, lifting the three year siege of the Bosnian capital.

DELIBERATE FORCE

The RAF's Harrier GR7s were involved in *Deliberate Force* from the first hours, flying daily bombing raids as part of a combined strike force with Jaguar GR1Bs, of No 54 Squadron, that were newly equipped with the GEC-Marconi TIALD (Thermal Imaging Airborne Laser Designator) pods. The Jaguars and Harriers worked as team, with two Harriers each carrying two Paveway II laser guided bombs that were dropped on targets designated by a single Jaguar with a TIALD pod. This technique, known as 'buddy lasing' or 'spiking' proved to be highly effective, with the video imagery providing irrefutable evidence that the RAF had its bombs on target with little collateral damage against civilian targets. "The Serbs would have jumped on any bad publicity", said Gp Capt Thomas.

Flying from their base at Gioia del Colle, in southern Italy, the Jaguar/Harrier team worked as part of multi-national NATO strike packages, that attacked large targets such as Serb ammunition dumps or tank parks. Each day up to five strike packages were launched over Bosnia, but it was not always an easy ride for the RAF crews. On a number of occasions attacks were aborted in the air because bad weather made it impossible to locate their targets.

No 4 Squadron had arrived in Gioia del Colle at the beginning of August to take over from RAF Coltishall's Jaguar GR1As, that returned home after maintaining the Jaguar Detachment for just over two years. The arriving squadron's Harrier GR7s benefitted from many of the modifications fitted to allow the Harrier Force to take part in Operation *Warden* over Northern Iraq. These included GPS, a special IFF fit and changes to allow some US weapons to be carried. Photographic reconnaissance pods were also reintroduced to the Harrier Force.

The Harriers were regularly tasked to fly photo reconnaissance missions with the LOROP and VICON pods. They always flew armed with 1,000lb general purpose bombs and on one occasion a pair of Harriers was

Left: *RAF Chinooks, initially deployed in support of the Rapid Reaction Force, remained in Ploce to assist the NATO Peace Implementation Force.*

Above: *VC10s from No 10 Squadron were used to transport personnel to Split from the UK and Germany as the Rapid Reaction Force took shape.* Tim Ripley

diverted from a recce mission to provide close air support for UN troops under fire by Serb forces. By the time that the Bosnian Serbs climbed down, NATO forces had caused heavy damage to at least 48 target complexes, with a total of 663 laser guided bombs being dropped, of which around 10% were delivered by the RAF.

DENY FLIGHT

Supporting the NATO effort throughout *Deliberate Force* were fighter, tanker, reconnaissance and airborne early warning assets. To protect NATO strike packages RAF Tornado F3 fighters, of No 111 Squadron, flew daily combat air patrols over Bosnia to deter Serb fighters from taking to the air. These missions were a continuation of the Operation *Deny Flight* patrols that had enforced the UN *No Fly Zone* since April 1993. Each of the RAF's Tornado F3 squadrons rotated through Gioia del Colle, Italy at three month periods providing the detachment. The No 111 Squadron Tornado F3 crews had a more exciting time in the aftermath of *Deliberate Force*. They were tasked to fly daylight patrols over north-west Bosnia to stop the Bosnian Serb Air Force from flying missions out of the base at Banja Luka, in a desperate attempt to hold back the Bosnian and Croatian offensives.

Central to all the NATO operations were the efforts of the two E-3D Sentries of No 8 Squadron, that had been operating from Aviano AB, in northern Italy since October 1992. The AWACS crews co-ordinated the hundreds of sorties over Bosnia by allied aircraft and alerted them to any unauthorised air activity. Providing important back-up to all the RAF tactical aircraft and a number of NATO air forces were the two No 216 Squadron Tristar tankers that operated from Palermo airport on Sicily. The Tristars together with other allied tankers maintained around the clock refuelling tracks over the Adriatic, so that tactical aircraft heading inland could refuel or top up on the way home.

Kinloss Nimrod MR2 squadrons were active throughout the year sending aircraft for two-week detachments to Sigonella in Sicily, to provide maritime reconnaissance patrols over the Adriatic in support of the NATO/WEU embargo operation.

After the successful completion of *Deliberate Force*, the RAF contingent reverted to its previous job of enforcing the No Fly Zone and standing by to provide close air support for UN ground troops.

UN SUPPORT

The RAF provided extensive support for the United Nations Protection Force (UNPROFOR) on the ground in the former Yugoslavia. This ranged from individuals assigned to key staff posts or as UN Military Observers (UNMOs) to helicopter detachments.

Since early 1993 the RAF Tactical Support Wing (TSW) has been heavily engaged providing fuel for UN helicopters operations throughout Bosnia. This involved running refuelling points at the main helicopter landing sites (HLS) at Split in Croatia, Gornji Vakuf and Kiseljak up country in central Bosnia. Maintaining the later two HLS was a difficult and dangerous job for the TSW fuel tanker drivers who had to drive across treacherous roads, near to active frontlines.

At Split's airport a UK Mobile Air Movement Squadron (UKMAMS) Flight has been in almost permanent residence since British troops deployed to the former Yugoslavia in 1992, to handle the arrival of supplies and reinforcements bound for UN duty in Bosnia.

Within the UN's Bosnia-Herzegovina Command (BHC) Headquarters in Sarajevo, RAF staff officers and communications personnel manned the Air Operation Co-ordination Centre (AOCC), which was the interface between UN commanders such as Lt Gen Sir Michael Rose and NATO's 5 ATAF headquarters in Italy. When the UN wanted air support the AOCC was tasked with getting the aircraft to the right place, at the right time.

At UNPROFOR Headquarters in Zagreb, Croatia, the RAF provided a one-star Air Commodore to act as the head of the NATO liaison office. He co-ordinated any joint UN and NATO operations.

Based outside Zagreb at Pleso Airport was the UN's 'G3 Air Operations' centre which in effect ran the UN's own air force of chartered aircraft and helicopters. For most of 1995 this organisation was headed by an RAF wing commander on secondment to the UN.

In August 1995, after the Croats drove thousands of Serb refugees from their homes in the Krajina region, the Chinook HC2s were deployed from RAF Odiham to Pleso to set up a humanitarian airlift to Serb refugee camps around Banja Luka. This was the second aid airlift to Bosnia; the first had involved RAF Hercules aid flights to Sarajevo, which continued through until January 1996.

RAPID REACTION FORCE

During the summer of 1995, the British Government decided to send major reinforcements to UNPROFOR, after some 500 UN personnel, including 34 British soldiers, were taken hostage by the Serbs in response to NATO air-strikes on an ammunition dump near Pale. Within a week RAF Hercules and VC10 transport aircraft were in action flying the first wave of troops and equipment to the Balkans. The Lyneham Transport Wing was tasked with moving the 105mm Light Guns and equipment of 19 Regiment Royal Artillery

Right: *A No 54 Squadron Jaguar GR1B carrying a TIALD (Thermal Imaging Airborne Laser Designator) pod on the centreline.* CPRO HQ STC

and two Army Air Corps Lynx helicopters of 664 Squadron, to Split in Croatia. Some 74 Hercules sorties moved 131 vehicles, 68 trailers, 12 artillery pieces and 65 tonnes of palletised freight. No 10 Squadron VC10s moved most of the extra personnel to Split from airports in the UK and Germany.

The next wave of reinforcements, centred around 24 Airmobile Brigade, took longer to deploy to Croatia because of diplomatic and logistic holdups. By early August the brigade had set up its base at Ploce in southern Croatia ready for elements of the RAF Support Helicopter Force (SHF) to fly in. Six Chinook HC2s of No 7 Squadron and six Puma HC1s of No 33 Squadron deployed from RAF Odiham to Ploce in the first week of August, to activate the SHF.

To provide ground support for the brigade a large RAF contingent was also deployed to Ploce. These include the TSW for refuelling, No 1 Field Squadron, RAF Regiment, from ground security of HLS and air traffic and firefighting elements of the Survive to Operate organisation.

Throughout August the SHF was unable to fly into Bosnian airspace because of obstruction by the Sarajevo regime but this changed after NATO started bombing Serb targets in September.

SHF helicopters made regular flights to Mt Igman to support British and French troops of the UN Rapid Reaction Force. When is was announced in October that 24 Airmobile Brigade would be returning home, the SHF was ordered to remain in Ploce ready to support the new NATO Peace Implementation Force that was then just beginning to form.

NATO MISSION

At the beginning of 1996, UNPROFOR had all but wrapped up its mission in Bosnia, ready to hand over to NATO. This, however, did not mean the end of RAF involvement in the former Yugoslavia. Units operating in Italy, Bosnia and Croatia remained on duty doing very much the same tasks, but for a different international chain of command. RAF personnel simply took off their blue UN berets and badges, before reverting to their normal service uniform. Different hats – but still the same job.

Above: *Combat air patrols over Bosnia were flown by No 111 Squadron Tornado F3s in support of Operation* Deliberate Force. Tim Ripley

Below: *During Operation* Deliberate Force, *Harrier GR7s were employed on bombing missions flown in conjunction with TIALD-equipped Jaguar GR1Bs acting as target designators.* BAe

HERCULES over Sarajevo

Tim Ripley joins a Royal Air Force flight into the heart of the war-torn Bosnian capital during the UNHCR relief operation.

"Only two RAF aircraft have been hit since we started flying into Sarajevo three years ago. We stay out of the way of small arms fire", said Flt Lt Mark White, who was at the controls of the No 47 Squadron Hercules for our flight into Sarajevo.

Our mission began at Ancona's Falconara airport on the east coast of Italy on a hot October morning, two weeks after sustained air raids by NATO jets had forced the Bosnian Serbs to withdraw their heavy weapons from around Sarajevo. The RAF detachment in Ancona had begun work early in the morning to get their aircraft ready for take off at 0820hr for the first of its three sorties into Sarajevo. They were obviously working hard at what some considered was a thankless task. Between July 1992, when the RAF began Operation *Cheshire* (as its involvement in the United Nations High Commission for Refugees aid air-bridge was code-named) and January 1996, a No 47 Squadron Hercules flew into Sarajevo almost every day, clocking up 1,902 sorties in total, in what has become the longest such operation since the Berlin Airlift in 1948.

Sitting in the portacabin, next to the airport's civil passenger terminal that doubled as the RAF detachment's headquarters, was Sqn Ldr Stuart Vince who had just been seconded from RAF Lyneham's simulator flight to head up the airlift operation. Outside was a single RAF Hercules C1, alongside a German C.160 Transall, a French C-130H and a Canadian CC-130. Across the runway were two USAF C-130Es – all there for a single humanitarian purpose.

UNHCR AIRLIFT

"We are here to support the UNHCR. We fly three lifts a day, which is around 40 tons of cargo daily, 150 tons a week. The other nations all fly similar amounts" said Sqn Ldr Vince. "We only have one crew and they fly six days on the trot which is just about the limit we are allowed to fly".

The RAF had begun the current phase of the airlift on 16 September after a break of over four months because of the increasing Serb seige of the city which was only broken by NATO launching Operation *Deliberate Force* in the final days of August. A French aircraft was the first to land on 15 September after the Serbs gave in to NATO's overwhelming military force, and the RAF soon followed in. During the shutdown the RAF had withdrawn its Hercules and most of its personnel back to the UK but the airlift team was re-activated in mid-September to get Operation *Cheshire* up and running again.

Some 35 RAF personnel drawn from a number of bases in the UK and Germany were at Ancona, maintaining aircraft, loading cargo, weather forecasting, mounting guard, providing communications, administration and medical support. A single Royal Engineers lance corporal handled BFPO post for the detachment. Some were in Ancona for a few weeks, while others were tasked for four months. The aircrew usually spent two weeks at Ancona before rotating back to UK. The RAF forms part of the multi-national Joint Air Operation Centre, which co-ordinates the airlift on behalf of UNHCR, with each of the national contingent commanders taking it in turns to be duty officer for the day, dealing with UNHCR headquarters in Geneva to plan the daily flight schedule into Sarajevo.

SARAJEVO MISSION

UN Flight 406 was scheduled to take off at 0820hr but prospective passengers had to be at the terminal some two hours earlier to be

Above: *Sarajevo from the air. Only three weeks before, NATO aircraft were dodging Serb surface-to-air missiles in the area.* All photographs Tim Ripley

Right: *French and British personnel join forces to turn around our Hercules at Sarajevo.*

checked on the flight by the RAF Police. They provided security for the UNHCR airbridge. There are strict rules about what can and cannot be carried on aircraft heading to Sarajevo. Under the complex diplomatic arrangements necessary to allow the city's airport to operate, only *bona fide* items of humanitarian aid could be carried, so as not to compromise the UNHCR's neutrality.

Every passenger no matter how important, even the BBC's Kate Adie, had to empty out their luggage to ensure they were not carrying prohibited items. RAF Policemen were posted to Ancona for four months at a time and take turns between searching passengers and flying security on the RAF Hercules bound for Sarajevo, dressed in UN regulation blue helmet and flak jacket.

At the controls of UN406 is Flt Lt White, a veteran of more Sarajevo missions than he cares to remember. Lifting off from Ancona airport we climb over the oil tanks and jetty's of the Falconara. It is a clear day with no clouds to be seen. Some 40 minutes later we cross the coast of Croatia and a large cloud bank was in front of us. The weather is a constant problem for Sarajevo bound aircraft even before the Balkan winter has set in.

Over the Croatian city of Split we spot an outbound aircraft on the horizon. Closer inspection with binoculars reveals it to be a UN Ilyushin Il-76 heading for Zagreb. We headed into the cloud bank and Bosnia disappeared from view until Flt Lt White started his final approach into Sarajevo.

Dropping out of the cloud near Kiseljak to the west of the city, Sarajevo was almost totally obscured by haze. From the cockpit of the Hercules we could clearly see the airport's runway ahead. It is in a wide valley that does not attract as much fog and haze as the city itself.

We hit the runway and Flt White quickly brought the aircraft to a halt before turning into the French controlled terminal area. At the end of the runway is a reminder to pilots landing at Sarajevo airport, the ruined carcass of an overloaded Il-76 that had been unable to stop. The chartered aircraft had been carrying extra rations for the French garrison when its pilot put the aircraft down at above the recommended landing speed.

After we come to a halt outside the terminal, a posse of forklifts gather around the back of the aircraft to unload our cargo of

Above: *The Hercules crew await clearance to take off from Sarajevo having unloaded their cargo of plastic sheeting.*

plastic sheeting, needed to repair the windows of war damaged buildings. This task was completed without fuss by the French Air Force unloading team who have grown expert at turning around aircraft. The record is just under ten minutes, although the norm is nearer 15 minutes.

KHE SANH APPROACH

On the flight deck, the co-pilot is reading a novel. The control tower has just told us that a Canadian CC-130 is inbound so we have to wait until he is clear before we can take off. There is little else to do but wait. I recalled Sqn Ldr Vince's comment, not to be taken in by the nonchalance of the Hercules' crew. "They seem casual, but they are very professional and they all have such a very high level of experience, some have more than 600 sorties under their belts".

Flt Lt White however was not taken in by the seemingly peaceful atmosphere in Sarajevo. "There were 450 shooting incidents in the city yesterday", he commented. Looking out of the cockpit window we get a clear view of Mt Igman, the scene of the action during the recent battles between the UN Rapid Reaction Force and the Serbs. It is peaceful now with a large convoy of civilian trucks winding its way down towards the UN check point at the west of the airfield.

When the airlift restarted NATO fighters flew 'shotgun' for the UNHCR aircraft but tension is so reduced now the RAF does not fully employ the famous high angle *Khe Sanh* landing approach. The theory behind using this method, developed by the US forces in Vietnam, is that by limiting the time the aircraft is inside the small arms envelope, the less chance there is of it being hit.

Although the alert state at Sarajevo had now dropped to 'green' or normal, Flt Lt White was still flying a fairly steep approach to avoid any possible small arms fire. "Some of the aircraft don't use such a steep approach angle. Obviously they pick up small arms rounds from time to time," said Flt Lt White.

TAKE OFF

With our take off clearance granted, we were soon in the air bound for Ancona. Two of the crew stood looking intently out of the windows holding triggers for the aircraft's chaff and flare decoy system, ready to fire if there was any indication of a heat seeking missile being launched at us. Thankfully their services were not required as we climbed over the ruins of the Serb-held Ilidza district of Sarajevo.

Little did we know it at the time but the days of the UNHCR airlift were soon to be numbered. With road convoys now entering Sarajevo freely the airlift was quickly becoming redundant. During November the airbridge was all but closed down as the UNHCR decided to concentrate on road convoys. The UNHCR then announced that the airlift would be started up again in December to clear out its aid stockpile in Ancona, with the final sorties being flown on 9 January 1996, after three and a half years of the airbridge being in operation. It was not expected that this would be the end of No 47's involvement in Bosnia air operations, with the deployment of 13,000 British troops as part of the NATO Peace Implementation Force gaining momentum in late December 1995.

In the meantime, flight UN406 headed back across the Adriatic to Ancona. On the ground the air crew adjourned to the RAF detachment's portacabin for a quick cup of tea, while the UK Mobile Air Movements Squadron (UKMAMS) personnel loaded up the Hercules for it next mission to Sarajevo. It was proof, if any more were needed, that the RAF is more than on top of the highly dangerous and demanding business of running humanitarian airlift operations into war zones.

Below: *Hercules XV206 of No 47 Squadron at Ancona-Falconara Airport prior to the sortie described in this article. Note wingtip ECM pods.*

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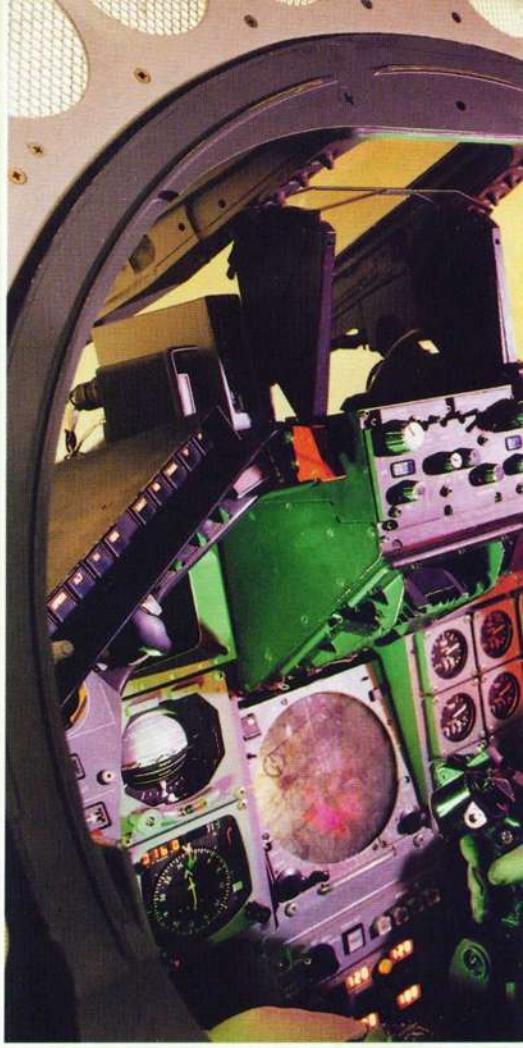
Virtual Flying

Michael Fishpool



Every year Royal Air Force aircrew can gain many hours of flying experience without leaving the ground by entering the computerised virtual world of flight simulators. Some of these simulators have hydraulically-driven motion platforms and various other methods of providing flight characteristics, while Computer Generated Image (CGI) displays around the cockpit provide the pilots with their own views of the outside world.

To a casual observer it might appear that RAF aircrew now spend most of their time meddling with the ultimate in arcade games. However, these flight simulators do perform a vital function for aircrew by providing extremely realistic flying training. Furthermore, budget restraints caused by the *Options for Change* and *Front Line First* defence cuts have resulted in a particular requirement for cost-effective training aids. Flight simulators meet this criteria by costing in the region of one-tenth the operating expenditure of the associated aircraft. These devices have also demonstrated their usefulness when applied to the modern combat environments that a mock exercise like *Red Flag* cannot completely replicate. Simulators also provide safe flying training which benefits both the RAF and the general public.

At present, the RAF operates approximately 15 different types of flight simulator, catering for nearly every aircraft in service.

While flight simulators are specifically designed to provide realistic flying and combat training, other types cater for the familiarisation of cockpit layouts, while desk-top computers provide instrument and radar training. Some 30% of basic and advanced flying training is now undertaken using Synthetic Training Equipment (STE) although the amount of time spent on STE by front-line aircrew is considerably less.

At present, the RAF operates approximately 15 different types of flight simulator, catering for nearly every aircraft in service. Most of these have been supplied by UK manufacturers Link-Miles and Hughes Rediffusion Simulation. Despite being well established providing air, land and maritime simulation training devices, both companies merged with the simulation division of France's Thomson-CSF during 1994 to form Thomson Training & Simulation (TTS). As a result, TTS now accounts for around 40% of the world's military simulator market.

Virtual Tornado

To get a better understanding of the function of simulators in RAF service, a closer look must be made at the types available for one area which the RAF is tasked – air defence with the Panavia Tornado F3.

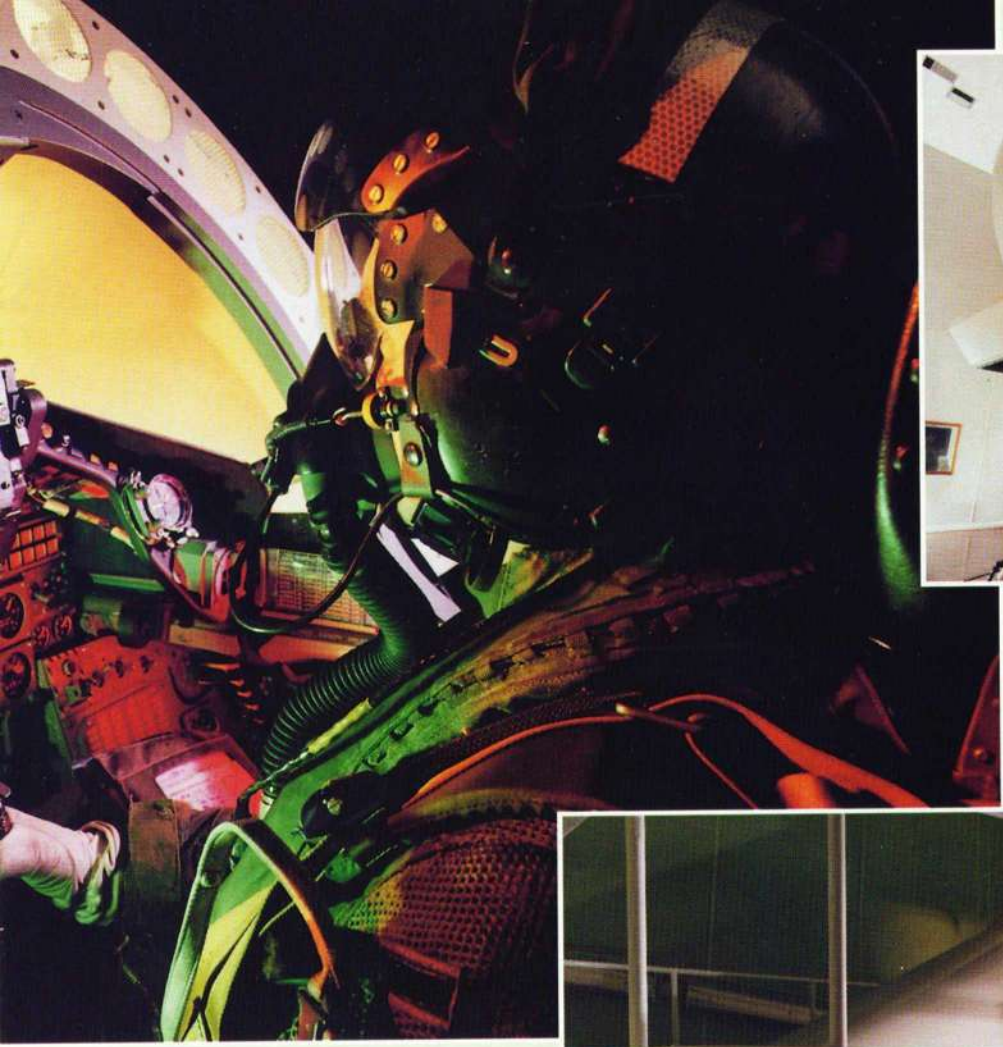
Some five simulators are presently in service with the Ground Training Flight (GTF) of the Tornado F3 Operational Conversion Unit (No 56 (Reserve) Squadron) at RAF Coningsby. Apart from providing Tornado F3 conversion to pilots and navigators fresh out of fast-jet training, some of the simulators are used by crews of other Coningsby-based F3 squadrons.

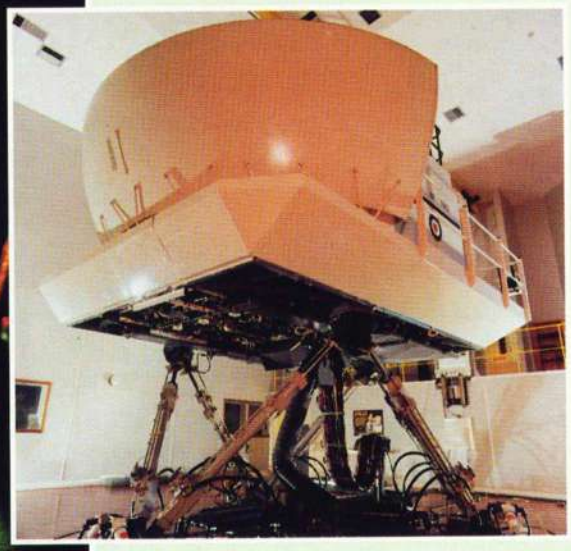
The basic form of simulator in operation at this base is a Hughes Rediffusion Simulation (TTS) Tornado F3 Cockpit Procedures Trainer (CPT) which, as the name suggests, provides prospective fighter aircrew with their first encounter with the cockpit layouts (instruments and switches only) of the Tornado F3. This has no motion or visual display, although some element of realism is created through working instruments and audio sound effects. To get further used to the cockpit instruments and to make first acquaintances with the F3's Foxhunter radar, students also undertake desk-top computer training on a Keyboard and Display Trainer (KDT). In total, students will undertake about 22 hours of training on these before moving onto the larger and more advanced Link-Miles/Hughes Rediffusion (TTS) Tornado F3 Full Mission Simulator (FMS) for flying and interception training.

Housed in the GTF's own simulation complex, the advanced FMS consists of a full mock-up of the Tornado F3 front-fuselage (minus the nose) in an interlocking container. Even though the FMS incorporates the aircraft's full cockpit systems in both the front and rear cockpits, it also has no motion or imaging facilities. The latter is not really needed; with the FMS' white-tinted opaque canopy, student aircrew can easily imagine that they are flying through cloud – something that RAF crews spend considerable time doing over the UK. Moreover, as the Tornado F3 was originally designed as an interceptor, air combat is supposed to take place Beyond Visual Range (BVR). As a result, targets would only require identification via radar displays rather than visually.

Another important element of Tornado F3 flying training in the FMS are emergency procedures which are controlled by instructors via a systems management control panel. Here, they can monitor all

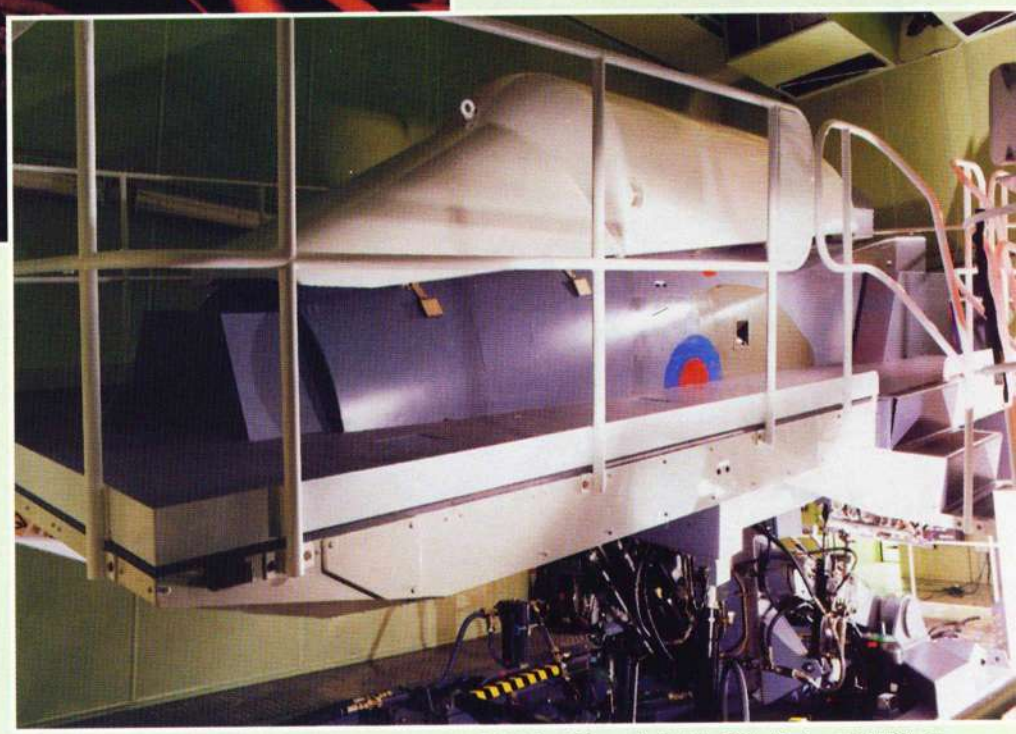
Above: *The Link-Miles Harrier GR7 FMS for use by Nos 3 and 4 Squadrons at RAF Laarbruch, Germany.* RAF Laarbruch





Above: *Two VC10 FMS are currently in service with the VC10 OCU (No 55(R) Sqn) at Brize Norton. The type has six motion axes and provides both day and night CGI effects.*

Left: *An RAF pilot gets some training time on the realistic Tornado GR1 FMS.*
Photographs Thomson Training & Simulation



Above: *A Tornado GR1 simulator is operated by the Tri-National Tornado Training Establishment (TTTE) at RAF Cottesmore. It shares similarities with the Tornado F3 FMS; however, it only has three axes of motion.*
Thomson Training & Simulation

cockpit instruments and displays, and place emergencies in the way of the aircrew – this could take the form of hydraulic and fuel failures or even decompression problems. Obviously, the FMS is a necessity as a training aid as emergencies are an event that aircrew must be prepared for. The main role of the FMS, however, is to teach cockpit co-ordination between the pilot and navigator. Aircrew fly two one-hour sorties per month in the FMS which are combined with flights in the real Tornado F3. Aircrew also undertake further desk-top radar training on the Easams Tornado Airborne Interceptor Trainer (TAIT).

Any Tornado F3 pilot or navigator can undertake Close-In-Combat (CIC) training on the British Aerospace Twin-Dome Air Combat Simulator (ACS). The ACS was delivered to the GTF in 1987. It consists of two 9.1m (30ft) diameter inflated domes housing a motionless fighter-type cockpit that includes all the essential equipment, such as radar and head-up displays, needed for dogfighting and BVR engagements. A main colour imaging camera projects the landscape on the inside of the dome; a second laser-targeting camera projects the image of the adversary aircraft. The pilot/navigator can either play against a computer-controlled opponent, which is known as the British Aircraft Corporation Air Combatant (BACTAC), or against another pilot in the other dome. The BACTAC is capable of simulating numerous aircraft types, all with different levels of aggressiveness.

The highly detailed simulated terrain, airfield, weather and visibility effects are provided by Evans and Sutherland/Hughes Rediffusion (TTS) SPX 500-HT CGIs. During combat simulations, realism can be created by adding Electronic Warfare (EW) environments, Surface-to-Air Missile (SAM) threats, and multi-engagement scenarios. Cockpit noise, seat movement, and g-force visual effects further add to the authenticity. These are particularly useful providing the pilot of the ACS with the sounds and sensations of fast jet flying, such as aircraft buffeting, that arises at low-level and during high g-manoeuvres, or the gradual deterioration of vision (known as 'greying-out') which could also be experienced during very high g-manoeuvres.

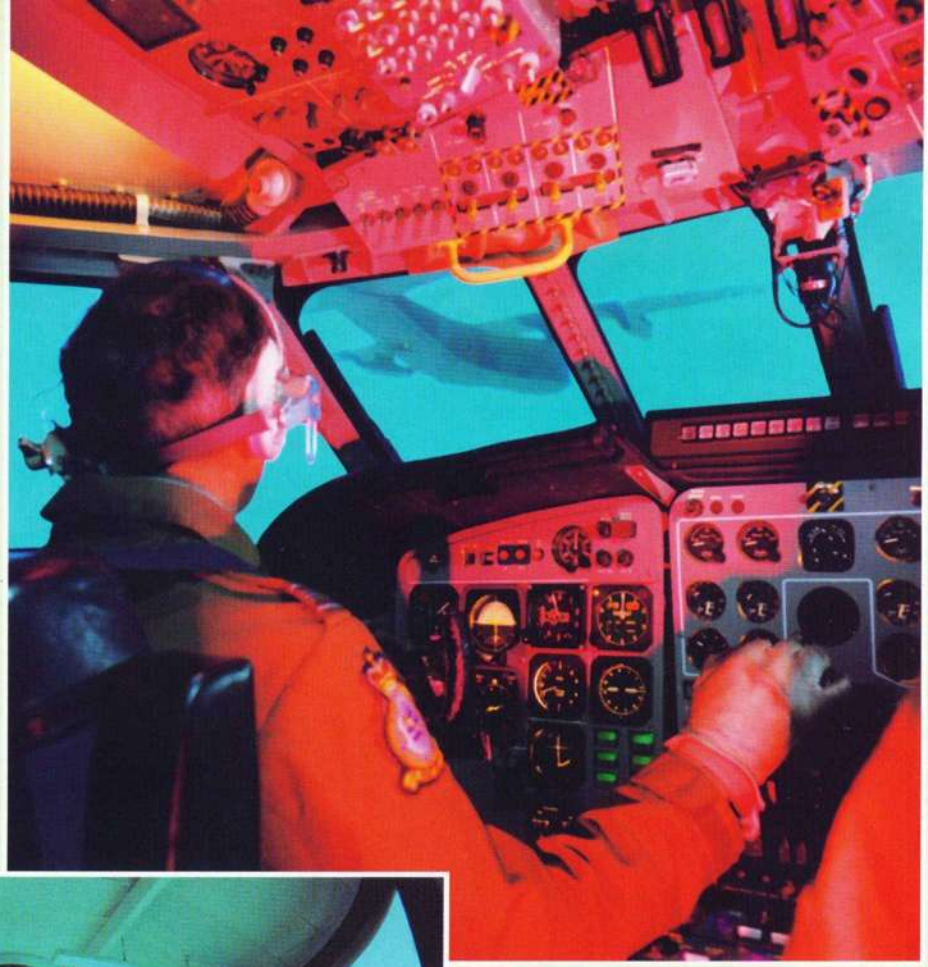
While Tornado F3 crews are not using all of the cutting edge of simulator technology, the RAF does operate some motion/imaging types. The most advanced type presently in service is the Link-Miles (TTS) Harrier GR7 FMS which is operated by the Harrier OCU (No 20(R) Squadron) at RAF Wittering. It entered service in 1991 and includes six axes of motion and CGI displays, providing a detailed low-level simulation for ground attack work. It also has an eye or head tracked area of interest projection system. With the introduction, from 1988, of the advanced GR5 and the later GR7 variants, this was a welcome addition to the RAF's simulator inventory. The OCU only had three dated GR1/3 simulators to provide training (the GR1/3 FMS had four motion axes) and TV displays providing images of scale model maps that are still used in Link-Miles Jaguar GR1 simulators at Coltishall and Lossiemouth. Harrier pilots also had to undertake training in the US on McDonnell-Douglas AV-8B simulators belonging to the US Marine Corps. Systems are also operated for the Hercules, Tristar, VC10, Sentry, Nimrod and Tucano. There will be a further addition to the RAF's simulator inventory with the Hughes Rediffusion (TTS) Sea King HAR

Mk3/3A Mission Simulator, scheduled for delivery in May 1996. Another addition will come from US simulator manufacturer Reflectone who will provide two advanced FMS' and associated training equipment for the RAF's new transport, the Lockheed-Martin C-130J Hercules II. These will replace the current Link-Miles (TTS) C-130K Hercules FMS at RAF Lyneham and will feature Evans & Sutherland ESIG-3000 GGIs, motion facilities and full C-130J cockpit systems.

Virtual Research

While the main purpose of flight simulators in RAF service is for flying and combat training, they are invaluable tools for research into flying characteristics, cockpit layouts and the ergonomics involved in flying present and future RAF aircraft. In particular, the use of simulators for research can greatly reduce the cost of aircraft development, particularly by cutting the need to build expensive research aircraft.

Research flight simulation has taken place at DRA (formerly RAE) Bedford since the mid-1950s. The site currently houses the Advanced Flight Simulation (AFS) complex which is part of the Flight Dynamics and Simulation (FDS) Department. This complex contains some of the most advanced simulators in the world and is primarily used for aircraft research for all three British services. Over recent years, the FDS has also undertaken work for other organisations including NASA.



The BAe Wide Screen Visual Simulator at Warton has been often used for the development of EF2000. Simulators are cost-effective equipment for research and development. BAe

The complex underwent a major refurbishment during 1985 and now operates several simulation facilities including a Large Motion System (LMS). This device, which is the largest motion cuing system in Europe, has five axes of motion and is capable of 10 metres vertical and 8 metres lateral movement. Such a level of motion cue may be used to provide extremely realistic flying characteristics (for example, it is possible to experience weightlessness). The cockpits of the LMS can be operated either as a fast-jet/fixed-wing or a rotary-wing aircraft. Visual systems are powered by Link-Miles (TTS) IMAGE 600PT CGIs or by multiple TV cameras providing modelboard images. Weather and time of the day conditions can also be created for the LMS. CGIs have a high degree of realism and detail which have been enhanced using photographs.

The FDS Department also undertakes some air combat research using a simulator called MANTIS based on workstation computers. This is a multi-player scenario using a mixture of combat aircraft but includes the use of the high fidelity AFS. To give some degree of realism, without having outside interruptions or mock-up aircraft cockpits, the players use 'virtual reality' headsets. Most recently, the AFS has been used in programmes of research for the next generation of RAF aircraft, the Eurofighter 2000 and the Westland-Agusta EH101.

The Flight Simulation Department of British Aerospace's Military Aircraft Division at Warton also operates a number of simulators that have been used for the research and development of the Tornado GR4 and, in particular, EF2000. Apart from the ACS, a Wide Screen Visual Simulator (WSVS) and mission simulator have been used for the testing of EF2000's flight characteristics and cockpit layout. The WSVS contains a fixed cockpit which includes all the multi-function colour displays of EF2000. A 3.5m (11ft 6in) radius, semi-circular, wide-screen colour visual system gives the pilot a realistic 180° wide by 48° high view of the outside environment.

Above: *Most of the RAF's simulators equipped with CGIs can represent air-to-air refuelling, although the training value of all AAR simulation is low due to limitations of current visual systems. Here, a Nimrod MR2 simulator pilot prepares to receive fuel from a 'virtual' C-130 Hercules.* Thomson Training & Simulation

Supplementing the WSVS is the Mission Simulator Dome (MDS). This has similar levels of equipment as in the WSVS and ACS, however, it has six axes of motion. This has mostly been used for the testing of EF2000's take-off/landing, in-flight refuelling, attack and air-to-air combat capabilities. Warton's own ACS has also been used for the study into the types of weapons that EF2000 will use. Other equipment of EF2000 such as Direct Voice Input (DVI) and helmet-mounted sight operations have also been tested in all three simulators. Over the last four years of EF2000's development, approximately 1000 hours and half a million nautical miles have been flown in BAe's simulators. Despite criticisms from the National Audit Office during July 1995, over increases in the UK's share of EF2000's development costs, significant savings have been made using these flight simulators.

The advent of computer based simulators has opened up entirely new opportunities for the training of RAF aircrew and for aircraft research. This is reflected in their increased usage in recent years, although simulator technology has not yet become advanced enough to surpass all the established methods applied to military flying and research.

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EUROFIGHTER 2000

Developing the potential

Gordon Bartley

Eurofighter 2000 is the largest collaborative military aircraft programme in the world today and is a key element in the future air defence of both Great Britain and Europe. Optimised for the air superiority role, but also possessing a formidable ground attack capability, Eurofighter 2000 has been designed to defeat all current and projected threats, well into the next century.

The early development the programme, and the technicalities of Eurofighter 2000 itself, were comprehensively covered in last year's *RAF Yearbook*. This article aims to provide an insight into Eurofighter 2000 development flying to date, with particular emphasis on the activities of the first British-built prototype DA2/ZH588, based at Warton, Lancashire. Clearly, as Eurofighter 2000 is a new aircraft, some aspects of its performance remain classified, but those details that can be released make interesting reading.

The Eurofighter programme has had more than its fair share of bad publicity, since its launch in late-1988 and, on occasions, may even have seemed ripe for cancellation – as development costs soared and the date for entry into service slipped ever further back. However, most of the problems which beset the programme, have been of a political or financial nature and technical problems with the aircraft itself have been comparatively few, considering its overall complexity.

From the outset, the four partner companies involved in the programme – British Aerospace, Dasa in Germany, Alenia in Italy and CASA in Spain – have adopted a cautious, phased approach to the development of the aircraft, particularly with regard to the flight control system software. This is because everyone is anxious to avoid a repeat of the tragedies which befell the JAS 39 Gripen in Sweden and, more recently, the F-22 ATF in the USA. To further minimise risk to the programme, in the critical first phase of development flying, the decision was taken to equip the first two prototypes – DA1 in Germany and DA2 in Great Britain – with Turbo-Union RB199 turbofan engines, that were proven and reliable, having accumulated many thousands of operational flight hours in the Tornado. This action neatly side-stepped the high risk scenario of a new airframe/new engine combination taking to the skies.

The first Eurofighter 2000 (DA1) was airborne from Manching, Germany on 27 March 1994, in the hands of test pilot Peter Weger. Just nine days later, on 6 April 1994, Chris Yeo, BAe's Director of Flight Operations at Warton, took Eurofighter 2000 DA2 aloft for the first time. Both flights were highly successful and, as well as providing a much-needed boost for the many contractors involved with the programme, also effectively silenced many of the programme's critics. DA1 and DA2 made nine flights each during the first phase of development flying, before going on lay-up for rigorous inspection and pre-programmed modification.

Both aircraft performed well in the air, and a considerable amount of valuable data was gathered, in spite of the restrictions imposed by the Flight Control System (FCS) software. Each aircraft was flown by three pilots, all of whom expressed delight at the aircraft's precise handling, exceptional cockpit visibility and the obvious future potential of the fully-developed Eurofighter 2000. When John Turner, British Aerospace EF2000 Project Pilot, landed DA2 at Warton on 24 May 1994, at the end of its ninth flight, the aircraft had accumulated seven hours 14 minutes flight time, attained a maximum speed of 320 kt, a maximum altitude of 26,000ft and had manoeuvred at up to 3.5g.

Interviewed shortly after their respective maiden flights in Eurofighter 2000, test pilots Peter Weger and Chris Yeo, could barely

Top: *Eurofighter 2000 DA2 began the second phase of its flight development programme on 18 May 1995, after lay-up for rigorous inspection and programmed modification work.* BAe

Above: *The Eurofighter 2000 cockpit layout will be based around three full-colour multi-function displays, but current development aircraft feature a set of standby analogue instruments in place of the left hand display.* BAe

contain their delight with the aircraft. For his part, Peter Weger said that he had "never seen such an elegant airplane and such a nice airplane to fly". He added "We will open it up step-by-step and I think it will be a perfect airplane". At Warton, Chris Yeo confidently said of EF2000 "It's going to be a fighter pilot's aircraft. It accelerates rapidly, it's clearly going to turn quickly, and the rate of climb is going to be spectacular. I would say that although it is at the beginning of its development, the Eurofighter 20000 is already demonstrating a great potential." In 1995, some of it was realised, as Eurofighter's flight envelope was progressively opened up. 1996 promises even greater things, but much work remains to be done before a full Operational Flight Clearance for the type can be achieved.

By the end of 1995, considerable progress had been made with the EF2000 flight development programme. DA2 at Warton had made 67 flights, DA1 in Germany just 12 flights and these aircraft had been joined by the Italian-assembled prototype, DA3, which had made 25 flights. Between them, the three aircraft had accumulated over 100 hours of development flying. DA3 joined the programme on 4 June 1995 – when it made its maiden flight from Caselle, in the hands of Italian test pilot Commandante Napoleone Bragagnolo. It differs from its predecessors, in that it is equipped with more powerful Eurojet EJ200 turbofan engines. EJ200 engines will also power all of the remaining development aircraft and all production aircraft. The engine manufacturers – Rolls-Royce, MTU in Germany, Fiat of Italy and ITP of Spain – are, however, being every bit as

The first two-seat Eurofighter 2000 to fly will be DA6 in Spain, followed by the Warton-based prototype DA4 (below). Both aircraft are set to fly in mid-1996. BAe

Left: *Eurofighter 2000 DA2 pictured over Preston during a test flight close to its Warton base.* BAe

cautious as the airframe manufacturers and are adopting a phased approach to engine development. The EJ200 engines currently flying in DA3 are to an initial standard only and will soon be replaced by interim standard units. It will, however, be some time yet before the final (20,250lb st) production engines will be available for flight.

By far the greatest contribution to Eurofighter 2000 has been made by prototype DA2 based at Warton. DA2 resumed flying on 18 May 1995, after an extensive lay-up for structural inspection, the installation of new FCS software and extensive, pre-programmed, modification to the cockpit. For the initial phase of development flying, DA2 was equipped with Tornado-style, analogue cockpit instrumentation. This has now been superseded by dual, six-inch colour Multi-Function Displays (MFDs), located centrally and at the right hand side of the front console. A set of analogue standby instruments are located at the left side of the front console. A wide-angle Head-Up Display (HUD) has also now been introduced into the cockpit, thereby greatly improving situational awareness for the pilot – the cockpits of prototypes DA1 and DA3 are similarly equipped.

DA2's achievements, to date, again make impressive reading particularly when you realise that the FCS is still only operating in Reversionary Mode or, in layman's terms, the standby/get-you-home mode of the final production standard aircraft. The aircraft retains all its fighter-like manoeuvrability in this mode – a fact that is borne out by some of the latest performance figures. To date, DA2 has attained a maximum level speed of 580 kt IAS, achieved Mach 1.5 at 32,000ft, has manoeuvred at up to 5.8g and angles of attack up to 20 degrees and has reached a maximum altitude of over 36,000ft. The aircraft has also carried out rapid rolling manoeuvres and looping trials with impressive results.

Whilst six pilots have now flown DA2, the bulk of the development flying task has been undertaken by John Turner, EF2000 Project Pilot at Warton. John has also displayed the aircraft at three separate venues, one unplanned, the other two pre-programmed. Ironically, on 24 May 1995, during flight 13, John Turner was airborne in DA2, accompanied by a Tornado GR1 chase aircraft, when Warton was hit by one of the worst storms for many years. Initially, the plan was for DA2 to remain airborne until the storm had moved off, taking its torrential rain, high winds and thunder and lightning with it. With the storm stubbornly refusing to release its grip on Warton, and a Tornado chase aircraft running low on fuel, the decision was taken that DA2 – still with generous quantities of fuel remaining – would divert to RAF Leeming in North Yorkshire, along with the chase. RAF personnel on the base must have thought that they had entered a time warp when DA2 touched down, many years in advance of its planned entry-into-service date and the aircraft itself was the object of much scrutiny by all ranks during its short stay. The local 'spotters' too, were quick to learn of the aircraft's presence at Leeming and one leading aviation magazine inaccurately reported that the diversion was the result of FCSW failure. Needless to say, the editorial staff of that magazine were quickly advised of the true situation and politely advised, in future, to check their facts before publication.

1996 will see further significant milestones for the Eurofighter programme as a whole, and by the year end, all seven Development Aircraft will have flown.

Flight 18, on 9 June 1995, saw DA2 depart Warton for the Paris Air Show, once again in the hands of John Turner. The aircraft was restricted to an appearance in the static aircraft park at the show and, along with the Hawk 200 mockup and JAS 39 Gripen introduced the world to British Aerospace's new 'family of multi-role combat aircraft'. DA2 left Paris on the evening of Monday 12 June, after demonstrating its impressive take-off and turning capabilities, and returned to Warton in readiness for its first supersonic flight. This was duly performed on 15 June (flight 20), when, with Chris Yeo at the controls, DA2 recorded a speed of Mach 1.05.

The next significant milestones were accomplished with test pilot Derek Reeh at the controls. During flights 22 and 23, on 28 June, DA2 performed rapid rolling manoeuvres and a series of loops. Entry into the loops, at 5,000ft, began at 300kt, but speed was progressively reduced to just 200kt resulting in an over-the-top speed as high as 190kt!

John Turner's final public engagements with DA2 occurred in late July when Eurofighter 2000 made its display début at the International Air Tattoo at RAF Fairford. The Ministry of Defence was adamant that DA2's appearances had to be part of scheduled development flights, so, for flights 31, 33 and 34, DA2 left Warton and carried out a series of radio communications trials at heights of 25,000 to 30,000 ft off the south coast of England. It then gave a brief display at Fairford, before completing a series of engine handling trials en route back to Warton. Not long after its display début at IAT 95, DA2 was briefly laid-up for a programmed 50-hour inspection, but was soon able to rejoin DA3, and latterly DA1, in the flight development programme.

On 9 November, flight 57, the final significant milestone of 1995 was achieved, when Sqn Ldr Simon Dyde, Royal Air Force EF2000 Project Pilot, flew DA2 for the first time. He was greatly impressed with the aircraft and said of his flight " ... it was an absolute joy from start to finish. Take-off was brisk with a prompt rotation and, once airborne, it was easy to fly. I could not believe that this was 'reversionary' flight control laws...it flies much better than any other fighter that I have flown...a tremendous field

Above: *The Italian-assembled Eurofighter 2000 prototype DA3 made its maiden flight from Caselle on 4 June 1995 and is the first Eurojet EJ200-powered prototype.*

Eurofighter 2000 DA1 resumed development flying from Manching in Germany in late 1995 and had completed 12 flights by the end of the year.

of view. On approach to land, I could control the speed to within one knot. Landing was as easy as all other phases of flight and the first landing was the gentlest I have ever done!" He did however remark that the cockpit was noisy and rather hot and the brakes were difficult to apply smoothly, but these were previously identified problems and solutions to them are already in hand.

1996 will see further significant milestones for the Eurofighter programme as a whole and, by the year end, all seven Development Aircraft will have flown. Of particular interest will be the maiden flights of the two-seater aircraft – DA6 in Spain and DA4 in Great Britain. Both aircraft are scheduled to fly in the middle of the year and both will be equipped with the latest standard of Flight Control System software, giving further significant improvements in aircraft manoeuvrability. All other development aircraft, including those currently flying, will be equipped with this upgraded software.

1996 will also see the first flight of a radar-equipped EF2000, when DA5 makes its maiden flight from Manching later in the year. Eurofighter 2000 aircraft will be equipped with the ECR-90 radar system, which is a development of the highly-capable 'Blue Vixen' radar used in the Sea Harrier FA2. Since early 1993, an ECR-90 trial installation has been flying in the modified nose of a BAC One-Eleven test aircraft, based in Scotland. Radar performance, which is highly classified, is said to be impressive, with all air-to-air and air-to-surface modes convincingly demonstrated.

Of particular interest to the aviation community this year is the Farnborough Air Show in September and plans are already in hand to display Eurofighter 2000 DA2 at the show. With considerable development flying experience behind them, the Eurofighter partners are confident that they will be able to show the world – and the French in particular – what a real fighter aircraft can do! The partners also hope that, at around this time too, the Production Investment (PI) contract, vital to the future of the Eurofighter programme, will at last be signed, clearing the way for the full production go-ahead soon afterwards.

As for DA2, following the Farnborough Air Show, it is once again scheduled to undergo routine maintenance, during the course of which, a spin chute will be fitted in readiness for flight trials at very high angles of attack later in the year.

As the flight envelope is opened up ever further, the true potential of this remarkable aircraft will doubtless be realised and the Eurofighter partner nations will look forward with increasing confidence to the operational début of an outstanding European collaborative success story.

new generation Helicopters

Patrick Allen

An order was confirmed last year by the Ministry of Defence for 22 Westland-Agusta EH101 medium-lift support helicopters and an additional 14 new Boeing Chinooks, that will enter service with the RAF by the turn of the century. As widely reported by the media and the aviation press last September, eight of the new Chinooks will be equipped for 'special operations' and designated Chinook HC3s. The RAF will become the first overseas air arm to receive this very capable CH-47E version of the Chinook. Both the new EH101, that will probably be designated Griffin HC1, and the Chinook HC3, will be equipped for air-to-air refuelling (AAR). They will be the first UK helicopters to have an extended operating capability provided by AAR.

Both helicopters will be equipped with 'state of the art' technology, enabling them to operate in adverse weather, by night or day. This will also allow them to undertake a wider range of support helicopter and special operations roles, including the increasingly important combat search and rescue. Both the Chinook HC3 and EH101 will be capable of extended range self-deployment and be

Top: *RAF EH101s will have air-to-air refuelling capability and FLIR for long-range, all-weather operations.* Westland Helicopters Above: *The RAF's Chinook HC3/CH-47E will be similar to this US Army Special Operations MH-47E.* Boeing Helicopters

able to fly long distance covert missions over any type of terrain. The mixed fleet of Chinook HC3s and EH101s will compliment one another, giving the RAF's Support Helicopter Force an enhanced operational flexibility and the ability to undertake a fuller range of missions than the present helicopters.

The 22 EH101 medium-lift support helicopters, ordered by the Ministry of Defence in a £500 million contract, will give the RAF an adverse weather, long-range helicopter with fixed-wing standards of reliability and operability. RAF EH101s carrying fuel reserves and full role equipment necessary for operational readiness will be capable of self deploying 1,020km on standard fuel, with 1,250kg of spares and support equipment on board – or 1,300km with an auxiliary tank. Carrying a 3,000 litre internal fuel tank, the range can be further increased to 1,600km. Using a detachable refuelling probe that can be fitted in less than four man-hours, the EH101's range is virtually unlimited. A further operational enhancement is a de-icing system to allow operations in severe icing conditions.

Role equipment for the EH101 reflects the tasks envisaged by the RAF in the next century. A fully Night Vision Goggles (NVG) compatible cockpit is complimented by an advanced integrated navigation suite which includes Doppler, Inertial and GPS systems along with a multi-function digital mission management/tactical/navigational system. A dual-duplex Automatic Flight Control System (AFCS), allowing automatic transition to the hover, and FLIR will permit operations in the worst weather conditions. Operational availability will be improved as the EH101 is planned to fly over 200 hours between (preventative) maintenance.

The RAF's forthcoming Chinook HC3 is developed from Boeing Helicopters' CH-47E Chinook and is the first dedicated 'Special Operations' helicopter to be purchased by the Ministry of Defence. The US Army's version (designated MH-47E) is already in service with the 160th Special Operations Aviation Regiment (Airborne). It features two 1,030 gallon, long range, side fairing, fuel tanks, an air-to-air refuelling probe, additional weapon mounts and provision for fast roping and internal cargo handling systems.

The Chinook HC3 will supplement the RAF's existing fleet of HC2s (above). Patrick Allen

The two additional long-range tanks will give the Chinook HC3 a standard fuel capacity of over 2,060 gallons that will enable it to transit over 600nm or have an endurance of 5.5 hours. This is will give the HC3 more than twice the range/endurance of the current Chinook HC2 (CH-47D). Range for both the Chinook HC2 and HC3 can be further extended with the fitting of up to three internal 800 gallon Extended Range Tanks (ERT), although these reduce the cabin space for troops and cargo. Like the EH101, its AAR capability also gives the Chinook HC3 almost unlimited range and endurance.

The full cockpit specification for the RAF Chinook HC3 has yet to be finalised. The present Chinook HC2 already boasts a comprehensive avionics suite and full NVG compatible cockpit lighting. This will be further updated with the Racal AMS 2000 Multi-function Control Display Navigation Unit. The digital Navigation/Mission Management System with imbedded military standard Global Positioning System (GPS) also uses Air Data, Doppler and Inertial Navigation inputs and can be interfaced with other mission/operational equipment such as SATCOMs and countermeasure suites etc. The RAF's HC3s will also have a FLIR system to permit operations in the worst of weathers. It has yet to be confirmed if they will incorporate a fully integrated 'glass cockpit' to include Terrain Following/Terrain Avoidance (TF/TA) multi-mode radar similar to that fitted to the MH-47E.

The new AAR capability for the Support Helicopter Force will require compatible and dedicated RAF tanker aircraft. The present centre-line hose and drogue system, as fitted to a handful of Hercules C1Ks for use in the Falklands, is not suitable for helicopter refuelling. This requires the helicopter to fly through the tanker aircraft's slipstream or propwash and to refuel in disturbed air. It is likely that an answer to this problem will be provided from amongst the RAF's new C-130J Hercules fleet. A wing-mounted hose and drogue system similar to that presently fitted to USMC and USAF C-130 tanker aircraft to refuel their helicopters, could well be on order for the short-fuselage Hercules C5s destined for No 47 Squadron.

The new generation helicopters with their greatly enhanced operational capability and flexibility will assist the RAF's Support Helicopter Force in the next century, as it undertakes significantly more demanding roles supporting the UK's new mobile forces and other specialist units – wherever and whenever they are needed.

Features of the new generation CH-47E Chinook

AIRSHOW EUROPE

Royal Netherlands Air Force Base Deelen - 31st August/1st September

The Dutch National Confederation for Historical Aviation (Stichting Nationale Federatie Historische Luchtvaart - SNFHL) was founded in 1990, bringing together 18 organisations. The Confederation's 100 plus historic aircraft are in the process of restoration to their original flying condition by hundreds of volunteers. This will be a collection of supreme importance and testament to the Dutch people's love of aviation.

SNFHL, in association with the The Royal Air Force Benevolent Fund's International Air Tattoo, is staging Airshow Europe 96 to raise money for this continual restoration and maintenance work and to help meet the Fund's welfare needs. Deelen Air Base is set in wooded countryside near Arnhem and Ede, close to the Dutch/German border.

Airshow Europe 96 is the Continent's biggest international military and civil aviation event for nearly a decade - a full day's programme featuring state-of-the art aircraft, some of the rarer types, and peerless flying - and is expected to attract up to 150,000 spectators. Support for this spearhead European airshow will see over 200 aircraft from across the world arriving to take part. Many of the SNFHL's vintage aeroplanes will also be on show.

Team all this with a static line-up of some of the most fascinating hardware to be seen anywhere, Trade & Exhibition Fair, Marching Bands, Arena performances and Hot Air Balloons - and Airshow Europe 96 will be remembered as one of the major airshows of the year.

Airshow Europe 96 is supported by Toyota, Martinair, Transavia and Budget Rent-a-Car.

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Deelen Air Base is close to the historic cities of Arnhem and Ede, and surrounded by forests, stretches of moorland, rolling fields, rivers and pleasure lakes. Gelderland is high on the list for many European holiday-makers, attracted by ancient Hanseatic towns, romantic castles, the major Van Gogh collection housed by the Kroller-Muller National Museum and the handsome formal gardens at Queen Wilhelmina residence, Palace 't Loo.

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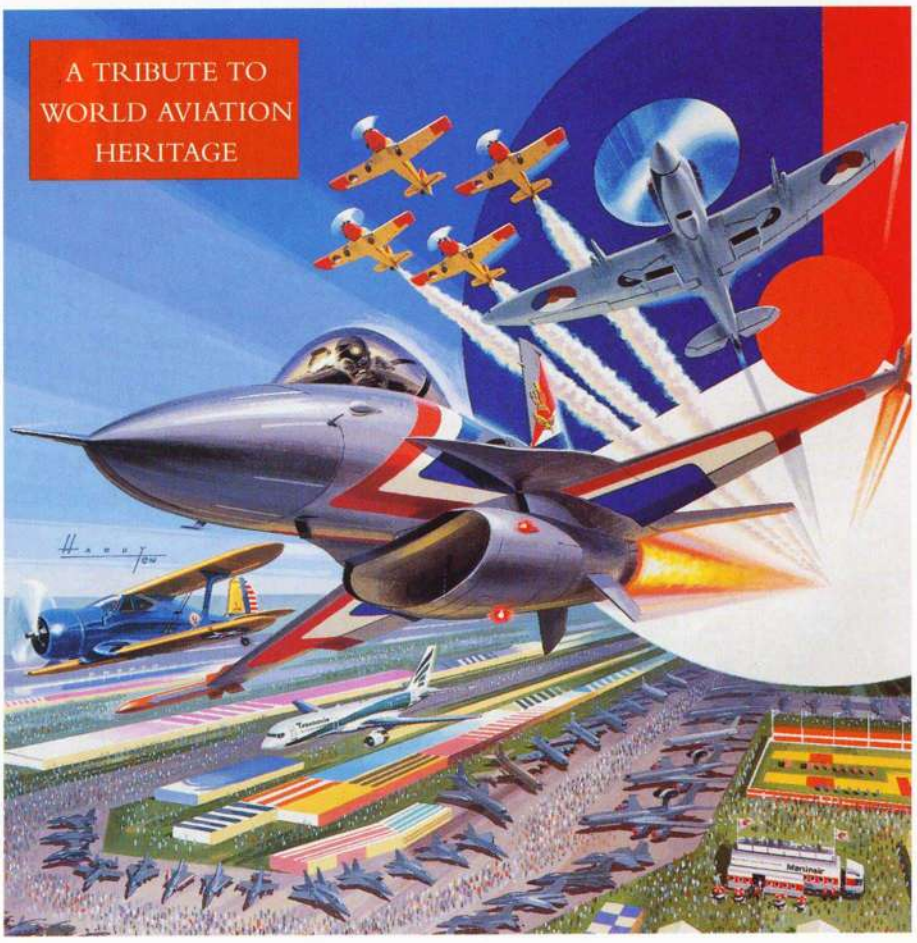

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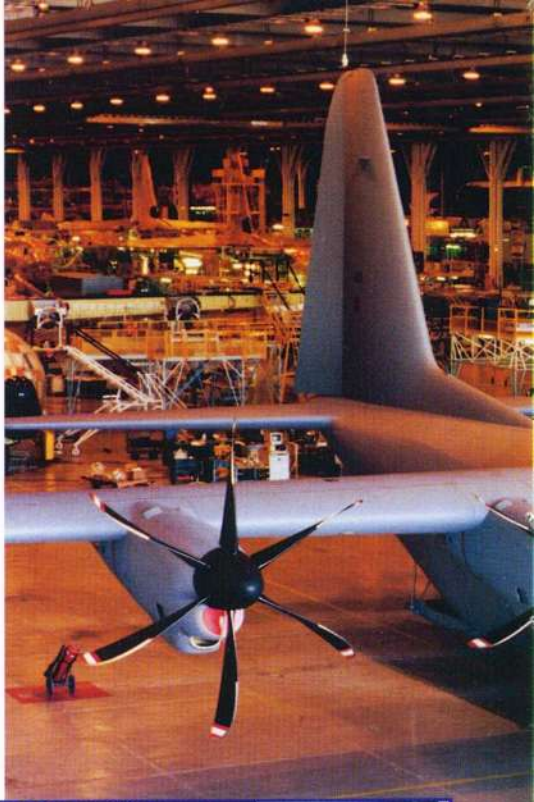


Paul Jackson previews the RAF's new airlifter, the Lockheed Martin C-130J Hercules II.

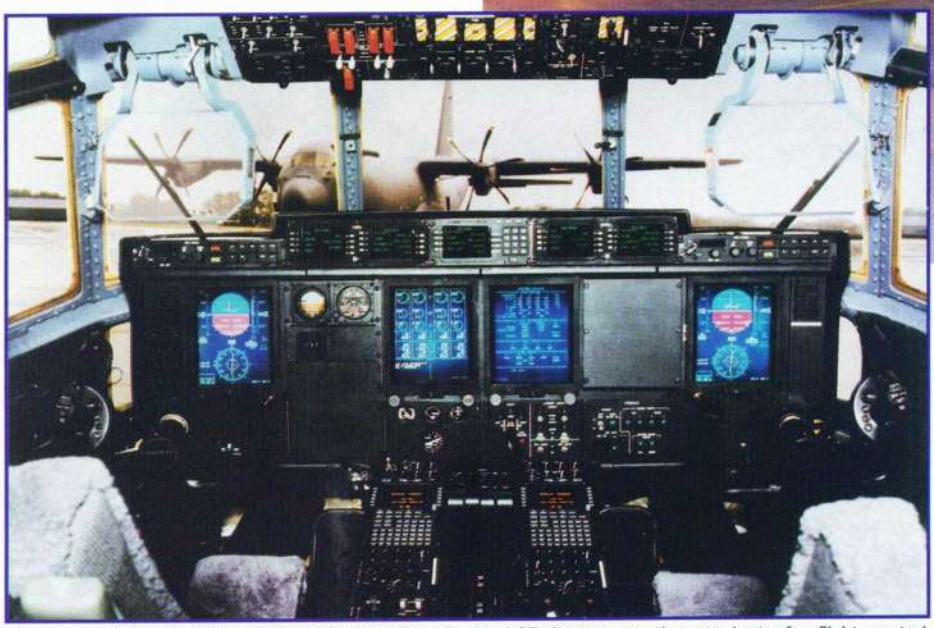
It looks like the *Fat Albert* we all know and love, except that the refuelling probe seems to have slipped part-way down the port side of the flight-deck to rest at a more jaunty angle. It's in the latest fashionable light grey with tiny 'ROYAL AIR FORCE' titles in black, and only the most knowledgable Hercules aficionado will notice that the parachute door windows are now square and the undercarriage panniers slightly modified: the port containing an auxiliary power unit; starboard with intake and exhaust for the cargo hold air conditioning. When the propellers stop, it can be seen that they have six blades (courtesy of the UK's Dowty company) ahead of an engine cowling (Westland-built) of revised shape.

Concealing four (Rolls-Royce) Allison AE 2100D3 engines, the cowlings encompass a total of 1,600 extra horsepower, compared with the old Allison T56s. Added to the more efficient propellers, this power surge can give the aptly-named Hercules II significant advantages over its predecessor: 22% less take-off roll; 46% better climb rate; 50% reduction in time-to-cruise height; 21% faster cruising speed; and 40% more range. Lockheed Martin, to use its manufacturer's post-merger name, predicts manpower savings of 38% as the result of eliminating two flight-deck crew positions and decreasing the maintenance requirements by 50%.

The first of the new Hercules will arrive in the UK later this year for trials at Boscombe Down, before issue to the transport wing at Lyneham. The RAF will be the first air arm – even ahead of the USAF – to operate the second-generation Hercules, and as a consequence, it has been deeply involved with the programme since its inception. So, too, has been a broad spectrum of 36 UK aerospace companies, all of which were selected by Lockheed on their merits as subcontractors long before the RAF order was placed.

The competition is won

A formal announcement of the C-130J's selection was made in Parliament on 16 December 1994 after a bitter and public fight against the Airbus FLA, championed by BAe. Although refurbishment of the existing C-130K Hercules C1 and stretched C3 force had been a further option, the two new aircraft were front runners to meet Staff Requirement (Air) 435 for a two-stage replacement of the 60-strong RAF fleet. The FLA, likely to be considerably more expensive, was still on the drawing board and unable to meet the tight schedules necessary to keep the world's hardest-worked (and increasingly tired) Hercules fleet operational. Indeed, subsequent French financial constraints have pushed the European airlifter even further into the future, posing the question of whether it will even be around in time to satisfy even the second stage of the RAF requirement, early next century.



The heart of the C-130J's advanced technology is its LCD instrumentation readouts for flight control, operating systems and navigation. Lockheed Martin

Upon that possibility will depend the composition of the current RAF order. In becoming the first major C-130J customer, the UK has gained financial advantages from Lockheed Martin through buying a respectably-sized batch of 25. The serial numbers ZH865 to ZH889 are allocated, of which the first 15 will be the stretched model (the Dash 30, with two inserts totalling 15 feet), to be designated Hercules C4. It will be decided later whether the next 10 are also to be C4s or the standard length version, which would take the designation C5, if ordered.

There is no conventional prototype of the C-130J-30 Hercules C4. The initial aircraft, with the constructor's number 5408, had its first preliminary parts manufactured on 2 March 1994 and subsequently took shape on the Marietta, Georgia, production line. Retrospectively allocated to the RAF when the

Below: *The C-130J's new engine and propeller were successfully flight-tested on an RAF Hercules in the spring of 1994.*

Lockheed Martin

order was confirmed, it was rolled out as ZH865 on 18 October 1995 in the presence of Air Marshal Sir John Allison, the Deputy C-in-C of Strike Command. Flight testing, for which the US civil registration N130JA was allocated, began soon afterwards. Only four more 'Hercules Is' were built before production turned entirely to the new version. No 5413/N130JC was the first of the USAF's initial toe-in-the-water order for just two of the 'short' fuselage version (rolled out on 20 October), and was followed by ZH866/N130JE, N130JG (USAF No 2) and ZH867/N130JJ.

These five are currently involved in the flight-test programme. ZH865 is the most heavily instrumented of the trials aircraft and is being used for most of the performance testing. ZH866 and the two USAF C-130Js are mainly assigned to avionics testing, while ZH867 is earmarked for a 150 hour function and reliability test.

The RAF's first two aircraft will transfer to Boscombe Down from November 1996 onwards, so making ZH867 the first operational C-130J when it arrives at Lyneham in July 1997. Conducted to achieve Controller (Aircraft) clearance for RAF operations, the Boscombe trials are to be managed by the Defence Test & Evaluation Organisation (the new name for the A&AEE). Following the two Hercules due for delivery this year will come nine in 1997, eight in 1998 and the final five in 1999. Older aircraft will be withdrawn from service on a one-for-one basis and taken in part-exchange by Lockheed.

Hercules II will not descend upon Boscombe from out of the blue. What was the Central Servicing Development Establishment at now-closed Swanton Morley had been monitoring the C-130J programme since 1992. The Project Team was rapidly expanded from three to nine members immediately the RAF order was announced and on 1 May 1995 it formally established a detachment at Marietta (and elsewhere in the USA). Working closely with Lockheed Martin and selected subcontractors, the Team, led by Sqn Ldr Paul Melling, is studying the Hercules II's support requirements in order that its early service years will be as free as possible from the 'teething troubles' which affect all new aircraft.

Flying experience of the Hercules II is also being amassed in advance of delivery, the DTEO's Flt Lt Mark Robinson being one of the first to pilot the new aircraft. One early flying and maintenance decision to be made concerns the higher-powered engines of the Hercules II, which the RAF will not use to their full potential. Instead, the AE 2100s will be down-rated to conserve airframe life. Performance will still be improved, however, as the scimitar-shaped Dowty propellers are up to 29% more efficient than their predecessors when driven by the same power. The AE 2100 engine has already flown in other testbeds (including one nacelle of the RAF's XV181).

Different under the skin

The Hercules II may look a lot like the *Fat Albert* that first flew in 1954, but it is a very different machine under the skin. The deletion of four windows in the lower part of the flight-deck is not all that has happened to the Hercules' front end. Behind the glass, the old instrument panels have been stripped out, the rows and rows of dials replaced by four large (6 in x 8 in) multi-function liquid crystal screens, augmented by five smaller displays immediately below the coaming.

Most surprising of all to old-time 'truckies' is the addition of a head-up display (HUD), previously regarded as the hallmark of a combat aircraft. Hinged from the roof like a car's sun visor, the HUD displays essential flight information and guidance cues for precision short landings on rough airstrips. Similarities to the modern airliner extend behind the two pilots – or, rather, do not, because the flight engineer and navigator are now eliminated by a combination of a computerised flight control system and modern position-finding techniques. The third and last crew member is the NCO loadmaster, although there is still rest accommodation for extra personnel on long sorties.

Throughout the rest of the airframe, functions have been digitalized and some wiring looms the thickness of a man's wrist replaced by a single digital databus. Only the hydraulic system survives as before, but even it has had sensors tapped on in order that it can be monitored by the flight control computers. Many of the 'black boxes' have been borrowed from the futuristic F-22 fighter also being developed by Lockheed Martin – different programming does the rest.

As with the latest generation of fighters, the pace of Hercules II development is being controlled by the availability of software. *Fat Albert* now needs almost 600,000 lines of software code for 21st Century 'trash hauling', prompting Lockheed Martin to embark on what it claims is the most comprehensive software testing programme of any aircraft, civil or military. Software Release 1.1 was for ground testing only, being followed by 1.2 for the first flight. Release 2 configures the aircraft for its certification trials (about 90% of full functioning) and Release 3, due in the middle of 1996, adds military flight functions, including the self-protection kit of radar/laser-warning sensors, infra-red jammer and chaff/flare dispensers. RAF squadron aircraft will be equipped with Release 4.1, the USAF having a very slightly different 4.2.

The old Hercules C1 tried to incorporate as many British avionics and parts as possible, making it a non-standard machine. No such Government constraints apply to its successor (which, in any event, has a respectable UK content), so uniformity can bring cost savings.

Lockheed Martin

The first C-130J for the RAF undergoing engine runs at Marietta, Georgia. Lockheed Martin

Apart from the refuelling probe (by Marshall Aerospace of Cambridge) the main difference between RAF and USAF C-130Js will be the cargo handling system, the former having elected to stay with the equipment already in the Lyneham fleet. The USAF (and Royal Australian Air Force, which became the third customer with an initial order for 12 on 21 December 1995) have a more modern loadmaster's workstation based on the C-17 Globemaster III.

Having an aircraft run by 'wiggly Amps' may be intimidating to older RAF tradesmen, but the time savings in maintenance can be very significant. The Ground Maintenance System (GMS) is a computer that will be installed at Lyneham to record operating details of the RAF C-130J fleet, as is the case in paper format in the traditional flight-line office. Individual aircraft's Form 700s are to be held in electronic form and the technical manuals will be on CD-ROM discs. A hand-held computer called a Portable Maintenance Aid (PMA) is the interface between the aircraft's systems and the GMS.

Readouts are downloaded to the GMS, which logs each snag revealed by the aircraft's on-board systems and even generates a work number for remedial action. The tasking is assigned to a tradesman, who then returns to the GMS to look up the nature of the fault and the appropriate maintenance procedures. These, and any relevant pages from the CD-ROM manual, are lodged in a memory card called the Removable Memory Module, which is taken out to the aircraft, inserted in the PMA, and used to interrogate the aircraft's systems. When the job is done, details of the remedial action are fed back into the GMS to keep fleet records updated.

As well as its 25 C-130Js, the RAF will obtain two full-flight simulators, a flight-training device and three maintenance trainers, all from Reflectone in the USA. The same company's UK division is to provide Lyneham with a new training centre and develop computer-based training and instructional software to provide simulator maintenance and software support for the first five years.

First to benefit from these will be No 24 Squadron which, as noted earlier, is to receive ZH867 in July 1997. No 70 Squadron, the other route-flying unit at Lyneham, will be the second RAF Hercules II operator. Short fuselage Hercules are more suited to tactical flying, so if the C5 option is exercised, No 47 Squadron will probably be the third user, upgrading its potential for covert operations in the process. No 30 Squadron, also in the tactical role, sees no prospect of fresh equipment until FLA or more new Hercules are ordered. Neither will there be any C-130Js in the OCU, as No 55 (R) Squadron will concentrate on ground training, aircrew completing conversion on their assigned squadrons.

Lyneham will take on a new-yet-familiar appearance when the 'J' version of the C-130 enters service next year. The original Hercules has established for itself a fine reputation for hard work and reliability; there can be little doubt that the equally promising *Young Albert* will be undertaking the lion's share of RAF air transport tasks for many years to come.

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THE ULTIMATE JIGSAW

Peter J Cooper

Fragmented wreckage was strewn across the moorland and nearby lay a used ejection seat. A large crater some 20m in diameter gave testimony that the impact had been at high speed. A debris trail spanned out for a kilometre down wind, but no large pieces of wreckage could be immediately seen. Only when excavation of the site was under way was the compressed forward fuselage and engines found. They had been driven by explosive force, some 15m underground. The remainder of the aircraft fuselage, wings and tail surfaces, etc were blown into smaller pieces, creating what can be termed as perhaps one of the most difficult jigsaw puzzles ever seen.

This is the scenario at many aircraft accident sites when the investigating team arrives. The area may be cordoned off to protect the wreckage trail and thus preserve the all important evidence for detailed examination.

So what went wrong? It is now up to the dedicated and highly experienced investigating team to determine what happened and through its findings try to prevent any reoccurrence in the future. This is where the Air Accidents Investigation Branch (AAIB) of the Department of Transport (DoT), comes into its own, having been requested by the Royal Air Force to assist in the investigation. This role has its firm roots in the foundation of the 'Branch' way back in 1915 and it has been continually investigating accidents since that time.

It is up to the dedicated and highly experienced investigating team to determine what happened and through its findings try to prevent any reoccurrence in the future.

In 1915, Captain C B Cockburn, a founder member of the Royal Aero Club, holding Pilot Certificate number 5 and known as 'the famous instructor', was appointed to the independent post of Inspector of Accidents of the Accidents Investigation Branch (AIB) for the Royal Flying Corps (RFC). Reporting directly to the Director General of Military Aeronautics in the War Office, the learning curve was just beginning in an endeavour to make flying safer. Following the cessation of hostilities, the first Department of Civil Aviation (DCA), was established within the Air Ministry (AM), as there were a growing number of aircraft now being used for limited passenger and recreational purposes. The early AIB then became part of the new DCA and was concerned with investigating both civil and military accidents within the UK.

In 1920, the Air Navigation Act was formulated, giving power to the Secretary of State to make statutory regulations for the investigation of civil air accidents and these were first given under the Air Navigation (Investigation of Accidents) Regulations 1922.

With renewed hostilities in 1939, all civilian flying was once again terminated. Attention was redirected towards military aircraft accidents. During World War 2, many new types of aircraft were developed, inevitably leading to a significant increase in the number of accidents and incidents. Therefore, during this period, the AIB was at its peak, with some 80 inspectors having the task of investigating these occurrences all over the UK, one accident never being exactly the same as the next. Much was learnt during these years, and the methods of investigation, which paved the way for future design and operations of civilian aircraft after the war.

Left: *This No 5 Squadron Lightning F6 may have met a watery fate, but after the aircraft had been located it was quickly recovered for detailed investigation into the cause of the accident. It is being lifted from the sea, six days after crashing, in October 1970.* AAIB

Above: *A Belvedere HC1 about to strike the ground somewhat heavily during an SBAC practice display at Farnborough in August 1961.* AAIB

In 1946 the Ministry of Civil Aviation (MCA) was established and the AIB became part of the structure, having full control of investigations into all accidents and incidents to civil aircraft in the United Kingdom. However, because of the AIB's valuable assistance in military investigations, there was some concern and disapproval within military circles who had perhaps taken it for granted that the AIB was there for their own specialist investigations. Nevertheless it was decided that the Branch would continue assisting the RAF with accident investigations, a legacy that still continues today.

Parented by various Ministries, due to changes in government structures throughout the years, the AIB became firmly rooted within the Department of Transport (DoT) in 1983 and its name underwent a subtle change to the Air Accidents Investigation Branch (AAIB) in November 1987.

The AAIB has its headquarters on the southern side of the Defence Research Agency (DRA), formerly the Royal Aircraft Establishment (RAE), at Farnborough, with purpose built office accommodation in an area known as Berkshire Copse. This is defined as part of the original Laffans Plain, close to where balloons, airships and those epic powered flights by Cody were first conducted. The RAE had its own accident investigation hangar (T49) on this site, where the AIB was originally a lodger unit. The AIB moved to this site and took over the hangar with its smaller annex and wreckage compound in 1977. The annex has recently

Left: *Although much of this Vulcan was burnt beyond recognition, all the remaining debris was within a confined area, which assisted with the investigation process.* AAIB

Right: *The ditching of a Nimrod R1 into the Moray Firth during May 1995, following an engine fire, resulted in a difficult recovery operation. Although advised immediately of the incident, the AAIB's assistance in investigating the loss commenced after the aircraft was recovered from the seabed some two weeks later, when it was shipped to Rosyth Naval Dockyard. The aircraft is pictured still afloat, with a Sea King HAR3 of No 202 Squadron 'D' Flight standing by, having picked up survivors from the dinghy.* CFSO HQ STC

Below right: *The RAF Salvage and Transportation Flight assist in the recovery of a Tornado GR1 that had made a high speed impact with the ground. The wreckage shown, apart from minor debris, was practically all that remained above ground, the rest of the aircraft being buried to a depth of some 30ft. All wreckage was recovered for a detailed investigation by the AAIB.* AAIB

been demolished and a new small, but modern, hangar (T10) built in its place. This affords a further element of security away from prying eyes.

Contrary to popular belief, the AAIB is not part of the DRA nor was it ever part of the RAE structure. Valuable assistance has been given by the RAE over the years, particularly in respect of scientific and investigative expertise in areas of materials and structural failures such as the early Comet I accidents. RAE departments have been instrumental in many firm conclusions being drawn over causation factors. This is still true today as various DRA departments are still actively assisting in aircraft accident investigations into material and structural failures, lightning strikes, explosive force and forensic evidence.

The AAIB has Inspectors of Air Accidents who are drawn from two disciplines, pilots and engineers. They, along with the other administrative and support staff are

Below: *An RAF Harrier T4 that had crashed into the Ems Canal, Germany, whilst attempting to return to its base after suffering a loss of control during an overshoot, being recovered. Chris Protheroe, an AAIB Senior Inspector of Air Accidents (Engineering), is already on the scene commencing his investigation.* CFSO HQ STC

responsible to the Chief Inspector of Air Accidents and his deputy. The Chief Inspector of Air Accidents is directly reportable to the Secretary of State for Transport, under the Civil Aviation (Investigation of Accidents) Regulations 1989 that provide the framework and powers for the investigation of the majority of accidents.

The AAIB has a mandate to investigate all aircraft accidents that occur in the UK and to participate in overseas investigations when a British registered or British manufactured aircraft is involved. Separate regulations provide for investigations where there is a civil and military involvement and for the different legal systems of Jersey, Guernsey and the Isle of Man. In addition, the AAIB receives many requests for participation

The wreckage above is from a Chinook HC2 that crashed into a hillside and was spread over a wide area. It is shown laid out at the AAIB Farnborough facility where analysis of all systems and components was conducted. The instruments and avionics (top) were inspected in detail for their correct functioning. Peter J Cooper

in accident investigations and to provide direct assistance to foreign countries, which could involve both military and civil types.

All accidents are reported via a 'reporting hotline' that is connected to the AAIB Headquarters at Farnborough. A Duty Officer in the Department of Transport working outside of normal hours would receive a call and immediately transfer it to the AAIB Duty Co-ordinator. An immediate plan of action is formulated, if necessary, to provide an Engineering and Operations team to travel to the respective site forthwith.

There are currently some 27 Inspectors of Air Accidents, 18 of which come with an engineering background (Engineers), either from the Forces or from manufacturers, and the remaining nine being classified as Inspectors of Air Accidents (Operations) who

Above: *Electronic Flight Instrumentation System data is analysed from the Flight Data Recorder onto a computer display screen which can indicate precisely what the various instrument parameters were displaying during the flight and just prior to impact. A modern Flight Data Recorder is shown at right, this example recording on magnetic tape from a solid state memory, whilst the earlier version on the left recorded on magnetic wire.* Peter J Cooper

are all pilots. They are all qualified to at least Air Transport Pilots Licence (ATPL) standard, having had considerable experience of being in command of large commercial jet aircraft, and/ or have been manufacturer's or military test pilots. Indeed the pilots still retain currency on a number of commercial aircraft types and it is not uncommon to find an AAIB Inspector of Air Accidents (Operations) flying a commercial airliner to some European or holiday destination. The Inspectors of Air Accidents (Engineering) are qualified to Chartered Aeronautical Engineer level in their discipline and again retain currency of aircraft types and systems, by regularly attending manufacturers courses.

The AAIB inspectors are supported in their investigations by a large number of specialist organisations. Apart from the DRA, this also includes various other laboratories, manufacturing and overhaul agencies, universities and other individual specialists. The Royal Air Force Institute of Pathology and Tropical Medicine, formerly at RAF Halton (transferred to the Royal Naval Hospital Haslar from 1 April 1996), the DRA Centre for Human Sciences, (previously known as the Institute of Aviation Medicine and Army Personnel Research Establishment), and the RAF School of Aviation Medicine at Farnborough, also play an important role particularly where fatalities or human factors are a main concern.

Not all civilian accidents will undergo a field investigation by the AAIB, as these will depend largely upon the accident or the incident and whether there have been any casualties. Accidents and serious incidents are required to be reported to the AAIB in accordance with the provision of Annex 13 to the Convention on International Civil Aviation (the Chicago Convention). An Accident is defined as an occurrence associated with the operation of an aircraft which takes place between the time when any person boards the aircraft with the intention of flight, until such time as all persons have disembarked, in which any person suffers death or serious injury, the aircraft incurs damage or structural failure, the aircraft becomes overdue and is missing, or is completely inaccessible. Damage is defined as such impact or deformation that would adversely affect the aircraft's structure, its performance and flight characteristics which necessitate major repair or replacement of damaged components. Serious injury or death is defined as resulting from being in or upon or by direct contact with the aircraft whilst within the aforementioned parameters. A serious incident is an occurrence defined as when an accident almost occurred.

All aircraft accidents must be reported to the AAIB, and to the police, and in the case of military accidents these again are normally reported as soon as they occur although the request for the AAIB's assistance in investigation may not necessarily be made there and then. For example, a minor incident to an RAF training aircraft will not involve the AAIB, whereas the loss of a transport or fast jet type may well require immediate assistance and expertise to investigate a smouldering crater or a mid-air collision. The Royal Navy and Army Air Corps have their own service aircraft accident investigation teams.

Where no Field Investigation is required, the AAIB will investigate an incident from data received from the pilot and operator who would have been furnished with their standard Aircraft Accident Report Form (AARF), that has to be returned to the AAIB within 14 days. Many incidents are in fact reported directly by Air Traffic Control as they are often the first to be aware of an incident or accident, sometimes unfolding in front of their very eyes.

Wreckage sites, and trails, can, and do, differ considerably. One of the largest trails that the AAIB has seen in recent years concerns the Pan Am Boeing 747 that was blown up by a terrorist bomb over Lockerbie, Dumfrieshire, in December 1988, where the

Left: *Westland EH101 engines, main transmission, main rotor head and centre section structure, with nose area beyond, laid out in the AAIB Famborough facility for wreckage analysis.* Peter J Cooper

Below: *The largest reconstruction of wreckage that has been undertaken in recent years is that of the Pan Am Boeing 747 that was blown up by a terrorist bomb over Lockerbie on 21 December 1988. This area of the forward fuselage clearly shows the 'starburst' fracture and torn skin created by the explosive force. This wreckage is currently held as the prime exhibit for any criminal court case brought against those responsible.* Peter J Cooper

wreckage trail extended some 150km to the east of the actual incident site due to various floating wreckage having drifted by the high winds at altitude. Other cases involve large craters in the ground, debris strewn over a wide area from a structural break up, an aircraft lost in the sea that requires an intricate and specialised Marine recovery process. In some cases this results in the entire aircraft not being recovered, to that of a more compact type accident where the aircraft is indeed concentrated in one place which may not necessarily be broken up significantly from impact forces.

Other incidents are also investigated, such as air-misses between civil or military aircraft that have come into close proximity to each other, which necessitates investigations into air traffic procedures where voice and radar tapes will be closely scrutinised.

An important AAIB asset is its sophisticated laboratory equipment for the playback of Cockpit Voice Recorders (CVR) and Flight Data Recorders (FDR) at its Farnborough facility. Black boxes, that are really bright orange in colour, and capable of withstanding high impacts up to one thousand G and heat up to 1,100°C, are very valuable and important keys to assist accident inspectors in piecing together the factors leading up to, and including, the accident, in a real time scenario.

By use of sophisticated equipment, the FDR can give an actual simulation of what was happening at the time of the accident which can then be re-constructed on video from flight recorder data. Similarly, the CVR read-outs can be edited with highlights on specific channels, or elimination of background noise, giving clearer audible data to the investigators. Valuable data has been secured from damaged FDRs and even some that have been immersed in sea water for lengthy periods have still produced detailed information.

Another valuable asset available to the AAIB, is the Royal Air Force Salvage and Transportation Flight (STF), based at RAF St Athan. Not only does it transport all Service fixed-wing aircraft around the UK by road as required, but is available to the AAIB to assist in the recovery of damaged aircraft or clearing a site totally of aircraft debris. A team of RAF personnel, led by a Flight Lieutenant, can be called to assist and tasked under the direction of the AAIB Inspector of Air Accidents (Engineering).

On many occasions the STF will transport military wreckage to a nearby RAF station, or take it directly to the AAIB Farnborough facility where it will undergo detailed examination. Smaller civilian aircraft are usually recovered by the Branch itself or a commercial organisation.

Right: *Wreckage of a Tornado GR1 indicates the aircraft had impacted the ground in a flat attitude, having been shot down by AAA fire after an attack on Ar Rumayah airfield in southern Iraq. The AAIB was requested by the MoD to investigate the Tornado crash sites, this being accomplished under allied armed escort.* AAIB

Wreckage, or in some cases fragments, can be laid out in the AAIB hangar and 'rebuilt' as far as possible to simulate the whole aircraft, to facilitate the integrity of such parts as control runs, fuel and hydraulic systems or airframe structures, which may yield an all important clue to the disaster. Recent 'lay-outs' have included a Hercules, Harrier, Tornado and Jaguar, some of them in an RAF Hardened Aircraft Shelter (HAS), at places such as Boscombe Down and Honington, whilst dominating the AAIB hangar for the past six years has been the forward cabin section of the Lockerbie Pan Am Boeing 747 with the explosive structural fracture being prominently displayed. This is held as the prime exhibit for any criminal court case brought against those responsible.

Inspectors of Air Accidents (Operations) are usually required to interview all surviving crew and passengers, some of whom may be suffering from severe shock after the incident, including people who might have been bereaved and perhaps, more importantly, witnesses to the actual accident. Detailed statements are taken for future use in the investigation process. Despite the fact that eye witness accounts can vary considerably, every detail will be recorded by the Inspectors although some of what they find may be of no direct assistance.

Photography has a high priority in aircraft accident investigation. In some cases aircraft have been photographed as the accident occurs, such as the famous series of photographs showing a Vulcan breaking up in flight, and the more recent MiG-29 collision at RAF Fairford. Air-to-ground photography can assist greatly in the investigation, as much can be learnt from the plot of a wreckage trail or tell-tale signs of the scar left in the ground where an impact has occurred. Some high altitude RAF photo-reconnaissance has also been used in the past, particularly where a wide wreckage trail is concerned, and also video recordings have, both from official and unofficial sources, played key roles in recent investigations.

Preservation of the wreckage is of paramount importance in that so much can be determined from the parts and components found. Instruments normally 'freeze' at the moment of impact and other items such as engine throttles, positions of screw jacks and flying control actuators all have their part to play. With regard to propeller driven aircraft, the actual position and the deformation of the propeller blades can give a good indication as to whether the engine was developing power at the time of impact. For helicopters with their considerable number of rotating and dynamic components, the investigation may be somewhat more onerous.

On the whole, the main area of accidents that occur within the United Kingdom fall into the General Aviation category accounting for approximately 80% of the annual figure. The other 20% of the UK accidents are mainly within the Public Transport category, which may not be of a disastrous nature but nonetheless requires investigation. Full investigations are carried out into some General Aviation accidents where fatalities occur.

A detailed investigation into an accident, albeit military or civil, can take approximately eight months to complete.

In addition to the Lockerbie tragedy, some of the more recent commercial accidents have included aircraft such as the Coventry and Kegworth Boeing 737s, the Cannock Chase Viscount and North Sea Super Puma aircraft, all of which were sent to Farnborough for analysis.

A detailed investigation into an accident, albeit military or civil, can take approximately eight months to complete and four months of legal process in order to finalise and produce a report. Once this has been defined by the investigators there are then requirements for the draft report to be submitted to any person, or organisation, who has had a direct involvement with the accident or whose reputation is likely to be adversely affected by the report. An opportunity is then given to take into consideration any representations they may make to the AAIB prior to issue of the final version to the Secretary of State. This process can be lengthy, particularly if there are any further representations or evidence to be considered, and when finalised the report will be submitted by the Chief Inspector of Air Accidents to the Secretary of State who will agree to its publication by Her Majesty's Stationery Office (HMSO). Before final publication, all parties involved have 21 days in which to ask for a Review Board during which the findings and conclusions may be further reviewed. Any safety recommendations arising out of the investigations are passed to the relevant Authority (i.e., the FAA in the USA or the CAA in the UK) for their review or implementation, or other recommendations can be made to the manufacturers of the respective type under investigation.

The familiar yellow *Aircraft Accident Report* will then be published and will be available for general release to all interested parties. With investigations into military aircraft accidents, the AAIB report will be presented to a Service Board of Inquiry (BOI). Any flight safety recommendations are circulated widely within the MoD as well as to manufacturers. BOI findings are published in the form of Military Aircraft Accident Summaries. These provide information on the circumstances leading up to the accident and its cause.

Participation in overseas investigations can also be requested by a foreign government, particularly where a British registered or manufactured aircraft is involved or a commercial accident has occurred that has resulted in the death of United Kingdom subjects. These arrangements are covered by Annex 13 which provides for representation from all interested parties. This results in a multi-national investigating team, which would be supervised and handled directly by the specific investigating authority within the respective country. Other occasions sees the AAIB's assistance in analysing CVR and FDR equipment for which they are considered the leading experts in this field.

There are approximately 360 reportable civil aviation air accidents in the UK each year, and the AAIB is called to assist at approximately 8-10 military accidents annually. This burdensome, but nevertheless rewarding task is handled by a dedicated band of AAIB Inspectors of Air Accidents (Engineering) and (Operations) who all play a key part in establishing the cause of the accident and overall improving flight safety which is of foremost importance to the furtherance and development of both military and commercial aviation.

So next time an aircraft accident features on the news headlines, spare a thought for the dedicated team from the AAIB who face the difficult situation and tasks of piecing the *ultimate jigsaw* together.

Left: *This rear fuselage, although burnt, is still recognisable as being a Jaguar, which has impacted in a field. In instances such as this, the RAF would require the assistance of the AAIB to investigate the accident.* CFSO HQ STC

Who's for Combat-SAR?

Paul Jackson considers the future of the 'yellow helicopter'.

In these money-conscious, post Cold War days, an RAF officer who declares his function to be 'making savings' is more likely to be in the administrative branch than the pilot of a yellow helicopter. Now, inevitably, the two types of 'savers' are being brought together for joint studies, as the pros and cons of privatising the SAR (search and rescue) force are debated. An official conclusion has yet to be reached, but this personal view suggests some ways in which RAF rescue services can be upgraded to meet the challenges of the next century.

Air-Sea Rescue (ASR) was the term in vogue when No 275 Squadron formed with Bristol Sycamores at Linton-on-Ouse in April 1953 as the first RAF helicopter squadron specifically assigned to SAR. Gradually, rotating wings took over the duties of the fast launches which the RAF had introduced in response to the losses by drowning of pilots who had successfully baled out into the sea during the Battle of Britain. Reflecting that, No 275 was a component of Fighter Command, whereas today's Sea Kings and few remaining yellow Wessex belong to 'Coastal Command' (No 18 Group). However, from April 1996 No 11 Group ('Fighter Command') and No 18 Group have been combined in Strike Command.

Immense good-will towards the RAF has deservedly been generated by the SAR crews who have regularly risked their lives in appalling weather to rescue sailors and members of the public visited by misfortune or imperilled by their own foolhardiness. Last year (1995), helicopters and Mountain Rescue teams were called out on 1,473 occasions, assisting in the rescue of over 900 people, almost every one of them civilian. Others have cause to be grateful to the Royal Navy and HM Coastguard, which each maintain three

An air-sea rescue demonstration by a Sycamore of No 275 Sqn, the first RAF helicopter squadron dedicated to the role, in 1953. PRM

Main picture: *The Sea King HAR3: the big friendly helicopter may have to add camouflage and weapons to undertake a more warlike role, whilst maintaining the capability to rescue civilians in distress (inset).*

helicopter detachments, compared to the RAF's six.

Such SAR activities have always been regarded as training for the RAF helicopters' wartime role. However, since the collapse of the Warsaw Pact, it is pertinent to question the premise that aircrew will find themselves bobbing about in liferafts on the North Sea the next time the RAF is involved in hostilities. The case for privatisation seems unanswerable, but before calling in Alan Bristow, it would be wise to look at some trends outside of the United Kingdom.

Above: *Well kitted-out for its Combat SAR mission, the USAF's Pave Hawk carries radar and infra-red sensors, plus a refuelling probe.* PRM

Belated French lessons

Any Frenchman falling into the sea or off a mountain will find salvation in an Aerospatiale helicopter, probably a blue Ecureuil of the Gendarmerie or red Alouette III from the Securitee Civile. The French Air Force's Ecureuils and Pumas were largely used for communications and light transport until the Gulf War brought a re-think.

It is now more likely that French and allied combat aircrew will be brought down in non-NATO territory which, although in hostile hands, is not completely impenetrable. No crew of a Mirage IVA bomber hit by the Moscow air defences would reasonably have expected an Alouette to have come wokkering to their rescue. A mere hundred miles inside the uninhabited Iraqi desert – or even a shorter distance from the Bosnian border – a rescue mission is an imperative both for morale and moral considerations.

Thus, France recently augmented its 'privatised' national SAR assets with a combat rescue flight equipped with pilot's night vision goggles (NVGs) for *SARGuer nuit* missions. Based at Metz, EH 2/67 'Valmy' and its Ecureuils pioneered techniques later employed by the Pumas of EH 1/67 'Pyrenees' detached to Brindisi, Italy, in an experimental role to cover former Yugoslavia.

Prefixing SAR with the word 'Combat' implies that the helicopter must be equipped not only to fly in bad weather at night, but also to do so while being sought and shot-at by hostile forces. Having learned well from Vietnam, the US Air Force has equipped its Sikorsky Pave Hawks with the appropriate kit. Pave Hawk has the dual designation MH/HH-60G, meaning that with the rapid addition of strap-on equipment a rescue HH- variant can be upgraded to Special Forces MH- standard.

In addition to the usual SAR fit of rescue hoist, inertial navigation system with electronic map display and provision for NVGs, Pave Hawk has a ground mapping radar, forward-looking infra-red camera, in-flight refuelling probe, external pylons for extra fuel and/or weapons, door-mounted machine guns, secure speech radios, satellite communications, radar warning receiver (RWR) and chaff/flare dispensers.

SAR for the next century

The RAF's nearest approach to this standard was made immediately after the Falklands War of 1982 when two Sea Kings were painted in grey camouflage, given a dispenser and ex-Vulcan RWRs, and added to the South Atlantic garrison (where they remain to this day). Six new Sea King HAR3As are joining the RAF from this year, but their avionics are merely improved versions of the Mk 3's in its 'yellow' guise.

In common with France and other allies, the RAF is aware of the need for more robust helicopter rescue assets because of its peacekeeping and policing roles in the post Cold War world. As earlier noted, one logical option would be to contract a civil operator to take care of benighted walkers and yachts with holes in their bottoms and use the savings to modify the Sea King 3As with equipment similar to the Pave Hawk's.

However, that argument carries little weight with the helicopter crews already trained to deposit soldiers behind enemy lines or operate (as in Northern Ireland until recently) under constant threat of ambush in hostile country. Green-painted Wessex, Pumas and Chinook HC2s have varying standards of self-defence equipment and specialist crews to exploit it, and their case will be strengthened further when the RAF receives its eight Chinook HC3s, ordered (with six Mk 2s) last year. Their configuration has not been officially disclosed, but it has been revealed by the manufacturer that they are close equivalents to the MH-47Es that the US Army uses for long-range, covert penetration by its Special Forces.

Perhaps earmarked for No 7 Squadron at Odiham, the new Chinook appears to be the answer to the cost-cutter's prayer. What better option than to dispose of the Sea Kings and task No 7 with the occasional diversion to pick up a downed pilot?

Occasional roles are rarely performed with expertise, and No 7 will have other things to occupy most of its scarce operational training time. Furthermore, there is the SAR equivalent of the old joke which ends, 'If I were going to Dublin, I wouldn't start from here.' Parties of balaclava-ed soldiers choose sensible locations for their helicopter pick-ups, but any yellow helicopter crew will attest to the ability of Joe Public to select places excruciatingly difficult for aerial rescue when having his or her disaster.

Toned down in colour, beefed up with extra sensors and self-defences and kept in perfect fitness on a diet of daily civilian emergencies, the Sea King force would have no equal in providing a Combat SAR service to meet the RAF's 21st Century needs.

Left: *This grey-painted Sea King HAR3, with its radar warning receivers and other 'combat SAR' equipment, serves with No 78 Squadron in the Falklands.* PRM

Below: *The first Sea King HAR3A, newly arrived at RAF St Mawgan in January 1996.* Andrew March

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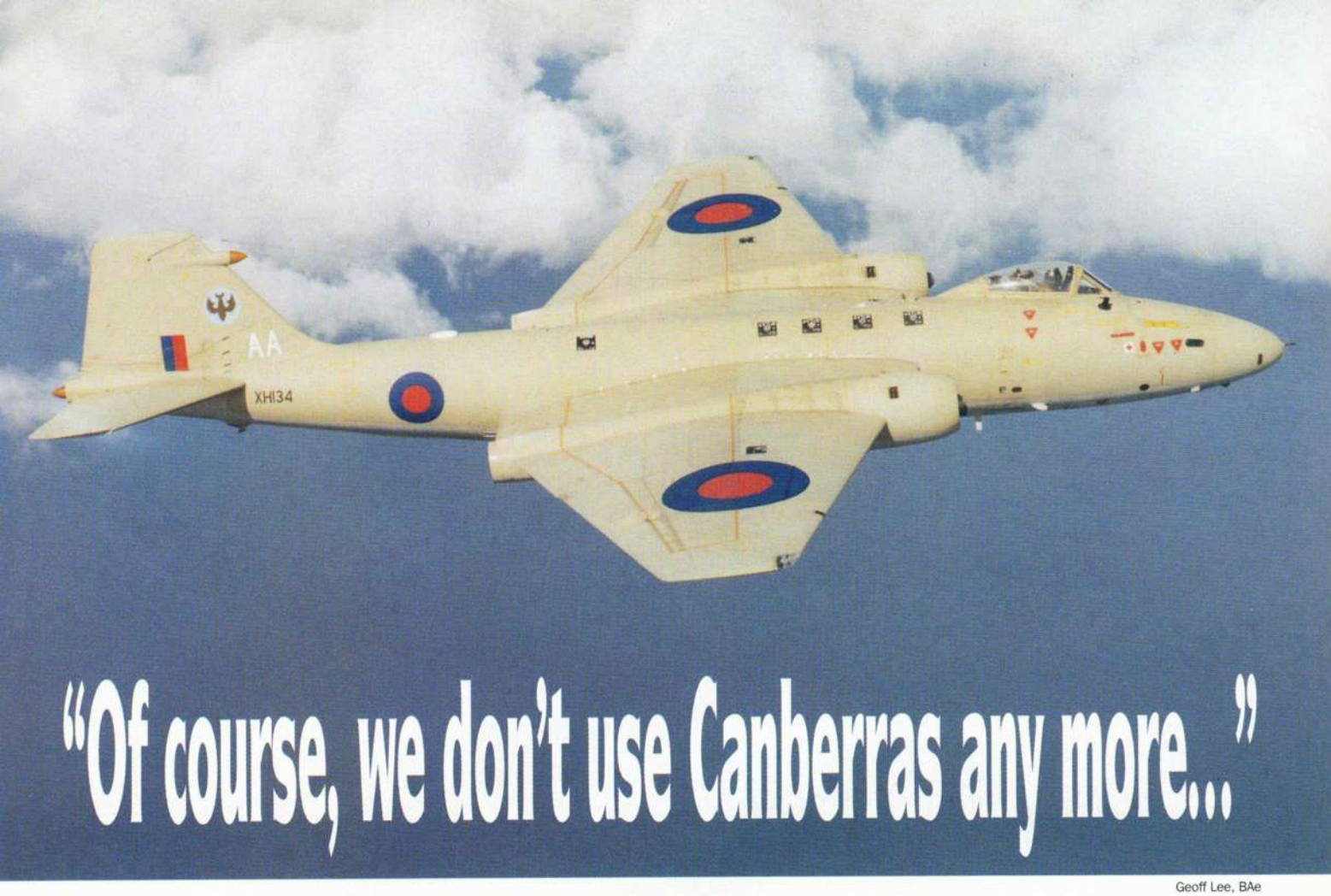

"Of course, we don't use Canberras any more..."

Geoff Lee, BAe

Lindsay Peacock

That seemingly innocuous remark was recently voiced within the portals of the Ministry of Defence in Whitehall. Unfortunately, it was directed at some individuals who knew better, by virtue of being called upon to operate Canberras on an almost daily basis. In view of that, they would have been quick to set the record straight and would have added that there appears every likelihood of the Canberra continuing to operate in RAF colours until some time after the dawn of the new millennium.

English Electric's highly versatile warplane has been around for quite a while. It flew for the first time on 13 May 1949 and more than 40 years have elapsed since it made its operational début with the RAF, almost exactly two years after its maiden flight. The RAF's new twin-jet bomber entered service with No 101 Squadron at Binbrook. This was the first of no fewer than 61 squadrons that subsequently used a dozen or so major variations on the Canberra theme for a variety of roles and missions. That diversity prompted extra tasks like photographic reconnaissance, electronic countermeasures training, target-towing and meteorological research during the course of a long and distinguished career. Furthermore, unless there is a change of plan, prospects are good that it will achieve the unique distinction of exceeding the half-century before the last examples are retired.

Today it functions in a role that is far removed from bombing and there is some excuse for overlooking the Canberra when considering the contemporary RAF, since the number of aircraft in the active inventory is nothing if not modest. Less than ten to be exact, all of which are assigned to No 39 (1 PRU) Squadron.

This particular unit's association with the Canberra is fairly long-lived, although not continuous, dating back to 1958. It has only been around in its current incarnation since 1 July 1992. On that date, aircraft and personnel of No 1 Photographic Reconnaissance Unit (PRU) at RAF Wyton were used to establish a reformed No 39 Squadron, hence the unusual title now adopted. As it happened, the period at Wyton proved short, with No 39 officially moving to new quarters at RAF Marham on 30 November 1993 and it has continued to fly from there, apart from a brief spell at Coltishall in late 1995, when Marham's runway was being resurfaced.

Today, as has been the case since it first equipped with the Canberra in 1958, No 39's mission is formally described as photographic reconnaissance. However, that is perhaps too narrow a definition to fully describe the work performed by the unit, for its brief is rather more extensive, in that it also embraces aerial survey, maritime photography and non-tactical reconnaissance.

There appears every likelihood of the Canberra continuing to operate in RAF colours until some time after the dawn of the new millennium.

In executing its various roles, No 39 presently has about 125 personnel, headed by Squadron Leader John Corden. Not surprisingly, the bulk of these are made up of the ground trades necessary to operate the aircraft efficiently and effectively. For instance, there are technicians to service the Canberra and its all-important sensor systems; laboratory staff to process the photographic material that is brought back by each sortie; interpreters to check the quality and coverage of the resultant imagery; administrative personnel to deal with the paperwork. The total also embraces half-a-dozen personnel from the Army's No 1 Air Survey Liaison Section who draw up survey mapping tasks and check that these have been satisfactorily accomplished by comparing the day's 'take' against the master plan.

On the flying side No 39 Squadron has six crews, each comprising a pilot and navigator, but they are not teamed on a permanent basis and any pilot may be tasked to fly with any navigator – or vice-versa. There is nothing unusual about this, but where the unit is perhaps rather different is in possessing a surplus of aircraft over crews. The main reason for this stems from No 39's unique position as the last Canberra squadron. As a consequence, it is unable to look to an outside agency such as an Operational Conversion Unit for replacement aircrew. Therefore, any ab initio or conversion training that is required is now undertaken 'in house', with members of the squadron managing their own training programme.

This is reflected by the aircraft 'mix', with No 39's flight line regularly accommodating three different models of Canberra. The PR9 is the most numerous version used by the squadron, which currently has five on strength (XH131/AA, XH134/AB, XH135/AC, XH168 and XH169). These are all that remain of 23 examples delivered to the RAF in the late 1950s and early 1960s. All of them feature the standard 'hemp' colour scheme, with the fin usually (but not invariably) adorned by No 39's distinctive dark green 'winged-bomb' motif on a light blue disc.

Above: *No 39 (1 PRU) Squadron flies three Canberra versions – lined up at RAF Marham are PR7 WT509, T4s WT480 & WJ866 and a PR9.* Lindsay Peacock

Top: *XH169 is one of five Canberra PR9s currently on strength with the squadron.* Lindsay Peacock

As the primary mission aircraft, the PR9 carries a crew of two. The pilot occupies a cockpit that offers a splendid field of view, unlike the navigator who is accommodated in the forward fuselage, with only a couple of tiny windows on the world outside. Of course, it is not actually necessary for the navigator to see anything (other than his instruments) in order to accurately fix his position, especially now the PR9 has GPS (Global Positioning System). Nevertheless, it is probably the most cramped and confined working environment of any current RAF aircraft.

Although the unit has five PR9s, it does not automatically follow that all will be available for use at any given time, since servicing requirements must be satisfied and there are also occasional modification projects that periodically limit the number of aircraft on hand, particularly in winter which is traditionally a 'slow' time for photographic reconnaissance. By way of illustration, in October 1995, only three PR9s were actually with No 39 – as for the missing examples, one was nearing the end of a major service at Hurn while the other was with British Aerospace at Warton for attention to its camera installation.

Moving on to the other versions, No 39 has a pair of T4s (WT480/AT and WJ866/AV), although a third example (WJ874/AS) has served with the unit. The latter is currently in store at RAF St Athan, but could rejoin No 39 should the need arise for any reason. Since it possesses dual controls, it follows that the T4 is the principal training tool, whether it be for *ab initio* instruction, 'refresher' training or periodic check rides and instrument ratings. As a consequence, it usually carries a crew of three – two pilots and a navigator. The T4 version is finished in a quite different scheme of dark sea grey and dark green upper surface camouflage, complimented by the usual squadron insignia.

When No 39 became the RAF's last Canberra unit on 31 October 1994, it inherited two PR7s (WH779/BP and WT509/AP but carries 'BR') from No 360 Squadron. Both are technically still on charge, although WH779 is evidently undergoing major repair and has not been seen for some months. Despite retaining the photo recce designation, the PR7 is not actually employed for reconnaissance and might more accurately be referred to as a PR7(T) in recognition of its training role. It is used as a 'stepping stone' between the T4 and the PR9. While the former model is fine for most facets of instruction, it is definitely lacking in 'oomph' when compared with the PR9, which is a fairly sprightly performer and one that may well come as a bit of a shock to the system after the somewhat sedate trainer derivative.

As far as training of aircrew is concerned, virtually all of the personnel that have recently been assigned are Canberra veterans who need little more than refresher training. However, the thinning of RAF ranks inevitably means that the pool of pilots and navigators with Canberra time is steadily diminishing. In view of that, No 39 expects soon to receive aircrew with no previous Canberra experience who will need more comprehensive tuition in order to reach operational status. Until recently, the PR7 did have another task to fulfil, namely that of acting as a 'target' for medium and high-altitude radar calibration. Some consideration has been given to relinquishing this mission, but it does still feature in the tasking list at intervals – and may well continue to do so for some time to come. For the most part, though, the PR7 is used for training; its colour scheme being similar to the T4's.

The Canberra PR9 is the primary mission aircraft used by No 39, that currently has four basic roles to fulfil. In no particular order of merit, these are: low-level non-tactical reconnaissance; medium and high-level vertical/oblique photography; maritime photography and aerial survey photography for mapping. Each of them has its own distinctive photographic requirements and the aircraft can be configured to operate with a variety of cameras, although the installation that is employed is obviously dependent upon the task being undertaken.

Four basic types of camera are presently available for use by the PR9s. Operations at low-level presently account for about 10% of No 39's tasking, with this small proportion being split fairly evenly between non-tactical reconnaissance and maritime work. In fact use of the term 'low-level' is an over-simplification, since the F95 camera is actually effective across an altitude band that extends from 100 ft to about 2,000 ft. A total of three F95s may be carried in the forward fuselage – one is sited in the extreme nose looking forward, with the others in the sides, looking to port and starboard respectively and slightly depressed from the horizon.

In addition, there is a Texas Instruments ARI 5969/3 infra-red linescanner (IRLS) in the aircraft's belly, which may be employed across an even broader band, from 100ft to about 4,000ft. Obviously, the standard optical cameras can only be employed by day, but the IRLS permits day and night missions to be flown, although it shares one important failing with optical cameras in that it needs clear skies, for it cannot see through cloud, mist or fog. Given satisfactory conditions, however, both systems can be used for these roles.

Like all of the imagery systems used by the Canberra, the F95 and IRLS rely on wet film, that of the F95 using 70mm wide strips while the IRLS material is five-inches wide. Both of the remaining two types of camera use nine-inch wide negative film. These include the F96, that is a particularly useful tool by virtue

Above and right: *All the squadron's PR9s are painted in the standard 'hemp' scheme and usually carry the distinctive 'winged bomb' motif.*

of its ability to produce imagery from 1,500 ft right up to 50,000 ft.

Finally, there is the Zeiss RMK, which is most effective between 2,000 ft to 40,000 ft. This is a quite recent addition that can replace the middle pair of the fan of four F96s. In general, however, what might be called the 'normal' fit (formally referred to as the Standard Camera Fit) comprises three F95s in the nose, one 24-inch focal length F96 facing to port, the IRLS and the Zeiss with a six-inch focal length lens. Like so many of these things, though, the term 'normal' should be used with care, for the PR9 is nothing if not versatile and can quickly be reconfigured to meet special needs.

The Standard Camera Fit is employed for the two remaining roles, with the effort expended by No 39 on medium and high-level vertical/oblique photography and aerial survey photography for mapping being roughly equal (about 45% on each).

It should not, of course, be forgotten that coverage is dependant upon the optical installation employed, in so far as use of a longer focal length lens results in a much narrower field of view. By way of illustration, in the case of the Zeiss, mapping tasks are usually undertaken at a scale of 1:25,000th which involves use of a six-inch lens by an aircraft flying at 12,500 ft above ground level. That is evidently the preferred configuration, although there are circumstances in which there is no option but to employ an alternative.

Working in and around the London air traffic control 'stack' is a classic example of these circumstances. For obvious reasons, it is not desirable to have a Canberra engaged on a mapping task that requires quite precise flying, operating in close proximity to other traffic. It might be acceptable if the other traffic was maintaining a constant height and course, but traffic in the stack is normally

Left: *Canberra PR7 WT509 was one of two PR7s inherited from No 360 Squadron.* Andrew March

doing anything but that. Although the stack could be moved in order to give the Canberra a clear run, this would be a rather extreme solution – and it is easier to fit a longer focal length lens to the camera and climb to greater height. In this instance, a Canberra flying at 25,000 ft with a 12-inch lens produces more or less identical results to the smaller lens used at a lower altitude.

The F96 can also be fitted with 24-inch and even 48-inch optics, so as to allow a really close look at what lies below – and there is, a yet more impressive camera kit that is euphemistically known as 'System 3'. In such cases, however, the resulting imagery probably has more to do with intelligence gathering and it should come as no surprise to learn that a polite invitation to discuss 39's recent activities in and around war-torn Bosnia met with an equally polite refusal.

As far as tasking is concerned, this rests with the Ministry of Defence, which works closely with the Director of Military Survey in planning No 39's work-load. As its title implies, the latter is responsible for the preparation of military maps, but the customer base does not end there, since quite a few other organisations at home and abroad are anxious to use the PR9's photographic abilities, especially in the mapping field.

Some idea of the extent of this work can be gleaned from the fact that No 39 has recently completed a survey of the United Kingdom, in order to update military maps. This was a major undertaking in that it required squadron members to fly some 70,000 miles in total, but that is only one of many survey taskings, for the Canberra has also performed similar duties on behalf of civilian and military agencies in such far flung locations as Gibraltar, Belize, Ascension Island, St Helena and Denmark.

Lindsay Peacock

Furthermore, there is no sign of a reduction in demand for No 39's services, with new customers appearing from time to time. Indeed, one candidate that might yet be added to the list is Zimbabwe, that is looking into the possibility of Canberra-style survey mapping and may well be visited by a couple of aircraft from Marham during 1996.

With their services clearly still in demand, the immediate future seems assured for No 39 Squadron, which in turn means that the Canberra is likely to be a fairly familiar sight in British skies until about the year 2003. After that, age will probably bring about its forced retirement, but the need for similar services is unlikely to diminish, which prompts the question of a replacement. Recent months have seen speculation that the Lockheed Martin U-2 might one day don RAF insignia and this would certainly be capable of doing some aspects of the job, although there's no way that we can expect to see the celebrated 'U-bird' rushing around at low level. In view of that, a more likely candidate might well be an unmanned aerial vehicle. Only time will tell...so enjoy the Canberra while you can – it won't be around for ever.

FOOTNOTE

A Canberra Reunion will be held at RAF Marham from 21-23 June 1996, with an Enthusiasts' Photo Day on Sunday 23 June (admission £10 in advance). For further details send SAE to:
Canberra Reunion, PO Box 100, Stamford, Lincs PE9 1XQ.

Preserving the Fleet

Peter J Cooper

Deep in the heart of rural Shropshire lies a dedicated band of aircraft engineers who are actively involved in aircraft preservation. Not another warbird restoration team but a professional engineering team tasked wholly for the preservation of some of the UK Armed Forces' front-line strike, attack, support and training aircraft. This is the Aircraft Storage Flight, based at RAF Shawbury, currently managed by FRA/SERCo, which has a team of personnel ranging from administrators to engineers, who, towards the end of 1995 were looking after 108 stored aircraft on the western side of the airfield. This area is accustomed to aircraft storage as for many years it was the home of No 27 Maintenance Unit (MU). Storage of service aircraft is not a recent innovation, indeed flimsy biplanes were held in Reserve during World War I and at the cessation of hostilities many aircraft were stored by Repair Depots and later MUs.

During the early 1960s there were lines of Vampires, Javelins, Ansons, Hastings and Lincolns in open storage.

Shawbury first became an airfield under the Royal Flying Corps in 1917 but then closed during 1922. It was not until 1 February 1938 that RAF Shawbury became a permanent airfield and at this time 27 MU was also formed on this site. Throughout the years 27 MU has been responsible for receipt and despatch of many thousands of different aircraft along with many others being stored and eventually withdrawn and scrapped. During the early 1960s for example, there were lines of Vampires, Javelins, Ansons, Hastings and Lincolns in open storage on the vast airfield, the majority of these being eventually broken up, whilst in storage were many others of the same types.

The Aircraft Storage Flight was formed at RAF Shawbury on 6 September 1982 due to the impending closure of RAF Kemble as a Maintenance and Storage unit. With the abolition of the RAF MU system during the early 1980s, and the rationalisation of aircraft storage sites, the mid-1980s saw an increase in aircraft arriving at Shawbury for storage. After the closure of RAF Abingdon in 1991 there were only two sites remaining for the storage of fixed-wing aircraft, these being RAF Shawbury and RAF St Athan. Storage at the latter is generally on a short-term basis, principally the Tornado, although other types have been stored prior to being declared Non Effective (NEF) and eventually disposed or scrapped. Helicopter types from all three services are currently stored at RNAY Fleetlands, Hants, and RNAY Almondbank, Perthshire, the Royal Navy having the rotary wing responsibility. The RAF Support Authority, however, still retains jurisdiction over the RAF helicopter types.

All fixed-wing aircraft storage, for all three services, is the responsibility of Headquarters Logistics Command at RAF Brampton under the Maintenance Group Defence Agency (MGDA), under which Aircraft Mechanical Maintenance 21 (AMM21) is the authority for aircraft storage, issuing the requirements and policy. The Support Authorities impose aircraft storage, to maintain attrition reserves, reduce fleet sizes, resulting from major policy changes and Defence Reviews and also cater for any major changes in aircraft type that may occur.

The Support Authority will advise AMM21 regarding aircraft type and tail numbers required for storage and will issue the directives accordingly to the parent RAF station or unit. Management of aircraft storage achieves a minimal deterioration of the airframe and systems, minimises fleet costs, and ensures that aircraft can be returned to service within a specified time. Conservation of aircraft fatigue life is also a major

Above: *Tucano T1 ZF142 undergoes Primary Star servicing for recovery and re-issue for service, having been held in Long Term Reserve at RAF Shawbury since arriving for storage in June 1992.*
All photographs Peter J Cooper unless otherwise credited

Main picture: *Several Tucano T1s, including this example formerly with the CFS, are held in Long Term Reserve in a de-humidified Lamella hangar.*

Above: *This close-up view of a Jaguar GR1A shows the cockpit transparencies covered with grease resistant paper and secured to the airframe by PVC tape, whilst all the apertures are covered with open weave mutton cloth and secured to the structure with spraylat.*

Top: *Piston engines are inhibited whilst in storage and this sign hanging from the propeller spinner of a Chipmunk T10 advises of this situation, and the date it was actually inhibited.*

consideration as a particular fleet of aircraft may all be rotated for storage during a ten year period to conserve fatigue. A continuous roll over of the fleet on the basis of maintaining a similar fatigue index throughout can then be accomplished. However, there is a slight disparity with this scenario as far as the Tucano is concerned, in that there has been a considerable reduction in the number of active aircraft and out of many currently in storage, a percentage of these are planned to be routinely rotated. If, for example, a Jaguar was required for storage at a given time, then an aircraft would also be prepared from storage for re-issue so that the squadron complement is maintained.

There are two fundamental storage requirements for aircraft, this being either Effective Aircraft (EF), that are aircraft that are held for future requirements; or Non-Effective Aircraft (NEF), these being aircraft that have no current operational requirement and are held in storage pending disposal. Effective aircraft are naturally held under the highest priority to meet any future requirements that occur whilst the Non-Effective types are held in whatever storage space remains available, many of these in the past being stored in the open. The Support Authority would make the decision for an aircraft to be categorised NEF and once this has been done there would be no further in-storage maintenance performed and the Joint Services Aircraft Disposal Committee (JSADC) would decide the method of disposal. In some cases, aircraft are reallocated for Ground Instructional duties, or as 'gate guardians', and will be distributed to required stations. Others may be put up for tender and disposed of commercially either for civilian or historic flying purposes, reduced to spares, or sold as scrap.

The Aircraft Storage Flight at RAF Shawbury is responsible for such types as the Canberra, Chipmunk, Harrier, Hawk, Jaguar and Tucano, although at the time of writing there was also a single RN Jetstream T3 in storage. Recently types such as the Hunter, with all the ex-Royal Navy GA11/T8 variants having arrived here for disposal and/or scrapping, and six ex-RAF Phantom FGR2s, were also held here in storage. The latter were disposed of as scrap during September 1995. Army Air Corps types such as Beavers and Chipmunks have also been stored here during recent years. As a joint service facility all three services have an input towards a ten year operational plan and costings for future aircraft strength requirements and movements.

Prior to an aircraft's arrival at RAF Shawbury, it would have already been decided by the Support Authority into which category of storage the aircraft should be placed. The aircraft is prepared at its parent station prior to transfer to the Aircraft Storage Flight and it is the responsibility of the ASF to ensure that it is to a current Standard of Issue (SOI) prior to being placed in storage. The aircraft should be in a serviceable state upon arrival, although any minor or deferred defects will be logged in the Form 700. All external tanks, pylons, gun packs or pods are removed by the parent station, this ensures that these items can be utilised and pooled for use with other aircraft of the same type. This also gives a clean configuration so that no external items need to be removed on receipt.

Once the aircraft has been shut down on the arrival pan, a standard 'after flight' is carried out, with the aircraft ejection seats, if fitted, made safe for servicing and the aircraft then refuelled. This prevents condensation in the fuel tanks and protects the fuel tank sealant from cracking. There is also safety reasons as a full tank is less likely to explode should there be any fire than a half tank that has a considerable amount of combustible gases present.

Having received an aircraft for storage it then takes between three and seven days to prepare, depending upon the aircraft type and whichever level of storage is required. Each type has its own specific preparation; a Chipmunk, for example, will not undergo exactly the same routine as a Jaguar, although certain basic maintenance requirements are performed to all types.

Cockpit transparencies are covered for protection with grease resistant paper and then secured to the airframe by PVC tape. All the apertures on the aircraft such as engine air intakes, exhaust pipes, cooling ducts, pitot tubes, etc., are all covered with open weave mutton cloth and secured to the airframe structure with spraylat. This is a proprietary substance that protects any surface, under normal, dry conditions and can easily be removed by peeling. However, it does not lend itself to de-humidified storage conditions and is therefore not used for any form of protective basis here in the UK, unlike its more extensive use in the USA.

The engine fuel system is inhibited, unless the engine is to be removed for use in another of the type. In many cases, when an aircraft is prepared to be reissued, the engine will remain with the specific airframe, but in the case of the Jaguar, for example, its engines will be removed to the respective maintenance and supply depot and once a directive has been given for re-issue of an aircraft, engines will in turn be received by the Aircraft Storage Flight for refitment. Naturally, engines are rotated throughout the remainder of the fleet fairly frequently with a number at any given time under routine maintenance or overhaul.

Other areas of preparatory work for storage include purging of a liquid oxygen (LOX) system to empty and removal of the LOX packs; rendering any oxygen bottle system inoperative, but retaining pressurisation in the bottle; discharging hydraulic oil accumulators; whilst the undercarriage oleo legs are maintained inflated. Wheels and tyres remain on the aircraft, although when an aircraft is being recovered for return to service the wheels, tyres and brakes all undergo bay servicing.

This Hunter T8C arrived at RAF Shawbury from FRADU/RNAS Yeovilton during April 1995 and has recently been sold by Tender. It is seen here being towed to a D-type hangar for preparatory work prior to being flown away by its new civilian owner.

Left: *A Canberra T4 of No 39 (1PRU) Squadron undergoing a routine Minor maintenance prior to being re-issued to the squadron during late 1995, having been held in Medium Term Reserve by the Aircraft Storage Flight at Shawbury.*

allotment' is retained fully serviceable, complete to a specific standard and ready for immediate delivery if required.

The Aircraft Storage Flight has eight hangars available at RAF Shawbury, two 'D' type and six Lamella type, although two of these are used primarily for Non-Effective (NEF) aircraft that may be required to be held prior to actual disposal. The six hangars on the main airfield site are utilised for either type of storage which consists of heated storage (HS), and de-humidified storage (DS). Aircraft in heated storage are housed in a frost free heated hangar where the temperature remains between 10°C and 15°C constantly. De-humidified storage, introduced at RAF Shawbury during 1986, and since then having provided savings on storage costs and maintenance, sees aircraft housed in a fully de-humidified environment where a relative humidity of between 40% and 55% is maintained. When a hangar is fully de-humidified there is no requirement for heating. Humidity graphs are checked weekly to ensure the correct level is maintained. Normally fitted in the hangar roof structure, the de-humidifying equipment is based upon the Munters Principle, named after the Swedish inventor. It employs a fixed moisture-absorbing

Above: *This D-type hangar offers heated storage for these five Hawk T1As, all in storage as Medium Term Reserve aircraft. They were delivered to Shawbury from RAF Valley, having previously flown with Nos 19, 74 and 208 (Reserve) Squadrons.*

As instructed by AMM21, the Aircraft Storage Flight, will put an arriving aircraft into one of four storage categories. The first is Immediate Readiness Reserve (IRR) – this is where an aircraft is held complete with its full inventory of equipment and is maintained to the fullest applicable SOI and is required to be recovered for service within three days of notification. The second is Short Term Reserve (STR). An aircraft in this category is prepared to the full SOI and limited anti-deterioration measures are carried out. This category requires an aircraft to be flight tested annually regardless of whether it is to be issued or not, and is required to be available for issue within one month. All Special Technical Instructions (STI) and Servicing Instructions (SI) are performed on a regular basis to keep it fully serviceable.

Medium Term Reserve (MTR), the third category is similar to the Short Term Reserve but there is no requirement for the full SOI or any annual flight test. An aircraft stored under MTR conditions should be available for recovery and preparation for issue within three months. All STI/SIs are carried out on a regular basis but, this is more likely to be undertaken during scheduled maintenance on an opportunity basis. Annual engine runs are required, depending upon the aircraft type. A Tucano, for example, has its Garrett TPE-331 engine run every 12 months, regardless of the storage category it is currently held in. If a Jaguar is held under MTR conditions, with engines fitted, then the Adour Mk 104 would be inhibited for two years, and re-inhibited without running; whilst engines removed and held away from the storage site would undergo their own anti-deterioration measures and be retained in a serviceable status.

Aircraft in Long Term Reserve (LTR) are held in deep storage with no SOI; modifications or STI/SI's embodied until the aircraft is required to be prepared for a higher state of readiness or reissue. However, any aircraft held in this category would undergo extensive anti-deterioration treatment to preserve them for future use. It would be expected to be readied and produced for issue within a given six month period. Naturally it would then require intensive work to bring it up to a fully serviceable status, embodying modifications, etc. All this is carried out during extensive maintenance in the lengthy six month recovery and preparation sequence.

Aircraft allocated to and from 'reserve' are further sub-divided into three more categories: reception, under preparation and ready for allotment. Aircraft can be held 'in reception' for up to six months, during which time they are kept fully serviceable and totally up to date with all maintenance and current modifications. When its future is decided it will be reclassified for whichever state of storage is required. An aircraft 'under preparation' is prepared to a specific standard for transfer to readiness or Long Term Reserve. The aircraft that is 'ready for

Below: *Previously used by the* Red Arrows, *this Hawk T1 was involved in an incident and has been held by the Aircraft Storage Flight at Shawbury for some time, pending a decision on its future.*

Above: *With the phasing out of the Chipmunk T10 from RAF service, there is a continual flow of this type through the Aircraft Storage Flight at RAF Shawbury where they are being held as Non-Effective aircraft prior to disposal. Five examples can be seen here, some without engines, awaiting disposal by Tender.*

salt, contained in a slowly rotating absorbtion wheel, made from incombustible material and corrugated to form a vast number of axially orientated air channels. This is a compact and efficient system, the air passing through the channels of the drying wheel, its moisture being absorbed by the salt and is retained in the corrugated material. The continuous slow rotation of the drying wheel, leads the moisture into the 'reactivation zone' where it meets a counter-stream of hot air. The heat is then used to re-evaporate the absorbed water which then leaves the de-humidifier as a stream of warm wet air. The drying wheel rotates slowly achieving continuous de-humidification, this being a controlled environment and remains constantly running with the aircraft being subjected to a dry and constant level. This type of de-humidification is seen as a major combatant against corrosion.

Preparation for de-humidified storage is slightly different than that for a heated environment in that all avionics can remain intact and fitted, whilst calendar life items are removed and returned to the relevant RAF stores station. Ejection seats are removed from the cockpit, the explosives removed for further storage, and the seat prepared for store and then refitted to the aircraft. Batteries are also removed and allocated for further use, through the RAF Supply network.

Perhaps contrary to popular belief, an aircraft in storage does undergo regular maintenance, depending upon the category and type of storage as to what the requirements would be. All work is carried out in accordance with the Joint Service Storage Manual sponsored by the RAF and RN. This defines the specific work for storage and re-issue requirements as well as routine in-storage tasks. The Support Authority decides if anything further is required for any specific aircraft or type. Depending upon the storage level and type of aircraft, maintenance is performed on a three, six, twelve or twenty-four months interval. This requires a range of checks, including inflation of tyres, oleos, looking for fuel leaks, aerial damage, electrical/avionic systems function checks, and in some cases engine runs. If a defect is found, it is logged in the aircraft Form 700 and rectified on an opportunity basis, depending upon the seriousness of the fault diagnosed. Aircraft in de-humidified storage, in general undergo six and twenty four month *in situ* maintenance inspection cycles, plus engine runs every twelve months.

Depending upon the storage level and type of aircraft, maintenance is performed on a three, six, twelve or twenty-four months interval.

Whilst an aircraft is held in storage, irrespective of category, all routine maintenance is planned and carried out on site by the Engineering Control and Planning section. Monthly reports are returned to HQ Logistics Command at RAF Brampton, which details aircraft preparation status, aircraft movements, change of storage category and lists the in-store state quoting all aircraft tail numbers. Quarterly returns reflect the maintenance status, manhours accrued on maintenance tasks, and the aircraft quantity and type in the respective storage category.

Future long-term requirements might see aircraft being cocooned. This will give de-humidified storage without the requirements for hangarage. Some Fleet Air Arm aircraft were cocooned for storage during the 1950-1960s, whilst the RAF had previously adopted the use of sealed polythene bags (Lightnings at 33 MU) and 'bagged' aircraft (such as the ex-BA Super VC10s held at Abingdon). A PVC jointless skin would be utilised in future, being held clear of the airframe skin, the air space being de-humidified by a portable unit. Various commercial trials have proved the feasibility of this method in maintaining an airframe in near perfect condition over a two-year period.

With a large number of aircraft retained in reserve for the UK's air arms, it is essential that the types held in readiness are fully maintained and kept up to date for immediate reissue with the latest modification standards. This ensures that front-line and training squadrons are maintained at full strength and are able to react accordingly in any time of tension. RAF Shawbury and its Aircraft Storage Flight has an essential task in ensuring the readiness state of these aircraft and the long-term preservation of a diminishing fleet.

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		✔	✘
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2.	**Bulldogs have replaced Chipmunks providing ATC air experience flights.**		
3.	**Hercules flew an airlift from Lyneham into Sarajevo for the UNHCR.**		
4.	**The maiden flight of the first Eurofighter 2000 prototype took place in Germany.**		
5.	**Human factors account for over 50% of aircraft accidents in the RAF.**		
6.	**The RAF's Jaguar GR1Bs can be equipped with TIALD pods.**		
7.	**Twin-rotor Chinooks from No 33 Squadron operated in support of UNPROFOR.**		
8.	**The C-130J Hercules II has propellers made by Dowty in the UK.**		
9.	**The first British jet powered aircraft, the Gloster Meteor, flew for the first time during the war.**		
10.	**The first International Air Tattoo was held at Greenham Common.**		

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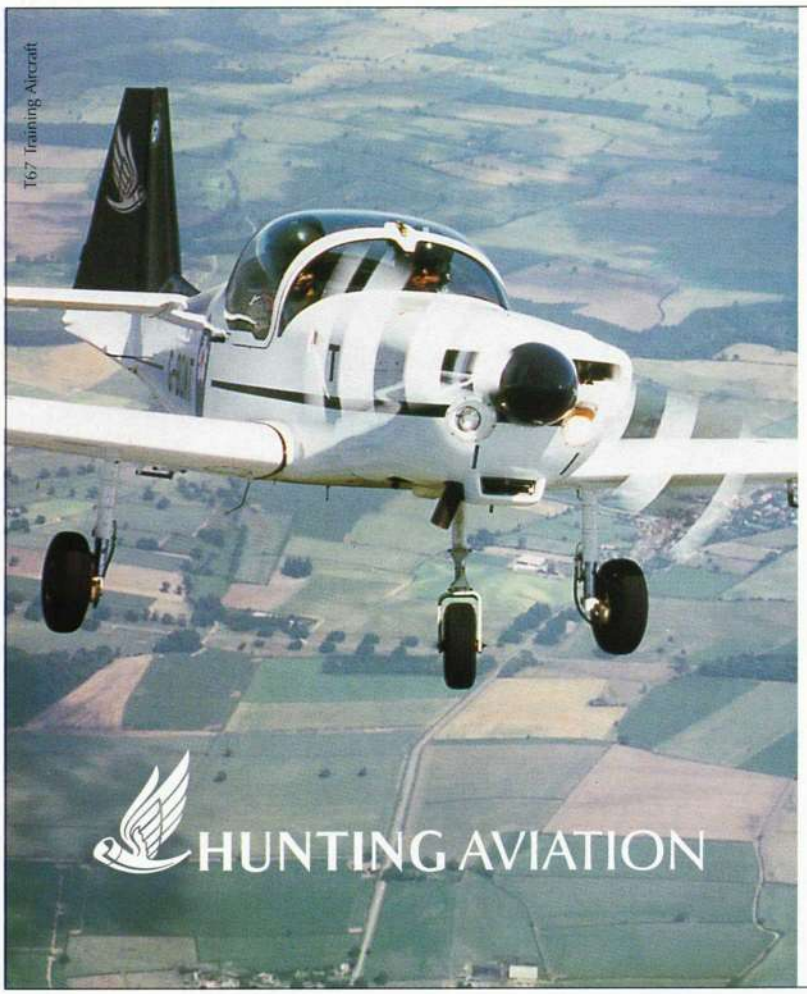

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Degrees of CHANGE

Lindsay Peacock

In an era when almost everything is driven by the desire to get the maximum return from available resources, rationalisation seems to be the name of the game. It is certainly a concept that will be familiar to Britain's armed forces, all of which have had to adapt to the paradox of satisfying ever-increasing commitments while simultaneously enduring ever-decreasing budgets at a time when pretty well every defence organisation and agency has faced some hard questions.

'Less is more' is an overworked cliché these days and is manifest across almost all walks of life. When it comes to the forces, however, 'less has to be more' might be a more precise definition for a process that continues to have wide-ranging consequences. Regardless of whether it be in the front-line or support areas, no element has escaped entirely, but one aspect that has been particularly hard-hit concerns the job of training personnel to operate aircraft and helicopters, with the various branches of our military services.

In that regard, the first joint training organisations have already been established and more are in prospect. Looking at purely financial aspects, when our forces are contracting in size, it clearly makes sense to consolidate training programmes. However, it should be noted that not all the changes now being implemented originate with a wish to eliminate wasteful duplication of effort, which may help to explain why the University Air Squadron (UAS) and Air Experience Flight (AEF) organisations have recently been the subjects of restructuring.

At first glance, even though the 'product' they offer is significantly different, these organisations are not so very dissimilar. For instance, they share a tradition of operating single-engined light aircraft, with the UASs utilising the Bulldog, while the AEFs were equipped until recently with the vintage Chipmunk, unique in being the RAF's last 'tail-dragger'. In addition, they were created in the first instance specifically to promote air-mindedness amongst young people. Also, in their different ways, they have often been the first rung on a ladder that led to an RAF career.

Above: *A University of London Air Squadron Bulldog flying over Oxfordshire.* Main picture: *Nostalgic view of a No 6 AEF Chipmunk – now just a memory.* Photos Lindsay Peacock

More recently, however, their roles have diverged to some extent. In the case of the UASs, while their main function was (and still is) the provision of opportunities for university students to learn to fly, they have increasingly been perceived as a breeding ground for future RAF aircrew. As for the AEFs, these had (and still have) a much simpler brief of giving members of the Air Training Corps (ATC) and Combined Cadet Force (CCF) what was often their very first opportunity to venture skywards and enjoy (usually) the thrill of flight.

Clearly, there are quite notable differences between the respective roles and this is also reflected by what might be called the 'customer base'. By way of illustration, UAS units offer a rather more ambitious training opportunity, but on a more restricted scale, with the number of carefully selected students receiving flying training throughout the United Kingdom typically totalling about 700 at any given time. AEF units, on the other hand, can be said to 'cater for the masses', which is best exemplified by mentioning that the entire organisation normally accumulates close to 50,000 sorties in any given year and that in its best ever year (1988) it logged 25,052 hours and flew 53,314 cadets.

These differences might expose UAS units to charges of elitism. Such an accusation would actually be well wide of the mark, for while it is fair to observe that they offer an elite training opportunity, the units themselves are far from elitist, as a visit to any UAS crew room during normal flying operations will confirm. When all is said and done, our universities are open to all who achieve the desired academic standards – and the same is broadly true of the UAS.

In the present climate, when defence economies are cutting deep, it would be

foolhardy to have expected these two organisations to escape the attention of those tasked with making savings. Once the process of scrutiny began, it would have been even more foolish to have expected them to survive the cost-cutting process unaffected. The big question that had to be faced was just how extensive the changes would be.

In the case of the UASs, it is perhaps not widely realised that their future was seriously threatened, but detailed examination proved them to be an excellent recruiting and training arm, with many of the brightest and best of British students opting to pursue a career with the RAF directly as a result of time spent with a University Air Squadron. If for no other reason than that, it made good sense to continue.

Turning to the AEFs, the situation was probably much less clear-cut and a hard-nosed outcome based on nothing more than financial criteria might have culminated in a decision to simply terminate this programme altogether. It could conceivably be argued that there would have been justification for that, since even the most ardent supporter might have difficulty in arguing that the AEFs directly aid RAF recruitment. They do, of course, but try proving it...

Furthermore, there was the matter of equipment, with all but one of the 13 AEFs that existed flying Chipmunks when their future came under review. As they say, there's many a good tune played on an old fiddle and there's no doubt the Chipmunk could have carried on quite happily for several more years. What probably finally tipped the balance against it was the fact that it was no longer used by any other RAF unit, save for one with the Battle of Britain Memorial Flight. Inevitably and regrettably, but understandably, this made it a candidate for retirement.

Having in principal decided to withdraw the Chipmunk, the next question to be faced was more far-reaching, since it related to the future of the entire AEF organisation. Happily for present and future ATC and CCF members, it was decided to continue, but in modified form through a process of amalgamation with the UAS structure. In essence, this meant that AEF units would cease to be separate and independent entities, but would henceforth function as subordinate flights within selected University Air Squadrons.

GOODBYE 'CHIPPIE'

Universally and affectionately known as the 'Chippie', the Chipmunk merited classification as a real old stager, which was certainly true of WB550, the oldest AEF machine. This was actually the second example built for the RAF, being handed over way back in November 1949 and by the time it was withdrawn 46 years later, it had logged over 12,000 hours.

Andrew March

Evaluation of the amalgamation option was undertaken by units at Newton (East Midlands UAS and No 7 AEF) and Finningley (Yorkshire UAS and No 9 AEF), with the AEFs converting from the Chipmunk to the Bulldog in early 1995 and simultaneously merging with the co-located UASs. It should be noted though, that these were not actually the first AEFs to use the Bulldog. That distinction was claimed by No 13 AEF in Northern Ireland quite a few years ago and it is perhaps ironic to note that this unit (and Queen's UAS) both now face the prospect of closure.

The trial proved successful and heralded the implementation of merger plans more or less across the board. However, it is worth emphasising that it is being undertaken in such a way as to permit the disparate elements to retain their unique identities and tasks, while simultaneously allowing savings to be made in administration and other areas, as well as through retirement of the Chipmunk.

Looking at the changes in more specific detail, the Benson-based units provide a good example of what has happened. In the case of No 6 AEF, this continued to fly the Chipmunk as an independent element until late November 1995, even as its pilots converted to the Bulldog. Subsequently, having consigned the last of the 'Chippies' to storage (and subsequent sale), No 6 AEF was officially absorbed by the University of London Air Squadron on 26 November, retaining its previous identity as a separate flight within the ULAS framework.

In the period leading up to reorganisation, the two UASs at Benson (London and Oxford) respectively flew nine and five Bulldogs, with No 6 AEF having a maximum of eight Chipmunks. After reorganisation, an extra Bulldog was added to the compliment, giving Benson a fleet of 15. On the face of it, that does not sound like an adequate replacement ratio. However, careful planning preceded the change and this showed that a combination of one extra aircraft, a moderate increase in utilisation and a reduction in flying time (three less hours, to 30 hours, for UAS students, and five minutes less at 20 minutes for an air experience flight) would allow the usual UAS tasks and the extra demands of AEF activity to be satisfactorily accomplished.

Looking at the broader picture of amalgamation, while the procedure detailed above applies to almost all AEFs, the nature of the changeover is such that it has affected different units in different ways. In eight cases, the process was straightforward, since they were simply absorbed by a UAS at the same airfield. Three others faced a more complex change, for re-equipment with the Bulldog was accompanied by a move to new quarters. Finally, two AEFs were less fortunate, in that they both disbanded, a fate that may yet befall No 13 AEF. All of these changes are detailed more fully in the accompanying table.

In addition to changes affecting the AEF units, there was a possibility that certain elements of the UAS organisation might also be merged in order to achieve further savings. To that end, serious thought was given to the idea of combining some units. As it transpired, such drastic action proved unnecessary, since the desired economies were achieved by doing away with one aircraft, one QFI (Qualified Flying Instructor) and ten students in each of the instances where a merger was mooted.

How have these changes affected the aims and objectives of the UAS? Generally speaking, these have remained unaltered, although it is not widely realised that there are two categories of UAS student.

Firstly, there are those who have secured a Cadetship or Bursary, whereby they are

UNIVERSITY AIR SQUADRONS & AIR EXPERIENCE FLIGHTS

The following table reflects the organisation as at 1 April 1996; all units are currently equipped with Scottish Aviation Bulldog T1s.

Headquarters University Air Squadrons, RAF College Cranwell [1]	
Aberdeen, Dundee and St Andrews Universities Air Squadron, RAF Leuchars **No 12 Air Experience Flight** [2]	
University of Birmingham Air Squadron, RAF Cosford **No 8 Air Experience Flight** [3]	
Bristol University Air Squadron, RAF Colerne **No 3 Air Experience Flight** [4]	
Cambridge University Air Squadron, Cambridge (Teversham) Airport **No 5 Air Experience Flight**	
East Lowlands Universities Air Squadron, RAF Leuchars [2]	
East Midlands Universities Air Squadron, RAF Newton **No 7 Air Experience Flight**	
Universities of Glasgow and Strathclyde Air Squadron, Glasgow Airport [5]	
Liverpool University Air Squadron, RAF Woodvale **No 10 Air Experience Flight**	
University of London Air Squadron, RAF Benson **No 6 Air Experience Flight**	
Manchester and Salford Universities Air Squadron, RAF Woodvale	
Northumbrian Universities Air Squadron, RAF Leeming **No 11 Air Experience Flight**	
Oxford University Air Squadron, RAF Benson	
Queen's University Air Squadron, RAF Aldergrove [6] **No 13 Air Experience Flight** [6]	
Royal Military College Air Squadron, Shrivenham [7]	
Southampton University Air Squadron, Boscombe Down **No 2 Air Experience Flight** [8]	
University of Wales Air Squadron, St Athan [9]	
Yorkshire Universities Air Squadron, Church Fenton [10] **No 9 Air Experience Flight** [10]	

Notes

[1] Two other units were disbanded during the reorganisation process, these being No 1 AEF at RAF Manston and No 4 AEF at Exeter Airport.
[2] Previously at Edinburgh (Turnhouse) Airport.
[3] Previously at RAF Shawbury.
[4] Provides AEF detachments periodically at St Athan, Exeter and St Mawgan.
[5] May move to Prestwick Airport on expiration of lease in 1997
[6] Currently active, but expected to cease operations in 1996.
[7] Pilot training with OUAS; air experience with ULAS/No 6 AEF.
[8] Previously at Bournemouth (Hurn) Airport.
[9] AEF tasking satisfied by aircraft detached from Colerne.
[10] Previously at RAF Finningley.

Above: *Bulldogs of Oxford UAS (XX551) and London UAS (XX547) lined up at RAF Benson last year.* Lindsay Peacock

sponsored by the RAF and paid during their studies, in return for a commitment to join the Air Force at the end of their degree course. Sponsored students are usually financially better off than many others and are automatically enrolled in the appropriate UAS.

Secondly, there are those who join as a result of what is known as 'Freshers' Week', when the many and varied university societies canvass the latest intake of undergraduates for new members. Individuals in this category will not necessarily be looking for a career in the RAF, but will have a yearning to learn to fly – or, at least, a desire to find out if they have the aptitude.

In fact, those who join in this way form the majority of the annual intake and about the only stipulation is that of joining the Volunteer Reserve. That is not accompanied by any other obligation other than full participation in UAS activities. However, quite a few of them seriously consider joining the RAF at the end of their degree course as a direct result of UAS experience. These may often elect to extend their membership and quite a number of them might also secure sponsorship at a later stage.

All UAS students receive a full elementary flying training programme, although just how far a student progresses naturally depends upon the length of his or her membership. In the case of those who stay for the full three-years of a degree course, they can expect to master basic aeronautical skills and navigation as well as more advanced disciplines like formation flying, aerobatics and instrument flying.

Tuition is by qualified flying instructors and conforms to service procedures and standards which means that the end product (for lack of a better term) is fully conversant with RAF methods, something that will stand them in good stead in a subsequent service career. Furthermore, it provides a cost-effective way of assessing the ability and potential of the various students, for there will always be those who fall short of the standard sought by the RAF.

Putting a cost on that aspect is exceedingly difficult, but it is significant that student members who complete the three-year course are twice as likely to end up on fast jets than those from other sources. And that, in effect, pays for the whole UAS structure, since it clearly makes sense to scratch unsuitable candidates earlier rather than later.

While it may be the main attraction, a UAS is not necessarily all about flying, for the RAF has openings for other trades and skills where sponsorship opportunities also exist and this is particularly true in the areas of engineering and medicine. In addition, there are social aspects, which should not be ignored. Whether it be at home base; at the town headquarters on training nights or during the annual 'summer camp' at an active RAF station, those who run the various squadrons dotted around the country recognise clearly that it would be unfair to confine their endeavours to work.

By comparison, the AEF is focused much more on flying, as its *raison d'etre* is to give Air Training Corps and Combined Cadet Force members the opportunity to get airborne. At times, this means that it is accomplished almost on a 'production line' basis, with the engine kept running during the changeover and one cadet hopping into an aircraft almost before the seat has had time to cool from the previous occupant.

The flying time of 20-25 minutes allows some scope. For obvious reasons, novices, first-timers and the plainly nervous are treated quite gently. The objective is to provide an experience they will want to remember with pleasure rather than regret, as well as one they will be eager to repeat. It is not just pleasure flying though, as those cadets with more experience are given the chance to fit in a few minutes of 'stick-time' or enjoy some aerobatics.

Moreover, the AEF organisation has expanded the scope of flying opportunities on offer. For instance, the Pilot Navigation Training Scheme provides a two-week course (ten flying hours) whereby selected cadets undertake a series of ever more complex cross-country navigation exercises in which they do their own planning and brief the pilot who will fly them. On completion of the course, award ceremonies are staged in which certificates and a navigator's 'wing' are presented to successful cadets.

Above: *Bristol University Air Squadron Bulldog on a training flight with a No 3 AEF pilot over the new Second Severn Crossing, in February this year.* PRM

An even more ambitious programme known as the Initial Flying Course has also been undertaken by No 6 AEF with 12 of the most outstanding local cadets, during summer camp at Benson. This is quite a recent innovation and one that requires each cadet to complete a ground lecture programme that is interspersed with six 40-minute sorties of basic flying instruction, which includes specific exercises such as climb and descent; turns; stalls and effects of control surfaces.

Similar exercises are already undertaken by cadets on an *ad hoc* basis during routine AEF sorties, but the Benson 'experiment' represented the first attempt at creating a formal and structured programme of instruction of this kind, with additional benefits accruing from continuity. This experiment was successful and seems likely to presage similar developments amongst other AEFs in the future.

New initiatives such as these and the recent changes that have been made to the UAS and AEF structure seem set to ensure the continued existence of an organisation that may well be considerably leaner – but which is at the same time much fitter and far better equipped to face fresh challenges in the future.

25 YEARS OF IAT

Peter R March looks back at the first Air Tattoo in 1971 and outlines the story of the world's biggest and best military air display across a quarter of a century.

There are probably few people reading this *Royal Air Force Yearbook* who have not heard of the International Air Tattoo – unquestionably the world's greatest military aviation spectacle. With regular participation by air arms from New Zealand to Russia, Chile to Canada and Spain to Jordan, it has become the annual mecca for everyone who has an interest in military flying, as well as tens of thousands of people wanting a fascinating and enjoyable day's entertainment. This year, the Royal Air Force Benevolent Fund's International Air Tattoo 96, that is being held at RAF Fairford, Glos on 20-21 July, will again be rather special, as this is the 25th anniversary of the first in the long line of air tattoos that was held at North Weald, Essex in May 1971.

Through the late 1960s, the Royal Air Forces Association's South Eastern Area organised a number of one-day air displays on the Spring Bank Holiday Monday at this former Battle of Britain airfield. In 1970 RAFA appointed a new Area Secretary, Jack Currie, who had the task of organising the 1971 display with the object of increasing the profits for the Association's Welfare Fund. He decided that a radical change of approach could substantially improve both the image and profits of such an event. The main thrust of his plan was the creation of a team of enthusiastic volunteer helpers for the various tasks, that did not require professional expertise, while quite rightly insisting that essential services such as catering, ground displays, advertising, public relations, security and air traffic control, remained firmly in the hands of professionals.

On Monday 31 May 1971, at 10.00am, North Weald's gates were opened to the public. The airfield, then still owned by the Ministry of Defence, was no longer active and thus had to be re-activated for the event. The aim of the show was to provide entertainment for all the family and, as befits a Tattoo, it included arena events, and a ground as well as a flying display. Paul Bowen, today's Director of IAT, who was then an Air Traffic Control Officer, had built up the aerodrome control organisation, receiving considerable help from the staff of the Aeroplane and Armament Experimental Establishment at Boscombe Down, including the Operations Officer, Tim Prince, who is today the IAT Director of Flying.

The first Air Tattoo flying display commenced at 2.00pm with a Formula One Air Race for the Duke of Edinburgh Trophy. The RAF gave excellent support with a wide range of types from the Battle of Britain Memorial Flight to a Lightning F1A. Display teams included the RAF Falcons parachutists, a Nimrod MR1, Belfast, Phantom FGR2 and the RAF's mirror-formation team of Jet Provost T5s, the *Gemini Pair*. To recall the past, there was the privately-owned Supermarine Spitfire IX, flown in characteristic style by Ray Hanna, former leader of the *Red Arrows* and a vintage pair from Old Warden – the Gloster Gladiator and Avro Tutor. The Army Air Corps' *Blue Eagles* team also gave its immaculate formation helicopter display.

Amongst the overseas participants was the Austrian Air Force, that sent a big Sikorsky S-65 helicopter. Four Saab AJ-35XD Drakens came from the Royal Danish Air Force in another first-time appearance in the UK. Particularly welcome were the pilots of two Northrop F-5 fighters from 332 Squadron of the Royal Norwegian Air Force. Their squadron had actually been formed at North Weald in 1942. The Royal Netherlands Air Force also sent a Northrop NF-5B, whilst the French Air Force provided an immaculate display of flying by the Fouga CM170 Magisters of the *Patrouille de France*.

In comparison with later shows this was a small event, but it had provided an insight into the complexities of what lay ahead and had given the various managers practice in the necessary arts of diplomacy and flexibility. The weather had been kind, a large crowd attendance had provided the hitherto unheard of profit of £10,000 for RAFA and the team welded together under Jack Currie's unobtrusive yet insistent leadership had, all things considered, achieved a success. The new formula show had arrived to replace the old. The seeds of the 'Air Tattoo' had been sown but would they continue to bear fruit in the following years?

For Air Tattoo 72, the Spring Bank Holiday was chosen as the date and North Weald again the venue. Using the same management structure, the Air Tattoo team looked for solutions to the problems encountered the previous year – traffic control, car parking, aircrew accommodation and transport for participants. A new problem encountered was brought about by the RAF's departure from North Weald, which had resulted in the deterioration of some of the paved surfaces.

Despite the worst Bank Holiday weather for many years, the airshow went ahead and once again included a number of items new to the UK and return visits from overseas air arms such as Austria with Saab 105s, the Netherlands with a Breguet Atlantic and NF-5A, and Belgium with the *Diables Rouges* aerobatic team of Fouga Magisters. An RAF participant, Fg Off Rod Dean from No 79 Squadron, was awarded the new Embassy Trophy for the best solo jet performance in a Hunter. This trophy has continued to be awarded at each Air Tattoo by W D & H O Wills, although in recent years it has been known as the Superkings Trophy. Imperial Tobacco has given considerable support to the event throughout its 25 years. The outcome of Air Tattoo 72 was better than the organisers

Ray Hanna flying Spitfire IX MH434 (that he still displays today) at Air Tattoo '71. PRM

could have dared to hope, considering the poor weather which marred the day.

A major setback then faced the organisers. The M11 motorway was being constructed very close to the southwest end of North Weald's main runway and it was clear that the site could not be used for a major airshow while this work was in progress. A replacement airfield had to be found and RAF Greenham Common, near Newbury was eventually selected thanks to the help and co-operation of the Base Commander and HQ Third Air Force, USAFE.

The Embassy Air Tattoo 1973, the first 'Greenham Common' as it became popularly known, took place on 7-8 July 1973. It continued the international bias established at North Weald with ten overseas air arms taking part. With more aircraft and an extensive ground display and trade exhibition, it was a logical step to run the event over two days. At the end of the weekend a total of £13,000 was handed to RAFA, the proceeds from what aircrew, spectators, distinguished visitors and the organising team felt was a thoroughly enjoyable airshow.

1974 was another turning point for the Air Tattoo team, with Jack Currie stepping down as the Tattoo Director. The airshow went ahead on the first weekend in July, the formula much the same as in 1973, with special attention being given to a wide variety of family attractions as well as the presentation of unusual aircraft for the enthusiasts. With a 50,000 crowd and a profit of more than £15,000, the last RAFA-controlled Air Tattoo was again very successful.

The loss of Jack Currie as Director of the Tattoo, the withdrawal of a major sponsor and the international fuel crisis prevented there being an airshow at Greenham Common in 1975. Paul Bowen used this opportunity to put forward a proposal to the Royal Air Force Benevolent Fund, the upshot of which was that the Fund decided to support future Air Tattoos at Greenham Common using its Development Trust, which had been set up with the proceeds from a successful RAF Airshow at Farnborough in 1950.

Therefore, planning began for the Royal Air Force Benevolent Fund's first International Air Tattoo, to be held at Greenham Common on 31 July and 1 August 1976. For the first time an aircraft type, the Hawker Hunter, was adopted as the focus of a 'meet'. As it was the 25th anniversary of the classic British jet fighter's first flight, the prototype, WB188, was brought in by road from St. Athan and two dozen other examples were flown in to be lined up alongside it. IAT 76 contributed in excess of £35,000 to the RAF Benevolent Fund from an attendance of over 120,000 people. The show had been well regulated and safe, despite the large number of aerobatic teams and the inevitable competitive spirit amongst the crews.

That was 20 years ago, and a great deal has happened since. 1977 was the last of the annual Air Tattoos, but in itself very special, as it was the year of the Queen's Silver Jubilee. An important organisational development in 1977 was the introduction of the IAT Flying Control Committee. A team of eminent pilots established the flight safety rules and regulations for the flying display, briefed the pilots each day and monitored their flying, both at rehearsal and during the displays. The committee had the power to stop a display if it was considered unsafe – a power that has been invoked on a number of occasions. The constitution of this important team has contributed to the excellent safety record at IAT events and has become a model for use at many major air events world-wide.

The International Air Tattoos in 1979, 1981 and 1983 became bigger and better, following the pattern established in having a number of special aeronautical features and a wide range of family entertainment. Sadly IAT 83 was the last to be held at Greenham Common. The build up of the cruise missile facilities reduced the area available for IAT, which made it impracticable for a civil organisation to continue presenting a large air show at Greenham. Once again a number of locations were investigated with the final choice resting between RAE Thurleigh, Bedford and RAF Fairford, Gloucestershire, both very large airfields. The latter was eventually chosen as it lay in broadly the same catchment area as Greenham Common.

Moving the world's biggest military air show from a long-established venue to the new location at Fairford was something of a gamble for the RAF Benevolent Fund and the team of IAT volunteers. The essential differences included moving from what was a non-operational (in flying terms) airfield to an active US Air Force base with a flying task that had to continue with as little interruption as possible; finding accommodation for the hundreds of air and ground crews together with the teams of fire, medical and support staff in a completely new area, and above all attracting the public to a new location and arranging the traffic along routes which enabled the best possible access to the airfield which is farther away from motorways and trunk routes.

Participants at the first Air Tattoo included this Royal Norwegian Air Force F-5 (above), *an Austrian Air Force Sikorsky S-65* (left) *and Fouga Magisters of the* Patrouille de France *aerobatic team* (top). PRM

Over 200,000 people attended IAT 85, resulting in some £120,000 being donated to the RAF Benevolent Fund. Those who walked the whole length of the aircraft static display will vouch that it stretched for nearly two miles and was the longest single line-up ever presented in the UK. So it has continued, with IATs at Fairford biennially until 1993 and once again annually since then.

Having become full-time Directors of IAT back in the Greenham Common days, Paul Bowen and Tim Prince have built up a permanent staff and tremendous voluntary help over the years, and through the airshows raised several million pounds of much needed income for the RAF Benevolent Fund. Their considerable experience has also been used to produce airshows at other venues in the years between IATs – Bournemouth, Boscombe Down and Middle Wallop most notably.

From modest beginnings 25 years ago at North Weald, the enthusiasm and dedication of Messrs Bowen and Prince has inspired many thousands of civilian and military personnel to give their services freely to present a weekend of unparalleled entertainment for everyone, from enthusiast to the family on a day's outing, that has become famous across the world as the International Air Tattoo – or just plain IAT.

A special ***Silver Jubilee of IAT*** *book, giving a more detailed account and photographic highlights of the last 25 years of IATs, together with a pictorial record of IAT 96 at Fairford on 20-21 July 1996, will be published by the RAF Benevolent Fund Enterprises in October 1996.*

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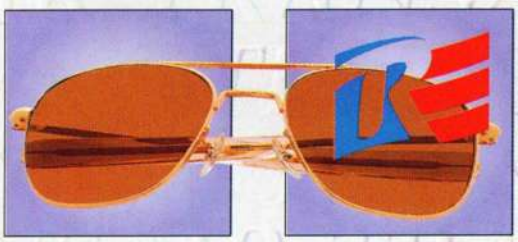

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ENTER THE JETS

Michael J F Bowyer reflects on the amazing technological changes that 50 years ago introduced the turbojet and brought about the realisation that the era of mighty piston engines was about to pass into history.

"Jet propulsion is bound to come – sometime. It is possibly the only way to get high power for large, heavily loaded aircraft of 100 tons. But the practical difficulty is getting enough overall efficiency." So Sir Henry Tizard wrote prophetically in 1936.

Up to the early years of World War 2 the power of piston engines dominated aircraft design. Rapidly power being sought climbed from 1,000hp to 2,000hp. By 1941 designers wanted 3,000hp, which the Armstrong Siddeley Wolfhound might have produced, although four years of development would have been required. Such powerplants were heavy, mechanically complex, difficult to simplify and hard to maintain. Something different was needed and it came as the gas turbine, linked with reaction propulsion.

It was not a new idea. Sir Isaac Newton in 1680 propounded his Third Law of Motion – that every action produces a reaction – and in 1791 John Barber patented a gas turbine, believing that its exhaust might propel a ship. Even jet propulsion resulting from air compression, fuel ignition and expansion of the resulting gas to produce thrust was not new. Piston engines could drive a compressor preceding a combustion chamber, then discharge a powerful jet of gas from a nozzle. None of these ideas generated sufficient thrust for jet propelled flight. The breakthrough came from the use of a rotary compressor driven by a turbine. This process consumes some of the power created by burning fuel in the compressed air, leaving the remainder available as thrust, generated by the expansion of the hot gas through the nozzle. In Britain that idea came from Air Commodore Sir Frank Whittle.

Above: *Gloster E.28/39 W4041/G made history as Britain's first jet-powered aircraft when it first flew from RAF Cranwell in great secrecy on 15 May 1941.*

Above: *Rare wartime colour photographs of Meteor 1s of No 616 Squadron based at RAF Manston, in 1944.*

Born in Coventry on 1 June 1907, he entered RAF Cranwell's School of Technical Training as a boy apprentice, was later selected for officer and pilot training and graduated in July 1928. He was then posted to the Central Flying School, RAF Wittering. With a strong interest in scientific matters he directed his thoughts towards alternatives to the piston engine and propeller, proposing a rotary compressor, increasing its compression ratio and fitting it on the same shaft as a turbine, thereby producing a piston engine substitute.

High speed gas turbines had looked unlikely to succeed due to inappropriate turbine blade material and general low efficiencies. This was until 1926, when Dr A A Griffith of RAE Farnborough, proposed a propeller driving a multi-stage gas turbine, with an axial-flow compressor.

Nevertheless, Frank Whittle realised that he would have to design his own gas turbine, and opted for a simpler, single-stage unit with a centrifugal blower. When he presented his ideas in 1929 to the Air Ministry they were dismissed as 'impracticable'. Undaunted he applied on 16 January 1930 for a British Patent that was eventually granted as No 347206. It covered the linking of an internal combustion turbine to a jet nozzle so 'the excess of momentum of the jet over that of the inspired air provides propulsive effect'.

He tried to interest industrial concerns, including British Thompson Houston Co, (BTH) and Armstrong Siddeley Motors, neither of which responded. Whittle had a good idea that nobody seemed to want. His fortune changed in 1934 when he started a two-year

secondment to read Mechanical Sciences at Cambridge. There his advanced project attracted the attention of influential people and led him to O T Falk & Partners, investment bankers, who supported innovative ideas. Whittle then began, in June 1935, to design his first jet propulsion engine. He called it his 'Gyrone'. In March 1936 Falk & Co provided funding and a small company, Power Jets, was established. BTH having worked on industrial turbines since 1933, was contracted to build parts. Although the Air Ministry was generally hostile towards his ideas, Whittle was granted a post-graduate year in which to further pursue his project, and he kept the Ministry abreast of developments. He also requested

preparations to flight test an engine, suggesting that a jet propelled aircraft might reach 500mph at 15,000ft, thereby making clear just how far in advance of existing aircraft design his engines were. The Air Ministry at least took note of that forecast.

Whittle's first engine, the WU (Whittle Unit) constructed with BTH help, was completed in April 1937. It comprised three main components – a single-stage, double-sided, centrifugal compressor, a single-stage axial flow turbine and a helical combustion chamber connecting them and into which liquid fuel was injected. The resulting gas drove the turbine and expanded through a jet nozzle. Mounted on a trailer at BTH's Rugby works the engine was fired up on 12 April 1937. Its early tests proved highly spectacular for it raced frighteningly into uncontrollable acceleration which only stopped when its fuel flow eased or ceased. Controlled combustion was to be one of the most difficult aspects to engineer for the team aiming at an intensity 24 times anything so far reached. One advance came as the result of switching fuel from diesel oil to kerosene.

Modifications to the combustion layout led to the 'gyrone' performing well for an hour and reaching 13,600 revs, but the new blower casing was distorted by excessive heat, the turbine too inefficient and the exhaust temperature very high. Not surprisingly the engine was soon now worn out. Nevertheless, Sir Henry Tizard of the Imperial College of Science, impressed by the engine's potential, wrote of Whittle "He has a lot of ability and tremendous enthusiasm.....he deserves encouragement." Tizard also pointed out that the engine used lower grade fuel than piston engines, was easier to maintain and potentially offered much higher power output.

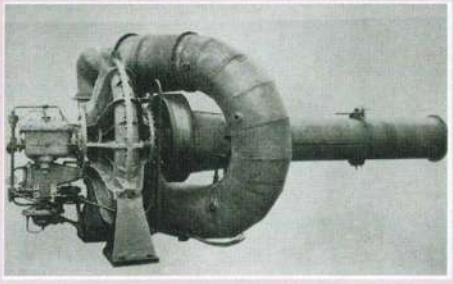
Due to the risk of a serious test accident, Power Jets moved in July 1937 from Rugby into a crude, disused foundry at BTH's Ladywood Works at Lutterworth, where a core store was converted to house a test rig. With questionable financial return on its investment Falk decided not to fund to the agreed amount. Fortunately, the Air Ministry, acknowledging that a new propulsive system was needed and after recommendation by the Aeronautical Research Committee, decided to take an interest. In March 1938 official funding was injected towards the cost of a new engine, again sub-contracted to BTH. Whittle was commissioned to provide a report on his work and everything suddenly became 'secret'!

In a submission of 25 October 1938 he rated speed and climb as the first requirements of a fighter, with fuel consumption secondary. He pointed out that because an enemy bomber would reach London ten minutes after crossing the coast, only eight minutes was available for interception – and that could only be achieved by a jet propelled interceptor.

On 6 May 1938 the new W.1 power plant broke down after a mere 4.5 hours running. The cause was blade failure and not a basic design fault. Radical reconstruction, completed in October 1938, resulted in what was virtually a prototype of future engines and featured not one but ten counter-flow combustion chambers encircling the engine shaft. For this the Air Ministry again provided money, but Power Jets was disappointed at the limited commercial input by others. By April 1939 the latest engine was performing well and reliably under control at 13,500 rpm and by June that had risen to 16,000 rpm. Mr David Pye, Director of Scientific Research, saw the engine running at Lutterworth and rated it a 'serious power plant', an example of 'practical engineering, easy to start, and perfect to control'. A lightened version for flight testing was now needed and Air Marshal Sir Wilfrid Freeman and Air Vice-Marshal Arthur Tedder gave full support to its construction along with a flying test-bed. First though, it was imperative to master combustion and Isaac Lubbock of Shell Petroleum produced the breakthrough by substituting an atomising fuel injector in place of a vaporizer.

In a paper dated 7 July 1939, Whittle claimed that a small jet fighter would climb to 20,000ft in 3 min 48 sec, have a sea level top speed of 400mph and reach 500mph at 50,000ft. A 1,000hp piston-engined fighter would weigh about 4,500lb, whereas a comparable jet fighter would tip the scales at about 2,500lb, its centrally sited engine weighing only 400lb and the fuel 700lb, all of which resulted in a favourable power/weight ratio. A boom could carry the tail unit well above the propulsion unit and, sitting in the aircraft's nose, the pilot would have a splendid view. To air test his engine Whittle asked for it to be fitted in the belly of either a Hampden or a Wellington bomber. Sparing any of those was apparently expecting too much!

Below: *Whittle's U Type gas turbine, its single combustion chamber curling between compressor and turbine.* BTH Co



Mr W G Carter, Chief Designer of the Gloster Aircraft Co.,had an interest in gas turbines, so Whittle visited him in June 1939. After hearing about the Gloster twin-boom fighter that featured a Napier Sabre powerplant, Whittle suggested to the Air Ministry that its layout lent itself to jet propulsion. When, in July 1939, formulation of a simple jet engined test bed to attain 400 mph and climb fast began, Gloster and its parent Hawker Siddeley were invited along for consultations and Carter was soon planning the aircraft. Although a team from the controlling Hawker Siddeley Group saw the latest engine running and producing only 600lb st they tried to interest Armstrong Siddeley in building jet engines, but unfortunately no agreement on design rights could be obtained. The company's involvement would have considerably hastened wartime development of the jet engine.

They would all undoubtedly have been surprised had they been aware that a German jet aeroplane, the Heinkel He 178 powered by a centrifugal flow engine, had flown in August 1939. The development of gas turbine engines in Germany was remarkably similar to the British pattern and equally pioneering. Hans von Ohain had designed a centrifugal type turbo-jet with Heinkel financial help and, although not hampered by cautious bureaucrats, he had instead to tackle their belief that such things should be left to Messerschmitt. The first engine ran in 1937, while axial type compressors were being developed as superchargers for piston engines in fighters. Although very basic, the engine in the Heinkel had attracted sufficient interest in 1938 for BMW and Junkers to be officially encouraged to start designing axial flow engines under close government supervision.

By the outbreak of war the financial position of Power Jets had much improved. The government investment represented a fifth of the development funding, and on 28 September 1939 a Royal Aircraft Establishment team discussed with Carter his proposed jet design. With a nose cockpit and space for a 20mm cannon, Carter had incorporated wing leading edge engine air intakes but these were agreed as likely to weaken the structure. Instead, the aircraft would feature an 18in diameter nose intake leading to airtight bifurcated piping passing to either side of the pilot. A wing span reduction to 27ft meant a critical all-up weight forecast to be 2,800lb,

After seeing a Whittle engine run the Deputy Director of Technical Development commented "I'm frankly very surprised at the results he's achieved. I'm very intrigued at the possibilities ahead for the unit for a small aircraft of the interceptor type". Although he also expressed concern at the relatively low thrust and high specific fuel consumption that appeared to limit jet propulsion to interceptors. No existing aircraft seemed able to be converted to have the new engines.

There was temptation to hasten progress at the outset by asking for a fighter, but the eventual design was stressed only to carry four wing mounted machine guns and 2,000 rounds of ammunition, or two 20mm cannon. With a structure weight of about 1,190lb, the aircraft's engine sited aft of the rear spar was expected to deliver up to 1,200lb st. Based upon Whittle's figures, a four-gun version of the aeroplane therefore looked likely to attain 350mph at sea level, 370mph at 10,000ft,

Above: *Test flying of the Gloster E.28/39 took place either in the early morning or just before dusk.*

reach 30,000ft in just under ten minutes and there be capable of 410mph. Coupled with a ceiling of 47,000ft that would be outstanding.

Two layouts of the aircraft, each having a wing loading about 27lb/sq ft, were finalised at Gloster Aircraft, Hucclecote on 2 October 1939, and were presented to the Air Ministry on 13 October at the RAE, that had devised an alternative version featuring air entry through a large duct. Carter's Scheme 1 was conventional, the centrally placed engine being fed through a nose intake and exhausted via a long tail pipe. Easy to install, the latter meant a speed loss of about 10 mph, but a major problem seemed to be getting sufficiently highly pressurised air to the compressor. Calculations showed that at sea level the unit would consume 26lb/330 cu ft per second, and there was some consternation because it was thought undesirable to exceed 200 cu ft/sec in the nose ducting. A short leg nose wheel undercarriage layout had been made possible by the engine's positioning.

Scheme 2 had a 24ft long fuselage, including a boom following the line of the top of the pilot's cockpit and faired into the power plant bay below. This meant a very short tail pipe, that was thought likely to increase the speed to 450mph at 20,000ft and to 460 mph at 30,000ft reached in nine minutes. Whichever layout was chosen there needed to be 'a high degree of aerodynamic perfection ...more than usually desirable', to offset fuel consumption amounting to 120 gallons per hour at 10,000ft, falling to 47 gallons at 40,000ft. Just over 80 gallons of fuel was to be carried and April 1940's demand for 105 gallons was never met. All-up weight and the centre of gravity position had to be watched; the aircraft's sole purpose was for engine research and not 'aerodynamic wrestling'. Before a final decision the RAE was to carry out more tunnel tests. There was one other problem to settle, what to 'call' the aircraft. Placating all interests, on 27 October it became the 'Power Jets Gloster-Whittle Aeroplane or Fighter'. Frank Whittle suggested that it should be test flown from Cranwell, Martlesham or Farnborough.

On 29 November 1939 the interested parties met again, and this time in the requisitioned Grand Hotel, Harrogate, to discuss the E.28 now weighing 3,130lb, likely to have a speed of 401 mph at sea level - and again carrying guns. Whittle protested at that feature, emphasising that his engine was designed for a lighter airframe without military equipment. He also still preferred the tail boom/short pipe layout, but RAE wind tunnel tests favoured the long pipe. The latter version won the day. Further agreement followed – the aeroplane would definitely be unarmed.

The order was given on 21 January 1940 for the E.28/39 specification to be finalised around a lower and achievable top speed of 380 mph and a suggested all-up weight of 3,200lb. A pair of 'high speed' thinner wings, spanning slightly less than the normal pair, were planned for a second aircraft that was intended to explore the full performance of Whittle's 'gyrone'.

On 3 February 1940 the contract for two E.28/39s was signed. A mock-up conference followed on 22 April, and on 11 May 1940 the specification outlining the E.28/39 was finally issued. It called for a 'single-engined, single-seater aircraft for research into the Whittle engine... based upon requirements for a 6-gun interceptor fighter' or one carrying four Browning guns each having 500 rounds. On an engine output of 1,200lb st the 380 mph TAS maximum speed was linked with a 4,000 fpm rate of climb. Take off and landing runs would be around 500 yards. Gloster was to pay £500 to Power Jets for their contribution, and construction started during May 1940, by which time engine development was sufficiently advanced for operational aircraft to at least be considered.

Most favoured was a high-altitude reconnaissance-bomber operating where fuel consumption would permit a reasonable range. Against it was the need to develop a pressure cabin likely to add too much weight. On 10 April 1940 William Farren, Director of Technical Development, visited George Carter to discuss the company's promotion of an 11,000lb operational jet propelled aircraft carrying a 3,000lb offensive load. Official belief was that one of the proposed new W.2s would be insufficient to power such a machine.

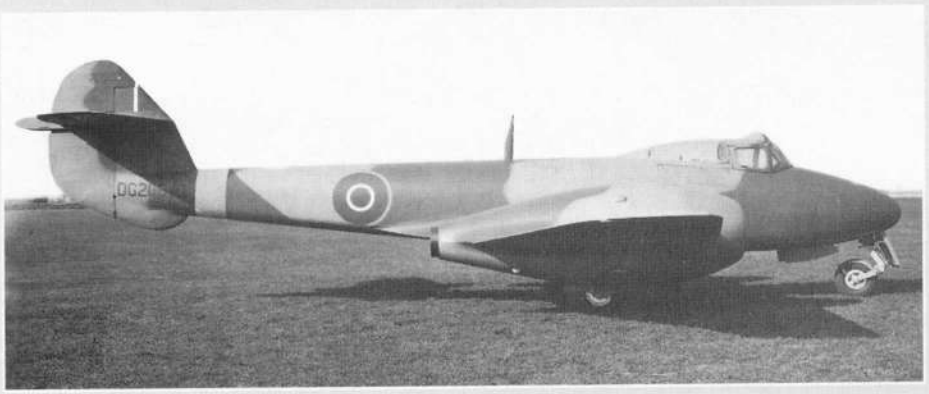
RAE Farnborough therefore considered the possibility of a smaller aircraft of 8,500-9,000lb carrying a military load of about 1,500lb. Mr Farren asked Carter if he thought that, flying faster and higher than any other planned British machine, it could carry at least four and possibly six 20mm cannon, or two cannon and six .303 in guns. If it could, then it would be able to deal with an expected high-speed high-altitude bomber campaign. Carter, though, still favoured development of a fast high-altitude reconnaissance-bomber. While that was not abandoned out of hand, continuing concern over insufficient engine thrust caused it to fade and ten days later came agreement with Farnborough's suggestion, for a high-speed, high-altitude, light weight, short duration interceptor, powered by two jet engines.

Basing calculations upon a sea level thrust of 1,040lb, Carter calculated that an 8,600lb fighter reaching 420 mph at sea level would have a top speed of about 455mph at 30,000ft – maybe even faster, and at that height a range of around 750 miles. Its service ceiling should be 48,000ft. More powerful engines likely to become available would allow a heavier aircraft, of around 9,800lb.

The promoters met again, first on 2 and then on 6 May 1940 – four days before the German blitzkrieg on the West. Agreeing their estimates as forming the basis of a good military jet, Gloster Aircraft was asked to build a full-scale mock up of such an aircraft. The lowest weight possible was essential, and even self sealing fuel tanks – said to be less necessary for paraffin – would be omitted. Current plans called for the pressure cabin equipped Westland F.4/40 Welkin high-altitude fighter and therefore the unpressurised jet came to be looked upon as a medium level performer.

A more powerful engine being clearly desirable for the fighter, the Air Ministry arranged for development of the W.2, a 1,600lb st version of the W.1, including much bench running. Power Jets work was expanding, and the Ministry of Aircraft Production (MAP) was now encouraging Whittle. However, the special burners and flame tubes would not be available until the autumn to allow engines to run continuously for ten hours.

A new difficulty now arose. Who could produce the engines in quantity? Power Jets, not a producer, had found BTH none too easy to co-operate with, and all the aero engine firms were busy. Consideration then switched to employing car firms, and after some persuasion Rover, who had built Bristol aero-engines, agreed to make the W.2 'producible' and carry out any necessary modifications. As a result of that, on 4 August 1940, MAP



Left top: *Gloster F.9/40 DG206/G is shown fitted with the bulbous engine nacelles required to contain the Halford H1.*

Left: *Meteor 1 EE211, fitted with long nacelles, was used by the RAE in 1945 for compressibility tests and measurement of tail loads.*

ROYAL AIR FORCE

awarded the firm a contract. But being sub-contracted to and advised by a small firm did not please Rover over-much. Without informing Power Jets, Rover went to the Director of Engine Development and persuaded him to put the company in full charge of production planning. Power Jets was then instructed to provide Rover with the necessary commercially valuable diagrams and information to bring this about. Metropolitan-Vickers (MV) and Armstrong Siddeley (AS) had by July 1940 become separately involved with the RAE/Griffith axial compressor development. Although heavy and complex, the lower frontal area of such engines commended them, and in October 1940 MV won a contract for two of its F2 (**F**arnborough **2**) engines.

While the Battle of Britain raged Gloster worked hard on the jets. By 8 July 1940 fuselage frames of the first E.28/39 (W4041) were finished. Wing spars for the second machine (W4046) were 90% complete, and W4041's air duct was being strengthened. By early August the fuselage of W4041 was being skinned, the wings assembled, tail construction commencing, and on 'Battle of Britain Day', 1940, the prototype was basically complete, with 90% of the engine unit installed. To be safer from bombing W4041 was moved into premises previously occupied by Regent Motors at Cheltenham, and after the desperate battle was won jet aircraft became high priority items.

The third week of October 1940 saw agreement concerning the layout of a five-ton Whittle-engined four or six cannon fighter. Although its airframe would be stressed to accept 4,000lb st, power that was still many months away, with the most powerful jet engine in the foreseeable future able to deliver no more than 1,600lb st, for which 250 gallons of jet grade paraffin could be carried. There was no alternative but to fit two engines. As to their position, first preference was to place them in 'bulges' on the fuselage sides and thus close to a centre thrust line. Engine bulk and weight cast a shadow across that idea, so wing mounting in conventional style nacelles was chosen.

Hanging them below the wings meant lengthy undercarriage legs and housing problems after retraction, therefore the engine nacelles were mid-wing mounted with the spars embracing the installations.

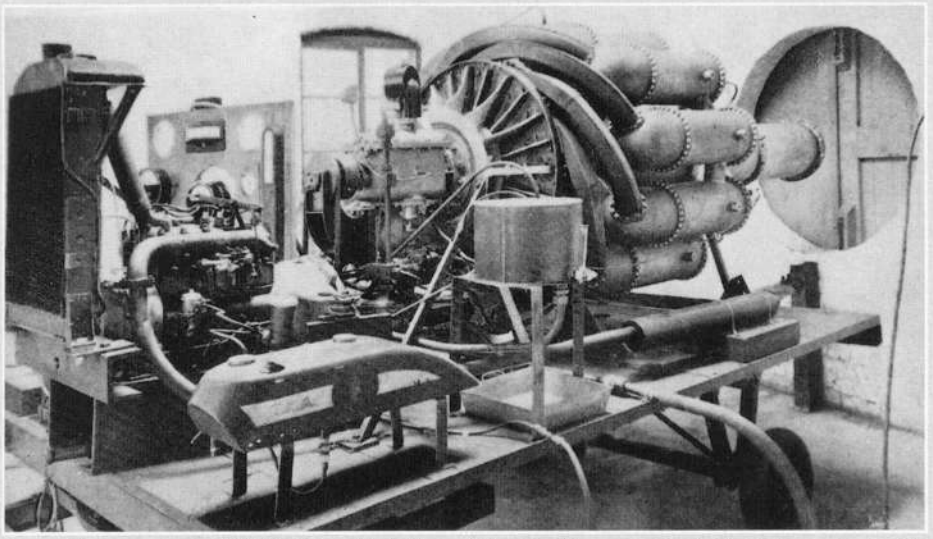
Guidelines for the F.9/40 issued on 14 November 1940 stated that 'The DTD requires development of a single-seat fighter using the Whittle system of jet propulsion giving speeds, particularly at high altitude, not possible on orthodox engines. To make full use of it a small aircraft is essential. Its maximum speed at 30,000ft must be not less than 430mph.' With a projected ceiling of 43,500ft the F.9/40 was expected to reach 30,000ft in 12.9 minutes, clear 50ft within 600yd and land in 700yd. The importance of a simple structure was stressed to keep the cost low and facilitate manufacture. A wing span of 39ft 6in was suggested later.

During December 1940, with a priority requirement for large numbers of high altitude fighters, Tizard pushed hard in the Air Council for the F.9/40, of which 80 airframes and 160 engines a month became the basis for production planning. Purchase of two F.9/40 prototypes, complete with engines at a total cost £20,000, received Treasury approval on 10 January 1941. Because of the project's importance MAP pressed for, and obtained on 24 January 1941, the go-ahead to increase the order to a dozen F.9/40 fighters, (serialled DG202 to 213 inclusive). Some were to be powered by Rover-built W.2B engines, the first of which was expected to fly in December 1941. When BTH gradually dropped out of the engine field, partly because they felt the MAP interfered too much, Rover was left as the only firm building engines. Power Jets did the development work, and relationships thus involved private enterprise, government money and the value of Power Jets engine plans that were being passed to a private firm just on the basis of a gentleman's agreement.

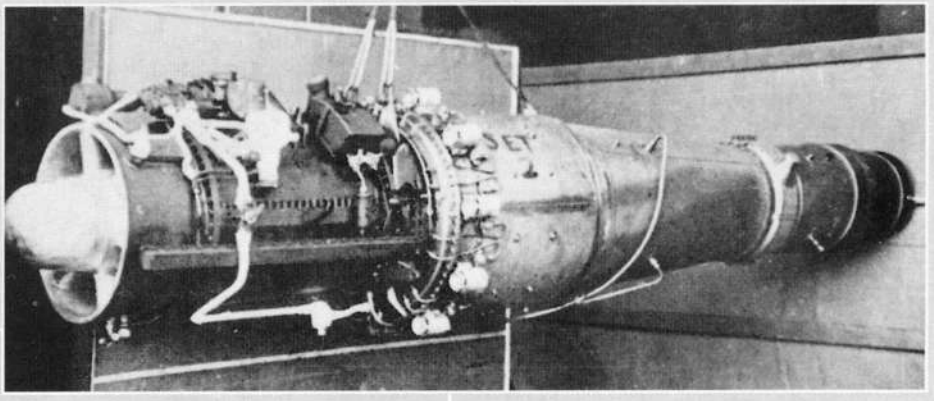
The F.9/40 now had priority over the E.28/39 popularly called the 'Pioneer'. Nevertheless, and possibly as a stand-by, Gloster was ordered on 12 January 1941 not only 'to proceed at all speed' on the twin, but also to keep under consideration the idea of developing the 'E.28' as an operational fighter. That meant taking even greater care during its flight trials.

A more realistic appraisal of the 'Pioneer' was possible as soon as it was finished. With a wing span increased to 29ft, length of 25ft 3in and a wing loading of 29.5lb/sq ft, it was able to carry 81 gallons of fuel. A top speed of 450 mph at 30,000 ft was expected when the 1,267lb st W.1 was fitted (higher when a change to the 1,600lb st W.2 was effected). Cruising at 280mph at 30,000ft the range would be 460 miles.

Boscombe Down, favoured for flight trials, fell from choice when its surface was rated too undulating. Instead, Jerry Sayer, Gloster's Chief Test Pilot, opted for RAF Cranwell, Whittle's favourite, which had a flatter surface and open land around. First, though, the prototype needed to return to Brockworth where, just before darkness fell on 6 April 1941, Sayer carried out the first taxiing and discovered that it took 10,000 rpm even to move the aeroplane fitted, at this stage, with



Above: *The reconstructed Whittle U.1 on the Lutterworth test rig. The car engine (left) acted as a starter. The doors in the test cell wall opened before running commenced.* BTH Co



Right: *The axial-flow Metropolitan-Vickers F2 was the forerunner of the Beryl and Sapphire of later years.*

Below: *Tethered for engine runs at Bentham, F.9/40 DG204/G was fitted with powerful F2s in underslung nacelles.*

a W.1X built from spares and intended for taxying only. Next day 15,000 rpm were produced, but the lack of propeller slipstream on the elevators being obvious. Foreseeing that, a large tail plane had deliberately been designed. During two taxiing runs on 7 April Jerry Sayer lifted the aircraft a few inches above the ground and Whittle, who also carried out a run, is thought to have flown the aircraft slightly above the ground as well.

After the W.1 flight engine was installed, W4041 was conveyed by road to Cranwell. In great secrecy at about 19.40hr on 15 May 1941, Jerry Sayer released the brakes as the engine reached 16,500 rpm and produced 860lb st. After about 580 yards, with everyone involved watching anxiously, the 'Pioneer' made its historic lift off from Cranwell's runway. Cruising away at 16,000 rpm and soon disappearing into cloud it was making one of the most significant first test flights ever undertaken from Britain and was almost completely ignored officially. Starting out at 3,450lb with 50 gallons of fuel aboard, W4041 reached 240mph ASI at 4,020ft. during its historic 17 minute journey. Sayer made another three flights on the following day, and a fourth lasting 46 minutes. On 18 May, with the engine running at 16,500 revs he took the aircraft to 317mph at 20,000ft during a 56 minute flight. That left him with only seven gallons of fuel as, with care, he joined the Cranwell circuit knowing that this type of engine does not readily produce sufficient increased thrust in the event of a balked approach.

On 21 May W4041 was demonstrated to VIPs, many of them letting it be known, to the astonishment of Whittle and his colleagues, how strongly in favour of jet engines they were! Over 13 days Sayer had made 15 flights, the highest to 25,000ft. Only once during ten hours flying did the engine need some superficial attention, which was no mean achievement. On all but the first flight a full fuel load was carried, making the starting weight 3,690lb – higher than estimated. As a result the take-off run was longer than forecast, the initial climb slow, the thrust less than expected and the drag below the estimate. Low stressing of the engine's compressor casing restricted in-flight manoeuvring, otherwise W4041 achieved all that was hoped for. Whittle's engine had performed superbly – as did Cranwell's fire brigade, that had to put out a number of grass fires caused by the taxiing jet.

On 23 May the prototype was grounded for a W.1A engine to be fitted and EC 1240 'high speed' wings, along with minor modifications before flying resumed seven months later. Throughout Phase 1 the Pioneer's engine ran smoothly, albeit rather noisily to 14,000ft. where turbine whine became more apparent. The jet pipe temperature never exceeded 580°C. All flights took place in the early morning or just before dusk, to avoid interference with other air activity and preserve as much secrecy as possible. But news of the jet's flights spread surprisingly fast.

This early success heightened interest in jet aircraft and engines. At de Havilland's engine division, where spare design capacity existed, links with Major F. B. Halford, independent consultant to Napier and of Sabre engine fame, were strong. Under his guidance work had commenced in April 1941 on a single-sided compressor, 'straight through' turbine engine. MAP officials, their faith in Halford strong, persuaded him and the company to attempt a 3,000lb st engine for a single-engined fighter, and four

Top: *The prototype Vampire LZ548/G photographed in November 1944.* Above: *The Gloster E1/44 was built as a possible fighter-bomber. Note the wide undercarriage track and obvious ancestry with the Gloster E.28/39, apart from side air intakes.*

examples of the H1 ('Halford 1) were ordered in May. Enormous stresses within the engine were only surmounted by an ample application of de Havilland enterprise. MAP tried without success to interest the company in developing an economical turbo-prop design, but instead, de Havilland designed an experimental jet aircraft, the E.6/41 or DH 99 (renamed DH 100 Vampire) to test the H1, choosing a twin-boom layout whose small surface area reduced drag. Fitting the engine in a central nacelle gave it an advantageous short tail pipe. It was a tough struggle to persuade MAP to place an order. Behind the backs of the de Havilland team attempts were made to get Hawker's Sydney Camm to design a Halford jet fighter in lieu of his B.11/41 fast bomber. He declined and eventually two DH 100 prototypes were ordered on 29 July 1941.

The 'Pioneer's' success encouraged a production order for the Gloster F.9/40. Now with a 43ft wing span, and powered by a 1,640lb st Whittle W.2B (B denoting its Rover Barnoldswick origin), such an F.9/40 was on 21 June 1941 forecast to reach 30,000ft in 24 minutes, have a top speed of 440mph and cruise for 1.54 hours at 300mph. With 1,800lb st engines it looked likely to reach 460mph. Intimation of production intent in June 1941 was followed in August 1941 by an order for 300 examples and on 11 August the name Thunderbolt was promulgated for it. Sufficient examples were being ordered to support the equipment and wastage of six squadrons over a six month period.

Consumption of up to 250 gallons of 'high grade paraffin' per sortie meant that extensive new storage facilities were also needed. Revised plans called for the fighter to be operational before the close of 1942, which meant delivery of the first four production aircraft during July 1942, 80 a month by December and eventually a monthly output of 160. Optimism indeed, for by February 1942 the E.28/39 had yet to test from Edgehill a smoother, quieter engine, the Whittle W.1A while Rover's W.2B for the Thunderbolt was still months away. With the USA now in the war the fighter was renamed Meteor, to prevent confusion with the Republic P-47 Thunderbolt.

Attention had to be particularly directed onto the Rover W.2B/26. It was under attaining so badly that, in November 1941, it had been de-rated to 1,000lb st. Sub-contracting, production planning, labour problems, skills acquisition, all plagued the engine. Delivery of the dozen prototype Gloster F.9/40s by March 1942 was to have been synchronised with that of 30 Rover developed engines. Instead, development was so slow that May 1942 saw a decision - despite the major wing and nacelle changes necessary – to install the Metro-Vick F2 in DG204 and Halford H1 in DG206 to hasten F.9/40 airframe flight trials. By the next month only DG202 was complete, with DG204 following in August.

In the meantime F.9/40 DG202 was fitted with 1,000lb st W.2Bs for taxying only. Weighing in at Rowley Mile and showing 9,570lb with tanks half full, it made its first high speed taxi run on Newmarket Heath on 10 July 1942. During the second run, with its engines at 15,000 revs, the aircraft was flown a few inches above the rough grass runway.

W.2B progress was very slow and Rover so uncooperative, that on 2 March 1942 Whittle and Power Jets began a redesign called the W.2/500, getting up and running well within six months. New materials improved the turbine blades although they suffered from resonance problems. So serious was the W.2B situation that orders were given in September 1942 to fit H1s to a second F.9/40 and complete it to operational standard as a Mk II, as the prototype of what was now to be the prime variant. That must have been a disappointment to Frank Whittle.

Possibly the W.2 was too ambitious, but a few days after the decision to re-engine the F.9/40, cancellation of the entire jet programme was mooted. Not until 1944, it

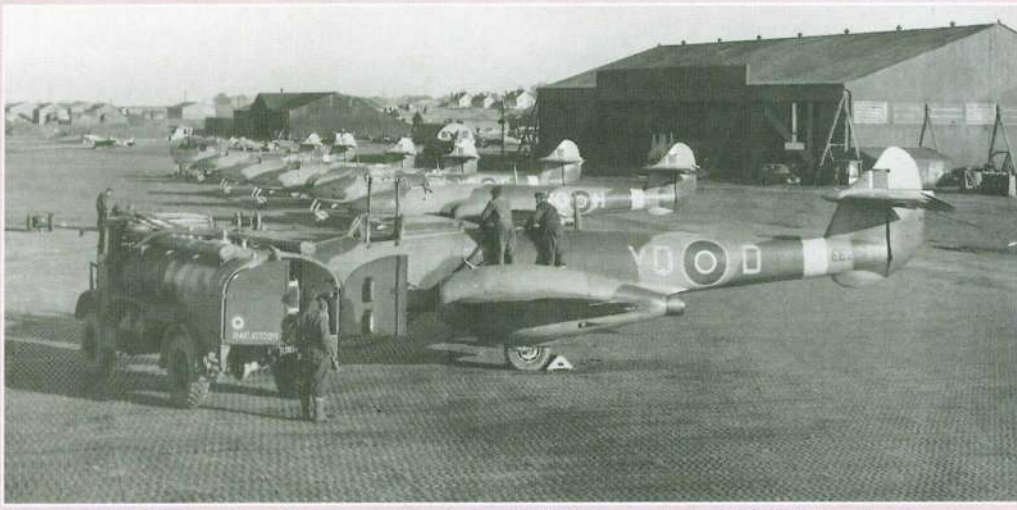
was claimed, would any engine perform satisfactorily, by which time the Meteor would be obsolete. Strident voices persistently called for cancellation, especially as the Merlin 61 high-altitude Mosquito was performing superbly and the Luftwaffe high-altitude bomber threat had faded. On 21 October Air Marshal Sir Ralph Sorley, Assistant Chief of the Air Staff, expressed his disappointment with the likely Meteor I, reckoned that the Mk II was only a little better and that a W.2/500 or B37 engined Mk III would be merely 'superior'. He reckoned that all would be 'surpassed by the Westland Welkin', and 'only good for a short while.' In its Stage 4 edition the Welkin was expected to reach 460 mph at 35,000ft and have a 49,000ft ceiling. General belief now was that piston-engine fighters would remain superior for many years. Calls for cancellation became stronger still, although one bizarre feature in the jet's favour was the ease by which it could be air-towed to overseas theatres because it lacked a propeller!

Early in 1942 Rover had received permission from MAP to develop a 'straight through' design based upon the W.2B. Called the B26 it began running in November 1942 and was soon producing 1,450lb st and showing good promise. That at least helped the Controller Research & Development to rescue the Meteor with a suggestion to cut the contract to just 50 aircraft for trials. Instead, and after much consideration, the existing production order survived, although the F.9/40 order was reduced to eight. By February 1943 27 Meteor airframes (six for engine development) were under construction and a call made for 30 Meteors a month to be built by September 1943.

In an attempt to speed development of the Power Jets W.2/500 the MAP had in December 1942 requested that an example of that engine be installed in the E.28 W4041 for flight testing from Farnborough. The second E.28 W4046 was having a 1,200lb st Rover W.2B fitted – for which there were now three basic versions: the Series I, the 1,600lb st Series III (now named the Welland I) and the Series IV Welland II, fitted with a 'Nimonic 80' blade turbine'. By December 1942 the W.2B's highest power output was still 1,450lb, and only a de-rated W.2B version had flown in the E.28/39. Worst of all, the Meteor I's top speed looked likely to be only 430mph, reached at 30,000ft, a performance no better than the Hawker Tempest's

Major problems that had overtaken Rover's Barnoldswick factory, came mainly from attempts to put the W.2B into production too soon. Surge, combustion, airflow irregularity, high temperature affects upon materials, all needed correction. Rover's investment in its jet programme had been high, yet at the end of 1942, the 1,600 production work force was still awaiting a chance to build the W.2B. Power Jets, who had passed design plans and patents to Rover without any firm commercial agreement, were resenting the way in which the company was 'interfering' with fundamental engine development.

At the start of 1943 only the Whittle W.2/500 and Halford H1 were available for installation in any F.9/40, only four airframes of which were complete. First run on 13 June 1942 the H1 was forecast to be the first 3,000lb st engine. On 8 August 1942 with the second H1 running well, 100 production engines were ordered from de Havilland although by November it was clear that the high thrust forecast would only be produced by installing a larger turbine. DG206/G fitted with two H1s was taken by road under close guard to Cranwell. Taxiing and a few moments of flight at 11,500lb weight were undertaken on 3 March 1943 – just before production began of the W.2B Welland. Two days later Michael Daunt took the aircraft on its first flight, quickly ended because of excessive yaw as soon as about 230 mph ASI was reached. Rudder modifications were essential, but before any more flights took place DG206 was moved by road to Newmarket Heath where security was better, with soldiers, instead of airmen, guarding the aircraft. Using the 3,000 yd grass run, the longest available in Britain at that time, the first of five brief early morning flights with tanks half full, was made on 17 April 1943. Then on 28 May, DG206 (weighing 12,508lb) took off on a cross country flight to the airfield at Barford St John, near Banbury.



Line-up of No 616 Squadron Meteor 1s at Manston in 1944. The nearest aircraft, EE219, flew the first operational sortie by a Meteor.

As early as 1940 Whittle had asked Tizard to try involving Rolls-Royce in his work but was told that the company had its own plans. When E W Hives and Dr Stanley Hooker saw the W.1 run, an engine as powerful as a Merlin and weighing half as much, co-operation began and slowly developed. Late in 1942, when Air Chief Marshal Freeman revealed plans to cut turbo-jet production, Rolls-Royce came to the rescue by trading its armoured fighting vehicle engine division for the Rover jet factories at Barnoldswick and Clitheroe. Roll-Royce took over full technical management on 1 January 1943, quickly revitalised the W.2 and soon had the W.2B/B23 in production. With two of those 1,400lb st engines installed, DG205 first flew from Barford on 23 June 1943. Development of the Meteor then forged ahead. High hopes were also pinned on DG204 with its slim, underwing, low revving axial flow F2 engines featuring the lowest stressed engine parts and lowest fuel consumption. Nothing is perfect. A heavy unit, its compressor was difficult to start and easily stalled, and when DG204 began taxying trials at Barford on 3 August 1943 the F2s high idling performance put excessive demands upon the brakes. Technically highly advanced, the F2 layout formed the basis of many a future engine.

Fitted with a new centre section in August 1943, DG209 became the test bed for the Rolls-Royce W.2B/37 Derwent 1, a robust B23 embracing the Whittle W2/500. By 1944 the B23 Welland was running trouble free for 100 hours, and the focus had switched to larger turbines and stronger engines giving much higher thrust. Power Jets W.2/700 typical in those respects was influencing the design of the Derwent V and more powerful B.41 Nene. There was also the realisation that the problems of high speed flight, and the adventurous world of supersonics, would soon have to be explored. Almost in a matter of weeks the entire prospects of the jet era were radically transformed, and Rolls-Royce had a large share in that.

On 11 June 1943 agreement was reached to fit only the first 20 Meteors with Welland 1s making them little more than development aircraft. The Mk II being too heavy to proceed with, the remaining 280 Meteors would be Mk IIIs powered by superior W.2B W.2/500 derivatives.

An important official review of June 1943 advocated a second generation of British jets comprising a short range interceptor fighter and a medium range high-speed bomber. The former, with a 3,000lb st engine for rapid climb, or a 4,000lb st engine specially for speed, eventually emerged as the Gloster Ace nearly chosen as the RAF's standard fighter to serve well into the 1950s. As for the bomber? Estimates suggested that a Lancaster-sized aircraft needed four 7,000lb st ducted fan turbines, that in 1943 was a distant dream. The RAF would first have to exploit the Meteor, the first production example of which flew on 12 January 1944.

Postscript

A pair of Meteor 1s from Farnborough arrived at RAF Culmhead on the afternoon of 21 July 1944 on attachment to No 616 (South Yorkshire) Squadron. EE213/G and EE214/G were the first to see service with a squadron, a further five joining them two days later.

They all moved to RAF Manston, Kent to combat V-1 flying-bombs, from where, at 14.30 hr on 27 July, Flying Officer McKenzie in EE219 'D-Dog' made the RAF's first operational jet flight, patrolling between Ashford and Robertsbridge. Flying Officer T D Dean later chased a V-1, reaching a speed of 405 mph. On 29 July Wing Commander Wilson was the first to open fire on a V-1 and Flying Officer Dean made the first kill in the mid-afternoon of 4 August. He dived on his quarry, closed at 450mph, discovered all guns had stoppages, then tipped the bomb over with his wing tip and saw it crash south of Tonbridge.

Fired in large salvoes confusingly and to no set pattern, V-1s were most numerous at the start and end of each phase. When the main daylight assault ended on 5 September 1944, Meteors – too few to really influence events – were credited with 8.5 destroyed, out of about 1,900.

Prune's Message

Wing Commander David Roome

Prune's Progress

"It is impossible to exaggerate the importance of constant training in ensuring the highest operational efficiency. We must never regard training as being confined to the early stages. Training never stops, and Tee Emm *contains valuable hints and lessons for you all at all stages of your Air Force careers."*

From April 1941 to March 1946 the Royal Air Force tried to inculcate a good Flight Safety awareness amongst its aircrew, together with survival hints, gunnery techniques, how to navigate etc, through the medium of Training Memoranda, issued monthly and soon abbreviated by everyone to *Tee Emm*. The front page of every issue bore an exhortation from the Chief of the Air Staff, Air Chief Marshal Sir Charles (later Lord) Portal and his Foreword in 1943 included the words above.

To get across the message *Tee Emm* used a hapless band of disaster-prone aircrew including Plt Off Prune the pilot, Fg Off Fixe the navigator, Sgt Burste the air gunner and others, including Sub Lt Swingit of the Fleet Air Arm and, to keep up the male interest, the delightful WAAF Winsum.

The magazine was not simply a Flight Safety publication, (there was, after all, a war on), and many of the articles covered operational aspects, such as how to be successful at air-to-air gunnery without tracer (which had induced a form of 'hosepipe' aiming, ie trying to run the line of tracer through the target instead of using a calculated deflection). But the end of the war brought about many changes within the RAF and in March 1946 the final issue of *Tee Emm* 'hit the streets'. MRAF Lord Tedder, the CAS of the day, wrote the final Foreword:

"I am sure that the Service has benefitted greatly from reading its characteristically humorous and readable pages, which have enabled a vast quantity of 'gen' of the most serious and important kind to be absorbed. Many a prospective 'Prune' is alive now because he read 'Tee Emm'.

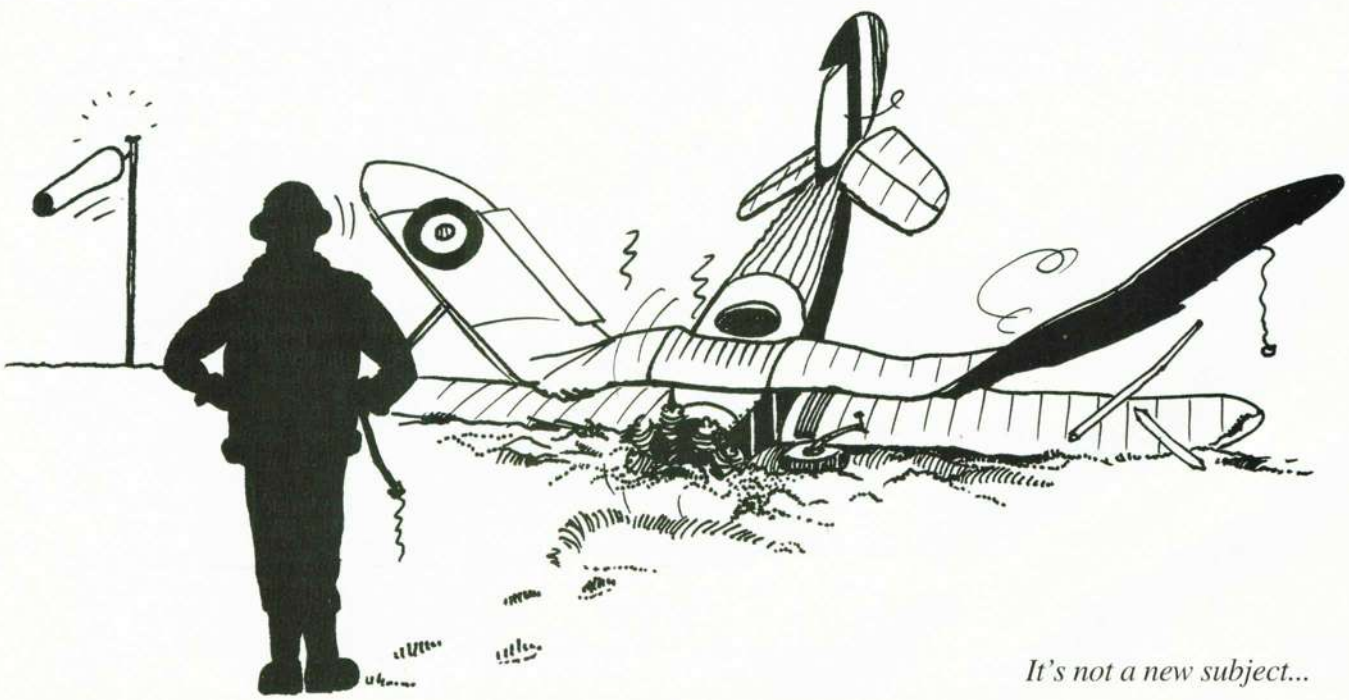
I hope that, throughout the Service, bound copies of 'Tee Emm' *will be kept accessible, so that the odd moment may be beguiled with tastes of that blend of wit and wisdom which has been the essence of* 'Tee Emm'.

Although the time has come when 'Tee Emm' *must cease, Prune and his fellows are still with us; they are eternal, they typify human fallibility, carelessness and folly. Thanks to* 'Tee Emm' *we have been helped to see them for what they are; we must not let them hide themselves in the crowd again. The cold air of publicity and ridicule is one of the most valuable weapons in the campaign against finger-trouble."*

Although using somewhat outdated phraseology those words are as valid today as they were 50 or so years ago. Although we have achieved a massive improvement in accident numbers – the RAF had 310 major accidents in 1946 – there is never room for complacency when it comes to Flight Safety. One unfortunate fact about today's accidents is that they cost somewhat more than those of 50 years ago. Comparison of prices between Meteors and Tornados is meaningless unless expressed in percentage terms of the Defence Budget, but today an aircraft lost may never be replaced; attrition buys are vulnerable to budget economies and eventually the aircraft manufacturer's line closes, thereby making replacement using a new aircraft impossible. As an example, the crash of a USAF E-3 in 1995 with the loss of all 22 on board means one less Boeing 707 airframe, with no new 707s available.

It's not a new subject...

You may say that there is nothing about Flight Safety that hasn't already been said,



It's not a new subject...

indeed nothing new about Flight Safety since Daedalus and Icarus found out about solar heating by refusing to accept the level cleared to by ATC and climbing higher, and you would probably be right. We continue to have accidents because some of the lessons have to be learned time and again. The difficulty lies in getting the point home and typical of this is the operation of aircraft in winter weather. In the UK we have been lucky in recent years and experienced a series of mild winters; there are those who have been flying for some years without ever seeing extreme weather. However, the winters of 1947, 1963 and 1979 were all very severe (by the time you read this we shall know if the 16 year interval between such events has been maintained!). So, in teaching aircrew and groundcrew how to prepare for winter operations we find that the 'corporate memory' plays a useful part. You'd be amazed at how apposite some old articles can be; dusted off, perhaps updated to improve their topicality and then used to good effect, their message can be as effective now as it was on first printing. Not always, though. In 1943, aircrew were encouraged to read their Pilots' Notes – an idea which only originated in 1939 – and to sell this line, the back cover of *Tee Emm* portrayed a cartoon, usually a play on well known adverts of the day, along the lines of 'What we want is Pilots' Notes' rather than a well known beer, but they even used..... it wouldn't be allowed these days!

So, what lessons are the most important?

There will always be those who are new to aviation, both to flying or maintaining aircraft. These new people are keen to learn, usually with a thirst for knowledge, and not just for the simple motor skills. Those of us with more experience must be willing to pass it on – and I don't mean by boring the pants off people with long-winded tales of flying Sharjah Shackletons or Borneo Belvederes, but by imparting the knowledge in a way that encourages the individual to learn more. Moreover, we should aim to put a gloss on the basic knowledge. For example, specialists teach the various ground subjects, meteorology, air traffic control, navigation, technical systems and so forth, but it is the experienced aviator who is best placed to pass on the ways in which that specific knowledge should be applied. The blend of overall knowledge – airmanship in the true sense of the word – is what we should be aiming to impart, though we must accept that much comes only with time.

Allied to the imparting of information to the less experienced is the vital need for all of us involved with aviation to be totally honest, particularly when reporting an incident or, more importantly, a near-incident. Despite all the publicity exhorting honest and open reporting, there is still a great deal of reluctance on the part of individuals to report incidents.

In the RAF, whilst 40% of accidents are attributed to Aircrew Human Factors only 4% of reported incidents have the same cause code. Put baldly, there is little doubt that much goes unreported. Does anyone really want to read the account of a fatal accident and realise that *they* had faced the same problem some time before and got away with it, but had chosen to keep quiet? Had they reported the problem the other crew might still be alive. We have to encourage honest reporting by everyone involved in aviation, and general discussion is often a good way to do so, whether that is in the crewroom, conference room, bar or wherever.

Although there are those who fear that any admission of a mistake will bring down the wrath of their superiors, and abbreviate their career length accordingly, those at the top of the tree in aviation have stated again and again that honest admission of genuine mistakes will not be punished. Remember though, that no one should expect the results of reckless behaviour or of gross errors of skill to be treated sympathetically, especially where it results in the loss of valuable equipment or, worse still, of life.

Resource Management

Make best use of resources. This does not mean the storeman who refuses to issue his last set of flying gloves 'because they might be needed at short notice', but is the management of what is available to you in the cockpit, Flight Deck, Air Traffic Tower and so on.

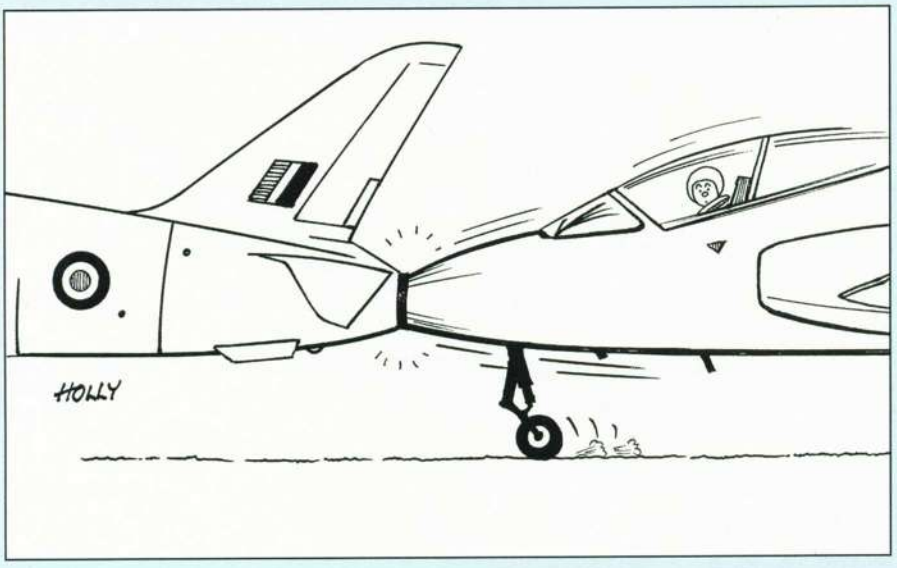
Crew (or cockpit) resource management has been around for years in the civil aviation fraternity and on the large aircraft flight deck, but is a newer concept for the military fast jet aircrew. We used to call it 'Crew Co-operation', but that often meant little more than the pilot keeping his nav in the picture about what he planned to do next. For the majority it also implied coordination only within the individual crew or aircraft. But it is just as important for the good fast jet four-ship leader to use his No 3 to complete a complex fuel burn calculation and the No 4 to pass an emergency message on another frequency, leaving the Lead with no distractions while he checks his wingman for damage after a birdstrike.

Sit down and work out for yourself how you can make best use of the resources generally available to you in the air, whether by use of your crew or by other aircraft in the formation. Do not forget, use those on the ground if they can be of help. Expertise can be obtained from air traffic control, or from other aircrew who, as they don't have the same levels of adrenalin as the pilot trying to deal with the problem, can provide balanced and sensible assistance quickly.

To finish on a lighter note, back in the *Tee Emm* days, there was the *Most Highly Derogatory Award of the Immovable Finger* (MHDOIF) which, of course, were awarded to examples of the 'finger-trouble' to which Lord Tedder referred. Some of the 'awards' may not be seen today, for example:

'To Sqn Ldr Plum for a notable attempt to exercise wartime economy, when he jettisoned his depth charges over land rather than over the sea. His explanation was that they might then be used again'.

But how many of us have heard a lengthy transmission go out, followed by the statement 'You're still on Approach frequency!' I know I have, it's been said to me!



Wing Commander David Roome OBE, MRAeS, RAF is Command Flight Safety Officer, Personnel & Training Command, RAF.

THE RAF's YEAR 1995

Brian Strickland reviews some of the highlights of 1995.

JANUARY

•The E-3D Sentry AEW1 component of the NATO Airborne Early Warning (AEW) Force, based at **RAF Waddington**, was declared fully operational. It has been involved in UN operations over the former Yugoslavia since July 1992 when Operation *Maritime Monitor* commenced.

While on their fourth deployment to **Incirlik** in Turkey, as part of Operation *Warden* (which is the British contribution to the coalition Operation *Provide Comfort*) to protect the Kurds in Northern Iraq) a sortie by four **Harrier GR7s** of **No 4 Squadron** passed the landmark of 5,000 hours flown by **Harriers** since they took over from Jaguars in April 1993.

Damien Brogden

•**Rapier 2000**, the new low-level air defence system, was rolled out by the Dynamics Division of British Aerospace at Lostock. The system is set to enter service with the RAF Regiment.

•On 27 January a parade, flypast and ceremony marked the closure of **No 11 Maintenance Unit** at **RAF Chilmark, Wilts**.

•By 31 January, RAF **Hercules** aircraft had airlifted 22,345 tons of humanitarian aid into the war-torn former Yugoslavia during the previous two-and-a-half years, as part of Operation *Cheshire*. On average, 14 flights a day had delivered a load of 163 tons of food, medicine and other aid to Sarajevo.

FEBRUARY

•A new **Harrier GR7** Mission Simulator was handed over to **RAF Laarbruch** by MoD(PE) and Thomson Training and Simulation.

•The first of the RAF's six new **Sea King HAR3As** search and rescue helicopters (ZH540) made its maiden flight at Westlands, Yeovil. It is the most advanced SAR Sea King, and has a Thorn EMI colour radar, Racal RNS 252 navigation computer together with improved communications, using Rockwell-Collins VHF/UHF radios. A new Smith-Newark SN500 automatic flying control system is also fitted.

•**No 84 Squadron** flew its last ex-Royal Navy **Wessex HU5C** (XT463), at RAF Akrotiri, Cyprus following the changeover to the **Wessex HC2**. The paint scheme has also been changed to an all-over grey with low visibility markings.

Flt Lt Jo Salter, aged 26, of **No 617 Squadron** became the first female combat pilot. Jo gained her wings at **RAF Valley** in April 1992 and was posted to **RAF Lossiemouth** to fly the **Tornado GR1B**. She was commissioned into the Engineering Branch, gaining a B Eng degree from the Royal Military College of Science at Shrivenham before starting initial officer training at Cranwell in October 1989 – just two months after the announcement that women could qualify to fly non-combat aircraft (the decision to extend female aircrew to combat roles was taken in December 1991).

PRM

•On 24 February the first **Jaguar GR1B** modified to take the TIALD thermal imaging and laser designation pod was formally handed over to the RAF by the Defence Research Agency at **Boscombe Down**. The Jaguar GR1B will also be equipped with a 1,000lb laser-guided bomb, Phimat chaff dispenser and ECM pod. A further seven **GR1s** to be converted at **RAF St Athan** and two T2 trainers will be similarly modified to T2B standard.

MARCH

•FR Serco Ltd was awarded a five-year multi-million pound contract to carry out maintenance on the RAF's fleet of **Nimrod** maritime patrol aircraft. The work will be done at **RAF Kinloss**.

•GEC-Marconi Avionics won a contract to supply modifications to the AQS901 acoustic processor on the **Nimrod MR2**.

•Flt Lt Elaine Taylor became the RAF's first fast jet navigator with **No 25 Squadron** at **RAF Leeming** flying on air defence duties.

•The RAF's latest tactical trainer, JOUST, was installed at **RAF Coningsby** – a system that was developed to validate the design philosophy behind **Eurofighter 2000**, but has wider potential as a training aid for fast jet pilots and navigators.

•The Harrier OCU/No 20 (Reserve) Squadron made its first operational sortie with a new **Harrier T10** two-seat trainer, at **RAF Wittering**. The RAF is due to receive 13 T10s, which is a two-seat version of the GR7 day/night all-weather capable aircraft and is fully equipped to train pilots for day and night attack missions.

•The Armed Forces Minister announced the closure of **RAF Scampton**, **Finningley** and **Locking** by 1 April 1996. There were plans to reduce **RAF Newton** to an enclave.

The **Queen's Flight** disbanded at **RAF Benson** on 31 March, after more than 50 years of service. Groundcrew dispersed to other units while the aircrew and aircraft became part of **No 32 (Royal) Squadron**, restructured into three flights at RAF **Northolt**.

Brian Strickland

Below: *In March 1995, the Harrier OCU/No 20 (Reserve) Squadron made its first operational sortie with the new Harrier T10 two-seat trainer, at RAF Wittering.* Phil Boyden, BAe

•**RAF Stanbridge** closed as a self-accounting unit on 31 March and became a satellite of RAF **Henlow**.

•On 31 March a formation flypast of nine **Tucanos** flew over **RAF Cranwell** to mark the trainer's withdrawal from No 3 FTS – and the end of basic flying training at Cranwell. This task is now concentrated at **RAF Linton-on-Ouse**.

APRIL

•On 1 April RAF **Wyton** ceased as an independent station and became part of **RAF Brampton**.

•The first deployment of RAF **Tornados**, six GR1A/Bs, arrived at Incirlik, Turkey on 3 April, replacing the **Harrier GR7s** on Operation *Warden*.

ANDOVER RETIRED FROM RAF SERVICE

Daniel March

On 31 March the last **Andover** was retired from RAF service after 30 years. Thirty-one of these aircraft were built and delivered between July 1965 and September 1967. One Andover remains with the Defence Research Agency and another for Open Skies Monitoring of former Warsaw Pact countries. The two **Andover CC2s** of **No 32 Squadron** were put up for sale.

•Used by the USAF since WW2, for storing conventional weapons, **RAF Welford** was handed back to the RAF.

•The **Joint Elementary Flying Training School** (JEFTS) moved from Topcliffe to RAF **Barkston Heath**. It continues to be operated by Hunting Aviation and is equipped with 18 civil registered **Slingsby T67M Fireflies**.

The RAF's oldest operational aircraft – **Canberra T17A** WD955 – ended its military service on 27 April. It was originally delivered to the RAF on 14 November 1951 and became the first Canberra B2 with **No 617 Squadron** at RAF Binbrook. Later converted to a T17 it was operated by No 360 Squadron. The veteran was flown from **RAF Marham** to Bodo in Norway, where it became an exhibit in the Norwegian Aviation Museum.

PRM

•Two further **Tucano** operators re-located to the Vale of York when the **Central Flying School** (instructor training) and **No 6 FTS** (navigator training) moved from **Scampton** and **Finningley** respectively to **RAF Topcliffe**.

•The RAF's two **Operational Evaluation Units** (the F3 OEU at RAF Coningsby and the Strike/Attack OEU at Boscombe Down) were renamed as elements of the **Air Warfare Centre**, that was established in 1994 with its headquarters at High Wycombe.

•**RAF Newton's** 55-year history as a flying and ground training unit came to an end on 1 April when it was reduced from station to enclave status. Administrative responsibility was transferred to RAF **Cranwell**.

•Catering training in the RAF returned to its roots of 76 years ago when the RAF School of Catering reformed at **Halton** as the Catering Training Squadron (CTS) under the Specialist Training Wing on 1 April.

•Two **Hercules** left **RAF Lyneham** on 14 April for Catumbela in Angola, where they were the initial activation of the United Nations Angola Verification Mission code-named Operation *Chantress*.

MAY

•An electronic reconnaissance **Nimrod R1** (XV666) of No 51 Sqn ditched off **Lossiemouth** on 16 May when both starboard engines caught fire during a test flight following major servicing at RAF Kinloss. All seven crew were rescued less than ten minutes after the aircraft hit the water.

On 12 May **No 216 Squadron** celebrated ten years flying the **Tristar** over the South Atlantic to the Falkland Islands. The journey, via Ascension Island, has now been successfully repeated more than 1,100 times since the late Spring of 1985.

PRM

•**RAF Portreath** ceased as an independent station, when it became a satellite station of **RAF St Mawgan.**

•RAF **Harrier GR7s** deployed to **Chivenor** to take part in Exercise **Hill Foil 95** – a 12-day operation conducted as part of the preparation of air and ground crews for their role with NATO's rapid reaction forces. Aircraft were drawn from **No 1 Squadron** based at **RAF Wittering** and **Nos 3 and 4 Squadrons**, from **RAF Laarbruch.**

NEW PLATFORM FOR PARACHUTISTS

Peter J Cooper

More than a hundred years of British military ballooning came to an end on 31 March with the disbandment of the RAF's Balloon Operations Squadron. It had been based at **RAF Hullavington** since the early 1950s. The gas balloons were replaced by Skyvan light aircraft operated by a private contractor.

•During Exercise **Strong Resolve** that took place in Norway, **No 2 Squadron** from **RAF Marham** tested white/grey and white/green camouflage on two of its **Tornado GR1As**.

JUNE

It was announced that the Defence Helicopter Flying School (DHFS) will form at RAF **Shawbury** on 1 April 1997. The school will consolidate the helicopter training of all three services (No 2 FTS, RAF; 705 Naval Air Squadron and 670 Squadron, AAC). It will be operated under a civilian contract, using either existing Gazelles or an alternative civil helicopter. Final details to be announced in April 1996.

Twelve **Chipmunks**, one from each RAF Air Experience Flight, flew into Cranfield for the Popular Flying Association Rally on 30 June. 1995 was the last year in which the majority of **Air Experience Flights** were equipped with the Chipmunk.

PRM

•It was announced that the RAF's **WE177** free-fall nuclear weapons were to be withdrawn from service by the end of 1998. They are available to the RAF's six **Tornado GR1** squadrons.

JULY

•A belated celebration was held at **RAF Marham** on 8 July, with a formation flypast of Tornado GR1As, to mark **No 13 Squadron's** 80th anniversary. In January, the squadron was involved in Operation *Jural*, far from its base.

•In the last week in July, twelve **Harrier GR7s** of **No 4 Squadron** deployed from **RAF Laarbruch** to begin duties on NATO's Operation *Deny Flight* over the former Yugoslavia. Flying from the Italian AF base at Gioia del Colle, they were the first RAF **Harriers** to participate in this operation.

LAST CFS FLYING AT SCAMPTON

Phil Crow

In May, on the Central Flying School's last flying day at **RAF Scampton**, the Commandant and Deputy Commandant, each flew in all four aircraft types that had operated from Scampton – **Bulldog, Hawk, Tucano** and **Chipmunk**.

•To celebrate the 50th Anniversary of VE and VJ days **International Air Tattoo 95** was designated by the MoD and RAF as **The Victory Airshow**. This was the most ambitious and successful event organised by the RAF Benevolent Fund Enterprises.

AUGUST

•The Air Traffic Control Centre at **RAF Brize Norton** re-opened after completion of a major improvement programme to the radar and communications facilities, costing £1.2million. **Brize Norton** is the UK's second largest military air traffic unit.

•On deployment to Zagreb in the former Yugoslavia, an all-white **Chinook HC2** of **No 7 Squadron, RAF Odiham** became the first UN helicopter to deliver relief supplies to Krajinan refugees on 16 August.

•The first modified **Dominie T2** navigation trainer (XS728) was delivered from Marshall of Cambridge to DTEO Boscombe Down on 15 August for pre-service trials.

•Five **Chinook HC2s**, together with six **Puma HC1s,** deployed to the Croatian port of Ploce on 8 August to provide heavylift support to the elements of 24 Airmobile Brigade already located there.

•As part of the 50th anniversary of VJ Day and the end of World War 2 on 19 August, the BBMF's **Lancaster** dropped poppies along The Mall in an act of remembrance for those who died. It was followed by a large flypast including **Hawks** in a figure of 50 formation, by four **Tornados** and **Harriers,** eight **Jaguars,** four **Hercules,** a **Tristar,** a **VC10** and a **Nimrod** – plus the BBMF **Hurricane.** A variety of helicopters also took part including three **Puma HC1s,** two **Chinook HC2s,** two **Sea King HAR3s** and a single **Wessex HC2** from the RAF.

•For 25 years, except for short periods during the Falklands conflict and the Gulf War, **No 10 Squadron** maintained a twice-weekly VC-10 service to Washington-Dulles from RAF Brize Norton. RAF involvement ceased when British Airways was contracted to provide seats on its scheduled service. VC10 C1K XV103 *Major Edward Mannock VC* made the last flight on 25 August.

FIRST ITALIAN TORNADO F3

Brian Strickland

The first of 24 RAF **Tornado F3s** being leased to the Italian Air Force was handed over at RAF St Athan in June. The first modified aircraft (ZE832/MM7202) was first flown on 22 June.

SEPTEMBER

•The first **Tucano T1** from **No 1FTS** at **RAF Linton-on-Ouse** was finished in the high visibility black colour scheme. This scheme will be adopted by the whole fleet.

•The RAF's new airborne warfare centre was officially opened at **RAF Waddington** on 4 September. The Thomson building (named after the late Air Chief Marshal Sir John Thomson) enables the key areas of tactics, electronic warfare, scientific research and analysis, and air warfare, to be joined in a single centre for the first time.

•A Closure Day Ceremony was held at **RAF Swanton Morley**, the service's largest grass airfield, on 6 September. A **Blenheim** (the aircraft was originally flown by No 105 Squadron into Swanton Morley in 1940) joined other associated aircraft in a farewell flypast. The station was handed over to the Army.

•**No 100 Squadron**, along with its complement of **Hawk T1As** arrived at **RAF Leeming** on 21 September on relocation from **RAF Finningley**.

CHINOOKS ON UN STANDBY

R J Ward

In July, three **Chinook HC2s** of **No 7 Squadron** were painted in UN colours and held on standby to support UNPROFOR.

•With the closure of **Finningley** the Joint Forward Air Control Training & Support Unit (JFACTSU) also relocated to **Leeming.**

•Seven aircrew, from **No 120 Squadron** at RAF **Kinloss**, were killed when their **Nimrod MR2** (XV239) crashed into Lake Ontario on 2 September whilst taking part in the CNE Airshow at Toronto.

OCTOBER

•Yorkshire Universities' Air Squadron returned to **RAF Church Fenton** with a formation fly-in from **RAF Finningley.** The squadron relocated as part of the closure of **Finningley** – having originally formed at **Church Fenton** in 1969.

•On 1 October the final **Dominie T1s** and **Jetstream T1s** were transferred from **RAF Finningley** as the build up of **No 3FTS** at **RAF Cranwell** was completed. Twelve of each type joined the **Bulldog T1s** already in residence.

•The RAF's first **C-130J-30 Hercules C4** (ZH865) was rolled out of Lockheed Martin's factory at Marietta, Georgia on 18 October. Twenty five examples of the new type have been ordered, of which the first 15 will be the stretched C-130J-30 (C4) version.

•**RAF Chivenor** was handed over to the Royal Marines on 26 October. A Sea King HAR3 of A Flight, No 22 Squadron made a flypast. The SAR Flt, that was called out 300 times in 1995 (the UK's highest), continues to operate from Chivenor.

•A new alliance between the air forces of Britain and France was inaugurated by the heads of the two countries on 30 October at **HQ Strike Command, High Wycombe**. The formation of the Franco-British Euro Air Group (FBEAG) is intended to build upon the existing complementary elements of the RAF and French AF and to improve their capability to undertake combined operations.

NOVEMBER

The last operational sortie by a **VC10 C1** of **No 10 Squadron** was flown on 20 November by XR808 *Kenneth Campbell VC*. The aircraft was delivered to FR Aviation at Bournemouth for conversion to **C1K** tanker/transport configuration.


PRM

•Sq Ldr Simon Dyde became the first RAF test pilot to fly the **Eurofighter 2000**. He took Development Aircraft 2 (DA2) ZH588 on its 57th flight from BAe's flight facility at Warton on 9 November.

•The first **Puma HC1** to have a comprehensive Navigation Update was delivered to the RAF at **Odiham** 10 November. Three specific areas have been upgraded – night operations, the navigation suite and the installation of a self-defence suite.

•The *Red Arrows* left RAF **Scampton** for the last time when they set off on their world tour on 23 November. On return, they will be based at **RAF Cranwell,** although continuing to use Scampton's airspace for training flights.

DECEMBER

•David McCafferty, aged 15 of Durham School CCF became the last cadet to fly in a **Chipmunk** from **RAF Leeming**. The Air Experience Flights were being reduced from 13 to 11 and amalgamated with University Air Squadrons – the remaining RAF **Chipmunks** were to be finally retired by April 1996 and replaced by **Bulldogs**.

More than 1300 people were rescued by **RAF and RN SAR helicopters** and **RAF Mountain Rescue Teams** in 1995, a small increase on the previous year. There was a 13% increase in the number of times assistance was requested by the civilian emergency services. The total of 2250 call-outs to help the police, fire and ambulance services was the highest ever recorded.


Patrick Allen

•**Hercules** from all five **RAF Lyneham**-based squadrons completed 205 sorties during the month in support of Operation *Resolute,* airlifting men and equipment of the NATO Implementation Force to Bosnia and Croatia. Tristars of No 216 Sqn and **VC10s** of **No 10 Sqn**, also flew ten sorties carrying 1,600 personnel to Croatia.

•SAR crews of **No 202 Squadron, D Flight**, broke their own record of call-outs with a total of 247 in 1995. The previous highest number was 241 in 1992.

OPERATION DENY FLIGHT DETACHMENTS



Aviation Photographs International

On 1 August the **Jaguars** detached for *Operation Deny Flight* since 1993 relinquished their role to **Harrier GR7s** of **No 4 Squadron**. More than 5,000 hours of flight operations in support of the UN Protection Force in the former Yugoslavia had been accumulated by Jaguars from the three **Coltishall** squadrons. Some TIALD equipped **Jaguar GR1Bs** returned to provide laser designation for the Harriers later in the year.

THE 'BIG GREEN BUS'

Six specially equipped RAF Chinook HC2s were flown to Bosnia-Herzegovina in December to provide support for the NATO Implementation Force (IFOR) under Operation *Resolute*. Operating from Split, with a forward base at Gornji-Vakuf, the detachment is commanded by Group Captain Paul Luker OBE, AFC and includes four Royal Navy Sea King HC4s from 845 Naval Air Squadron. The Chinooks, of No 1310 (Split) Flight, flown by crews from No 7 Squadron, are supporting the Multi-National Division South-West (MNDSW).

For this very difficult task, that has been described as 'an enhanced Northern Ireland threat, in Alpine terrain, under Arctic weather conditions, to Falklands Islands requirements', the helicopters have a variety of special features. This includes an M134 4,000 round mini-gun, Sky Guardian 2/19 Radar Warning Receiver (RWR), improved, forward firing AN/ALE 40 chaff and flare dispenser, Bright Star nose-mounted floodlights and ALQ156-AAR47. Initial tasks included air-lifting troops and equipment from HMS *Illustrious* in the Adriatic to various parts of the MNDSW, during which the Chinooks were dubbed 'The Big Green Bus'.

Above: *The RAF/IFOR Chinook demonstrates its enhanced flare dispenser that provides a ring around the helicopter as a decoy for surface-to-air missiles.*

Left: *An armed No 7 Squadron Chinook HC2 (ZA704) en route between Split and Gornji-Vakuf with the Dinaric Alps in the background. All helicopters operating in the theatre are clearly marked IFOR.* Photos: Patrick Allen

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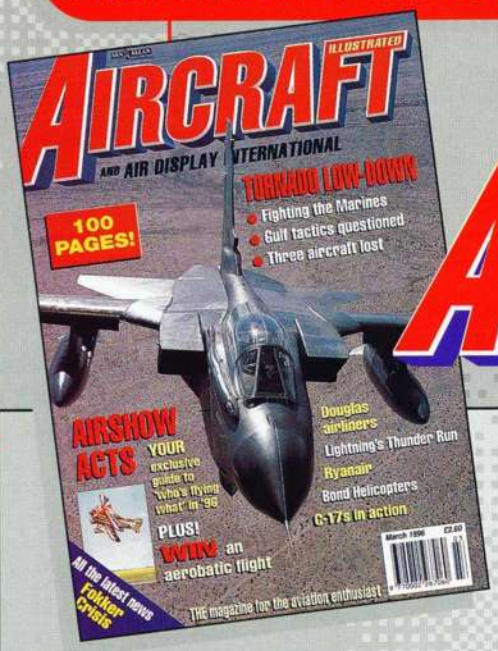

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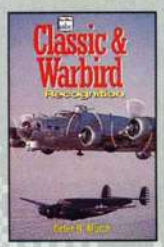

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THE ROYAL AIR FORCE 1996

Peter R March

FLYING SQUADRONS AND UNITS (as at 1 April 1996)

Squadron	Type & nominal strength	Base/Det
1 Sqn	Harrier GR7 (16)/T10 (1)	Wittering
2 Sqn	Tornado GR1A (13)	Marham
3 Sqn	Harrier GR7 (16)/T10 (1)	Laarbruch
4 Sqn	Harrier GR7 (16)/T10 (1)	Laarbruch
5 Sqn	Tornado F3 (14)	Coningsby
6 Sqn	Jaguar GR1A/B (13)/T2A/B (2)	Coltishall
7 Sqn	Chinook HC2 (18); Gazelle HT3 (2)	Odiham/Aldergrove
8 Sqn	Sentry AEW1 (7≠)	Waddingon
9 Sqn	Tornado GR1 (13)	Brüggen
10 Sqn	VC10 C1K (13)	Brize Norton
11 Sqn	Tornado F3 (17)	Leeming
12 Sqn	Tornado GR1B (13)	Lossiemouth
13 Sqn	Tornado GR1A (13)	Marham
14 Sqn	Tornado GR1 (13)	Brüggen
15(R) Sqn (TWCU)	Tornado GR1 (22)	Lossiemouth
16(R) Sqn (JOCU)	Jaguar GR1A (5)/T2A (5)	Lossiemouth
17 Sqn	Tornado GR1 (13)	Brüggen
18 Sqn	Puma HC1 (5); Chinook HC2 (6); Gazelle HT3 (1)	Laarbruch
19(R) Sqn (4 FTS)	Hawk T1/T1A (12)	Valley
20(R) Sqn (HOCU)	Harrier GR7 (11) T10 (6)	Wittering
22 Sqn HQ	Sea King HAR3	St Mawgan
A Flt	Sea King HAR3A (2)	Chivenor
B Flt	Sea King HAR3A (2)	Wattisham
C Flt	Sea King HAR3 (2) [from 1 July 1996]	Valley
23 Sqn (inc SOCU)	Sentry AEW1 (7≠)	Waddington
24 Sqn	Hercules C1/C3 (12)	Lyneham
25 Sqn	Tornado F3 (17)	Leeming
27(R) Sqn (OCU)	Puma HC1 (5); Chinook HC2 (6)	Odiham
28 Sqn	Wessex HC2 (6)	Sek Kong
29 Sqn	Tornado F3 (14)	Coningsby
30 Sqn	Hercules C1/C3 (12)	Lyneham
31 Sqn	Tornado GR1 (13)	Brüggen
32 (The Royal) Sqn	HS125 CC2 (2); BAe125 CC3 (6); Gazelle HCC4* (4);BAe 146 CC2 (3); Wessex HCC4 (2) [*to be replaced by Twin Squirrels from April 1996]	Northolt
33 Sqn	Puma HC1 (12)	Odiham
39 (1PRU) Sqn	Canberra PR9 (5)/PR7 (2)/T4 (1)	Marham
41 Sqn	Jaguar GR1A (13)/T2A (1)	Coltishall
42 (R) Sqn (NOCU)	Nimrod MR2 (#)	Kinloss
43 Sqn	Tornado F3 (15)	Leuchars
45(R) Sqn (3 FTS)	Jetstream T1 (10)	Cranwell
47 Sqn	Hercules C1/C3 (13)	Lyneham
51 Sqn	Nimrod R1 (2)	Waddington
54 Sqn	Jaguar GR1A/B (13)/T2A/B (2)	Coltishall

Harrier GR7 – No 4 Sqn & Bulldog T1 – Bristol UAS

RAF Laarbruch

VC10 K3 – No 101 Sqn & Harrier GR7s – No 1 Sqn

PRM

Sentry AEW1 – Nos 8/23 Sqn

Andrew March

Wessex HC 2 – No 72 Sqn

Bob Archer

OVERSEAS BASED FLIGHTS & OPERATIONAL DETACHMENTS

(included in squadron nominal strengths)

1310 Flt†	Chinook HC2 (4) Support Helicopter Chinook Flight	Split
1312 Flt	VC10 K2/3 (1); Hercules C1 (1)	Mount Pleasant
1435 Flt	Tornado F3 (4)	Mount Pleasant
Operation *Joint Endeavour*	Harrier GR7 (10); Jaguar GR1B (2); Tristar K (2); Sentry AEW1 (2)	Aviano
Operation *Warden*	Tornado GR1/1A (8); VC10 K2/3/4 (2)	Incirlik
Operation *Jural*	Tornado GR1 (8)	Dhahran
	VC10 C1K (1)	Muharraq
Operation *Sharp Guard*	Nimrod MR2 (1)	Sigonella

OTHER FLYING UNITS

1 FTS	Tucano T1 (66) Tucano T1	Linton-on-Ouse Topcliffe
2 FTS (inc CFS)	Gazelle HT3 (17); Wessex HC2 (10)	Shawbury
3 FTS	Dominie T1/T2 (10)	Cranwell
(45 (R) Sqn/METS)	Jetstream T1 (10)	Cranwell
(inc CFS)	Bulldog T1 (11)	Cranwell
4 FTS (inc CFS*)	Hawk T1/1A (72)	Valley
Joint Elementary Flying Training School (JEFTS)	T67M-2 Firefly (18 civilian)	Barkston Heath
Sea King Training Unit	Sea King HAR3 (3)/HAR3A (2) (To be No 203 (R) Sqn† SKOCU)	St Mawgan
Search and Rescue Training Unit	Wessex HC2 (5) [until June 1997]	Valley
Air Warfare Centre (HQ)		Waddington
(Strike/Attack OEU)	Harrier T10/GR7; Jaguar GR1B/T2B; Tornado GR1/1A/1B	Boscombe Down
(F3 OEU)	Tornado F3 (5)	Coningsby
Tri-National Tornado Training Establishment (TTTE)	Tornado GR1 (16)	Cottesmore
Northolt Stn Flt	Islander CC2/2A (2)	Northolt
St Athan Stn Flt	Hawk T1 (1)	St Athan
Red Arrows	Hawk T1/T1A (11)	Cranwell
Battle of Britain Memorial Flight	Spitfire; Hurricane; Lancaster; Chipmunk; Dakota	Coningsby

Notes

* See Nos 19(R), 74(R) and 208(R) Squadrons above.

† To be confirmed

(≠) Shared aircraft

(#) Aircraft from based squadrons

Squadron	Type & nominal strength	Base/Det
56 (R) Sqn (F3 OCU)	Tornado F3 (22)	Coningsby
57 (R) Sqn (OCU)	Hercules C1/C3 (5)	Lyneham
60 Sqn	Wessex HC2 (9)	Benson
70 Sqn	Hercules C1/C3 (13)	Lyneham
72 Sqn	Wessex HC2 (15)	Aldergrove
74 (R) Sqn (4 FTS)	Hawk T1/T1A (25)	Valley
78 Sqn	Chinook HC2 (2); Sea King HAR3 (2)	Mount Pleasant
84 Sqn	Wessex HC2 (5)	Akrotiri
100 Sqn	Hawk T1/T1A (16)	Leeming
101 Sqn	VC10 K2/K3 (9)/K4 (5)	Brize Norton
111 Sqn	Tornado F3 (15)	Leuchars
120 Sqn	Nimrod MR2 (8)	Kinloss
201 Sqn	Nimrod MR2 (8)	Kinloss
202 Sqn HQ	Sea King HAR3	Boulmer
A Flt	Sea King HAR3 (2)	Boulmer
D Flt	Sea King HAR3 (2)	Lossiemouth
E Flt	Sea King HAR3 (2)	Leconfield
206 Sqn	Nimrod MR2 (8)	Kinloss
208 (R) Sqn (4 FTS)	Hawk T1/T1A (25)	Valley
216 Sqn	Tristar K1(2)/KC1(4)/C2(2)/C2A(1)	Brize Norton
230 Sqn	Puma HC1 (15)	Aldergrove
617 Sqn	Tornado GR1B (13)	Lossiemouth

Spitfire XIX – BBMF

PRM

Tornado GR1 – No 31 Sqn

Andrew March

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Northumbrian Universities AS inc **No 11 Air Experience Flight**	Bulldog T1	RAF Leeming
Oxford University AS	Bulldog T1	RAF Benson
Queen's UAS[*] inc **No 13 Air Experience Flight**[*]	Bulldog T1	RAF Aldergrove
Southampton UAS inc **No 2 Air Experience Flight**	Bulldog T1	DTEO Boscombe Down
University of Wales AS	Bulldog T1	RAF St Athan
Yorkshire Universities AS inc **No 9 Air Experience Flight**	Bulldog T1	RAF Church Fenton

[*] Currently active, but expected to cease operations in 1996.

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615 VGS	Viking TX1 (5)	Kenley
616 VGS	Vigilant T1 (5)	Henlow
617 VGS	Viking TX1 (4)	Manston
618 VGS	Viking TX1 (7)	Challock
621 VGS	Viking TX1 (4)	Hullavington
622 VGS	Viking TX1 (6)	Upavon
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625 VGS	Viking TX1 (4)	Hullavington
626 VGS	Viking TX1 (3)	Predannack
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633 VGS	Vigilant T1 (5)	Cosford
634 VGS	Viking TX1 (3)	St Athan
635 VGS	Vigilant T1 (5)	Samlesbury
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637 VGS	Vigilant T1 (4)	Little Rissington
642 VGS	Vigilant T1 (5)	Church Fenton
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661 VGS	Viking TX1 (4)	Kirknewton
662 VGS	Viking TX1 (4)	Arbroath
663 VGS	Vigilant T1 (3)	Kinloss
Air Cadet CGS	Kestrel TX1 (2); Valiant TX1 (4); Vigilant T1 (12); Viking TX1 (20)	Syerston

Daniel March

Jetstream T1 – 3 FTS (45(R) Sqn/METS)

PRM

Bulldog T1 – Bristol UAS/No 3 AEF

PRM

Puma HC1 – No 33 Sqn

CHANGES 1996-1997

- **No 18 Sqn** with its Chinook HC2s, moving from RAF Laarbruch to RAF Odiham by 1 April 1997.
- **No 18 Sqn** Puma HC1s transferring to **No 72 Sqn** at RAF Aldergrove by 1 April 1997.
- **No 23 Sqn** formed at RAF Waddington with Sentry AEW1s; dual role including Sentry Operational Conversion Unit.
- **No 33 Sqn** moving from RAF Odiham to RAF Benson with Puma HC1s by 1 April 1997.
- **No 55 (R) Sqn** disbanded at RAF Brize Norton on 31 March 1996.
- **No 60 Sqn** to disband at Benson by 1 April 1997.
- **Sea King Training Unit** probably to be numbered **No 203 (R) Sqn**, when it becomes the Sea King OCU in mid-1996.
- **No 1310 Flt** adopted as title by RAF Support Helicopter (Chinook) Flight in Bosnia.
- **No 1312 Flt** at Mount Pleasant, FI replaced Hercules C1Ks by a VC10 K2/3/4 (No 101 Sqn) and Hercules C1 (RAF Lyneham Wing) from 1 January 1996.
- **No 2 Group** (previously RAF Germany) absorbed into **No 1 Group RAF Strike Command** on 1 April 1996.
- **Nos 11/18 Groups** merged under a single AOC at Bentley Priory, but retain their separate administrative structures at Bentley Priory and Northwood from 1 April 1996.
- RAF ***Red Arrows*** arrived at RAF Cranwell on 20 February 1996, the team's temporary base, pending a probable move to **RAF Marham** in 1998.
- **No 2 FTS** will become the Defence Helicopter Flying School at RAF Shawbury on 1 July 1997.

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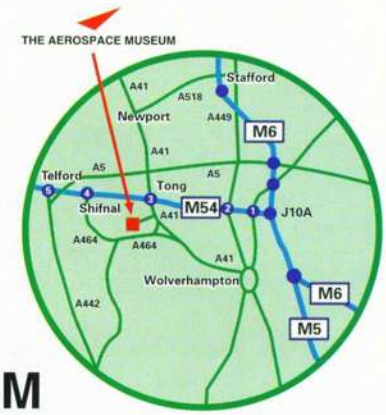

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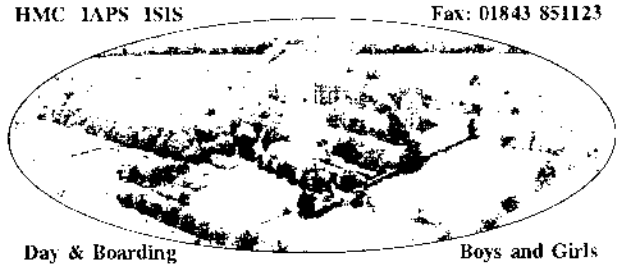

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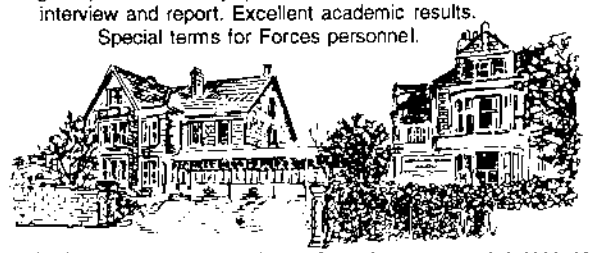

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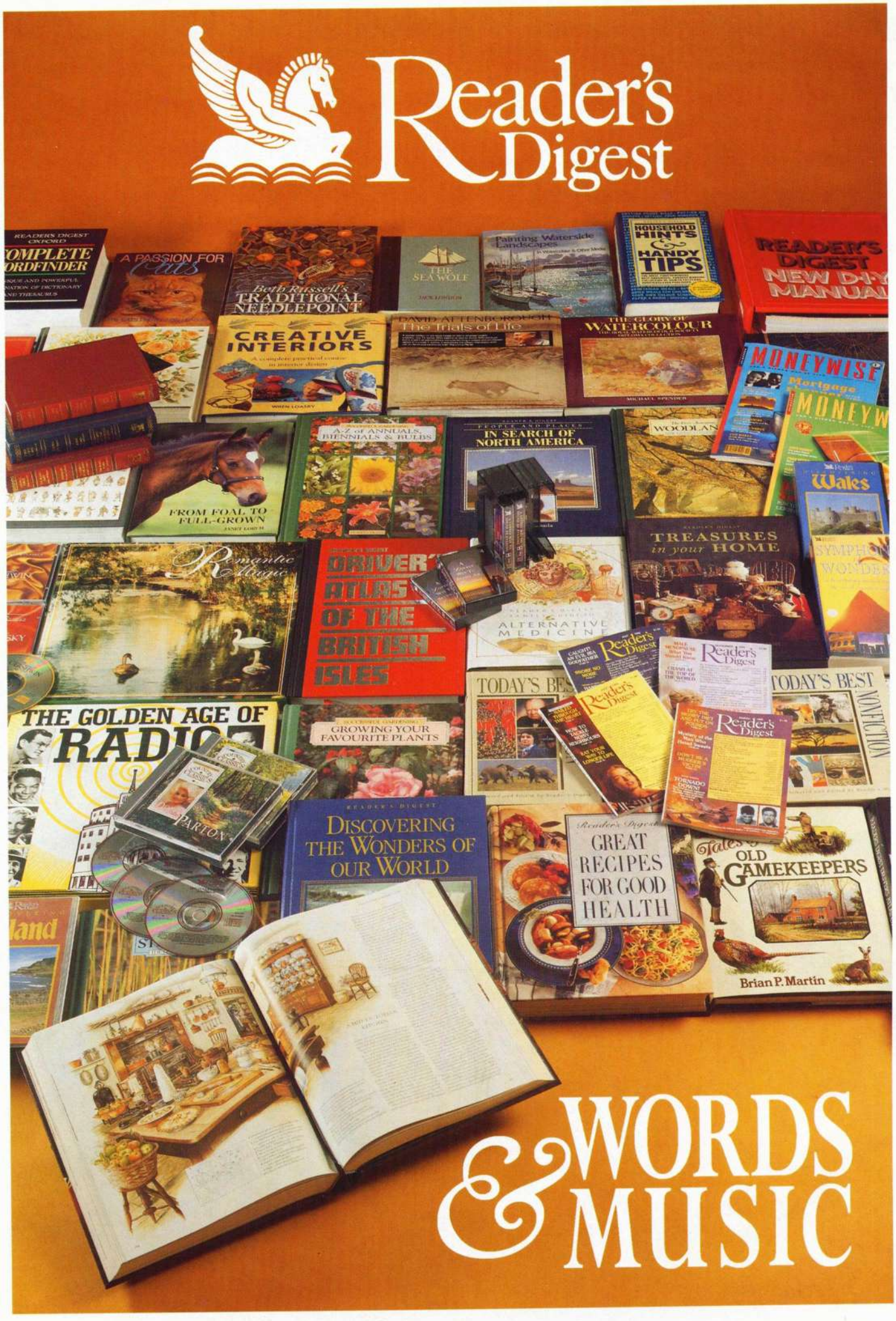
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