ROYAL AIR FORCE

HISTORICAL SOCIETY

JOURNAL

72

First published in the UK in 2019 by the Royal Air Force Historical Society

ISSN 1361 4231

Printed by Windrush Group
Windrush House
Avenue Two
Station Lane
Witney
OX28 4XW

ROYAL AIR FORCE HISTORICAL SOCIETY

President	Air Chief Marshal Sir Richard Johns GCB KCVO CBE
Vice-President	Air Marshal Sir Frederick Sowrey KCB CBE AFC

Committee

Chairman	Air Vice-Marshal N B Baldwin CB CBE
Vice-Chairman	Group Captain J D Heron OBE
Secretary	Group Captain K J Dearman FRAeS
Membership Secretary	Wing Commander C Cummings
Treasurer	J Boyes TD CA
Editor & Publications Manager	Wing Commander C G Jefford MBE BA
Members	Air Commodore G R Pitchfork MBE BA FRAes
	Group Captain S Chappell MA MSc
	Peter Elliott BSc MA
	*J S Cox Esq OBE BA MA
	*Maggie Appleton MBE
	*H Raffal MA
	*Group Captain J R Beldon MBE MPhil MA BSc
	* Wing Commander H Whitehill MA RAF

**Ex Officio*

CONTENTS

LIGHTNING GENESIS by Tony Wilson	7
THE AIR FIGHTING DEVELOPMENT SQUADRON by Air Cdre John Mitchell	51
THE INTRODUCTION OF THE LIGHTNING INTO SERVICE by Sqn Ldr Tim Nelson	66
ENTRY INTO SERVICE AND MAINTAINING THE MATURE PLATFORM by Wg Cdr Gareth Cunningham	74
LIGHTNING QRA – ALWAYS RUNNING HOT! by Captain Ian Black	81
FIRST DISCUSSION PERIOD	93
LIGHTNING DEVELOPMENT STUDIES AND PROPOSALS by Tony Wilson	98
LIGHTNING OPERATIONS IN THE KUWAIT AIR FORCE by Sqn Ldr Clive Brimson	128
LIGHTNING OPERATIONS IN THE ROYAL SAUDI AIR FORCE (RSAF) by Gp Capt Andy Williams	131
LIGHTNINGS IN RAF GERMANY by Air Cdre Rick Peacock-Edwards	137
LIGHTNINGS OVER CYPRUS by Gp Capt Geoff Brindle and Wg Cdr John Ward	144
LIGHTNING OPS IN THE FAR EAST by Air Cdre Dennis Caldwell	153
SECOND DISCUSSION PERIOD	155
SUPPLEMENTARY PAPER	
THE INADVERTENT FLIGHT OF LIGHTNING XM135 – SOME BACKGROUND CONSIDERATIONS by Wg Cdr W V Holden	160
BOOK REVIEWS	169

SELECTED GLOSSARY

AAM	Air-to-Air Missile
A&AEE	Aircraft and Armament Experimental Establishment
ACAS	Assistant Chief of the Air Staff
AD	Air Defence
ADC	Advisory Design Conference
AFDS	Air Fighting Development Squadron
AOG	Aircraft On the Ground
APC	Armament Practice Camp
ASP	Aircraft Servicing Platform
AUW	All Up Weight
BRITFORLEB	British Forces Lebanon
CA	Controller Aircraft
CAS	Chief of the Air Staff
CFE	Central Fighter Establishment
CGWE	Controller Guided Weapons and Electronics
CTTO	Central Tactics and Trials Organisation
CW	Continuous Wave
DDOR	Deputy Director of Operational Requirements
DGTD	Director General of Technical Development
DMARD	Director(ate) of Military Aircraft Research and Development
DOR	Director(ate) of Operational Requirements
DRPC	Defence Research Policy Committee
DSRD	Director Servicing Research and Development
FTRS	Full Time Reserve Service
HDU	Hose Drum Unit
ITP	Intention To Proceed
LTF	Lightning Training Flight
MAP	Ministry of Aircraft Production
NACA	National Advisory Committee for Aeronautics
OR	Operational Requirement
ORBAT	Order of Battle
PDSR(A)	Principal Director of Scientific Research (Air)
RAE	Royal Aircraft Establishment
RDQ(F)	Research Development Equipment Installation (Fighter Command)
RIAT	Royal International Air Tattoo
RRE	Royal Radar Establishment
RTO	Resident Technical Officer
RWR	Radar Warning Receiver
SAGW	Surface-to-Air Guided Weapons
SAM	Surface-to-Air Missile
SEngO	Senior Engineer Officer
TRE	Telecommunications Research Establishment
VCAS	Vice Chief of the Air Staff

THE ENGLISH ELECTRIC LIGHTNING

RAF MUSEUM, HENDON, 3 October 2018

WELCOME ADDRESS BY THE SOCIETY'S CHAIRMAN

Air Vice-Marshal Nigel Baldwin CB CBE–

Ladies and Gentlemen – welcome and good morning. It is a pleasure to see such a large gathering. We are, of course, heavily reinforced today by the WIWOL community. Having had a quiet and non-boisterous upbringing, until recently I had no idea what that meant – but I do now![1] Anyway, you are all very welcome and I hope you will continue to take an interest in our now 32-year-old Society.

My usual thanks to Maggie Appleton, the CEO of the RAF Museums, and to her always very helpful staff. Without their support, we would have difficulty in surviving.

Our Chairman for today, Air Vice-Marshal George Black, is probably the most experienced RAF pilot of his, or indeed my, generation. Having flown over 120 different types and with over 8,000 military flying hours, only the late Winkle Brown can surpass his flying experience I suspect. Not only that, and unlike Winkle Brown, he, with his wife's help, also produced an RAF Lightning pilot from whom we shall hear later.

George first flew the Lightning with No 74 Sqn when the aeroplane was being introduced to squadron service back in 1961; he went on to command No 111 Sqn at Wattisham, the Lightning OCU at Coltishall and then No 5 Sqn at Binbrook. As a group captain, he commanded RAF Wildenrath in Germany.

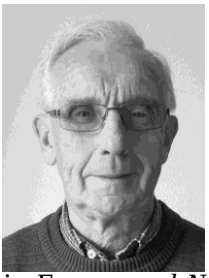
So this morning we will be in good hands.

George: you have control.

[1] WIWOL – When I Was On Lightnings.

LIGHTNING GENESIS

by Tony Wilson



On graduating from Loughborough with a BTech in Aeronautical Engineering in 1967, Tony Wilson joined BAC at Warton and remained with them until he retired, from what had become BAE Systems, in 2000. Throughout his career he specialised in operational analysis and participated in all major aircraft design studies, much of which involved working with industrial partners in Europe and North America and with a variety of NATO agencies. He is a member of the RAeS's Air Power Group, the Defence Electronics History Society and, in the context of this paper, BAE Systems' Heritage Department at Warton.

Introduction

On 17 June 1948, W E W 'Teddy' Petter wrote a report on a meeting held the previous day with the RAF Director of Operational Requirements (DOR) and his staff. The main topic was the progress of the Canberra, but a final paragraph was headed 'High Speed Fighter'. It said, 'Requirements for a high speed fighter are being sent to us and he hopes very much that we shall go for this. There would probably be two or three prototypes attached to a successful design and a reasonable chance of production orders. Supersonic speeds would be required for short periods.'

For the English Electric Company (EECo), this launched the effort that would lead to the production of the Lightning. This paper examines how that effort evolved. The many engineering challenges have been detailed elsewhere. Instead, this paper will focus on the procurement process and the factors that drove decisions about the aircraft configuration and its weapon system. In particular, it looks at how other procurement programmes influenced choices about the Lightning for good or ill. Some of the resulting missed opportunities are explored further in the companion paper *Lightning Development Studies and Proposals* (see page 98).

Origin and Initial Concepts

Just two weeks after the meeting with DOR, Petter received a letter

from the Principal Director of Scientific Research (Air) [PDSR(A)], Harry Garner, at the Ministry of Supply. This gave advanced warning that the MoS was about to issue the official requirement for a design study of a transonic aircraft. It would explore speeds from Mach 1 to Mach 1·4. In its first form it would probably not be suitable for operational use, but they would ask for alternative designs with and without cannon. After some comments on technical details, he went on to stress the desire for speedy progress and hence the need for a prompt reply as to the Company's interest. The hope was to have the design studies completed within three months leading to a go-ahead for two designs from different companies.

Petter's reply four days later, headed 'Transonic Aircraft', confirmed the Company's interest but emphasised the wish to relate new work to something that would provide continuity of employment at the factory. English Electric would therefore aim to provide, at least some of, the operational features required after the pre-requisite performance had been obtained.

Before the month of July was out, the companies that had expressed an interest had received the PDSR(A) specification for a 'Transonic Aircraft'. Just three small pages and without an official number, it set out performance goals of 700kts at 45,000ft (M=1·21) in dry power to be increased to Mach 1·4 with reheat and with an endurance of 10min at full throttle plus 15min economic cruise. A single pilot was specified and unconventional cockpit layouts were permissible with pilot ejection optional. A wide range of possible engines was offered, including a single Avon with reheat, multiple Avons with or without reheat, one or more other engines or a single jet engine plus a rocket engine. Guns, if fitted, would be two 30mm cannon. Airbrakes, a wheeled undercarriage and a pressure cabin cockpit were required and various loading and strength limits specified. Attention was drawn to two reports by the Royal Aircraft Establishment (RAE) laying out ideas for supersonic designs. Two typical RAE designs, each with three turbojet engines, are shown in Figure 1.

A contract followed on 3 August but, even before it arrived, work had begun. Dated 16 July 1948, the earliest surviving drawing shows a configuration simply labelled 'Scheme 2'. Before the end of the month, four further layouts followed. All were twin engine, two with

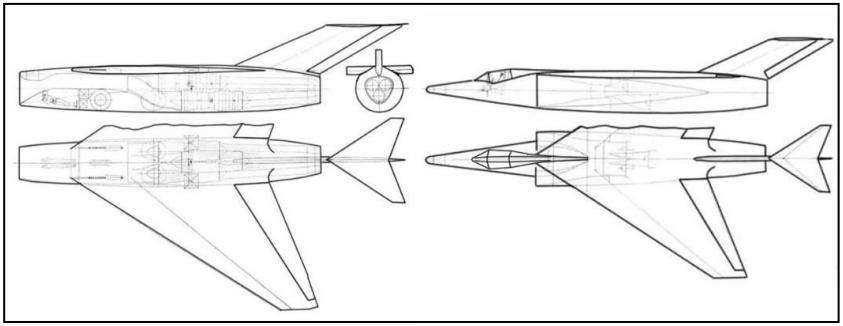


Fig 1. RAE design ideas, 1948.

Avons and two with Sapphires. As indicated by the examples shown in Figure 2, these early layouts employed staggered engines, modest wing sweep and a high-set tailplane. The vertical stagger of the engines was aimed at minimising presented frontal area with a seated pilot. The incipient fire hazard was not realised until much later. In common with the other competing companies, the designers had used RAE's design concepts as a starting point (but not going as far as three engines). During August, however, more radical concepts were explored including a butterfly tail and an annular intake. All of these drawings are titled 'Fighter' or 'Supersonic Fighter'.

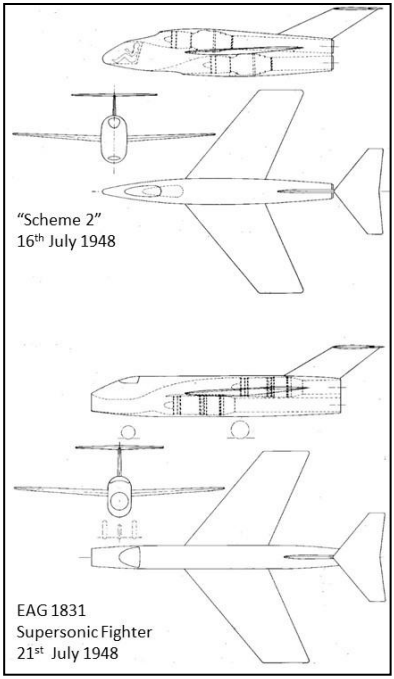


Fig 2. Early EECo designs.

The team working on these ideas was a group of engineers brought together by English Electric in 1945 to design a high speed high altitude bomber, successor to the Mosquito, the Canberra. They were led by Teddy Petter as Chief Engineer with F W 'Freddie' Page as his deputy and later his successor. Another key

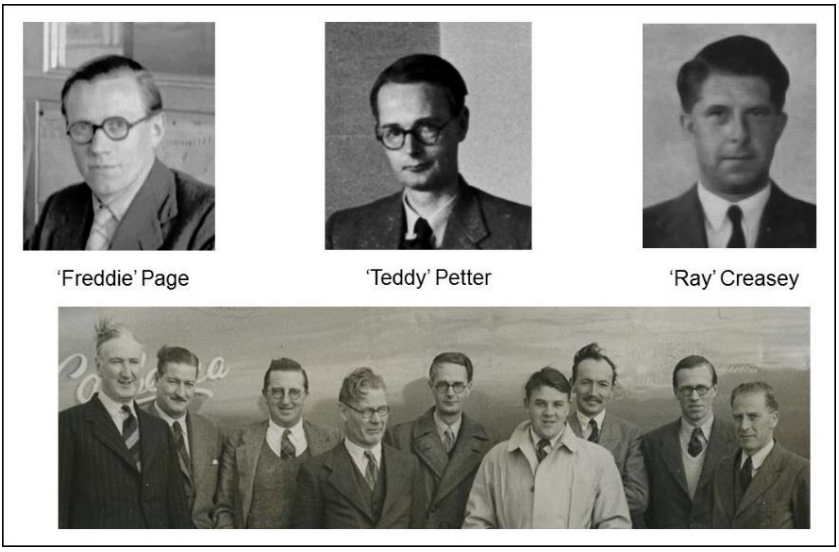


Fig 3. Some key members of the English Electric team.

contributor was R F 'Ray' Creasey who played the leading role in the aerodynamic design of the fighter that would later be labelled P1 and then 'Lightning'.

Their work on the Canberra had led them into the exploration of high altitude high speed flight. Taking this knowledge further into the transonic and supersonic regime would pose a major challenge. Initially, they would draw upon the research lessons being disseminated by the RAE. In addition, they had recourse to a vast body of research culled from German government and industry establishments at the end of the Second World War. Figure 4 shows examples of how the German results from different sources were drawn together. In this case, the graphs show the benefits of increasing wing sweep and reducing wing thickness. Interestingly, unnoticed among the German research papers, there was a discovery of the theory of 'Area Rule' and its application to the design of supersonic aircraft. It would eventually be re-invented by Richard Whitcomb at NACA in the mid-1950s. Until then, the rule of thumb for supersonic aircraft design would continue to be to minimise the aircraft's frontal area per pound of engine thrust.

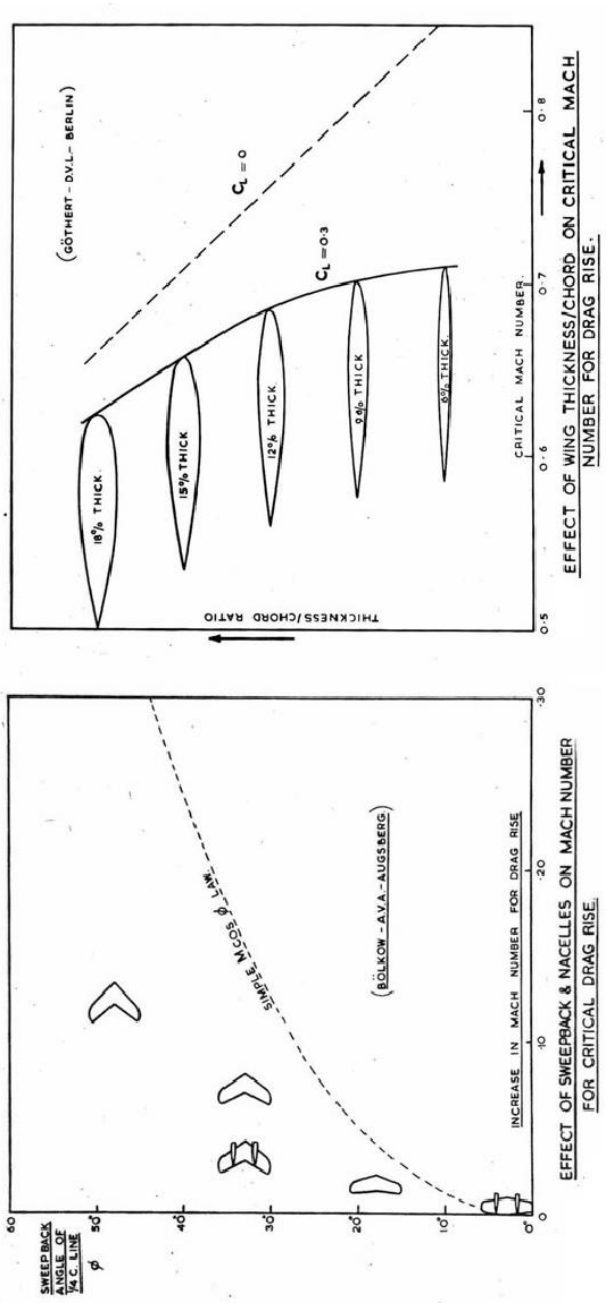


Fig 4. Typical EECo summaries of German research data.

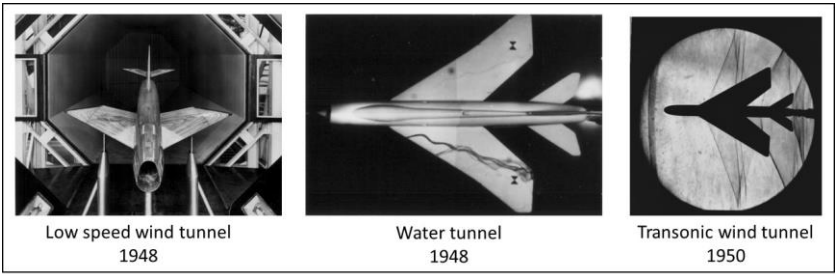


Fig 5. Aerodynamic test facilities.

In spite of the volume of general data available, the team had already realised, when working on the Canberra, that they could not rely on detailed design process. It was essential to gain first-hand experimental evidence specific to their evolving design. In 1946 the Company had begun a major programme of investment in test facilities. For aerodynamic design purposes, in 1946 it had acquired a small low speed wind tunnel. This was supplemented by a water tunnel and a much larger wind tunnel in 1948. Also in 1948, and crucial for the P1 development, English Electric had designed, patented and built a high speed wind tunnel powered by a jet engine. This could reach speeds approaching Mach 0·9 which was adequate for Canberra. Now, to address the problem of transonic flight, work was begun to develop this tunnel to be fully supersonic with a slotted working section. It came into use in 1950.

By October 1948, the configuration had been developed to that shown in Figure 6. This formed the basis for the official tender brochure for a Transonic Research and Fighter Aircraft and was shown with alternative Mark I and Mark II wing shapes. Armed and unarmed versions were offered with cannon fitted in the wing roots for the fighter option, together with a ranging radar in the intake lip. The fuselage design was intended to provide minimum frontal area per pound of engine thrust while accommodating a seated pilot and two Armstrong Siddeley Sapphire Sa2 engines with 7,500lb sea level static thrust. In this respect it was a 20% to 50% improvement over the various RAE proposals.

The predicted performance would be a massive step forward from previous generations of fighters, as shown in Figure 7. This shows the

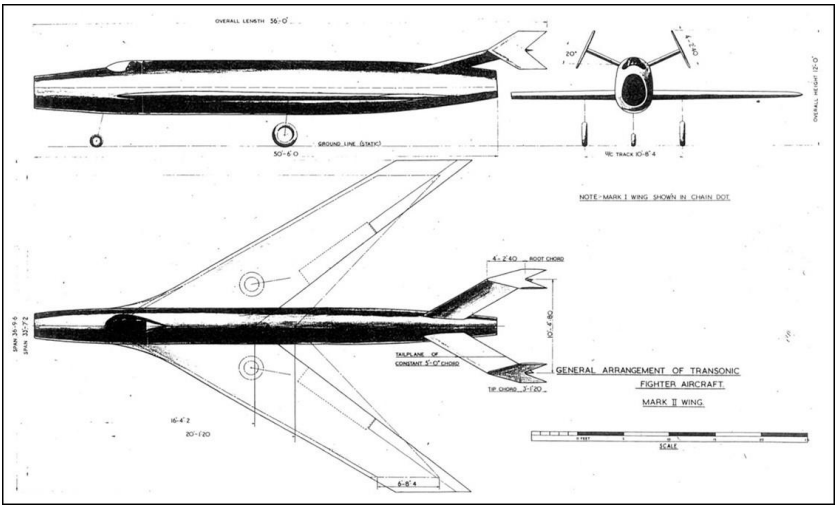


Fig 6. Configuration drawing dated 19 October 1948.

speed with and without the use of re-heat as Mach Number versus altitude compared to a variety of aircraft over the previous thirty years.

The brochure was dated 1 November 1948 and was submitted to the Ministry of Supply two days later. It was in competition with responses from Fairey, Hawker, Bristol, Boulton Paul and Armstrong Whitworth plus a private venture submission from Gloster.

While the MoS and RAF were considering these proposals, the EECo team continued to develop its transonic fighter design. They initially focused on improving the wing and the tail unit. Two key stages are shown in Figure 8.

The first step, in December 1948, was to introduce the ‘Mark III’ wing to improve roll control. The surviving drawing copy also shows a lightly pencilled idea for a single larger fin to improve directional stability (dotted outline added for clarity in Fig 8). In January 1949 the project was designated P1 in the new EECo project numbering system. By February 1949, the revised fin was established together with a new tailplane placed part-way up the fin.

Meanwhile, the conflicting demands by the RAF for a fighter and the MoS and RAE for a research aircraft were being addressed at a series of review meetings. On 17 December 1948, a meeting was

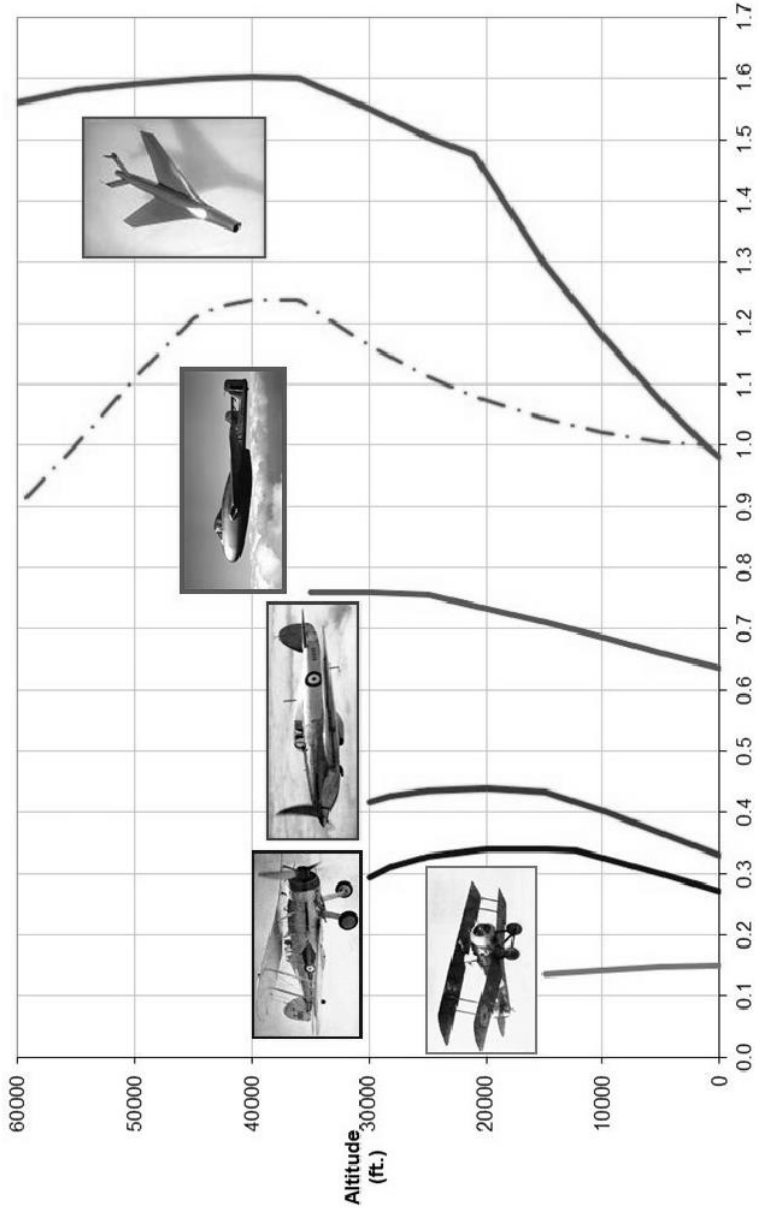


Fig 7. Fighter speed versus altitude, 1917-1948..

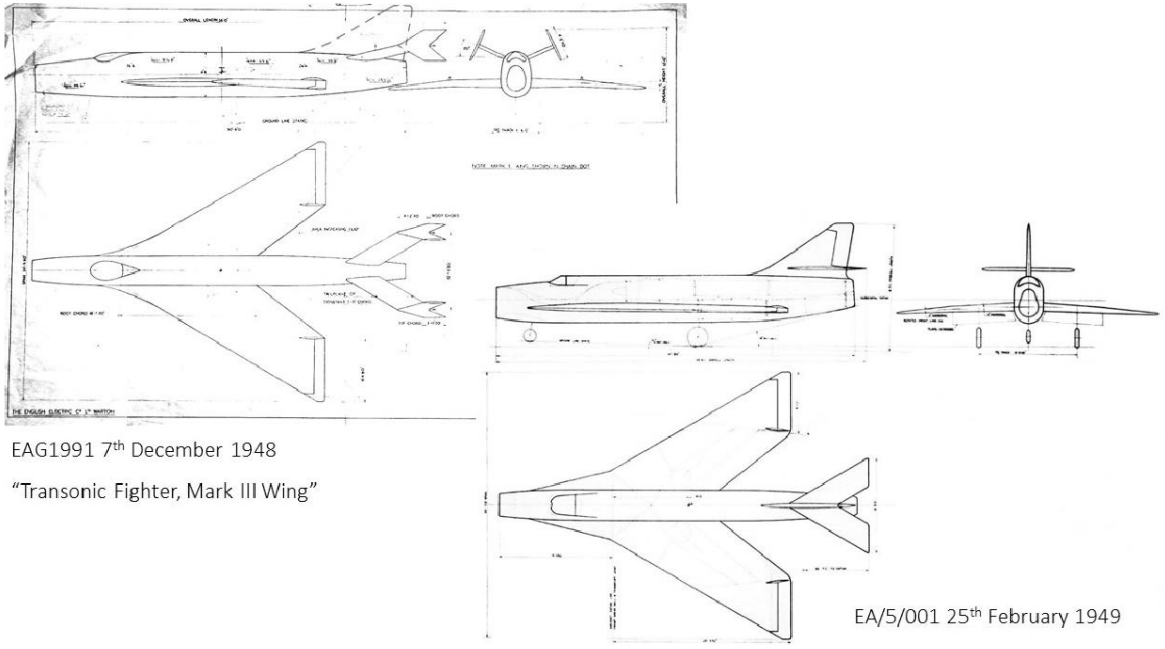


Fig 8. Configuration development to February 1949.

held to discuss Transonic Research Aircraft. It reviewed the designs that had been submitted against the RAE's draft specification. After much argument it was agreed that there should be orders for three, or possibly four, designs:

a. A military aircraft from English Electric.
b. The single-engine design from Armstrong Whitworth as a research aircraft from the Hawker-Siddeley Group.
c. A second research aircraft from Fairey.
d Possibly a second operational aircraft from Hawker-Siddeley once information was available on the thrust that might be obtained from new engine designs for supersonic flight.

By 30 December, the RAF was circulating a draft operational requirement for a transonic fighter. At a further meeting on 23 March 1949, it was finally decided that English Electric would be given a contract to develop the P1 as an operational aircraft to a new specification F23/49 to fulfil the new operational requirement OR268. In parallel, Armstrong Whitworth would be contracted to develop their AW58 as a research aircraft to a new specification E16/49. The financing of the Armstrong Whitworth machine was justified on the grounds that a single-engine research aircraft, without the burden of military equipment, could be produced more quickly and more cheaply. Within a few weeks of this agreement, the MoS asked for the addition of radar and guns. A new draft of OR268 was issued in July 1949, of F23/49 on 2 September and of E16/49 on 22 September. However, by 27 September the MoS was coming under financial pressure to choose between the AW58 and the on-going Fairey delta design. As it turned out, the AW58 with its modest wing sweep proved unworkable and on 12 November 1949 Armstrong Whitworth was asked to drop the swept wing design and to submit a delta in competition with the Fairey project. The choice eventually favoured Fairey's proposal and the AW58 production contract was cancelled on 16 May 1950. A new research requirement, ER103, was issued on 26 September 1950, written around the Fairey FD2.

The RAE had now lost its favoured medium-sweep research aircraft. It still included P1 in its research portfolio as covering the highly-swept option, although its experts were still sceptical of the EECo design. They persuaded the MoS to issue a new specification,

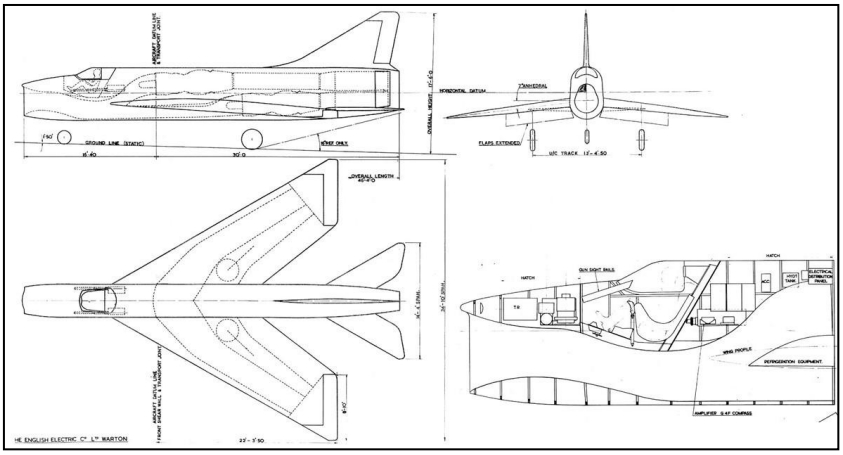


Fig 9. Layout in 1 October 1949 brochure.

ER100, on 25 October 1950 to finance a research aircraft to explore and compare the low-speed characteristics of medium sweep and highly swept wings. This led to the production of the Short SB5.

The RAE and MoS considered the P1 and FD2 to be Mach 1·5 aircraft. The next step in supersonic research would come in 1953 with the issue of specification ER134T for a Mach 2 research aircraft.

In spite of the agreement of 23 March, the MoS internally continued to emphasise the research aspects of the English Electric supersonic aircraft. A memorandum by Serby (DMARD) on 28 September 1949 summarises a high level agreement within the MoS to manage the programme as an aerodynamic research project. There should be no detailed design work on fitting armament or operational equipment, merely space provision. RAF representation at mock-up reviews would be limited and the aircraft would be known as an ‘experimental fighter’.

The firm, however, pressed on in response to the draft issue of F23/49 and delivered a new brochure on 1 October 1949 for an ‘Interceptor Fighter Aircraft with Supersonic Performance to Specification F23/49’. This presented the design shown at Figure 9. The Sapphire engines were replaced by Rolls-Royce RA4 Avons with 8,450lb thrust. Two 30mm cannon were fitted in the cockpit shoulders and a ranging radar with an 8-inch dish in the intake lip.

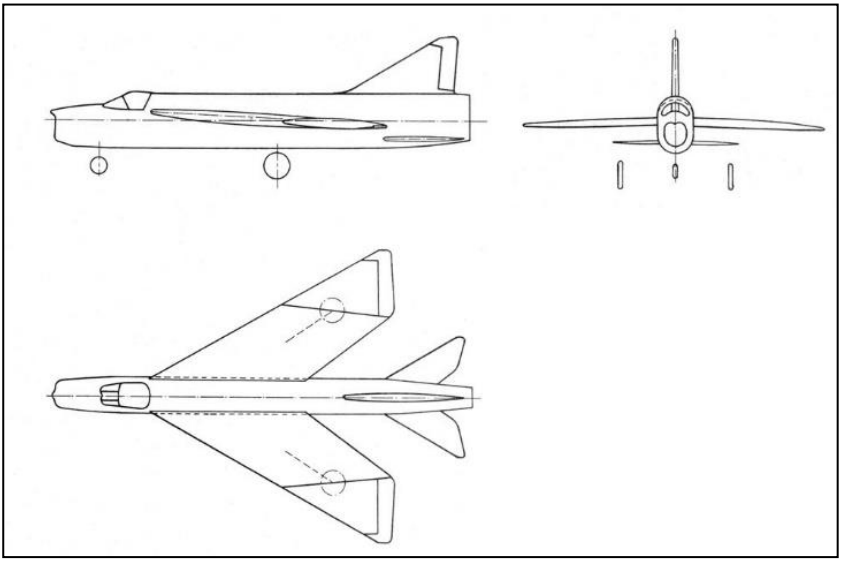


Fig 10. Revised layout at 18 October 1949.

As a result of extensive wind tunnel testing, the tailplane had been moved as low as possible on the fuselage to avoid adverse interference from the wing at high pitch angles. Continued testing revealed the need for even greater separation of the wing and tailplane. Less than three weeks after the brochure, the firm issued a replacement general arrangement drawing showing the configuration at Figure 10. The wing is raised higher on the fuselage to achieve an acceptable level of stability and control at high incidence. This was an extra bone of contention with RAE and its preference for high-set tailplanes. As a result, the identification of the best tailplane position became another objective for the ER100 research aircraft.

At this point in time, the now familiar aerodynamic configuration of the Lightning had been established, but it would be twelve years before the fighter entered RAF service. To understand this delay, the continued development of the aeroplane and its weapon system has to be considered in the context of the broader procurement environment.

The Procurement Process and Environment

At the end of the Second World War, the RAF and Fleet Air Arm had fifteen fighter types in service (nine British and six American

designs). Among these there were also specialist variants for high or low altitude operation or with different armament or equipment. To supply these aircraft, eighteen aircraft companies were competing for design and production contracts. The aircraft companies were expected to design and build airframes to meet specifications drawn up by the technical experts of the Ministry of Aircraft Production (MAP) (later the Ministry of Supply) and the government research establishments such as the RAE in response to Operational Requirements drafted by the armed services. The airframes would incorporate engines, armament, other items of equipment and fittings supplied by the government as 'embodiment loan' items. These were specified, designed and procured separately on the assumption that they would be fitted to a number of different aircraft types, thus achieving economies of scale.

The planning system for managing these procurement complexities had been developed by the MAP during WW II and was inherited by the MoS. Inevitably there were difficulties and conflicts that were a frequent source of frustration to both the Air Force and industry. By 1958, we find Geoffrey Tuttle as DCAS writing about P1 to CAS, '… the way the Ministry of Supply handles this project needs drastic re-organisation. You may, of course, feel that this issue is better tackled by you or me discussing it with CA. It is, however, an unfortunate fact that the project is divided between two Controllers and below them between no less than 11 Directors. There is no one man that we can discuss the matter with.' A year later, DDOR4 would repeat the complaint. In June 1967, British Aircraft Corporation would be making the same complaint to the Elstub Committee, citing the history of the Lightning programme in detail.

The legacy of multiple fighter types fulfilling niche roles led to a multitude of post-war projects proceeding in parallel, the demand exacerbated by a rapidly changing projection of the likely threat. At the start of the Lightning project the main threat was assumed to be large numbers of Tu-4 *Bull*s (B-29 copies), 'some armed with atomic bombs'. Jet bombers were foreseen, perhaps based on captured German technology. By 1954, actual jet strategic bombers had emerged in the form of the Type 37 (M-4 *Bison*) and Type 39 (Tu-16 *Badger*). Future higher and faster supersonic threats were forecast based on trends in Western designs. The M-50 *Bounder* would

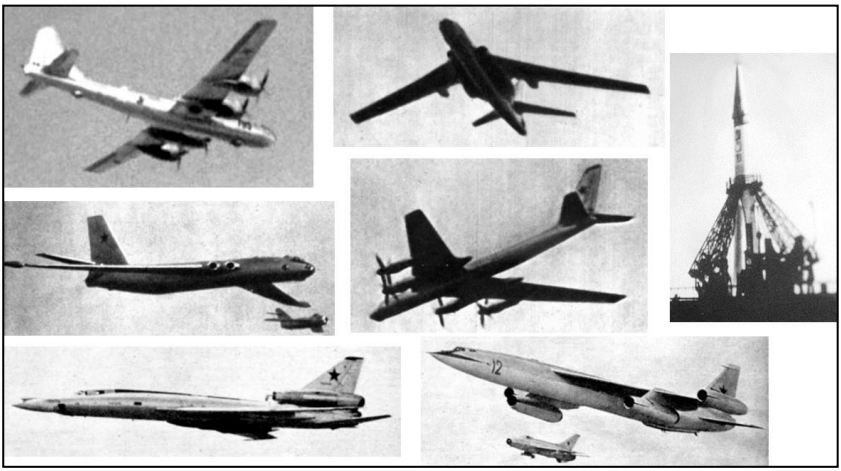


Fig 11. The changing threat 1949-1961.

eventually appear in 1958 and the Tu-22 *Blinder* in 1961. The severity of the threat was raised further over the same period by the deployment of increasingly capable air-launched stand-off missiles, initially referred to as ‘powered bombs’. More critically, from the mid-1950s it became clear that, while still developing advanced bombers, the Soviet Union was moving towards ballistic missiles as its main strategic weapons.

This growing threat caused continual debate as to what could be defended economically. With a chief focus on deterring strategic warfare, the objective shifted from defending the whole of the United Kingdom to ensuring the survival of the deterrent force. Even so, there had to be increasingly ambitious technical goals for the defence systems. As a result, operational requirements and design specifications were subject to regular change. For the Lightning alone, the draft issues of OR268 and F23/49 in 1949 were followed by six revised issues plus numerous interim amendments over the next eight years.

The spectrum of overlapping fighter programmes for the RAF and FAA is shown in Figure 12, covering the time period for the initial design of the Lightning. It also includes the surface-to-air missile programme that began as a requirement for an ‘unmanned interceptor’ and led to the Bloodhound SAM system. The ambitions for the fighter

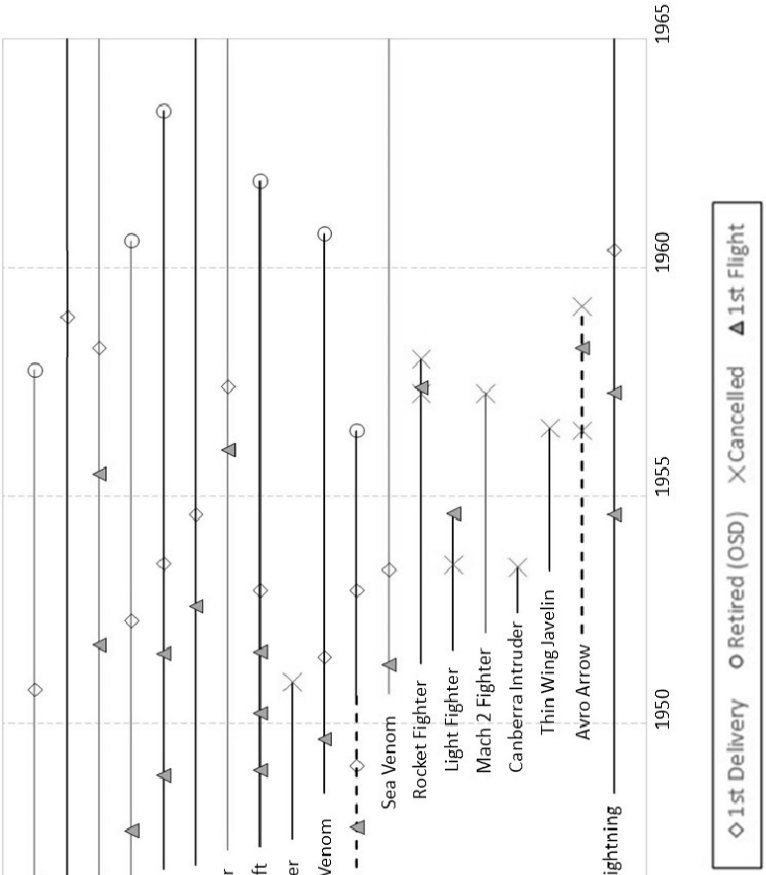


Fig 12. Interceptor programmes, 1945-1965.

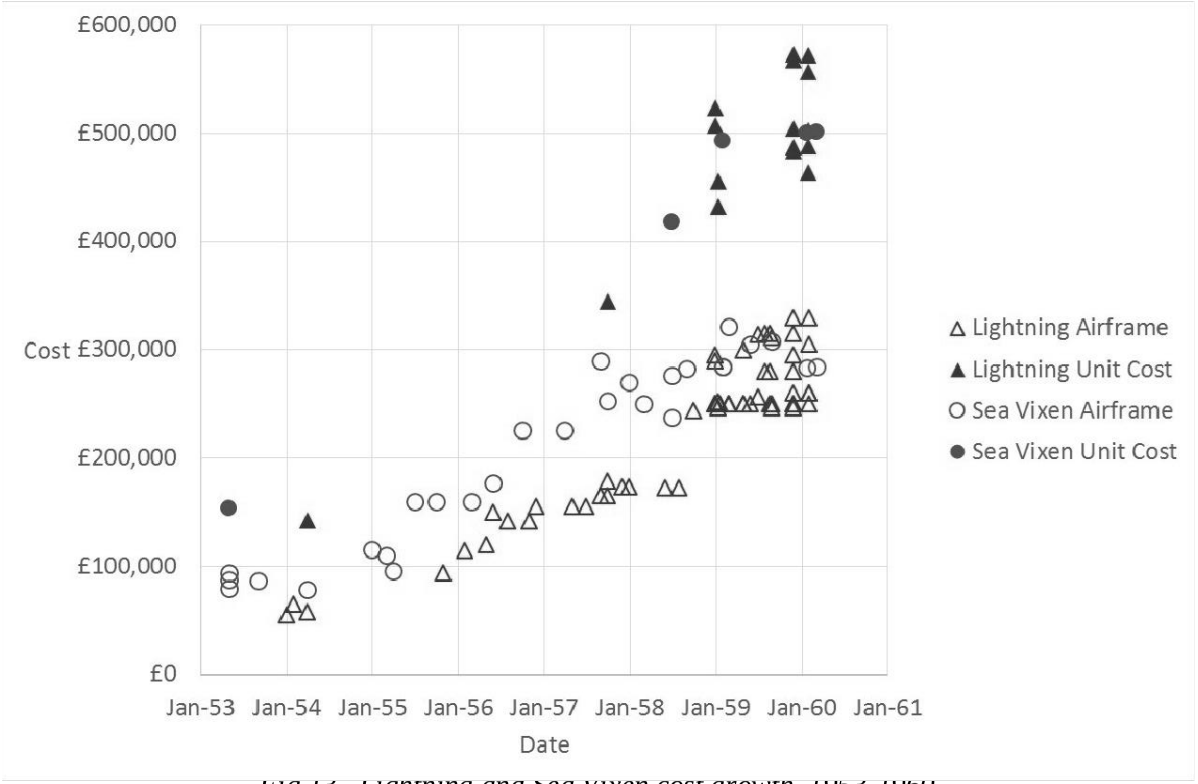


Fig 13. Lightning and Sea Vixen cost growth, 1953-1960.

defence were inevitably influenced by the prospects for SAM.

All of these programmes affected the progress of the Lightning. Until the 1957 Defence White Paper left Lightning as the only surviving RAF fighter project, the parallel plans for the 'Rocket Fighter', 'Thin-wing Javelin' and 'Mach 2 Fighter' all inhibited the goals for the Lightning which was to a large extent regarded as an interim type. Meanwhile, there was intermittent read-across of the lessons learned from earlier projects such as Hunter, Swift and Javelin. The historical overviews of the development troubles of Hunter and Swift prepared between 1953 and 1957 make salutary reading.

For all of these projects, rising costs were a looming problem. The typical scale of cost growth is shown in Figure 13 for Lightning and Sea Vixen as examples. This shows the official Ministry cost estimates at various points between 1953 and 1960. It indicates the rising cost for both the basic airframe and the fully-equipped aircraft for both types. Bear in mind that a Spitfire cost about £10,000 in 1939, a Mosquito about £16,000 in 1944 and a Meteor Mk 4 about £25,000 in 1949. We see here the earliest cost estimates for Lightning and Sea Vixen at about ten times the cost of a Spitfire rising by 1960 to about fifty times that of a Spitfire. Much of the scatter in the plot is due to variation in the production batch size assumed for costing purposes. The cost increases were driven by two main factors. Firstly, there were the numerous revisions to the customers' requirements and specifications. Secondly, the much higher maximum speeds imposed aerodynamic loads that demanded stronger, denser structures needing more machined components.

Affordability limits would combine with changing strategic and tactical perspectives to cause major changes in force planning.

The many aircraft programmes not only influenced each other but were jointly influenced by parallel on-going development of engines, weapons and sensors and the priorities that were assigned to their various applications.

For fighters, the choice of engines focused mainly on the Metrovick (later Armstrong Siddeley) Sapphire and the Rolls-Royce Avon. The Hunter and Swift would employ single engines without re-heat; the Javelin, Lightning, Scimitar and Sea Vixen twin engines with or without re-heat. The possibility of a larger single engine would also

be investigated for the Lightning. Each engine type was developed through a series of models with increasing performance. For the Lightning, this led to the engine choice switching between the Sapphire Sa2, Sa3, Sa4, Sa5, Sa7 and Avon RA2, RA4, RA5, RA6 and RA24 variants. This regular switching of the choice of engine was problematic for the vital task of designing an efficient intake and duct system. At one stage, the MoS asked for Sapphire engines to be fitted but with ducting to allow for the mass flow of Avon engines. EECo pointed out the inefficiency of such an arrangement. When, eventually, it was agreed that Sapphire Sa5s would power the first prototype, Freddie page wrote to DMARD: 'It is now clear that we have no alternative but to use the Sapphire on prototype P.1 aircraft. This being so – it is most important that we should receive full co-operation from Armstrong-Siddeley and I would therefore ask you if you would please write to Saxton of Armstrong-Siddeley informing him of the position. As a matter of fact at the moment Armstrong Siddeley's have no official indication that it is now necessary to fit Sapphire in the P.1, nor have they any official indication of the importance of this project.'

In the field of armaments, the experiences of WW II and the Korean War revealed the need for weapons with better hit probability and higher lethality. Larger calibre guns, salvoes of free-flight rockets and guided missiles were investigated. British development of air-to-air guided weapons began with the Red Hawk programme in 1947. This aimed sensibly at an ability to attack a target from any direction. Autonomous radar guidance seemed the logical route but proved challenging with existing technology. This led in 1949 to the launch of a less ambitious tail-chase weapon, initially specifying a homing weapon (Pink Hawk) but later relaxing the guidance options (Blue Sky). This became the Fairey Fireflash, a beam-riding weapon that required the fighter to maintain an accurate tracking solution throughout the flight of the missile. It was assumed that this could be developed rapidly to service entry. By 1951, however, research into infra-red detection had shown that a rear-hemisphere infra-red homing system might be possible. A second tail-chase weapon project (Blue Jay) was begun. This would be an autonomous weapon using an infra-red seeker to home on the hot jet-pipe of its target. It would become the de Havilland Firestreak. The development of the Fireflash proved

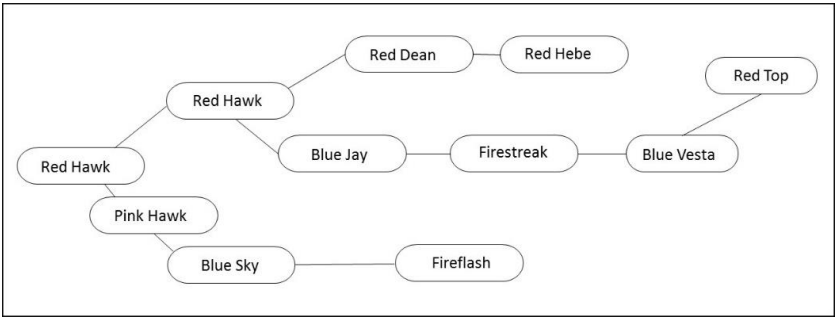


Fig 14. Air-to-air missile programmes, 1947-1957.

more protracted than expected. As a result, the gap between the anticipated service entry dates became so narrow that Firestreak, with its greater tactical freedom, was chosen as the preferred operational missile in 1954.

Meanwhile, the benefits of earlier interception achievable with head-on engagements meant that the search for an all-aspect weapon continued. Red Hawk led to Red Dean. Fifty percent bigger than Firestreak and twice as heavy, it had an active pulsed radar seeker whose development ultimately proved intractable. It was cancelled in 1956 along with the Thin-wing Javelin, its intended platform. In 1954 an even larger and heavier weapon was specified for the F155T Mach 2 fighter. This would emerge from the Red Dean programme as Red Hebe. It, in turn, was cancelled in 1957 along with F155T.

The only other British AAM option for collision course interception was a proposed development of Blue Jay using a seeker operating at longer infra-red wavelengths. It would allow homing against engine exhaust plumes or the hot skin of supersonic aircraft. This would be known as Blue Jay Mk IV, later Blue Vesta and finally Red Top. It was proposed for Lightning in 1956 and went into service on Lightning and Sea Vixen in 1964.

In the midst of this weapon development, in 1951, DDOR5 produced a report pointing out that none of the discussions on AI (Air Interception) radar were making any provision for the introduction of guided missiles. He suggested action to be taken in respect of Blue Sky and Red Dean for both day and night fighters. Between 1950 and 1953, AI policy was concerned entirely with night fighters. The main

focus was on the Gloster Javelin and the de Havilland Sea Vixen.

The British AI programme, however, was struggling. After the successful introduction of the spiral-scanning AI VIII in 1943, efforts to build on this had faltered. AI 9 was a failure and most British late-war and post-war night fighters were equipped with AI 10, a variant of the American SCR-720. The next major step, AI 17 derived from AI 9, was also a disappointment although pressed into service on early Javelins. In the interim, late Meteor and Venom night fighters had been equipped with another American radar, AN/APS-57, as AI 21. Hope now rested on a completely new development, AI 18. This was intended for Javelin and Sea Vixen, but as of December 1951 the operational requirement had not even been finalised and service introduction was not expected before 1957. In December 1951, CAS and VCAS jointly wrote to the Air Council, 'British industry has not produced a successful AI radar since the earliest marks which were used during the first half of the war.' This led to the search for another American AI as an interim solution. Thus, the next Javelin variant was fitted with AN/APQ-43 under the designation AI 22. In 1953 it was decided that all subsequent marks of Javelin would use either AI 17 or AI 22 since AI 18, once available, could not be retro-fitted to replace either of these sets economically. AI 18 would be employed on the Thin-wing Javelin, perhaps in a developed X-band version as AI 19. The RAF cancelled its requirement for AI 18 with the termination of the Thin-wing Javelin in 1956. AI 18 went into service with Sea Vixen in 1957. A requirement for a larger, more advanced AI was issued alongside the requirement for the Mach 2 Fighter, but cancelled with that programme in 1957.

The early issues of OR268 were for a day fighter, but the problems of high speed interception soon led to discussion of the benefit of an AI radar. At the Advisory Design Conference (ADC) on 7 April 1953, Freddie Page asked for consideration of a proper AI for the P1 since Radar Ranging Mk 3 was inadequate. In July 1953 an operational requirement was issued for an AI suitable for single-seat fighters, specifically F23/49, to be available by 1958. In December 1953, Ferranti produced a thorough analytical response with a proposed design that would become the basis of AI 23. Given the 1958 in-service date, however, there was now a perceived need for an earlier single-seat AI and in July 1954 a requirement was issued. It was

intended for the N.113 and Type 545 aircraft and as an interim for F23/49 in the event of a delay to the Ferranti system. This was written around another spiral-scan system being developed for TRE as AI 20 by E K Cole based on their experience with earlier AI radars and the Ranging Radar series.

The fluidity of all the above programmes was the major reason for continual revisions of OR268 and F23/49, but there were similar developments in many other areas that also influenced the evolution of the design. Among these were powered controls, navigation and communication systems, autopilots, ejector seats and brake parachutes. Their separate specification, procurement and technical management continued to complicate the design process.

Configuration and Weapon System Development

Against the above background, the design of the P1 went through a protracted series of revisions from which it emerged as the first British integrated weapon system.

Following the first response to the draft issue of F23/49 in October 1949, work continued with an initial emphasis on confirming the wing and tailplane layout and later focusing on airframe and engine integration. The latter aspect would also be influenced increasingly by armament and military equipment considerations.

Although English Electric were convinced that they had arrived at the best airframe layout, the experts at the RAE still had reservations, especially about the low-speed handling characteristics. The MoS decided that an additional P1 prototype dedicated to low-speed handling would be unnecessarily expensive and proposed the building of a cheaper alternative. Short Bros. were chosen as the contractors. In early 1950 there was a series of meetings to clarify the objectives for the aircraft. It was agreed that it was intended to explore the low-speed behaviour of P1's highly swept wing. In addition, it would have either adjustable wing sweep or the ability to fit alternative wings of reduced sweep if necessary. There was then an exchange of information between EECo and Shorts to ensure that the aeroplane would be adequately representative of the P1 configuration. It was believed that the P1 would fly around October 1952. Shorts' aircraft might not fly much before then. Nevertheless, it could provide useful information to guide any configuration changes that might prove necessary. A formal

specification, ER100, was issued on 28 October 1950. Leaning towards the RAE's preferences, this specified an initial configuration with 50° sweep, full span leading edge flaps and a high-set tailplane. Second would be 60° sweep, full span leading edge flaps and a high tailplane. This was the configuration that the RAE believed would cure the problems they foresaw for the English Electric design. Third would come the P1 layout with 60° sweep, small inboard leading edge flaps and a low-set tailplane. Finally, it would fly with even greater wing sweep of 70° and return to a high tailplane.

Meanwhile, confident in the general layout, EECo pressed on. A contract for the first two prototypes was awarded on 1 April 1950. The first formal issue of F23/49 came on 4 April; an advanced copy was received by EECo on 25 April and the contractual copies on 5 May. Design effort for the production drawings now passed from the Project Office to the main Drawing Office. At the first Advisory Design Conference on 24 November 1949, it had been reiterated that there would be no detailed design of the installation of operational equipment, merely appropriate space provision. Moreover, it was emphasised that there was no operational requirement for fitting an AI radar, only a simple ranging radar and gun armament. Nevertheless, when the first amendment of F23/49 was received on 2 June, it included a comment that there might be a future requirement for free-flight rocket armament as well as guns.

After almost a year's diversion to work on Canberra developments, in early 1951 the Project Office designers turned their attention to the task of fitting operational equipment into the P1 while maintaining or improving the performance of the air intake. To provide more equipment space, they proposed a solution that was so radical as to be given a new project number, P3. This involved moving the intake to the sides of the fuselage, leaving the full volume of the nose for sensors and weapons. This configuration is shown in Figure 15. To keep the frontal area small, the intake suggested was based on an NACA flush intake, but there were serious doubts as to its efficiency, especially at supersonic speeds.

An intensive programme of high-speed wind tunnel tests began. Given the potential benefits of this development, the Air Staff deferred the issue of the next revision of OR268 pending the results of the study.

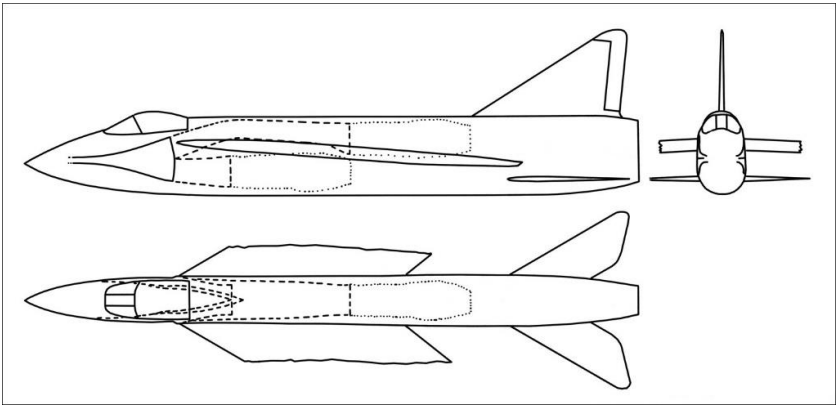


Fig 15. P3 Fuselage Layout (EAG 2142, 20 March 1951).

Initial exploration of future equipment requirements began on 25 April 1951 with a visit to Warton by RDQ(F) personnel. Many ideas of possible equipment were discussed. With regard to radar, it was noted that Ranging Radar was to be developed to support the Blue Sky missile. This was likely to be among future rocket weapon options. There were currently no AI options other than AI 17 and AN/APQ-43. These night fighter AIs required operation by a second crew member.

On 2 July, Freddie Page sent a drawing of P3 to DMARD with a request for advice on the planned equipment to be fitted in the new nose. A meeting was arranged for 11 July to move things forward. At this meeting, DOR(A) and DOR(B) said that, looking forward to 1957/59, it was difficult to predict the equipment required as the aircraft's role would not be settled for two or three months. Initially it would be a day interceptor as per the Specification. Later, assuming a need to operate against fighters, it would require two or four Aden guns plus a lock-on fire control system. A battery of air-to-air rockets would be a useful addition against bombers. As to guided weapons, these were likely to be of the homing variety but no particulars could be given yet. Page commented that supersonic external carriage would be impractical if they were on the lines of those currently being developed. On the question of radar, the MoS introduced consideration of the Hughes E4 fire control system (AN/APG-57 radar plus an AN/APA-84 computer) and its planned development, E6, as a

pilot-operated radar. EECo believed that the 22-inch diameter dish could be accommodated. Six months later, on 31 December, the firm was notified that the Hughes E4 was no longer being considered for fitment to British aircraft.

The problem of equipment planning lingered on. There was concern across industry about the growing weight and cost implications of emerging demands. In July 1951, a meeting was called between representatives from the major fighter design companies, the Air and Naval Staff, the Ministry of Supply and the Research Establishments. It was sparked by a note from Sidney Camm which, taking a Hunter type of aircraft as an example, showed the dramatic cumulative rise in weight and inevitable loss in performance that resulted from the addition of various items of equipment to the basic design. A follow up note from the Chief Designer at Glosters listed aspects of the procurement process that contributed to the problem. Freddie Page added a note enlarging on Camm's analysis and introducing other factors relating to the operational requirement. He noted that the problem came down to reconciling the three-way conflict between performance, equipment and cost. He ended, 'To arrive at any conclusion as to what equipment should be specified, it is essential that data regarding the probability of a kill with various types of armament and sighting equipment, the wastage rates with and without navigational and blind landing aids and the probability of engaging the target with varying performance and aids, etc, should be available. To analyse such data and arrive at a conclusion would be a formidable task. So far as we are aware, attempts have been made to analyse various portions of this field, and it would be interesting to know whether any attempts have been or are being made to cover the whole field.'

The meeting was held on 8 August. There was a wide ranging candid airing of views. It addressed both the technical issues and the dissatisfaction with the procurement process. (Camm's comment that industry had never produced a 'winner' by working to a Ministry Specification disappeared between the draft and the final official minutes.) In conclusion it was agreed to consider ways that designers could be consulted earlier in the requirement and specification process; also to investigate the practicality of ensuring that designers' criticisms of specifications were considered and the associated

operational requirements reviewed ahead of any Advisory Design Conference. The RAE would review the need for a number of specific items of equipment and the designers were invited to submit criticisms of specifications.

Later in the year, the subject of design for serviceability raised its head. EECo received the minutes of a Ministry meeting held on 8 October 1951. DSRD complained that the ADC had been his only opportunity to give advice on the topic. He was concerned that F23/49 would enter service without adequate facilities for servicing. DMARD said that he would welcome advice from DSRD but that it was essential to differentiate between research aircraft and operational types. In his opinion it was unlikely that an aircraft closely resembling the F23 would ever go into service. Discussion of the history and status of the project ensued. In the end it was agreed that the normal sequence of servicing conferences, which had not yet been planned, would indeed now go ahead. It was stressed, however, that any requirement that conflicted with the aircraft flying at supersonic speeds must be ignored. Furthermore, at a subsequent meeting at Warton on 30 October, it was agreed that the mock-up conference would not be held until the design work on the first, unequipped prototype was completed.

The meeting on 30 October also raised questions about various items of equipment: brake parachute, pitot head, flight instruments, windscreen and ejector seat. There were particular concerns about availability of Government supplied items. It was also noted that the MoS had given no priority to the prototype as regard materials. As a result, deliveries of forgings, castings and special steels were very poor and likely to be a limiting factor as regards the first flight.

Whilst the design of the first prototype progressed, attention returned to plans for the longer term. On 9 January 1952, a meeting was held to consider the need to order more prototypes and, if so, how many and of what design. All agreed that more prototypes were needed to complete the flight testing and tactical evaluation in a timely manner; although EECo were more confident than the RAE about the available wind tunnel results and believed that less flight research was needed than proposed by RAE. As to the design, the Air Force believed that, in order to fit four guns and all the equipment envisaged it would need the new nose with side intakes. The firm confirmed that

model tests at transonic and supersonic speeds were underway and they were confident that final proposals for the side intake version would be available by March. DOR said that the operational aircraft would benefit from additional armament and other items of normal fighter equipment. Any rewrite of OR268 was being deferred until the success of the side intake was known. Furthermore, it was complicated by the inability to define what armament would be required in the 1957/59 timeframe.

The meeting concluded that it was desirable to order three additional prototypes. These should be configured to carry four 30mm guns plus essential operational equipment. These prototypes would be required for both research and development testing to a detailed programme to be decided later. A requisition would be raised for an ITP and a specification prepared.

During January the inadequacy of the side intake seems to have emerged and alternatives were considered. During a visit to Warton on 31 January, DOR(A), Air Cdre Satterly, expressed a desire for mixed gun and rocket armament: a minimum of 50 air-to-air rockets plus two 30mm Aden guns and preferably 72 rockets plus four guns. This led to a work plan for February to produce a design armed with at least 50 air-to-air rockets and two 30mm guns together with a radar with an 18-inch scanner. Page suggested an ‘Oswaldisch’ type nose intake with a central bullet that could house the radar. They should aim to have a model ready for tunnel tests by 15 February.

On 29 February, the MoS requested a rough estimate of costs for the three extra prototypes so that contracting could proceed. It noted that the 9 January meeting had favoured the side intake design but the form of the aircraft to be built would not be decided until the firm’s brochure was received, hopefully in March. The RTO drafted a reply for the firm on 7 March, saying that the information could not be provided until the technical policy had been formulated. A follow-up request on 16 May received a reply with a provisional estimate of £800,000 to cover all costs including the extra jigs and tools requested. A brochure was being prepared.

During this time, work had continued to find an improved engine installation together with provision for the increased armament demands. As well as exploring intake options, there was a brief look at a design with a single large engine (Rolls-Royce RA12 with 2000°K

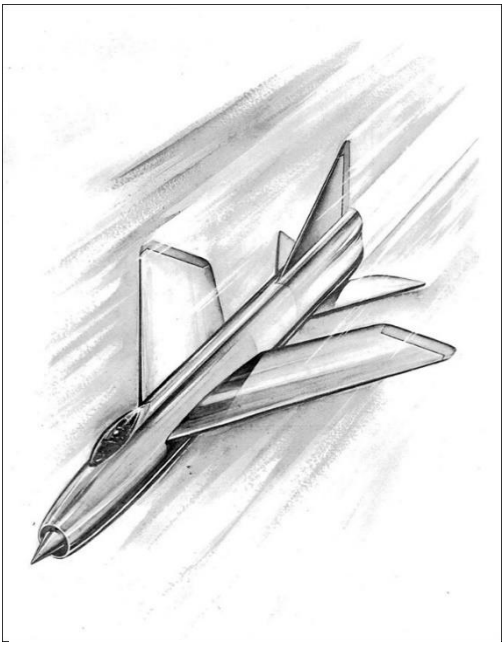


Fig 16. P1B drawing, 18 June 1952.

reheat), given a new project number, P5. This offered an easier four-gun installation but had some performance deficiencies. Meeting notes dated 22 May reported a detailed discussion of all the various design options with the MoS and RAE.

EECo then submitted its detailed brochure, dated 18 June 1952, which presented the proposed revised configuration for the third and subsequent prototypes. It finally dismissed the side intake option and focussed entirely on a new nose intake with a conical centrebody. The revised configuration is shown in Figure 16. This was given the designation P1B, while the first two prototypes became P1A. The difference was entirely in the nose area as shown in Figure 17. As well as improving the intake efficiency, the conical centrebody provided a suitable housing for the specified ranging radar. It was noted that it could accommodate a future larger AI radar. As shown, the scheme provided for alternative armament of either four Aden guns or two guns plus a retractable battery of 30 2-inch rockets. The text also mentioned a third option of two guns plus two Blue Jay missiles. The radars associated with each of these options were: Radar Ranging Mk 1 with an 8-inch dish, Radar Ranging Mk 1 with a 10-inch dish and Radar Ranging Mk 2. The layout also introduced a new bubble canopy design. This was one of the essential features stressed at a CFE review with industry of all fighter projects on 8/9 May. The new intake system improved the supersonic thrust, raising the maximum speed from Mach 1·56 to Mach 1·68 in spite of its increased weight.

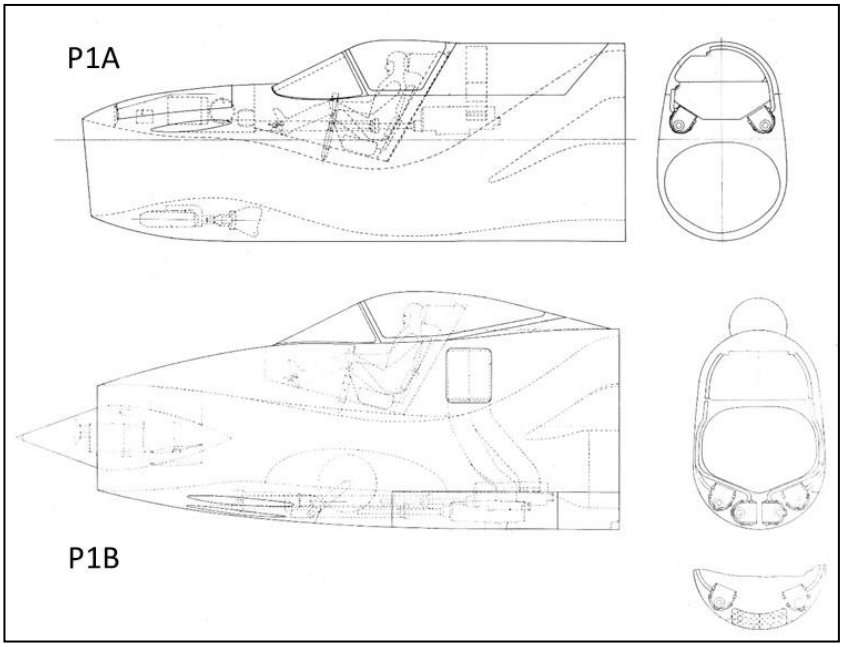


Fig 17. Proposed nose layouts P1A and P1B, 18 June 1952.

A June 1952 drawing (Figure 18), showing the initial idea for the carriage of Blue Jay also showed the first proposal for a slipper tank to increase the fuel volume by 300 gals (an extra 50%).

At this point, we see something approaching the final design of the Lightning, but much detailed work remained to be done. In a covering letter to ACAS(OR), Geoffrey Tuttle, on 23 July, Freddie Page wrote: 'As you know, these proposals are not based on any definite specification but really arise out of the opinions expressed by yourself and DOR in various discussions. I am however anxious that the weight should not get out of hand and spoil the altitude performance. I do think that this is a point which will have to be watched very

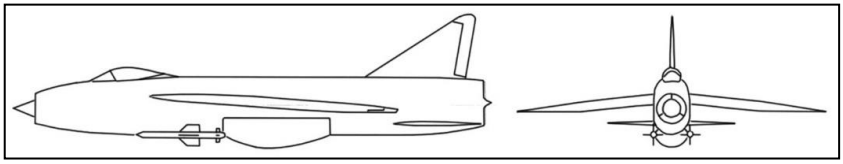


Fig 18. P1B with two Blue Jay and Slipper Tank, 18 June 1952.

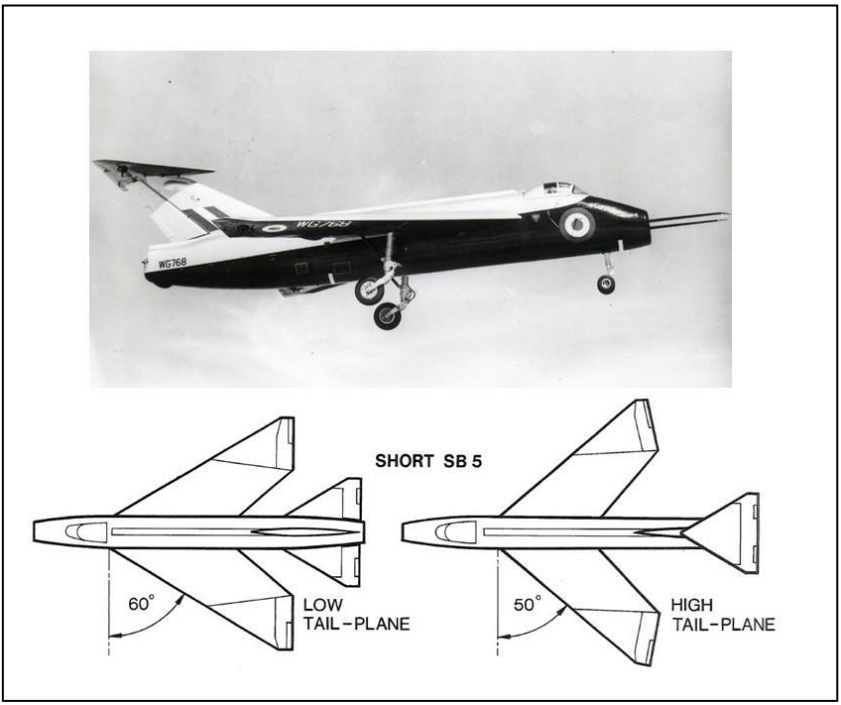


Fig 19. Short SB5 configuration options.

carefully.' On the same day, also in a covering letter for copies of the brochure, Page wrote to DMARD: 'These proposals are not based on any official MOS specification or Air Ministry operational requirement, but arise out of a meeting held at MOS under the Chairmanship of DMARD on 11 July 1951. Furthermore, at a meeting held at MOS on 9 June 1952, a decision was taken to order additional F23/49 prototypes and it was suggested that these should have the modified fuselage nose. We have now received instructions to proceed with these additional prototypes and would therefore appreciate your comments on our proposals as soon as possible.'

On 28 July, Page asked the production organisation to commence the manufacture of three additional sets of parts similar to those of the second prototype except for the fuselage nose, pending the decision on the nose design. He stressed that this work should not delay the flight dates of the first and second prototypes.

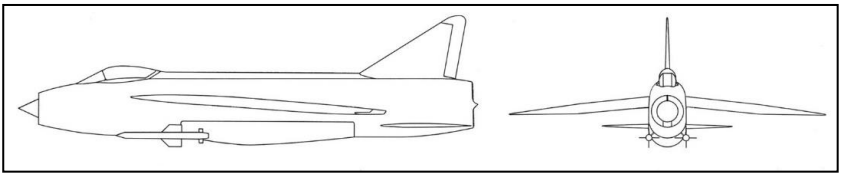


Fig 20. P1B with two Blue Jay and slipper tank, 5 February 1953.

Meanwhile, with the first prototype under construction to the original design, controversies remained to be resolved. The Short SB5 was nearing completion with the 50° wing and high-set tailplane. It flew for the first time on 2 December. By this time, the P1A's 60° wing was already under construction. The SB5 would fly with the 60° wing, but still with the high tailplane, on 29 July 1953; by which time P1A construction was well advanced. The SB5 would not fly in the P1 configuration (60° wing and low tailplane) until January 1954 when the P1A was almost complete. The results of the test flights showed that the English Electric wind tunnel analysis was correct and the P1 configuration offered superior handling characteristics. By this time, it had already been accepted that the only useful role of the SB5 in the P1 programme would be to allow Roland Beamont to familiarise himself with the flight characteristics of the highly swept wing.

Work had continued to refine the P1B design. By early 1953, the firm believed that design development had reached a stage that offered considerably better operational capabilities than first envisaged. Furthermore, the Deputy Controller of Supplies (Air), Walter Puckey, had asked if the firm, 'were taking into account all the latest experience and knowledge that was being gained at the expense of a great deal of trouble on the present new high speed fighters.' This led to an exchange between Freddie Page and the Deputy Director of the RAE, John Serby, which raised a wide range of topics to be examined in the context of the latest P1 design. As a basis for such discussions, on 5 February 1953, only two months after the first flight of the SB5, EECo issued the new brochure describing the latest design.

This gave a detailed description of P1A and P1B with performance estimates supported by evidence from sixty-nine research reports. The general arrangement of the P1B (see Figure 20) was little changed apart from a revision of the canopy, the addition of a dorsal spine to

house system runs and a revised slipper tank of 250 gals for subsonic flight only.

The main changes were internal to the nose. The four-gun installation had two in the upper nose and two in the lower nose. Alternative fits replaced the lower guns by either two Blue Jay missiles or drop-down packs containing sixty-two 2" rockets. The radar in all cases was Radar Ranging Mk 2. It was noted, however, that the 28-inch diameter centre-body could accommodate a larger search and track radar giving the potential for all-weather operation.

All the P1A and B prototypes were to be powered by the Sapphire Sa5. The predicted maximum speed was a little over Mach 1·6. In a final section of the brochure entitled 'Further Developments', it was noted that EECo was going to offer a version of F23/49 with Sa7 engines as one of its tender submissions against the research specification ER134T. This had a new project number, P6. It would have greatly increased performance, potentially well beyond M1·7 to M2·0 or more. Furthermore, the increased fuselage volume to fit the new engines would also allow a fuselage-mounted undercarriage and hence more fuel volume and better weapon carriage. The potential value of this route was stressed in covering letters to DMARD and ACAS(OR)

This brochure was still responding to the original specification from three years earlier. Now, on 25 February, a first draft of the second issue was published based on OR268 incorporating Amendment 1 and with an attached draft Standard of Preparation for the third and subsequent prototypes. It was dispatched to English Electric on 16 March. The specification incorporated the new nose design. The operational requirement was unchanged, calling for a day fighter with two or more guns and ranging radar and the longer term possibility of rocket armament. The Standard of Preparation, however, reflected the armament proposed in the brochure, calling for two or four Blue Jays plus two guns or sixty air-to-air rockets plus two guns or four guns. Mark 2 Ranging Radar was only required as an interim fit until a simple single-seat search radar became available.

The most recent discussion on equipment had been during a visit to Warton by Air Cdrs Kyle and Evans, DOR(A) and (B) on 18 February. They had resurrected the idea of fitting the Hughes E4 radar system. It was said that the F-86D achieved 20 miles detection

with a 22-inch dish and that F23/49 should have at least 10 miles detection range. It was desirable to design one type of fighter capable of both all-weather operation and day interception. They suggested armament for P1B of two guns plus Blue Jay and the Hughes E4 search radar or Mark 2 Ranging Radar. Alternatively, the Blue Jay could be replaced by two more guns or a rocket battery in that order. As to the possible Mach 2 fighter variant of P6 with Sa7 engines, they suggested an armament of Blue Jay (minimum of four) or Red Dean and two 30mm guns plus some form of pilot-operated AI equipment.

An ADC was called for 7 April to finalise Issue 2 of F23/49. In preparation, the specialists at EECo prepared comprehensive notes pointing out the inconsistencies between the draft documents, the challenges posed by the multiplicity of equipment items and noting the areas where the current design struggled to meet the requirements. Among other things, they stressed the high supersonic drag of some of the radio aerials and queried the apparently unnecessary duplication between some items.

For its part, the RAE produced a detailed commentary on the latest brochure. This was generally favourable, but listed detailed reservations in a number of areas particularly with reference to stability and control, design of the powered control system, a few equipment items and the armour protection proposed. In a covering letter, the Deputy Director described areas where the RAE might be able to give advice and recommended the approaches to be adopted in areas requiring further investigation. Page replied with thanks, adding two other topics of interest and looking forward to a joint review meeting on the day after the ADC.

The ADC was held on 7 April, attended by five representatives from English Electric and twenty-nine from the Air Ministry, Ministry of Supply and RAE. It addressed in detail the Standard of Preparation then the Operational Requirement and finally the Specification. Various changes were agreed or, where wording was left unchanged, possible difficulties were recognised and accepted. Page's criticism of the radar requirement as out of date and his plea for progress with a single-seat search radar was accepted. With regard to performance, it was accepted that the requirement would apply to the clean aircraft until such time as the effect of Blue Jay carriage and the slipper tank were better understood.

It was now about five years since the start of the project. The Air Force, however, was still concerned that MoS ambitions for the P1, as a research aircraft, might disrupt the development of the fighter. In early 1951, ACAS(OR), AVM Claude Pelly, had written to DGTD(A), Stewart Scott-Hall, emphasising that F23/49 was a 'development' programme for an operational aircraft and not a 'research' programme. Nevertheless, MoS technical oversight had continued to put a strong emphasis on the research element. Now, on 10 April 1953, ACAS(OR), Geoffrey Tuttle, wrote to PDSR(A), Ernest Jones, expressing his concern about attitudes within the MoS towards F23/49 as a research programme. He attached a detailed history of the RAF's leading role in the programme. In reply, Jones assured him that the MoS was not trying to run it as a research item, but he pressed the case for the RAE to take the lead in testing the aircraft. He urged that, given Roland Beamont's inexperience, the aircraft should be handed over to the expert pilots at the RAE as soon as possible for them to conduct the testing. Tuttle in response pointed out, 'You will know that the ace of aces on delta aircraft from RAE was sent down to fly the Javelin. He was such an expert that he crashed it.' He suggested that any flying by the RAE should be done at Boscombe Down. This ended the exchange, but the controversy lingered on. The design work, however, now focussed on the operational aspects of the aircraft.

Over the next five years, the official requirement and specification were subject to steady evolution and expansion. These changes were in response to changing military perspectives and increasing technical capabilities. Choices and progress continued to be affected by the goals for other projects.

The second issue of F23/49 finally emerged on 3 June 1953. The accompanying Appendix B was still OR268 plus Amendment List 1 but with a note acknowledging that changes agreed at the ADC had not yet been incorporated. The Specification itself introduced the fundamental change to both day *and* night operation, but EECo was disconcerted to find that many of the detailed changes agreed at the ADC had not been incorporated.

During the same month, OR268 draft Issue 3 began Ministry circulation. (There had never been a formal Issue 2. The number 3 was a typing error but was retained for the formal issue to avoid further

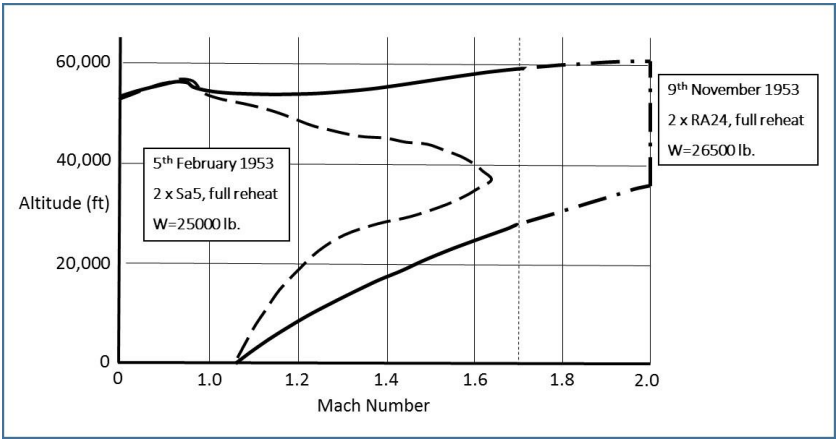


Fig 21. P1B improved performance with RA24 engines, 9 November 1953

confusion.) Also, on 19 June, the firm was sent a draft issue of OR318 for an Advanced Jet Trainer with the request to examine the possibility of meeting the requirement by modifying a fighter of the same generation. Meanwhile, over the same period, the on-going work on P6 to ER134T aroused ACAS(OR)'s interest in Mach 2 fighter possibilities or an F23/49 option with a single Gyron or RB106 and fuselage-mounted undercarriage.

After completing the P6 studies, in September 1953 attention turned to the response to OR318 with twin-seat variants of P1B with either Sa5 or RA24 engines. The latter were already the subject of a proposal being developed for P1B to overcome the endurance deficiency of the Sapphire-engined design. Also, compared to the Sa7 option examined for P6, the RA24 gave a similar dramatic increase in speed without needing major structural changes. A brochure was produced in October with RA24 as the chosen engine.

The change to the RA24 for P1B had already been agreed by the Air Staff and DMARD had requested go-ahead agreement from DGTD(A). In November, the Company produced a brochure in response to F23/49 Issue 2 based on P1B with RA24 engines. The large increase in speed is shown at Figure 21. This clearly shows P1B to be potentially a 'Mach 2 plus' fighter. Ideally, operation beyond Mach 1·7 was thought to require a variable intake but EECo believed

that operation up to Mach 2 might be possible with careful throttle handling. The brochure data is for a fixed intake.

At the end of November, Issue 3 of OR268 was published. The rationale for the new issue was that technical developments since the first issue allowed more ambitious operational objectives. It dropped the preamble about GCI-controlled visual interception. The role was to intercept bombers flying at speeds up to Mach 1 and heights up to 50,000 ft and above by day or night as soon as possible after detection by the early warning system. It was to be primarily a Blue Jay carrier and would be fitted with a search radar to OR3563 or Radar Ranging Mk 3 as an interim if necessary. The radar would be complemented by a wide-band homer, a VHF homer and new display and communication equipment, all covered by their own ORs. Entry into service was to be by 1957.

By this time the Operational Requirement and Standard of Preparation documents were all being framed to cover not only the two batches of prototypes (2 × P1A and 3 × P1B) but also 20 ‘pre-production’ or ‘development’ aircraft in two batches of 10.

The next few months saw extensive scrutiny of OR268 Issue 3. The firm provided detailed comments on the weight, space and performance implications of the requirements particularly in respect to the new items. It also queried the timescale for the availability of some equipment. An ADC was planned for February, but the number of topics raised concerning the OR led to a separate dedicated meeting on 23 February 1954. After this the firm produced a suggested revision of the OR. After consideration, Issue 4 of OR268 was sent out as a draft in March and issued on 6 April.

The new OR formed Appendix B of the 3rd Issue of Specification F23/49 which was circulated on 4 May. This then became the subject of an ADC held on 1 June. The chairman proposed that the specification should apply to the 20th aircraft of the development batch, but hoped that earlier aircraft would meet this standard. Many items from the requirement and specification were discussed as regards challenges and uncertainties and proposed solutions. As well as dealing with the details, EECo raised, once again, the general problem of the growing equipment load. They pointed out that they only controlled half of the final AUW of the aircraft, and that they must put certain provisos on their stated performance data. These

included tolerances on drag and engine power plus reservations due to the unsettled status of Blue Jay and the embodiment loan equipment that was out of their control.

EECo had completed a study which showed how critically dependent performance was on the size, weight and drag of ancillaries. At the Ministry's request it was agreed that this report should be distributed to equipment suppliers so that they could better appreciate the difficulties.

The firm pleaded for closer co-operation between the equipment suppliers and the airframe designer. The Chairman expressed the greatest sympathy with the firm and said that it was now Ministry policy that an aircraft, its equipment and armament should be considered as a weapon system and that no decisions on the equipment and armament which might affect the airframe should be made without consulting the airframe designer.

This new focus on the ‘weapon system’ concept would be a significant factor from now on.

As regards radar, it was agreed to drop Radar Ranging Mk 3 and instead to have AI 20 as the interim fit until AI 23 became available. OR268 was to be amended accordingly.

A revised draft of F23/49 Issue 3 was circulated on 7 July for comments prior to signing off by DMARD/RAF the next week. It was issued on 10 August.

Recent experience in developing a Canberra variant capable of operating at up to 60,000ft led EECo to examine P1 developments to intercept such targets. The method finally selected was to fit a pair of rocket motors in a detachable pack shaped like the ventral tank and fully interchangeable with it. The study results were reported in a brochure on 17 June. These showed that the interception ceiling could be raised to 60,000ft or higher by employing a zoom manoeuvre to reach that altitude and then using the thrust of a single rocket motor to sustain that altitude for the engagement. The second motor would be used when necessary to aid manoeuvring.

The P1A made its first flight on 4 August 1954. Although not fitted with reheat, it went supersonic on 11 August. The aircraft would prove to have none of the handling problems forecast by the RAE. In February 1958, a report to the DRPC would state, ‘This aircraft has to date been particularly free of major aerodynamic and structural

Fig 22. P1A first flight, 4 August 1954.

problems, in particular none of the vices such as pitch-up, which have afflicted the majority of recent fighter projects, including most of the American supersonic aircraft, have been encountered on the P1.' And in January 1959, DDOR4 would write, 'During the past year the flying characteristics of the Lightning have been shown to be good throughout, and even beyond, its specified performance envelope.'

The mixed power-plant concept was incorporated into a comprehensive response to Issue 3 of Specification F23/49 in a brochure dated 5 November 1954. The bulk of the brochure described P1B, but a brief initial review of P1A mentioned that drag measurements were in hand as part of the flight trials. When complete, they would be used to update the brochure performance estimates.

Externally, the P1B was basically as shown in previous brochures but with the definitive jettisonable ventral tank and exchangeable rocket motor pack as per the June brochure (see Figure 23). The maximum speed envelope was still shown up to Mach 2 – implying a potential Mach 2+ capability. Most changes were internal. It introduced the idea of exchangeable weapon packs in the lower nose fuselage. The radar was to be AI 23 or the interim AI 20, but as yet there were no installation details.

While these P1developments were underway, throughout 1954 on behalf of the Air Council, a working party chaired by Sir Arnold Hall studied the future of air defence in all its aspects. The conclusions with regard to fighters were to guide the specification of the new

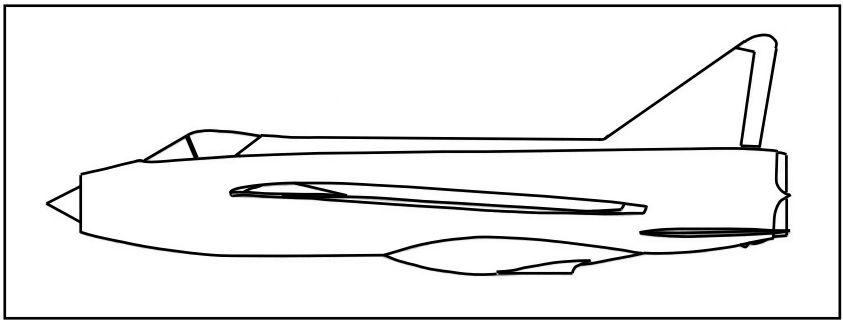


Fig 23. P1B with rocket motor pack, 5 November 1954.

fighter to requirement OR329 which was issued in the same month as the start of the working party. In the final report, the RAE specialists recommended fighter designs with long slender fuselages, straight wings, podded engines and high tailplanes. They bore a strong resemblance to the Bristol Type 188 that the RAE had chosen as meeting the E134 research aircraft specification. A Lightning-like configuration was presented as an unsatisfactory alternative. Specification F155T was issued in early 1955 at about the time of the final report.

Even before F155T was circulated, OR329 was affecting thinking about all the other fighter programmes. An example is found in a paper by OR16 making the case for continued investment in the Rocket Fighter. This looked at the period 1956 to 1964. It predicted that the Soviet Types 37 and 39 jet bombers could increase their attack altitude to about 47,000ft by operating at light fuel loads on short range missions. With engine development and reduced armament, they could increase this to over 50,000ft by 1960. From 1962 onwards, there could be a Mach 1·3 bomber operating at 60,000ft. It further predicted that, until the arrival of the OR329 fighter in 1962, most of the planned fighters (Hunter, Swift, Javelin, 545, F23, Thin-wing Javelin) would be unable to cope with this growing threat due to their inadequate realistic intercept ceiling (taken to be the 1·5g ceiling). Only the Rocket Fighter offered the necessary much higher ceiling. The day fighter prototypes from Avro and Saunders Roe (to F137 and F138 against OR301) or a possible new AI-equipped type with a larger jet engine (to F177 against OR337) would fill the gap between 1959 and 1962. They would also give the RAF experience of

operating rocket fighters ahead of the arrival of the OR329 which, it was assumed, would be a mixed power-plant fighter. In spite of the fact that only a small number of rocket fighters was required, there was no consideration of the rocket-boosting of P1B in the F23 figures quoted.

OR268 Issue 5 was published on 24 February 1955.

During the period 1954-56, three key items were central to the weapon system development: the radar, the air-to-air missile armament and the design of the cockpit displays for single-seat all-weather operation. EECo began discussions with Ferranti about AI 23 in February 1954. At about the same time, however, the RRE began promoting AI 20. At the review of Issue 3 of OR268 on 23 February 1954, there was still great official uncertainty about the radar options and their timescales for availability. However, after the selection of AI 20 at the ADC on 1 June in preference to Radar Ranging Mk 3 and the issue of OR3572 on 5 July, the installation design focused on AI 23 and AI 20. EECo were initially enthusiastic about AI 20 for its smallness and simplicity in spite of an unimpressive demonstration flight at Defford on 8 April. As time went on, however, installation problems emerged.

AI 23 was being designed specifically in response to OR3563 aimed at the P1B's needs, whereas AI 20 was an RRE experimental system that was now being productionised against OR3572. These different pedigrees impacted the installation design task. Thus, we find Freddie Page writing to DGTD(A), 'Whilst these arrangements have gone ahead satisfactorily with Messrs Ferranti, it is apparently the intention of RRE to develop their equipment on the old-fashioned lines.' The problem was that while Ferranti were making every effort to match AI 23 to the Lightning intake nose cone, both RRE and E K Cole were loath to adapt AI 20 accordingly in case it compromised its installation in other aircraft. Hence, although both radars continued to be assessed throughout 1955 and 1956; installation work focused increasingly on AI 23.

As well as the inherent installation design problems, further potential radar complications were raised by the air-to-air missile programme. Although Blue Jay was the specified armament; other missiles continued to be considered. On 7 August 1954, EECo was informed that the Air Staff, with the agreement of the MoS, had

proposed the development of a new high altitude version of Blue Sky for carriage by F23. Studies were now under way at Fairey, Ferranti and the RRE. EECo co-operation was requested. Freddie Page agreed but with a plea that this activity should in no way delay the radar programme. A meeting on 17 September revealed that the missile would be a completely new vehicle and that three guidance options were being considered. These were beam-riding, command guidance or semi-active homing. Whilst the missile could be carried in the same way as Blue Jay, all the guidance options presented problems with semi-active possibly being the least disruptive. On 9 December, EECo was informed that High Altitude Blue Sky had been cancelled.

On 22 May 1956, Mal Powley of Ferranti wrote to Page warning him that Sir Stewart Mitchell (CGWE) had recently enquired about the possibility of adding CW injection to AI 23. This was to support the use of Sparrow Mk 3 by the P.177 aircraft to overcome the weather limitations of Blue Jay. Obviously, the same rationale might apply to the P1 with severe repercussions due to the major increase in space and cooling requirements.

These were minor distractions and detailed design including installation mock-ups for Blue Jay proceeded through 1955 and ‘56.

Draft Specification F23/49 Issue 4 dated 24 February 1956, incorporating OR268 Issue 5, was circulated to industry on 23 March. It was intended to apply to the third, fourth and fifth prototypes and the twenty aircraft of the development batch. It was sent out for comment prior to issue in April, but the issues raised revealed developmental problems that delayed publication for a year.

In his initial eight page response to the draft, Freddie Page commented on over forty items in the Specification and the Requirement. He pointed out the inconsistencies between the documents especially in respect of performance goals. Among the detailed comments, many noted that progress against the specification was stalled by lack of information about items of equipment, all of which were out of the firm’s control. Furthermore, some items would not be available in time to fit to any of the development aircraft. His general conclusion was that the continual revision of the specification and the slipping schedule of equipment availability meant that the value of the development batch was being lost.

The operational utility of the radar and weapons was entirely

dependent on the successful integration of their displays and controls with the other cockpit instruments and equipment. Among these was a new suite of flight instruments to OR946, issued on 16 July 1954. This was required for all fighter aircraft with performance equal to or greater than F23/49 but was needed initially in time for F23. The RAE was the design authority. Detailed investigation for F23 only began in late 1955. During 1956, significant conflicts were revealed. The interaction between the OR946 suite and the Elliott autopilot needed rationalisation. Space conflicts between OR946, the pilot's sight and leg-room were hard to resolve. It was eventually agreed that a test version of OR946 would be fitted to the twelfth development aircraft, but the production standard would not be ready until after the first 40 to 50 production aircraft. It required redesign of several of the aircraft's equipment bays and revised wiring.

These development problems led to the realisation that weapon systems could not be developed piecemeal. The weapon system concept had been introduced for F23 at the ADC in June 1954 and had been declared as underpinning OR329 and its associated weapons and equipment in the same year. A detailed explanatory paper had been issued by OR16 in November 1955. Only now, however, was it acknowledged that a weapon system's development needed managing in its totality. In October 1956, EECo were asked to take on the management of the F23 system integration. Freddie Page accepted, but expressed concern that it would be hampered by the firm still having no design control over the equipment to be integrated.

During 1956, the theoretical basis for assessing supersonic performance underwent a major revision with the open publication of Richard Whitcomb's 'Area Rule' following its classified issue in the USA in 1954. This replaced the goal of minimising the aircraft's frontal area with a more refined approach aiming to achieve a smooth variation of cross-sectional area from nose to tail. Analysis showed that, fortuitously, the P1 measured up very well in this respect – see Figure 24. Some schemes were drawn up to add bulges to the fuselage to get further improvement, but these were found to be unnecessary when the air-to-air missiles were in place. On the other hand, the RAE's preferred configurations of the Bristol Type 188 and the Air Defence Working Party fighter recommendations required major revision.

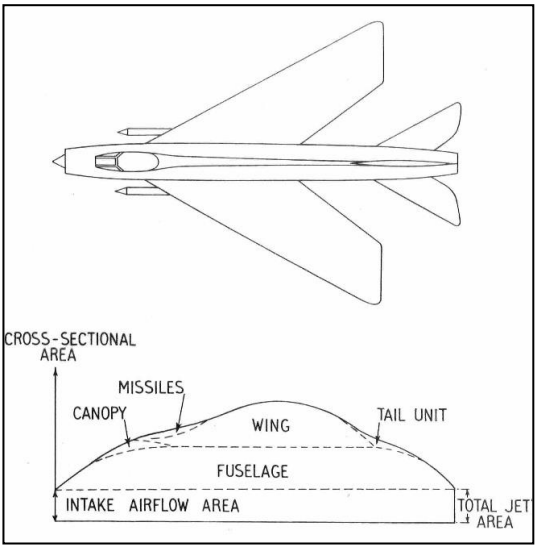


Fig 24. P1B Area Rule analysis.

As the integration of Blue Jay Mk 1 was firmed up, attention turned to the exploitation of three new versions. Of these, Blue Jay Mk 4 seemed to offer the most potential. With a seeker able to detect not only the hot jet pipe but also the engine exhaust plume, and even the warm skin of an aircraft, it could be fired from in front of the target. It had been suggested as an affordable way of meeting OR329 in EECo's tender to F155T, but rejected by the RAE as being too optimistic about seeker performance. The firm returned to the idea in the context of F23 with a study reported in June 1956. This showed that any realistic supersonic bomber would produce a signature that allowed Blue Jay Mk 4 attacks at up to 150° off the tail. This would actually allow head-on interception if the missile was fired in snap-up mode from 10,000ft below the target.

This analysis was taken further in a brochure issued in October 1956. This showed the significant benefits from head-on interceptions compared to tail-chase engagements. It analysed the potential target characteristics of bombers and reconnaissance aircraft and presented the results of interception studies against a Mach 1·3 target at 60,000ft and against subsonic targets. These showed that, against a subsonic target, front hemisphere attack with Blue Jay Mk 4 resulted in an interception 30nm further from the coast than the tail-chase with Blue Jay Mk 1. Against the Mach 1·3 target, Blue Jay Mk 4 allowed interception at distances that were only possible against subsonic targets with Blue Jay Mk 1.

OR 268 Issue 6 was circulated on 31 December 1956.

Fig 25. P1B, first flown 4 April 1957.

1957 brought major defence changes. On 21 February, in the light of the dominance of ballistic missiles as the future strategic threat and the increasing capabilities of surface-to-air guided weapons, on the advice of the Air Staff the Air Council agreed to cancel several major aircraft projects. These included the fighters F155 (OR329) and F177 (OR337). The F23 was to be retained and developed to its useful limit. The main development focus for air defence would be long range SAGW including an anti-ballistic missile capability. On 11 March, DOR(A) drafted a letter to the MoS explaining the reasons for the cancellations. The cancellations would then feature prominently in the Defence White Paper presented by Duncan Sandys in April.

The day after the Air Council meeting, and as yet unaffected by its decisions, Issue 4 of F23/49 was finally circulated.

The third prototype and first P1B flew on 4 April and went supersonic during the flight. During the same month, EECo produced a detailed brochure, ‘P1B Interceptor Fighter – Weapon System to Specification F23/49 (Issues 3 and 4) with Mixed Power Plant’. The main text gave a detailed description of the aircraft with the specified Blue Jay armament and presented performance for tail-chase attacks. The maximum speed was limited to Mach 1·7 pending further investigation and development. The use of rocket boost was shown to raise the ceiling to above 65,000ft via zoom manoeuvres with a note that recent testing of the Napier rocket motors had produced 50% more thrust than assumed in the study. AI 20 and AI 23 were presented as the radar options, but only AI 23 was described in detail.

(AI 20 would finally be cancelled for P1B and deleted from F23/49 Issue 4 on 17 April.)

Since it was not part of the official requirement or specification, discussion of collision-course interception with Blue Jay Mk 4 was confined to a section on 'Future Developments'. This also addressed the problems of intercepting bombers using 100 mile range powered bombs, bombers using ECM and targets flying at 60,000ft or more. It was suggested that the problem of bombers cruising at supersonic speed, and not just short dashes, was sufficiently far in the future to be left until later in the fighter's development.

The basic design of the Lightning was now firmly established. Much work remained for the development batch and beyond to introduce the numerous items of equipment and to integrate the system. It would take another three years to get the Mark 1 into service and seven years to get to nearly the full potential with the Mark 3, but it would be thirty-two years until it finally retired from the front line.

Glossary – for abbreviations, see pages 5 and 127.

Sources

BAE Systems Warton Heritage Department Drawing Archive

EAG Drawing Register
FWP 1-1_22f, FWP 4-1_7, FWP 4-1_17, FWP 4-1_18, FWP 4-1_28, FWP 4-3_LA033, FWP 4-3_LA036, FWP 5-3_59, FWP 6-2_10, FWP 6-2_11, FWP 7-2_5/9

HA413, HA765, HA913, HA2521, HA2543, HA2548, HA7047, HA7395

The National Archives (TNA):
ADM 1/25429, AIR 2/12686, AIR 2/13267, AIR 2/13554, AIR 2/14963, AIR 2/14965, AIR 6/110, AIR 8/1641, AIR 20/6721, AIR 20/7395, AIR 20/8594, AIR 20/8596, AIR 20/8598, AVIA 13/664, AVIA 13/1327, AVIA 53/14, AVIA 54/419, AVIA 54/427, AVIA 54/2258, AVIA 65/273, AVIA 65/1274, AVIA 65/1275, DEFE 8/46, T 225/1401

All illustrations courtesy of BAE Systems' Heritage Department.

THE AIR FIGHTING DEVELOPMENT SQUADRON (AFDS)

by Air Cdre John Mitchell

Having trained in Southern Rhodesia in 1951, John flew Meteors with Nos 256 and 72 Sqn, converting to Javelins with the latter. In 1960 he joined the AFDS and began a relationship with the Lightning which included tours with No 226 OCU and No 111 Sqn and command of No 92 Sqn in 1971. After a stint at the MOD, by 1977 he was Station Commander at RAF Wildenrath. Before leaving the service in 1984, there were two more AD staff appointments, with CTTO and MOD, and a final tour in Kuwait as Military Adviser to the Minister of Defence.

The AFDS that I will talk about this morning had its origins within Fighter Command, as the Air Fighting Development Unit – the AFDU – in the 1940s. In the '50s, as the AFDS, it had been absorbed into the Central Fighter Establishment (CFE) and was, at one stage, commanded by a Wg Cdr Roly Beamont, a name that will forever be associated with the testing and introduction into service of the Lightning. CFE, at that time, was based at West Raynham. The Commandant was an air commodore, in this case, Hughie Edwards VC, and the Gp Capt Operations was Denis Crowley-Milling of 'Bader Bus Company' fame; no lack of operational know-how there you might think. The CFE consisted of five units: the HQ with the Tactics and Trials think tank; the Day Fighter Combat School (DFCS) with up to sixteen Hunters; the All Weather Fighter Leaders School (AWFLS) equipped with Javelins; the AFDS with Lightnings, Javelins, a Hunter 6 and a Meteor 7; and the Fighter Command Instrument Rating Squadron with Hunters and Meteors. It is for consideration that those units, combined with the Central Gunnery School at Leconfield for the training of Pilot Attack Instructors (PAI), formed the nucleus of the most extensive and comprehensive post-graduate training ever available to RAF fighter pilots.

The first pre-production Lightning arrived in December 1959 and AFDS detached to Coltishall to take advantage of a longer runway.

Early in 1960 a short-duration move to Leconfield was necessary to allow resurfacing of the runway at Coltishall to take place. I was based at Leconfield with No 72 Sqn flying Javelins and was as impressed as anyone with this new, revolutionary shape in the sky. Disappointingly, the pilots seemed rather reluctant to talk about the aircraft and their tasks – even to a very enthusiastic audience. The exception, which will not surprise many, was Ken Goodwin who was happy to discuss performance and handling details and showed me around the cockpit. One evening, night flying complete, I was approached by a Sqn Ldr Frank Babst, of AFDS, and invited to meet his CO, Wg Cdr D C H Simmons, the following day – a Thursday. During the meeting I was asked if I was interested in joining the AFDS. It came as a total surprise and I mumbled something resembling, 'If it can be arranged.' He responded, your current Squadron Commander is aware, the Commandant has agreed, and Fighter Command has approved – you join us on Monday; I didn't fly that evening.

During this period, the first production Lightning F1, XM134 I think, was delivered to AFDS on 29 June 1960 by Roly Beamont. I am precise about the date because I flew him back to Warton in a Meteor 7. 'Bee', very kindly, took the opportunity to introduce me to his team; his newly arrived deputy, Jimmy Dell (whom I had met previously when completing the PAI Course), Sqn Ldr John Nicholls, the Fighter Command Liaison Officer at Warton and, unknown to us then, soon, on promotion, to be the next CO of the AFDS; Don Knight, 'Dizzy' de Villiers, Johnny Squire, Tim Ferguson, etc. I mention this, not just because of Bee's thoughtful action, but to pay tribute to the excellent relationship that existed between the manufacturer and the customer at that time and that, I think, continued throughout the life of the Lightning.

A short while after this, the squadron returned to Coltishall and I met the full complement of AFDS for the first time; a wing commander, three squadron leaders, five Lightning pilots, six Javelin pilots, four nav rads and two engineering officers. There were four Lightning F1s, four Javelin 6s, soon to be replaced by Mk 8s, a Meteor 7, a Hunter 6 and, soon, a Chipmunk. My initial role was flying the Javelins fitted with an instrument system designed to meet the RAF's OR946 requirement, and included an Elliott Bros autopilot, a master reference gyro, an auto attack system and an instrument

Led by an AFDS Lightning F1, XM137, the other aeroplanes in this 1960 formation were: Hurricane IIc, LF353; Spitfire PR19, PM631; Meteor F8, WL164; Hunter FGA9, XE610 and Javelin FAW9, XH894.

landing system; it was designed to be fitted to the Lightning Mk 2 and subsequent derivatives. The system came to AFDS for, supposedly, a 100-hour acceptance exercise; it was flown for well over 1,000 hours – I can only guess at whose expense. To the best of my knowledge it never met its full design criteria but was, nevertheless, accepted into service. One learned something about the procurement of defence equipment from that!!

The initial months provided a fascinating opportunity to evaluate my own suitability for this role as well as my new colleagues. Three factors stand out and are, of course, a purely personal view:

1. The reluctance to visit user units to discuss AFDS activities, first noticed at Leconfield, continued.
2. It appeared to me that Peter Collins was the solitary driving force in the essential, I thought overriding, task of evaluating the aircraft as a weapons system. The majority of the other pilots had a single-seat background with no previous experience of airborne radar interceptions – the imbalance did not seem logical to me

then, or now for that matter.

3. The massive, largely unrecognised, and, I suspect unplanned, contribution made by the nav rads of the AFDS in creating the initial attack profiles, teaching the pilots who had no previous experience, the fundamental points of radar controlled interceptions and undertaking a similar task with the new simulator instructors. Their services continued for several years; my own nav rad from 72 Squadron days, Donaldson-Davidson. became an instructor with Ken Goodwin on the Lightning Conversion Unit (LCU) and later, when I joined No 3 Sqn of the OCU, Alan Cushman fulfilled a similar role.

I doubt if my role on AFDS was ever explained to me in any detail and so it came as a pleasant surprise to be told only a few months after joining the squadron, to make preparations for a conversion to the Lightning. The conversion programme was self-constructed and managed and consisted, in the main, of satisfying the simulator fraternity that I was competent. My first sortie was in XM136 from Coltishall – in terms of performance, a quantum jump from anything I had flown previously but totally exhilarating.

My first impression was of a very comfortable but compact cockpit in keeping, I thought, with a contemporary, high speed fighter aircraft. I was less impressed with the ergonomic lay-out of the cockpit – but, after a series of simulator sorties, I became very familiar with the location and function of the switches and instruments and quickly accepted the less than ideal positioning of some. Fuel consumption was, and remained, an ever-present issue but, that said, it was a memorable occasion and I loved every minute of it.

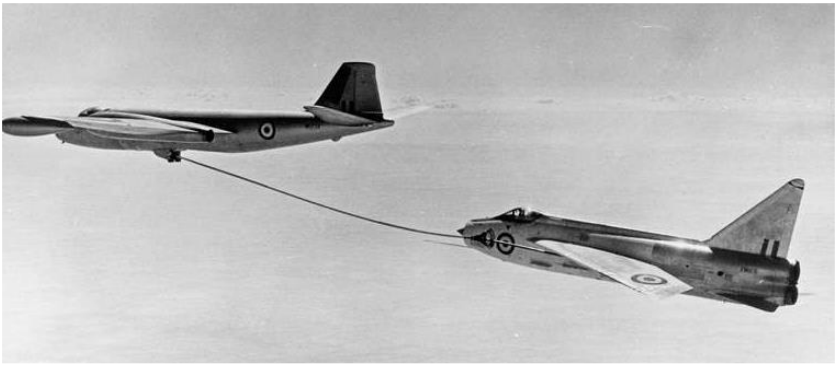
I created an 8-sortie weapon system familiarisation programme – with the assistance of Nick Thurston – and, on completion, considered myself ready to contribute to the real tasks of the squadron. In mid-1961, I was appointed as Project Officer for the Air-to-Air Refuelling (AAR) trials for the Lightning; in essence to develop and prove techniques for the exercise that was to culminate in a proving flight to Akrotiri. No 56 Sqn would supply the Mk 1A for the trial which would be conducted from Coltishall.

My first priority was to visit Warton to view XM169, the first production Mk 1A fitted with the refuelling probe and modified fuel

At one stage, to assist with air-to-air photography during the air-to-air refuelling trials, XM169, wore this unusual paint scheme.

system, and to discuss AAR techniques with the test pilots. The visit drew a blank; there was nobody who would admit to actually conducting AAR in a Lightning. The system had been cleared, I was told, by connecting a drogue to the probe and refuelling the aircraft from a bowser on the ground. In any event, XM169 was to longer at Warton as it had been transferred to Boscombe Down. This was almost typical of my experience in these circumstances; the information required might be available – if you could locate it.

Subsequent research revealed that Roly Beamont had done some testing, if not proving, of the configuration, with P.1B XA847 in 1959, but it was far from clear whether any airborne fuel transfers had taken place or whether it was only an exercise to approve the positioning of the probe. My next visit was to Boscombe Down; XM169 was indeed there and, after some discussion and to my great surprise, I was invited to fly it – subject to the approval of, I think, the Ministry of Supply and, of course, CFE. The latter was a simple matter; the former took a day or two. A sortie on 1 September was aborted because of tanker unserviceability. The sortie was rescheduled for the 5th, when I was the sole user of the A&AEE Canberra tanker and I enjoyed two hours of wet and dry contacts at circa 18,000 ft over the Solent. On completion, I felt I was now in a position to liaise with No 214 Sqn, with Valiant tankers at Marham, about my requirements and to alert



Lightning XM169 making contact with the A&AEE's Canberra B2 tanker, WH734.

No 56 Sqn to prepare to supply a Lightning 1A. Unfortunately, it was at this juncture that the Lightning 1A force was grounded for an extensive hydraulic and fire protection modification programme. The delay lasted a full 9 months.

During this period, the AFDS acquired a new CO; Wg Cdr John Nicholls, who, as I have mentioned before, had been the Fighter Command Liaison Officer with English Electric at Warton. With the change of command came, among many other preferences, a new emphasis in communication; a closer contact with squadrons and the passing-on of information to potential users. I took the opportunity to suggest that the AAR trial should take place with the squadron supplying the aircraft, ie at Wattisham, rather than at Coltishall. He agreed immediately; I would be attached to 56 Squadron for the duration of the trial. Furthermore, I suggested that the trial should also involve squadron pilots – although management should remain within the control of AFDS. He was more guarded on this proposal, although he did accept the suggestion in principle, particularly in view of the huge tanker effort required to get just my one aircraft to Akrotiri and back. He was prepared to reconsider squadron involvement only if the initial stages of the trial went smoothly.

The first sortie of a Lightning taking fuel from a Valiant took place on 13 June 1962; the second on the following day and both lasted 2 hours at heights around 34,000 ft; time of flight was limited only because the consumption of engine oil and liquid oxygen were under

review; all appeared to be satisfactory. These events gave me the confidence to rejoin the debate to urge the use of squadron pilots. I made the point that a successful technique had been developed; it was straightforward and could be readily taught by briefing and observation. I had established that 214 Squadron had the capacity and I was delighted when the new format was accepted. It was agreed that I would supervise a training programme for the Squadron Commander, Sqn Ldr Dave Seward, and that he and I would take the aircraft to Akrotiri and I would work-up two other pilots to complete the return journey. It was, to me, an arrangement much more in keeping with role of AFDS and was of immediate value to the user community.

The programme proceeded with few glitches with the tanker force exceptionally helpful, flexible and determined to succeed. A 5-hour flight was required to finally put the outstanding issue of oil/oxygen consumption to bed and when that was complete we had the necessary clearance to proceed with the deployment. And so, on 23 July, the two aircraft departed Wattisham and, after five or six air-to-air refuellings, and an elapsed time of 4 hours and 20 minutes, a new shape appeared in the skies over Cyprus. This was a memorable occasion, but it was soon to become a routine activity.

The return flight, with two different pilots, took place 48 hours later and was equally successful. The capability of the Lightning to be deployed relatively rapidly had been demonstrated; it was, after all, a pretty straightforward activity that would soon become old hat. Clearly, I was very pleased with the success of the trial but particularly satisfied that the results were immediately available to the user and the information not delayed by the issue of a formal report. As you have heard, the elapsed time from my first refuelling at Boscombe Down in September 1961 to the completion of the proving flight to Cyprus in July 1962 was pretty well 11 months; the planning and execution of trials was not as straightforward as I had imagined!

I thought it appropriate to raise the prospect of a fighter/tanker affiliation trial – a tanker on tap so to speak – and the tanker force was very enthusiastic. The aim was to extend the airborne duration of the Lightning so that it was a shortage of weapons, rather than fuel, that necessitated a return to base. In this way I hoped to create an operational scenario to justify the fitting of two more Firestreak

missiles to the weapon stations that had already been discussed; unfortunately, that suggestion fell on stony ground!

A few months later, I was tasked with an airborne evaluation of a Victor flown from Radlett, fitted with sideways looking radar pods under each wing, The flight was to assess the presence of any peculiar airflow patterns generated by the aircraft that would prevent it being converted into a tanker with three refuelling points. Once again, I insisted that a pilot from the user squadron should be involved and Les Swart accompanied me in a second AFDS Mk 1. No difficulties were revealed but it was gratifying to know that a replacement for the Valiant was being planned long before it was finally grounded with its main spar metal fatigue problem.

I was next tasked, as Project Officer, to develop and prove a profile for the interception of a very high-flying target. Three U-2 aircraft of the USAF had been deployed to Upper Heyford, in mid-October 1962, for what was thought to be a three- or four-week stay. Fighter Command had obtained agreement from the USAF authorities that their aircraft could be intercepted within UK airspace. As the aircraft had already been in the UK for three or four days, the clock was ticking and a pretty quick response was required.

By way of background, you may recall that the U-2 was a 'Black' programme that had started in the early 1950s. U, for utility, rather than R, for reconnaissance, gives a clue as to its likely employment. Initially, the project was sponsored by the Central Intelligence Agency (CIA), another clue perhaps, although the USAF did join the programme later. The aircraft was designed and constructed at Lockheed's 'Skunk Works' at Burbank before being flown from the secret Groom Lake facility in the high desert of Nevada in an elapsed 18 months – a remarkable achievement.

It was rumoured that incursions into Soviet airspace had become fairly commonplace but, on 1 May 1960, Gary Powers, a retired USAF major with a record of 26 successful covert reconnaissance missions in the aircraft in 'unfriendly airspace', took-off from Peshawar, Pakistan to overfly the Soviet Union and land at Bodø, Norway. A succession of attempts by manned aircraft to destroy the U-2 failed. Eventually, an SA-2 missile, one of a least eight fired at the aircraft, hit or damaged it sufficiently for Powers to be forced to bale out; he survived but was taken into custody by the Soviet

authorities.

A lively debate between Washington and Moscow ensued and further overflights of Soviet airspace were forbidden by President Eisenhower. Subsequently, all U-2s were fitted with a more powerful engine, allegedly capable of taking the aircraft to altitudes in excess of 75,000 ft and thus retaining their invulnerability to manned aircraft while also taking them outside the calculated performance parameters of known surface-to-air missiles. It was three of these aircraft that were deployed to Upper Heyford and, it seemed to me, among the rapidly competing actions, that a visit there was the priority.

The visit established, from the USAF pilots, that their mission was a daily flight to beyond the northern tip of Norway for upper air sampling which, when analysed, would provide details of the yield of the nuclear weapon recently discharged on the northern ranges of the Soviet Union – or perhaps that was the cover story – who knows? Little information on the performance of the U-2 was forthcoming; they did allow a look around the cockpit and I witnessed the return of that day's flight and watched a departure the following morning. The aircraft would depart at 0700 hrs each morning and return to UK airspace circa 1500 hrs. The aircraft's track was pre-planned, would not be subject to change and would coast-out and coast-in somewhere in the region of Cape Wrath. Details of heights and speeds were not forthcoming and any conversation on performance parameters was, at best, guarded. The impression I gained was that the pilots were convinced that they were operating beyond the reach of any manned aircraft – but that I was welcome to join the substantial list of unsuccessful interceptors . . .

What was absolutely clear was that the Lightning was going to have to operate outside of its currently authorised limits. A visit to Warton was the next priority; the test pilots anticipated no particular handling problems at the heights to which I alluded but admitted, as they hadn't actually been there, they really didn't know. However, perhaps as some sort of compensation, they offered the services of a design aerodynamicist. I readily accepted the offer and his assistance proved to be very beneficial later. A conversation with Rolls-Royce produced a similar response – no anticipated problems, although I might experience reheat extinction, or even a flame-out, at extreme altitudes or excessive angles of attack. A visit to de Havillands to

The full pressure suit was a 'cosy' fit in the Lightning.

discuss Firestreak performance at higher altitudes again produced the response of 'no anticipated problems'. I returned to AFDS well short of the advice I had anticipated.

Regulations required that, at the heights I proposed to fly, I should wear a full pressure suit. Accordingly, I went to a company in Newton Heath, Manchester that rejoiced in the name of Frankenstein and Sons; very appropriate I thought. The garment was then sent to the Aviation Medical Centre at Farnborough where I attended for fitting along with the statutory explosive decompression. I was acutely aware that the new equipment would make for a very cosy fit in the Lightning cockpit. Whilst at Farnborough, I took the opportunity to consult an expert on the propagation of supersonic shock waves. Clearly, as the target would not vary its track, the interception would take place with the fighter either pointing towards the mainland or actually over it. I was made aware, repeatedly, that a plethora of complaints of sonic bangs would bring a very speedy conclusion to the trial. There was now no justification for further delay; I had most, it not all, of the information I was likely to get. It was time to create an attack profile.

At AFDS we had our own fighter controller on the staff. He had been watching the U-2 over the last couple of days and could confirm its timing and track and he had a good idea of its ground speed – which varied a great deal more than we had expected. The aim of the planned profile was to get the Lightning to a key position 20 miles astern of the U-2 at a height of about 50,000 ft and as near to Mach

The very high-flying Lockheed U-2.

1·7 as possible. An energy climb would then be initiated, hopefully, to take out whatever height difference existed. I had been advised at Farnborough that the possibility of a supersonic bang reaching the surface could be minimised if the aircraft retained a climbing attitude. It was time now to employ intelligent guesswork – with the assistance of the friendly aerodynamicist I have mentioned.

A start height of 25,000 ft was selected to allow a climbing acceleration for which there was no confirmed data on performance or fuel consumption. The plan was to have the fighter at 90º to the target's track at an agreed range to be followed by a gentle, accelerating, climbing turn to achieve a position astern the target – to the key position I referred to earlier. That was the theory; when produced on a map the airspace used was enormous. Of infinitely more concern was that the initial acceleration would be too close to London for comfort and, critically, may not have allowed time for the target to achieve its cruise altitude; the whole centre of gravity of the intercept had to move north. Leuchars would be ideal, but could not accept the commitment. Middleton St George, the base for the Lightning Conversion Squadron, was the only option and they did not want the commitment. Nevertheless, Fighter Command approved and the deployment was hastily arranged. I was conscious that each day's delay was costing the opportunity of two interceptions against the U-2. This additional delay left no time to test the attack profile in a simulator prior to the real thing.

The date of the first intercept was 17 October 1962. Take-off was soon after 0700 hrs; the U-2 was on time, as it was throughout the trial. The manoeuvre to get to the acceleration point was straightforward and my track took me just north of the Wash. The profile seemed to be working well as the instruction to turn on to the target's heading coincided with speed increasing through 1·5M and climbing to 50,000 ft. I was very close to the pre-planned height and speed when the key position of 20 miles astern was achieved. I commenced the energy climb and almost immediately the target appeared on my radar at a range of 18 miles. Very little lateral movement was required to remain directly astern but the initial, and lasting, impression was of a very high closing rate – probably supersonic. The missiles acquisition lights illuminated, and I was elated to recognise the target as a U-2. The world's highest-flying spy plane was no longer invulnerable to a manned aircraft intercept; the Lightning had done it with a huge amount of energy to spare. The requirement not to approach closer than a half a mile or go in front of the target was, very simply, impossible. A climbing turn starboard towards the North Sea was initiated, very close to Edinburgh, and reheat was cancelled to regain subsonic flight. The U-2 continued on its mission well below me at a height I estimated to be below 65,000 ft. The exhilaration of a highly successful first sortie, and the incredible view outside, diminished slightly when I viewed the fuel gauges! That was to be the common denominator – low on fuel or VERY low on fuel. It created few problems in the morning sorties, as landing at about 0740 hrs, the airspace was relatively clear and I was the sole user of the airfield. It was not always so straightforward following the afternoon sortie, particularly if one was downwind of the Middlesbrough smog.

The afternoon followed much the same pattern with the acceleration in a westerly direction taking place just north of Edinburgh with completion in the Cambridge area. The target was invariably higher on the return flight but in my view never achieved heights in excess of 70,000 ft. The Lightning behaved perfectly throughout the trial; even at altitudes above 84,000 ft, at very low indicated airspeed, gentle manoeuvring was possible with no hint of uncontrollable yaw, wing drop or roll/yaw coupling that you might expect of an aircraft of this design and performance.

The AFDS was allotted XN726, its first F2, in February 1963.

After a couple of days, my Boss, John Nicholls, decided to follow me in a second aircraft. Following a successful sortie, I raised, once again, the thought that we should involve squadron pilots. To my surprise, he readily agreed and so, after a careful briefing several pilots from the Wattisham wing, including Peter Ginger, Henryk Ploszek and Terry Thompson, took turns to follow me in a second aircraft through several sorties. Sorties continued at two per day until 26 October when, with minimum warning, the U-2s failed to appear. Their absence for those two weeks was never explained but they may have had a role to play in the Cuban missile crisis. They returned on 12 November, just for three days, prior to returning to the States.

To summarise the events of that exciting month is difficult. Suffice to say that the trial was conducted, deliberately, in a close-control dominated, almost artificial, environment. For instance, all the RAF radar facilities, from Bawdsey in the south to Saxa Vord in the Shetlands, were manned to track the target and assist the fighter. My task was to design and prove an attack profile to bring weapons to bear on a specialist target; this was achieved with a 100% success rate.

On the conclusion of this trial, I had only a few months remaining on my AFDS tour. This coincided with the introduction into service of the Mk 2 and it was good to see the instrument system, to satisfy OR946, fitted in the aircraft for which it had been designed. I left the squadron before the arrival of the Mk 3, but I was to catch-up with that model a little later. As for trials flying, I was fortunate indeed to

The OR946 instrument panel.

be appointed as Project Officer for two important trials and, of course thrilled with the results. However, I think, on balance, that I was more pleased to be able to persuade higher authority to involve front-line squadron personnel at an early stage in any relevant trial. That, I believe, emphasised the real value of AFDS – the promulgation of the new data at the earliest possible moment to where it was most required and would be of most use.

With the demise of the CFE, the AFDS disbanded in 1966 to be replaced by the Fighter Command Trial Unit until that, in turn, became the Central Tactics and Trials Organisation (CTTO) based at Strike Command (as was) and which I joined as Gp Capt Air Defence/Offensive Support following my Station Commander tour at Wildenrath. CTTO was, in turn, replaced by the Tactics and Trials Wing of the Air Warfare Centre at Waddington. Today it has about sixteen officers, covering all aspects of air operations, but particularly Tornados, Typhoons and, of course, the very new and exciting F-35 or, perhaps, Lightning 3? It rejoices in the title of No 92(R) Sqn, which might just be a suitable opportunity for me to conclude this presentation.

'The ironmongery-dominated design of the windscreen and canopy' hindered visual acquisition.

However, I have deliberately omitted any mention of reliability, serviceability or operational issues; they will be covered by Gareth, Rick and others later. But, having experienced some of the frustrations of the early years, I think I am entitled to give, what I would consider to be, a more balanced view. The Lightning Mk 2A, arguably the best of breed, whilst in Germany demonstrated the best and, perhaps, the not so good aspects of this aircraft. Visual acquisition of targets was significantly impaired by the ironmongery-dominated design of the windscreen and canopy. The associated blind spots undoubtedly reduced mission effectiveness in our subsidiary role of visual low-level combat patrols. However, for our primary task, the integrity of the demarcation border between East and West, we maintained two aircraft at 5 mins readiness, 24/7, in all weathers not just day-by-day, but year-on-year and we never failed to meet the commitment; incidentally, we also achieved the monthly flying target on a routine basis. To achieve this, a reliable and serviceable aircraft was essential. Where those issues could not be resolved, they had to be, and were, managed. It was, after all, the role for which the aircraft was designed; speedy reliable response, rapid acceleration, prodigious rate of climb. In that role, at that time, no other aircraft in the world could match it.

THE INTRODUCTION OF THE LIGHTNING INTO SERVICE

by Sqn Ldr Tim Nelson

Having graduated from Cranwell in 1957, Tim Nelson flew Hunters and then Lightnings with Nos 74 and 92 Sqns. A Gnat QFI by 1965, he flew with the Red Arrows in 1966 and, following a staff tour at HQ Flying Training Command, again in 1969, as Team Leader. He spent 1971-73 back on the Lightning with No 5 Sqn but, after two more staff appointments, he left the service in 1980. Post-the RAF, apart from living in Italy for 8 years while restoring a villa, he has been a famer, manufactured furniture and worked in a number of facets of local government.

After a false start, aiming for a career in farming, I was at school near Dunsfold in the 1950s where, inspired by the likes of Neville Duke and the Hunter, I saw the light and went to Cranwell instead. That was in 1954 – 70 Entry. On graduation I was posted to Hunters at 229 OCU Chivenor and, at the end of 1957, I joined No 74 Sqn at Horsham St Faith. We knew that we were to get the first Lightnings but, as it turned out, it would be more than two years before that happened. In the meantime, because the new aeroplane would need a longer runway, we moved to Coltishall in 1959.

In February 1960 we got a new CO, Sqn Ldr John Howe, a South African, who took over from Sqn Ldr Pete Carr who was leaving the RAF to manage Donald Cambell's Bluebird water speed record project. John was an experienced fighter pilot who had flown F-86 Sabres with the South African Air Force in Korea. It was now his task to bring the Lightnings to operational readiness ASAP and, in his initial address, to the whole squadron, he announced that he hoped to achieve this within two months. I became the Squadron Adjutant.

We eventually began to send batches of groundcrew on a variety of courses run by English Electric, Rolls-Royce, Ferranti, de Havilland and others to learn about the very complex inner workings of the aircraft, its maintenance and its servicing requirements. Because the Lightning would be required to operate at very high altitudes, well

A Lightning F1 getting airborne and creating its own private 'cunim' in the intake.

above the troposphere, the pilots had to attend the RAF Aeromedical Centre to be fitted out, in addition to the familiar G Suit that we used in the Hunter, with a partial pressure jerkin and a Taylor helmet to enable us to breath at heights of the order of 70,000 feet. We were also put through their pressure chamber to experience the effects of a rapid decompression.

Being stationed at Coltishall meant that we were collocated with the AFDS. They had taken delivery of three Lightnings some months previously and were busily exploring the aircraft's capabilities and developing new tactics to permit the Lightning to counter the threat posed by the Soviet Badgers and Bears that were expected to attack our V-bomber bases in the event of WW III. Exploiting the AFDS's experience with the aeroplane, in January 1960 the Lightning Conversion Unit (LCU) was set up under the overall umbrella of the CFE for our benefit.

The aim of the game was to provide us with an initial week of lectures covering the aircraft's various systems – electrics, hydraulics, fuel management, the radar and its B Scope presentation, the pilot attack sight, the Firestreak missile, the autopilot, TACAN, the new OR946 flight instrument display and emergency procedures. This was backed-up by a rather basic simulator in which we each had ten one-hour sessions to familiarise ourselves with the cockpit layout and its

array of switches, tits and knobs and to gain some experience of the OR946 system, TACAN, ILS and, of course, practical experience of handling a variety of failures and emergencies. To support the flying exercises, there were another fifteen simulator sessions dedicated to the use of the radar and the B Scope. Then, after completing this phase, we still continued to use the simulator twice a month to practise emergencies and consolidate our familiarity with the radar and B Scope.

Only when we started the conversion programme did we begin to appreciate the enormity of the task that lay ahead of us, for both pilots and groundcrew. The Lightning was going to provide us with a quantum leap in our air defence capability, but it was also going to be a very demanding system to operate and maintain.

The aeroplane that eventually became the Lightning had originally been designed primarily as a research aircraft. But it had always had the potential to become a fighter and, following the decision to focus defence policy on the nuclear deterrent and its protection, the Lightning's remarkable rate of climb, acceleration and speed had made it the only advanced manned aircraft project to survive the Duncan Sandys White Paper of 1957.

Compared to its predecessor, the single-engined, gun-armed, transonic Hunter, which relied entirely on ground-based radar for its interceptions, we were now about to take on an aircraft having: two very powerful engines, with reheat; a maximum speed of Mach 1·6 (later Mach 2); the ability to fly at more than 70,000ft; a stand-alone intercept capacity conferred by its integrated Airborne Interception Radar and Pilot's Attack Sight System (AIRPASS) and a pair of infrared homing missiles. This was an awesome transition for the pilots, not least because, at this stage, there was no two-seat trainer.

Our first Lightning Mk 1, XM165, finally arrived on 11 July 1960 and John Howe was the first pilot to fly it. Because of the lack of a two-seater, we were all a little apprehensive about that first flight. However, the LCU provided a Lightning pilot in a Hunter chase aircraft and there was another in Air Traffic Control and, in his debrief, John said that he had been surprised at how easy the aircraft had been to handle. A second aircraft arrived the next day and by the end of August we had seven, which permitted the squadron to create a four-aircraft display team to show off the Lightning at the SBAC

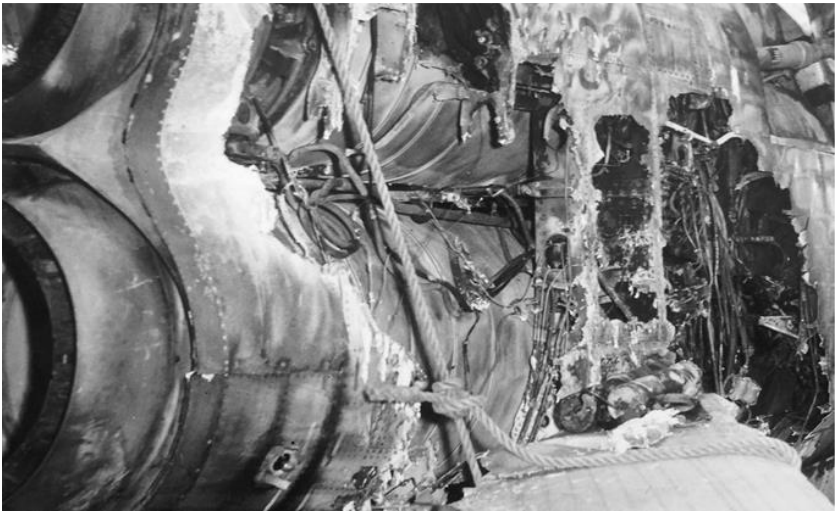
OC 74 Sqn, Sqn Ldr John Howe, showing the Queen Mother around Tim Nelson's aeroplane.

show in September.

My own first flight was on the 19 September, chased by Ken Goodwin, and it lasted for 45 minutes, which included two GCAs. For a first take off, reheat was not used but, even so, the acceleration had been incredible. Once airborne, however, the aircraft had proved easy to handle. For the landing, we were briefed to put it firmly on the runway and stream the 'chute. Having finally come to a halt, a sense of relief set in – I had made it! I had found the experience to be challenging, very exciting and exhilarating.

The downside was that flying hours were scarce. I had to wait a week for my next sortie, again only 45 minutes, followed by Convex 3 to 5 over the next three days. But my total flying time in the Lightning, accumulated in the course of twenty sorties flown during the first three months, amounted to a mere 15 hrs 15 mins, supplemented by another 8 hrs on the Hunter. Mine was not an unusual case; the shortage of flying time was a result of slow delivery of aircraft and poor availability due to unserviceability, compounded by the fact that priority had to be given to the four pilots of the formation team.

So why was serviceability such a problem? In short, because of a



Fire damage in the engine compartment, a not uncommon fault, especially in the early days.

chronic spares situation. With hindsight, it is clear that a far greater provision of spares – backed-up by adequately trained tradesmen – should have been made available at least a month before the aircraft started to arrive. In this respect, the RAF's logistic infrastructure had failed. But, supply and manning issues aside, the Lightning's engine installation proved to be its Achille's heel.

Although they were staggered, the engines were stacked one above the other and if a problem occurred with the lower engine, it was sometimes necessary to remove the top engine to solve it. As a consequence, a notionally three-hour snag could take three days to rectify.

Further serious problems arose due to chafing of hydraulic pipes, which were draped around the engines like spaghetti, along with fuel and hot gas leaks, which could give rise to fire warnings, both real and spurious. In the real case, there had been instances of the control rods that ran to the hydraulic motors that operated the tailplane being burnt through. In such cases the pilot had only 9 seconds warning of the need to eject. All of this meant that our aircraft were subject to a series of major modification programmes to alleviate these problems.

The Lightning's radar, Ferranti's AI 23, was claimed to be the

world's first operational monopulse system. When it worked, it could detect and track a Soviet Bear or Badger at 36,000ft and at a range of up to 60 nms. Unfortunately, at the time, it often didn't and, since a serviceable radar was an essential element of the Convex sorties many had to be aborted, which further delayed the squadron's achievement of operational status.

From the pilot's point of view, the Lightning was a relatively easy aircraft to fly, throughout its speed range, with no nasty tricks up its sleeve. That said, like any aircraft manoeuvring in combat at close to its stalling speed, about 150 kt in the case of the Lightning, it could flick, although rapid use of reheat could recover the situation without too much height loss.

The Lightning's engines had a voracious thirst, particularly when using reheat – full reheat at low level would empty the tanks in about 10 minutes. Even without reheat, because of the aircraft's limited fuel capacity, sorties lasted only 40-45 minutes. So constant attention had to be paid to fuel management and contents.

To fly the aircraft operationally, using the AIRPASS while keeping an eye on the fuel and monitoring TACAN was recognised to represent an extremely high workload, because the pilot had to have his head glued to the B Scope to find the target and then mentally plan his attack, while controlling the radar with his right hand and flying the aircraft with his left. Doing this at altitude was one thing but doing it over the sea at very low level, at night, or in fog could be pretty hair-raising. Other aircraft of this complexity and capability had a two-man crew to share the load.

Over time, the spares situation gradually improved; a number of significant Mods were incorporated; our tradesmen steadily accumulated experience and familiarity with the systems and, now with our full complement of twelve aircraft, flying times increased to between 8 and 10 hours per month. This enabled John Howe to declare the first eight pilots operational in March 1961, followed by the whole squadron in May. This had taken eight months, rather than the two that he had hoped for.

Apart from all the foregoing, there was a constant demand for this incredible aircraft to be shown to the British public, and indeed to the world. Needless to say, this required dedicated flying hours which had also served to extend the time it took for the squadron to become fully

No 74 Sqn's 1961 nine-man display team. L-R: Flt Lt Maurice Williams; Flt Lt Tim Nelson; Flt Lt Ted Nance; Sqn Ldr John Howe; Flt Lt Martin Bee; Flt Lt Jerry Cohu; Flt Lt George Black; Flt Lt 'Lefty' Wright and Flt Lt Mike Dodd.

operational.

The next interruption came in May when Fighter Command ordered us to form a nine-aircraft close formation display team for the Paris Air Show, and for other important events throughout the year. This absorbed another nineteen practice sorties plus five days for the show itself. Inevitably, this was followed by the SBAC Show in September – another sixteen rehearsals and nine days away at Farnborough.

The Farnborough routine included a fast pass at just below the speed of sound and on one memorable occasion, Ted Nance began to be left behind. He called the leader, John Howe, to let him know that he had only one reheat working. The CO's response, in his unmistakable Yarpie drawl, was 'For Chrissake Ted! – Catch Up!' The next call was, 'I'm catching up Boss.' He did, and all was well – until we landed when, over the R/T, Sqn Ldr Howe was asked to report to ATC. We taxied in and parked, only to find that we were being applauded by the groundcrew. 'What are you clapping for?' 'The supersonic bang! It was great!' John returned from his one-sided interview with Wg Cdr Ops to inform us that every plate glass window in the vicinity had been shattered . . . and, en route to the Officers Mess, we saw evidence of this ourselves at a couple of garages whose forecourts were littered with broken glass.

Farnborough was followed by several appearances at Battle of Britain Days, that first season finally being rounded off by the Queen Mother's visit to Coltishall on 23 October 1961.

I left No 74 Sqn at the end of 1961 having been posted to No 92 Sqn as a Flight Commander.

Thank you for listening.

The 1961 display team.

ENTRY INTO SERVICE AND MAINTAINING THE MATURE PLATFORM

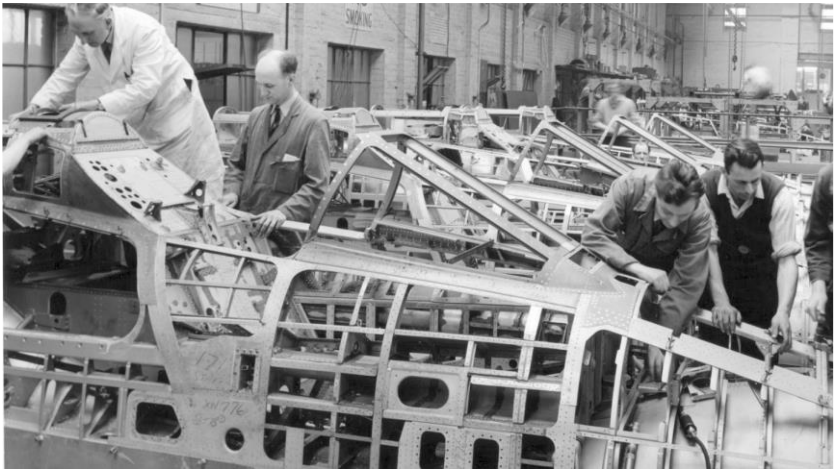
by Wg Cdr Gareth Cunningham

Gareth Cunningham was commissioned into the Engineer Branch in 1968. After gaining experience in junior posts, including a stint with No 92 Sqn on the Lightning, a particularly notable tour involved the early days of the Tornado with No 9 Sqn in 1984-86. He was OC Eng Wg at Brize Norton 1998-90 and his final tour was as Assistant Air Attaché in Paris. Since leaving the service in 1996 he has held a variety of senior appointments in commercial aviation, including being the Engineering Director at Air 2000. Along the way he has logged 600 hours as a private pilot and another 1,600 hours on gliders.

As a young air cadet in the early to mid-'60s I was absolutely fascinated by the Lightning, which was then the RAF's latest fighter. I was therefore delighted some years later, after passing out from the RAF College, to be posted as junior engineering officer to 92 Squadron at RAF Gütersloh, operating the Lightning F2A and T4. I will draw on that experience in the second part of my presentation, when I will talk about the challenges of maintaining the Lightning as a mature platform. But for the first part of my talk I want to look at its entry into service.

Let us not forget that the English Electric contract that led to development of the Lightning was awarded 70 years ago, less than ten years after the then state-of-the-art fighter – the Spitfire – had been doing its stuff over southern Britain. So it is hardly surprising, with such a quantum leap in technology, that there were some significant teething problems. The engineering issues which dominated the aircraft's entry into service can be grouped into three categories: configuration, reliability and support.

Looking first at configuration, it is noteworthy that the development batch aircraft were all very different in terms of build-standard and equipment. This 'bespoke tailoring' approach to aircraft



The 'bespoke tailoring' of the development batch Lightning aside, this picture seems to suggest that something of the 'hand made' was retained in the construction of the production models. These are F2s being built in the early 1960s – XN776 nearest to the camera. (BAE Systems)

manufacture was carried forward into the early production aircraft. In particular, the routing of hydraulic pipes and electrical cables was different in each aircraft. In-flight hydraulic and electrical failures were a common occurrence due to chafing because of poor routing. This was such a concern that it led to a heated debate between the Air Ministry, English Electric and the RAF about where the basic fault lay. With the benefit of hindsight, the blame could perhaps be apportioned to the Warton design office. Aircraft assembly line workers are rightly proud of their product, but they can only fit out each airframe in accordance with the drawings provided to them. In this case it seems that the production drawings were not fit for purpose. Also, in retrospect, it would have been more sensible for Lightnings coming off the production line to be issued to Maintenance Command for acceptance, rather than direct to the squadrons.

Turning now to reliability, I have already touched on hydraulics and electrics, but these were not the only serviceability problems during entry into service. Hot gas leaks, fire warnings (both spurious and real), fuel leaks, unreliable reheat, radar failure and gun stoppages

will all be familiar to those who operated the aircraft in the early days. The solution to these problems was a large number of modifications, which were performed both by contractor working parties, using English Electric personnel, and by Maintenance Units utilising RAF manpower. In the longer term this did lead to better aircraft availability and reliability, but in the early days the squadrons all suffered from a lack of airframes.

When looking at support, there is no doubt that inadequate initial spares provisioning adversely affected early Lightning operations. In 1960, 74 Squadron's diary notes that there was a chronic lack of spares and that 60% of all items demanded had to be placed on diversion order to the factories. No weapons were available and the complete inventory of weapon system test equipment was still awaited. At one stage, in November of that year, nine aircraft were AOG as a result of spares shortages. However, as the diarist wryly remarks 'an imminent press visit brought the spares flooding in and aircraft serviceability was soon doubled.'

The lack of support for the Lightning wasn't just spares related. An early AFDS report noted a lack of trained radar personnel, shortage of test equipment and non-availability of up-to-date test schedules and servicing documents. As late as 1963, when No 92 Sqn was re-equipping with the Lightning, the CO commented, 'It is a ridiculous and frustrating reality that we must fight tooth and nail for every improvement of the hangar, its servicing bays, crew rooms and ops room – total cost less than £500 – all necessary for the efficient operation of the Lightning, which is valued at close on £1M a copy.' Perhaps the Lightning was rushed into service too quickly? The fact is that that neither the infrastructure, nor the spares holdings were in place to adequately support the aircraft in its early years. I think this quote from Alan Merriman, a Boscombe Down pilot, is a neat summary of the aircraft's entry into service.

> 'It was a wonderful aircraft to fly, with delightful handling characteristics, although I believe the engineering aspects always left something to be desired.'

So let us now move forward into the mid-1970s, with the RAF operating nine Lightning squadrons, both at home and overseas, and an OCU. What was the aircraft like to maintain? Well let's just say

Lightnings, in this case of Nos 19 and 92 Sqns, undergoing second line servicing.

that it was a challenge and component reliability was no better than could be expected of 1950s technology! The aircraft was maintained on a periodic servicing schedule with inputs between 30-45 flying hours, 60-90 flying hours and so on, with each inspection becoming more comprehensive up to the Minor at 240-360 hours. Although having a flying hour window in which to perform these servicings was supposed to offer some flexibility in maintenance planning, in practice they were nearly always carried out at the flying hour backstop. Squadron servicing was the norm, with squadron engineers performing all maintenance in-house until the aircraft was due a Major servicing. Engineering Wing provided second line support with the various specialist servicing bays.

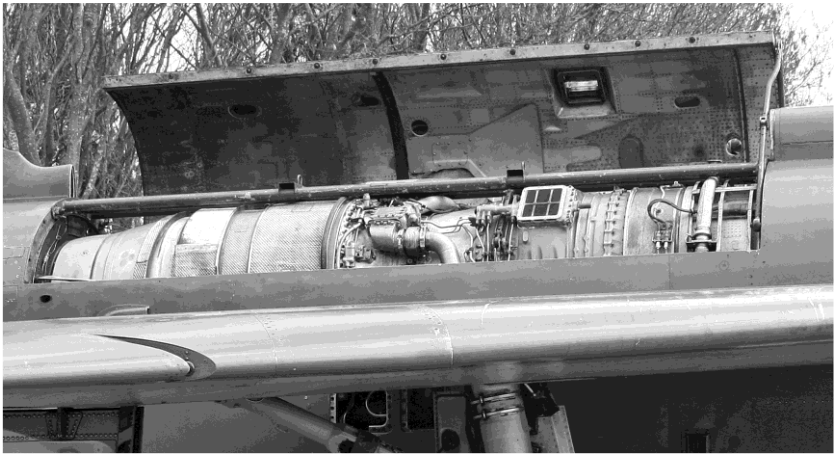
Majors were carried out at Leconfield by No 60 MU and during those events significant modifications were incorporated, including a fire integrity programme – more of that in a moment. In the mid-1970s centralised servicing became the norm. Whilst on paper, it seemed to offer efficiencies by having an Aircraft Servicing Flight within Engineering Wing doing the Minors for all squadrons on-base, in practice it offered few advantages. At squadron level the loss of engineering tradesmen to Engineering Wing led to a loss of the

flexibility to redeploy manpower from scheduled maintenance tasks to rectify aircraft to meet the flying programme. This leads me neatly into what it was like to maintain the Lightning on a day-to-day basis.

On the flight line the Lightning was a fairly simple aircraft to operate, although the groundcrew had to be cognisant of the hazards of LOX and AVPIN replenishment. A plunge bath full of water was positioned outside the line hut so that any tradesman unfortunate enough to get contaminated could jump in. A spin off from this was that by blasting LOX through the plunge bath the water temperature could be lowered to close to freezing, which enabled the lads to keep crates cold during beer calls! Of course, the AVPIN starter was not 100% reliable and all who have been associated with the aircraft will remember the 'wheee – phut' sound of a failed start. Flight line refuelling and replenishments were fairly straightforward, however, and all 'lineys' became adept at wheel changes. About seven landings per tyre was the norm, but less in strong crosswind conditions. If my memory serves me correctly the mainwheel tyre inflation pressure was 325 psi! Missile and ammunition box changes were also easily accomplished on the line. Brake parachute replacement was a bit of an art and the lads had to be careful with fitting the cables which led from the 'chute to the attachment point at the base of the fin. These cables were routed around the jet pipe nozzles and held in place by clips. Improperly clipped cables sometimes came loose and were burnt through by the reheat, leading to a 'chute failure on landing.

In the hangar the Lightning presented a few more challenges because of the nature of its structure and the way in which the flying controls and operational equipment – radios, guns, electronics and the like – were so tightly packed. That created a real problem for the engineers. To get at much of the equipment – pumps, actuators, etc – required not just removal of panels, but removal of other assemblies to gain access to the defective component. Often a jet pipe or, in the case of the No 1 engine, the inter pipe[1] and jet pipe had to be removed after

[1] The No 1 (lower) engine was positioned much further forward in the airframe than the No 2 engine. The jet pipes, however, were the same for both engines. In the case of the No 2 engine the jet pipe was connected directly to the rear of the engine. The inter pipe (basically just a tube) was required to connect the rear of the No 1 engine to its jet pipe. (**Ed)**



Opening the hatch, permitting some access to the topside of the Lightning's upper engine, provides some indication of just how tightly packed its airframe was.

which much care had to be taken during reinstallation to avoid potential hot gas leaks. Engine changes were not difficult but they were labour intensive, with numerous bolts having to be removed before lifting the top hatch or lowering the ventral tank. Of course, after any such equipment removal and replacement the aircraft had to be towed down to the reheat pan for ground runs.

I mentioned earlier the fire integrity programme. The Lightning was always susceptible to fuel leaks. When parked in the hangar overnight numerous drip drays were required under each aircraft. In-flight fires were certainly not unknown – more so with the Marks 3, 5 and 6 with their 300-series Avons. Whenever a jet pipe, inter pipe, or engine was removed, the engineers were able to examine the fuel pipes, which, of course, were routed inside the fuselage. These were closely inspected for leakage at every opportunity. We used to put a dye in the fuel, 'automate yellow', which glowed under ultraviolet light; this enabled the engineers to spot leaks and potential fire hazards in the engine bays and jet pipe bays.

Another major issue affecting the Lightning was aeration of the hydraulic fluid. After much research the issue was confronted by attacking the effect, rather than the cause. De-aeration rigs were built, which of course became known as milking machines!

There is no doubt that the Lightning was well built. Despite flying many more hours than originally specified there were few structural problems in its life. Moreover, the airframe of each Mark was identical, by which I mean you could easily swap components – panels, canopies, etc – between aircraft. On reflection, the Lightning was not a *difficult* aircraft to maintain, but it did consume an awful lot of engineering manhours – and throughout its life critical spares were often in short supply. It was an aircraft designed to meet operational targets rather than for easy maintenance.

Nevertheless, it was possible to produce the goods. A TACEVAL report from November 1971 states that 100% of the squadron aircraft – twelve – were serviceable within two hours of the alert and the serviceability remained above 80% throughout the two-day flying phase. Not bad for an aircraft whose design was started in the 1940s!

To conclude, I would like to quote from Stewart Scott's excellent work:[2]

> 'The engineers had to be innovative in their thinking in order to overcome everything that the aircraft could throw at them, whilst air and ground crew worked long hours in order the meet the commitments. To be part of the Lightning force was truly to be amongst the elite of the day.'

[2] Scott, Stewart A; *English Electric Lightning, Vol 2 – The Lightning Force* (GMS Enterprises, Peterborough; 2004).

LIGHTNING QRA – ALWAYS RUNNING HOT!

by Captain Ian Black

The son of AVM George Black, Ian joined the RAF in 1979 as a navigator. After a tour on Phantoms with No 19 Sqn, he re-trained as a pilot, becoming the last to qualify on the Lightning. He subsequently flew the Tornado F3 with Nos 23, 25 and 11 Sqns and the Mirage 2000 on a French exchange tour. During the 1990s he did a stint in the Falklands and flew operationally over Iraq and Bosnia. Ian left the RAF in 1997 for Virgin Atlantic and, having flown a variety of Airbus models, he is currently a captain on the Boeing 787.

Distinguished guests, thank you for inviting me to talk to you. I had rather hoped that, as I reached the end of my 50th year, I would not still have to be following in my father's footsteps. It seems, however, that I do still have to do that . . . but I do have one up on him. When he was introduced, as a latter day Eric 'Winkle' Brown, the Society's Chairman noted that he had flown some 8,000 hours. Well, I've got 25,000 hours – although I have to admit that I was probably asleep for most of them.

I have been asked to talk about QRA and I have about 40 slides to work my way through. I was briefed to stay on time so, unless we

A Bulldog and a Lightning illustrating the remarkable increase in performance between 1930 and 1960 – within a working lifetime fighter speeds had increased from 180 knots to Mach 2·0. (www.firestreakbooks.com)

Pilots and groundcrew run to their Siskins at an air display. Note to self – next time, stow the parachute in the aeroplane! (www.firestreakbooks.com)

delay lunch, I only have 5 minutes! Nevertheless, I will try to summarise a very brief history and then discuss how a Lightning pilot became 'Q qualified' and the sort of missions that he flew.

Launch mechanism for the alert force – 1940-style. (British Pathé)

The UK has had a QRA capability of some kind ever since the Zeppelin raids of WW I. It was occasionally exercised between the wars and when the Battle of Britain was being fought much of Fighter Command could be selectively scrambled at short notice. In the early post-war years there was an initial rather vague period (I did consult my father over this) with Meteors and Hunters on stand-by by day and Meteors, Venoms and Javelins at night – not until the Lightning did we have a fighter that was truly day *and* night capable.

The Lightning entered service with No 74 Sqn at Coltishall in 1960, followed by the Wattisham Wing, Nos 56 and 111 Sqns, and then Nos 19 and 92 Sqns with the F2 at Leconfield. In all cases the

Lightning had replaced the Hunter and it then began to displace the Javelin at home and, eventually in Germany, Cyprus and Singapore.

Until recently, the Javelin has been relatively unsung. It was twin-engined, had a crew of two and was armed with four Firestreaks, whereas, while also twin-engined, the Lightning was a single-seater with only two missiles. The Javelin didn't have a great reputation for performance and I think I am right in saying that its radar wasn't gyro stabilised. That meant that when the aircraft went into a turn, the radar display became more difficult for the back-seater to interpret. This was not the case with the Lightning because its radar was stabilised so it would 'come round the corner with you', as it were.

We should record when formal QRA started. In the early years of the Cold War most of the NATO allies maintained alert forces on an individual basis but in 1955 it was decided to co-ordinate their efforts while extending the radar coverage to create the NATO Air Defence Ground Environment – the NADGE – a programme that had been completed by about 1962. To exploit the enhanced warning that the NADGE provided, OPCON of all air defence assets was assigned to SACEUR in 1961 to establish the NATO Integrated Air Defence System (NATINADS) which, from a parochial RAF perspective, meant QRA in the UK and Battle Flight in Germany.

So far as the UK was concerned, the mainstay of our trade was the Tu-95 Bear operating from bases in the vicinity of Murmansk. They were in the habit of routing via the North Cape and then probing down the North Sea or into the Atlantic via the Greenland-Iceland-UK gap – the GIUK. They were tracked by radars in Norway, the Faroes (between Iceland and the Shetlands) and, in the UK, at Saxa Vord, Benbecula, Buchan, Boulmer, Staxton Wold and Neatishead. Back in the day, all of these were manned on a 24/7 basis but today most are now unmanned and operated remotely. The routine was for the Norwegians to pick them up as they headed south before handing them over to us. 'Us' was either Northern QRA at Leuchars or Southern QRA which rotated between Wattisham and Binbrook. Leuchars was the primary site, operating both Lightnings and Phantoms, on a permanent 24/7 basis. That said, there was some flexibility. For instance, if Leuchars had a major function – like a summer ball – one of the southern stations would send a couple of aeroplanes up to Scotland to take over the commitment.

A Red Top-armed Lightning in a QRA shed.
(www.firestreakbooks.com)

Readiness in the UK was 10 minutes but in Germany, being much closer to the border with the Warsaw Pact, Battle Flight was at 5 minutes. It was 5 minutes in Cyprus too but, with no immediate threat, post-Confrontation there was no permanent stand-by in Singapore. The option remained, however, and home-based Lightnings were capable of bolstering the resident overseas squadrons. Getting out to Cyprus was relatively straightforward, of course, and in 1969 the Lightning's ability to reinforce Singapore was convincingly demonstrated – twice – by No 11 Sqn in January and by No 5 Sqn in December.

So what did QRA in the UK entail? It is important, I think, to stress that it wasn't just a couple of pilots and a handful of groundcrew at 10 minutes notice – much of the station was involved on a 24/7 basis. By the mid-1960s the aircraft were housed in bespoke QRA sheds housing two aircraft with adjacent accommodation for the pilots and groundcrew with appropriate catering facilities. But apart from them, there were the bowser drivers, the crash/fire crews, the snow-clearance teams in winter, air traffic control, Met, all of the messes, photographers (to meet returning aircraft) and so on – and on. A fairly large proportion of the whole community was permanently on-state. And, of course, this extended to the GCI staffs at the radar sites, No 8 Sqn's Shackletons (callsign ANYFACE) and the Victor tankers.

The role of QRA in the 1960s was pretty much what it still is today

– the policing of UK airspace in peacetime. The task of the Lightning pilot, therefore, was to intercept and shepherd any unidentified or potentially hostile aircraft while within the UK's airspace. Until '9/11' there was not thought to be a problem with hi-jacking. They did occur, of course, but generally in the Middle East and it was not assumed to be part of our remit in the Lightning era. That said, there were occasional incidents involving civil aircraft that were lost or had a radio failure but that was about as far as we went in deviating from the primary task – keeping an eye on Ivan. I should, perhaps, make the point that QRA was a peacetime commitment. In the event of matters deteriorating to the extent that Military Vigilance was declared, QRA ceased, to be replaced by more armed aircraft and an overall increase in the readiness state across the whole force.[1]

Coincidentally, a few weeks ago I flew with an ex-tanker pilot and I asked him what QRA had involved for him. I was surprised to find that, presumably because they weren't subordinate to HQ 11 Gp, the tanker crews worked to a somewhat different, and comparatively relaxed, remit. At Leuchars or Binbrook the Lightning pilots would be togged-up in immersion suits and life jackets and lurking pretty much next to their aeroplanes. Meanwhile, and very sensibly, because they were held at one hour's readiness, the crews at Marham would cock their aeroplane then retire to the squadron or the Officers Mess or even, for those living on base, their married quarters. In pre-mobile phone days, they had a pager, or 'bleeper', and that sufficed to meet the obligation. Nevertheless, it seemed to me that, if an intruder managed to get a long way down the North Sea before he was detected we might have launched from Binbrook without tanker support. That didn't feel right and, with hindsight, I think that the tankers, or at least those on-state, should have been playing to 11 Group rules.

[1] In brief, the State of Military Vigilance catered for a period of tense international relations and consisted of purely military precautionary measures which could be sustained for a fairly long time without ill effects and which would facilitate a rapid transition, if necessary, to one of the stages of the Formal Alert System. The latter provided for an orderly transition from peace to war, embracing political and military measures divided into three stages – Simple Alert, Reinforced Alert and General Alert. The Counter-Surprise Military System comprised purely military measures which had to be implemented in the event of an attack, or imminent attack, with little or no warning. There were two stages – State ORANGE and State SCARLET. (**Ed)**

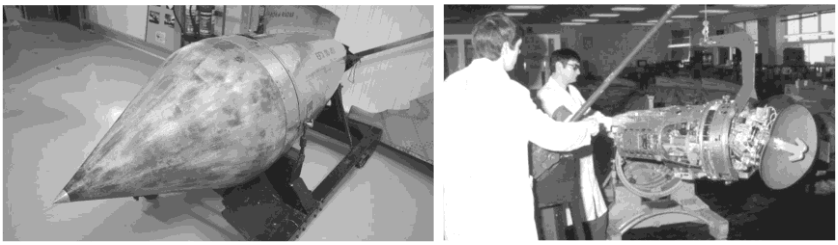
Once they were scrambled, the tankers provided much more than fuel. Once the Lightning was more than 190 miles from a TACAN it had no navigational facilities and its line-of-sight UHF radio meant that it couldn't communicate either. The Victors looked after navigation and their HF radios kept us in touch with our controlling authority, relaying messages in either direction, obtaining Met updates, handling diversions and so on. They were also very good for our morale because, without them, it was a lonely business – flying way up north, over the sea, in the dark.

If a Lightning lost its radios, it could sit on the Victor's wing and it would bring you home. Having done it once myself, it was not for the faint-hearted. Most tanker pilots were not accustomed to flying in close formation, or at least not leading single-seaters on a GCA or visual approach. When I did it, we were a pair of Lightnings flying in echelon left and right of the Victor. As we made a rather impressive low approach to Binbrook, the tanker throttled back and we shot past him to arrive in a reverse vic with the Victor behind and two Lightnings out in front! I never did it again.

When we made an interception, if the target turned out to be a pair, the understanding was that the Lightning would stay with the one that was perceived to be the lead Bear and the Victor would shadow the other one. I took this for granted at the time but, on thinking about it in arrears, a Lightning pilot spent up to six months becoming acquainted with the procedures for shadowing/shepherding, visual identification and flying in close formation and, with no disrespect to the Victor pilots, I just wonder whether sending them off to do the same with a Bear or a Badger was the wisest move.

That aside, Lightning pilots had to be cleared to refuel by day and night and, as I have already indicated, the tankers were pretty much our lifeline. Originally Victor Mk 1s and later Mk 2s, their twin underwing pods meant that they could handle two aircraft at a time, or take it in turns of one pod failed. The same was true of the VC10 but the TriStar had only a centreline HDU and we weren't cleared to use that.

Apart from tanking, we also had to work with the Shackletons and their venerable AN/APS-20 radars, salvaged from the FAA's Gannets, I believe. To be honest, I think that it was a bit of a DIY job and, while they did their best, at their operating heights their capability was



Left, the Lightning's intake 'bullet' housing the radar and, right, an AI 23 being worked on the electronics bay.(www.firestreakbooks.com)

limited and their radar really wasn't that much better than the Lightning's AI 23.

The AI 23 was also something of a curate's egg. One real plus was that it was a self-contained unit, so you could 'simply' take one 'bullet' out and replace it with another. And that bullet had been cleverly designed so that, despite being in the air intake, there were no issues with respect to aspirating two powerful engines at speeds between 180 knots and Mach 2·0 without having to resort to ramps or supplementary air intakes – aerodynamically, it was impressively uncomplicated and efficient. Its performance, however, was unspectacular, reflecting perhaps its 1950's state-of-the-art while still being in use 30 years later. You were unlikely to pick up a target at more than 25-28 miles and at low level over the sea perhaps as little as 10 miles. Reliability? Not perfect, a total failure on perhaps 10% of occasions, which left you pretty helpless.

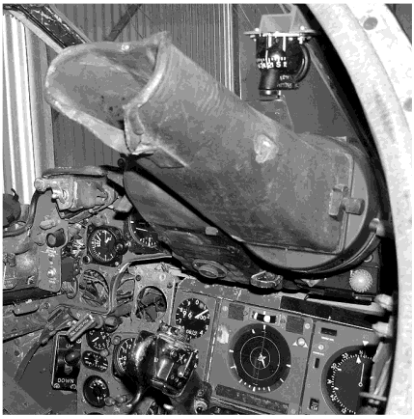
So what of the conversion process? Having flown about 50-60 hours with the Lightning Training Flight (LTF), you joined the squadron to become 'Q qualified'. That meant becoming really familiar with the AI 23's hand controller which was located on the port side of the cockpit immediately aft of the throttles. Moving it forward or back tilted the scanner up or down and, at the top, it had about 20 different functions to adjust the gain, or the range scale, make it lock-on and so on. But interpreting the presentation in order to carry out a successful engagement was heavily reliant on intuition – you needed to develop a kind of sixth sense in order to get it right.

There wasn't much room in a Lightning's cockpit. You didn't have maps or charts or scales, so pretty much everything you did, you did in your head. You watched the target response on the screen,

Left, the AI 23 controller and , right, its location aft of the throttle box. (www.firestreakbooks.com)

estimated its crossing speed and began your turn when it 'felt right' to achieve the correct 'profile' – and this was all happening very fast.

An intercept on a supersonic target from detection at 15 miles, to lock, to getting the geometry right, to firing the missile and breaking away took about 15 seconds. (*To prove the point, very convincingly, this description had been delivered as a commentary to a video of the radar display run in real time.* **Ed**) In short, the cockpit workload was extremely high. You viewed the radar through a visor, but for no more than 5 seconds at a time because you still had to fly the aeroplane, so you had to check the altimeter and the horizon. A Lightning pilot was *very* busy – especially at low level – in the dark!



The AI 23 display was viewed through a detachable visor. (Charles Polidarno)

The aim of all QRA missions was to approach the target from behind to carry out a visual identification (VID) and in order to be declared 'Limited Combat Ready' a new pilot had to be progressively cleared through the following sequence:

Phase 1 VID – day – lights on.
Phase 2 VID – night – lights on.
Phase 3 VID – simulated IMC or night – no lights.

In all cases the minimum range was 300 yards to breakaway by 200 yards. In the event that a target was so slow that it was impossible to stabilise behind it, it was permissible to carry out a 'passing VID' with the Lighting overtaking, sufficiently displaced to one side to avoid a collision.

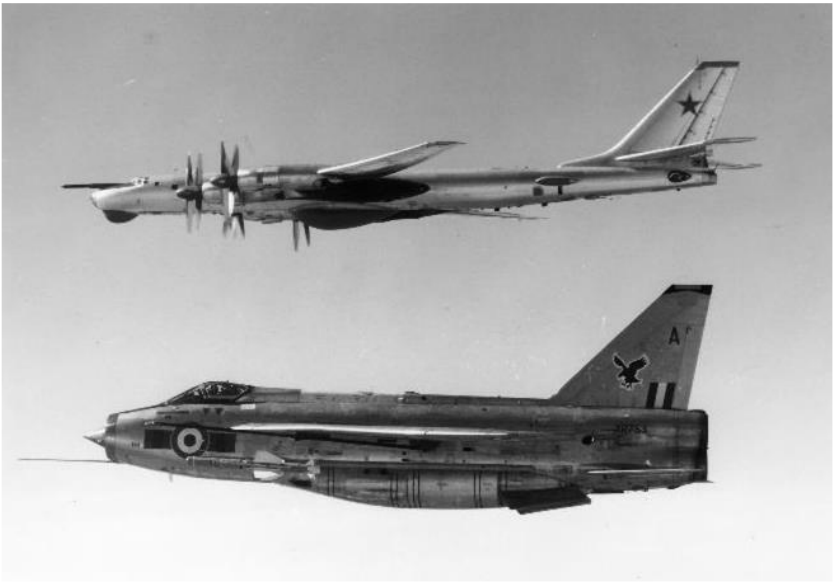
To stand QRA a new pilot was awarded a 'Battle Green' instrument rating. That meant that, although he still lacked sufficient flying hours to qualify for a full Green rating he was authorised – *but only on a QRA flight* – to fly down to green limits, ie 200 feet on an instrument approach, whereas a White-rated pilot had to overshoot at 400 feet.

Throughout an interception you were constantly checking your height, working out the target's azimuth and assessing its rate of change, comparing its speed with your own and using the result to control the overtake rate. All of this required very accurate instrument flying, of the order of +/-2 knots and +/-2° of heading and +/-50 feet in elevation. It was very demanding but, on the plus side, the Lightning's performance mean that it was do-able, even at night, and about 40% of our QRA sorties were flown in the dark.

Once you had made contact with your target you stayed with him as a shepherd or shadow. That could be problematic with a slow target in which case you had to fly a series of weaving dog legs to avoid overtaking him. At low level, that could be quite difficult – having to keep him in sight while flying at low speed over the sea.

We always took a camera on QRA sorties and, once you were alongside the target, you noted any markings that might identify the individual airframe. You took photographs of the whole aeroplane and any interesting lumps and bumps for the benefit of the intelligence analysts who could often to tell you where it was going – probably Cuba – or, if it was on its way back, when it had gone there.

I was caught out playing this game on one occasion. I was shadowing a Bear F, a maritime reconnaissance variant, and as I approached it from behind and below, the bomb bay doors opened. I thought that a shot of the inside of the weapons bay would be of particular interest to the folks back home. This was far too good an



*The prime target was the Bear which was comfortable at 35,000 feet and M 0·9, which did not present a problem for the Lightning. (*www.firestreakbooks.com)

opportunity to miss, so I moved forward to be directly underneath the aeroplane. Flying with my left hand and taking pictures with my right while craning my neck to look upwards, I was startled to see one of the sonobuoys leave the bomb bay! Its parachute deployed and it whizzed past my tail. At that point I resolved never to do *that* again.

Very occasionally the system was tested by launching one of the aeroplanes on QRA but, instead of sending it north as usual, it would be directed towards Cardigan Bay to fire one of its missiles at a target launched from Aberporth – not a specially prepared round, just a stock missile that happened to be on-state. I don't think that we ever had a failure. That said, both Firestreak and Red Top did have a significant operational limitation. Both missiles required some components to be cooled and, once you armed them, you began to consume the coolant. If you armed them too early, you could run out, leaving you with only the guns.

Just a thought on engineering. In the interests of managing the fleet, an increasing concern towards the end of the Lightning's career,

During the Lightning's twilight years, it shared QRA with the Phantom and Tornado with the Hawk sometimes playing long-stop during exercises. (www.firestreakbooks.com)

the aeroplanes earmarked for QRA tended to be those with high airframe hours or approaching the end of their fatigue life. They were perfectly serviceable, of course, just a bit limited in their remaining utility. The downside was that, if they were scrambled they were likely to fly for 5 hours or more which further compromised their limitations and that could make the engineers quite grumpy.

So what of the Lightning's limitations, from the pilot's perspective. We had no head-up display and no means of illuminating the target and, bearing in mind that we flew in the dark quite a lot, that was a significant deficiency. Our limited fuel capacity was an obvious drawback. In theory, this could have been alleviated to some extent by using the big overwing tanks but they were not cleared for supersonic speeds and involved, I believe, a quite restrictive cross wind limitation, so they weren't a practical proposition. Diversions could also be a problem. Using the brake parachute was SOP which was not popular at civil airports, nor was AVPIN starting and the presence of live weapons.

In summary, I would argue that, when the Lightning entered

On a gloomy day at Binbrook, one of No 11 Sqn's Lightnings demonstrates the aeroplane's always impressive ability to get airborne very smartly. (www.firestreakbooks.com).

service in 1960 it was pretty much a perfect fit – it could be airborne within 2 minutes and easily both outperform and outmanoeuvre anything it might encounter. Twenty-eight years later, it could *still* do that, certainly as far as any likely targets were concerned. But QRA wasn't really about speed and manoeuvrability. Rapid reaction was essential, of course, but by a sophisticated weapon system. Measured against that yardstick, the Lightning lacked the fuel capacity, the navigation and comms facilities, the far superior radars and the much heavier, and longer ranged, armament of the Phantom and Tornado. By the late-1980s the Lightning had reached its sell by date, but it had given sterling service until then.

And now – a slightly delayed lunch?

FIRST DISCUSSION PERIOD

Gp Capt Dave Roome. For Tony Wilson – all of your the drawings up to about 1962 showed the aeroplane with a cranked leading edge and inset ailerons and yet the Mks 1, 2, 3, 4 & 5 all originally retained the straight leading edge with the ailerons with horns. When did it change?

Tony Wilson. I can't answer that precisely offhand, but I'm sure that we'll have the answer in the archives. It was related to the cambered leading edge introduced to reduce transonic drag – I know *why* it was done, but I can't say exactly when it was introduced on the production line.

Wg Cdr Andy Brookes. When the Spec for the V-bombers was issued it was so cutting edge that the RAE decided that they needed to set up a panel of wise men, led by Morien Morgan, to determine the way ahead. It turned out that they couldn't, so we finished up with three different aeroplanes. Did they do that with the Advanced Fighter – set up a brains trust to try to advise on the best solution?

Tony Wilson. No – there was no dedicated panel. I think that the Advanced Fighter Group considered that it had already provided enough information to permit valid assessment of the proposals when they were eventually submitted by industry, so there was no need to set up a specific group to consider what would become the Lightning. It just went through the routine submission/procurement procedure between the company and the Ministry – and it seems to have been a relatively smooth process. There were other such studies, however. For instance, there was the Arnold Hall Committee of the mid-1950s to determine the way ahead on fighters and, once everyone had recovered from the Sandys White Paper, and decided that more fighters would actually be needed after all, there was an R V Jones Committee in 1964 – but there was never a committee specifically to deal with the Lightning.

Sqn Ldr Gwyn Williams. You spoke about the workload on the pilot, but you didn't mention ECM. Was that a factor – and did you get much training in that respect?

Ian Black. It wasn't a factor in the context of QRA, because the

A two-finger salute from a Tu 95 Bear. (US Department of Defense)

aircraft that we were intercepting were usually on routine transits to Cuba or just probing into the North Sea – so they weren't jamming. But we did do lots of training. I recall a routine exercise – a COFFEE CHARLIE – that involved Canberras dropping chaff and using ECM, including, if you locked-on to them with the radar, 'range-gate stealers', and noise and comms jamming. So we did do quite a lot of ECM training. The Lightning had an E/F Band homer, so you could actually lock-on to the jamming. It was quite easy to work out what the azimuth of the target was. If you got a big spike on the scope to left or right, you could just bring it onto the nose – but working out the elevation was far more difficult – a bit of a 'blind art' in fact.

Sqn Ldr Bob Tuxford. I'm a tanker man and in my many presentations I talk a lot about shadowing Bears in association with Lightnings. It is said that, when photographing the back end of the aeroplane, on at least one occasion, the tail gunner, held up the centrefold from *Playboy* magazine. Is that true? Have any of the Lightning pilots here seen that?

Ian Black. I never did. I only ever saw four Bears, and they didn't hold anything up to me – except two fingers!

Wg Cdr Tony Fraser. A comment on the early days, form an engineering standpoint. The arrival of the Lightning came as a considerable shock to us. There had been no coordination between the engineers and the suppliers over equipment. We were sent on a course

that told us how the aircraft worked, but we learned nothing about its servicing requirements or its long-term maintenance. So, when the first aircraft began to arrive, it came as a real shock to the engineering community. John has just told us what AFDS did for the pilots but there was nothing like that for the engineers – nothing at all in fact. We had no idea what we were going to be faced with. I suppose that that was simply how it was in those days – but it was not well done.

Wg Cdr Gareth Cunningham. I have to agree. By the time that I did my Lightning Managers Course, which was probably 10 or 12 years after you, things had improved somewhat – and the air force did keep on learning. When I did my Tornado Management Course, prior to my SEngO tour – it was both three times longer and far more comprehensive and that was in the *early* days of Tornado and things improved even further later on.

Gerry Pye. There has been a lot in the press recently about Russia reasserting itself – more Bears, and more up-to-date aircraft, coming through the Faeroes-Shetland gap. Bearing in mind how overstretched the RAF is, how important, in the context of the intercepting/shepherding function, is personal contact between the crews? To put it another way, could this be done by drones – or is mutual recognition between the players an essential factor?

Ian Black. I think it's very important – and it needs to be reactive. QRA lets the Russians know that, if they approach or enter UK airspace, they *will* be intercepted – that we are able to, and will, respond at any time, day or night, 24/7. You could probably do something with standing patrols using long endurance drones but that would not convey the same message – it's demonstrating our ability to respond that matters. They need to know that whenever they show up, we will be there too. If we fail to do that, they will try to push the boundaries – fly Blinders or Backfires further down the North Sea or round the west coast. And, of course, the Russians know when we are a bit stretched. If, for instance, with Typhoons already committed to Operation SHADER and others on policing duties in the Baltic, we then deploy a whole squadron to Oman, or somewhere, for an exercise, they will tend to increase their probing just to see how we cope – if only to see how many aircraft we can get serviceable. It's a

Thunder City's privately-owned Lightning T5, ZU-BEX (ex-XS451), was lost in a fatal accident on 14 November 2009, probably the result of fire fed by a leaking fuel coupling. (Lightning Association)

cat and mouse game and we just have to keep playing.

Referring back to the previous question – on engineering – I can offer a thought. Having flown a privately-owned Lightning, it brought home the fact that it had probably only been intended to have a life of perhaps 500 hours, as had been the case with aeroplanes like the Meteor and Hunter. I seriously doubt that English Electric ever envisaged its Lightnings flying for 3,000 hours – the one on display in the Museum here actually has more than 4,000 on its clock![1] I'm sure that it was never the plan to indulge in air combat at +6 to -1·5G four times a day for years on end, because once you start doing that all the hydraulic lines and fuel pipes begin to distort. These pipes don't run in straight lines, of course, they are basically hand-bent to conform to the shape of the engine, to fit around a control rod, go through a hole in the flap lever mechanism and so on. Because they don't have quick-release fasteners and clips, repeatedly pulling G means that the junctions in the pipes could start to leak. When I looked inside this 50-year-old aeroplane, with an engine out, it was apparent that English Electric (and I'm sure they will back me up on this) had devised a

[1] According to its CV on the RAF Museum website, having first flown in January 1967, XS925 was grounded in July 1987 having flown 4,015 hrs 30 mins. (**Ed)**

mod which, to put it crudely, involved wrapping the junctions with, what looked like, rubber bands. The effect was that, when a hydraulic pipe began to leak, rather than spraying fluid around the hot engine bay at, as I recall 3,000 psi, it just trickled out. This may sound a bit DIY, but employing such rough and ready engineering solutions provides some impression of just how fragile the Lightning really was and underlines the fact that it was never meant to fly for 3,000+ hours.

Richard Bateson. A question for Tony Wilson. The first image you showed us was from 1948 and associated with the RAE's Advanced Fighter Project Group – RAE Aero Report 2300. That was actually a development of an even earlier proposal, of February 1948, which had been designed by two ex-Focke Wulf engineers working at the RAE, Martin Winter and Hans Multhopp. It would seem that Multhopp's ideas had some influence on English Electric's thinking, but in 1949 he decided to move to the USA to work for the Glenn Martin Company.

Tony Wilson. I would not take issue with that. When my slide was made up, the drawings were scanned from Aero 2300, which was a compilation of two earlier reports, Aero 1928 and Aero, I think, 1960, the first of these reflected the Multhopp study, which was for a research aircraft to be powered by an AJ65. In the interests of time, I opted not to include this, specifically, *single*-engined project, although it is discussed in Aero 2300 which was offered to industry as background to the design. That said, I'm not sure of the extent to which Multhopp ever interacted personally with anyone at English Electric, if at all – I've never found any reference to him in the archive.

LIGHTNING DEVELOPMENT STUDIES AND PROPOSALS

by Tony Wilson

Introduction

The Lightning fighter is commonly also referred to by the English Electric project number 'P1'. But, in fact, there are fifteen project numbers between P1 and P34 that are associated with the Lightning. These are listed in Annex A. Some refer to development steps in the core programme as mentioned in the preceding paper *Lightning Genesis* (page 7). Others relate to studies to extend the aircraft's capabilities beyond the scope of the official requirement. This paper describes some of the latter studies together with some proposed developments that were never given 'P' numbers.

These studies fall broadly into five categories. First, early studies in response to other official requirements that presented opportunities to re-direct the main line of development. Secondly, studies to extend the basic aircraft's capabilities including additional roles. Later, these studies would be a basis for proposed export variants. Then came proposals to improve the basic fighter capability with new sensors and weapons. Finally, with the advent of the variable geometry or 'swing-wing' concept there were proposals to exploit this in Lightning developments.

Most of these studies took place in the ten years following the 1957 Defence White Paper. As with the core programme, the investment decisions for these various developments were affected by the other contemporary programmes. In the early stages, these included the many programmes highlighted in the companion paper, *Lightning Genesis*. Later, during the Lightning's long period of RAF service, there would be the P1154, AFVG, McDonnell Douglas Phantom, and Tornado ADV to be considered.

What Lightning might have been (P6 and P8)

During 1952, as the P1 design was still being developed, the F23/49 fighter (P1) and the ER103 research aircraft (Fairey FD2) were regarded respectively as Mach 1·5 and Mach 1·3 aeroplanes. It was recognised that they had the potential to be developed to a Mach 2 capability. Nevertheless, believing that future fighters, bombers and reconnaissance aircraft might be aimed at speeds of Mach 2 or more,

the RAE made the case for a new research aircraft to be designed from the outset as a Mach 2 vehicle. The RAE's ideas for ideal Mach 2 aircraft designs were presented in June 1952 in report Aero 2462. This proposed a twin-engine configuration with a long slender fuselage, thin straight wing, a high tailplane and the engines in mid-wing nacelles. The Ministry of Supply published an appropriate specification, ER134T, in December 1952. This was circulated to industry with an Invitation to Tender in January 1953.

As mentioned in *Lightning Genesis*, EECo's initial response was a development of the F23/49 design with the more powerful Sapphire Sa7 engines. Designated P6, it was included in the F23/49 brochure dated 5 February 1953 as offering a different route for the fighter project. The main response to ER134T was delivered in a brochure dated 15 May 1953. This proposed a more modest F23/49 derivative plus three new designs. The modified F23/49 retained the Sa5 engines of the P1 but with 25% re-heat boost and convergent-divergent nozzles. P6/1 was based on the P1 configuration but with a single Rolls Royce RB106 engine. P6/2 was based on the original P6 design with Sa7 engines but with the addition of convergent-divergent nozzles. Finally, bowing towards RAE's design preferences, P6B was a completely new design with straight wings, Sa7 engines in mid-wing nacelles and a high tailplane. All of these configurations are shown in Figure 1. A brief check on replacing the 'chevron' wing with a delta showed no areas of improvement but rather a loss of performance in speed, ceiling and climb. All of the designs had flight envelopes limited at Mach 2 but clearly showing the potential to achieve higher speeds as shown in Figure 2.

EECo presented the single-engine P6/1 as the most attractive option. Although not achieving quite the level of performance of the P6/2, it offered a simpler and cheaper solution. The swept wing offered better altitude and manoeuvre performance across the speed range compared to a straight wing. The retention of the wings and many other parts of the P1 made it much cheaper to design and build compared to a totally new design. Pending its development, it was suggested that the modified F23/49 proposal offered a quick way forward for an initial exploration of the Mach 2 flight regime and its attendant structural heating problems.

The straight wing P6B was viewed unfavourably by EECo. In a

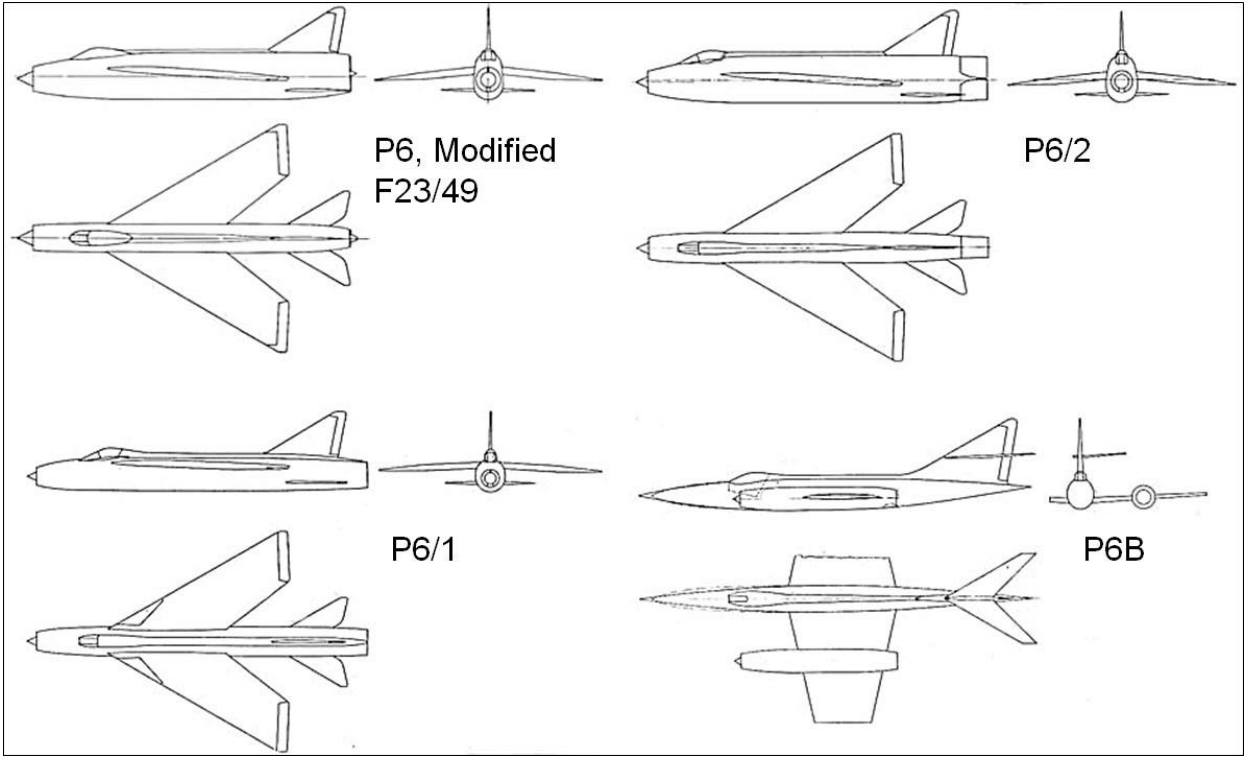


Fig 1. P6 proposals to ER134T, May 1953.

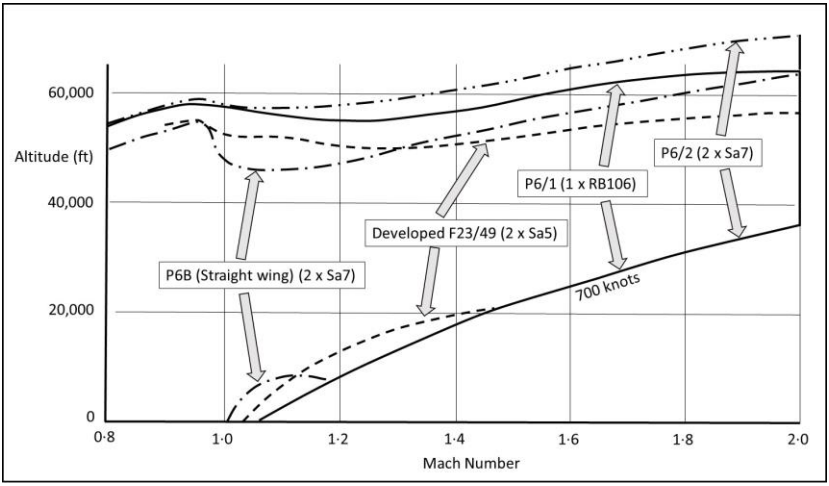


Fig 2. P6 flight envelopes, standard atmosphere.

straight line at a speed of Mach 2, the straight wing performed as well as any other. The aircraft, however, was heavy. It had poor transonic and altitude performance and had severe stability, control and aeroelastic problems that would need considerable research investigation themselves. Nevertheless, in view of the RAE's preferences, EECo continued to explore straight wing designs. In September 1953,

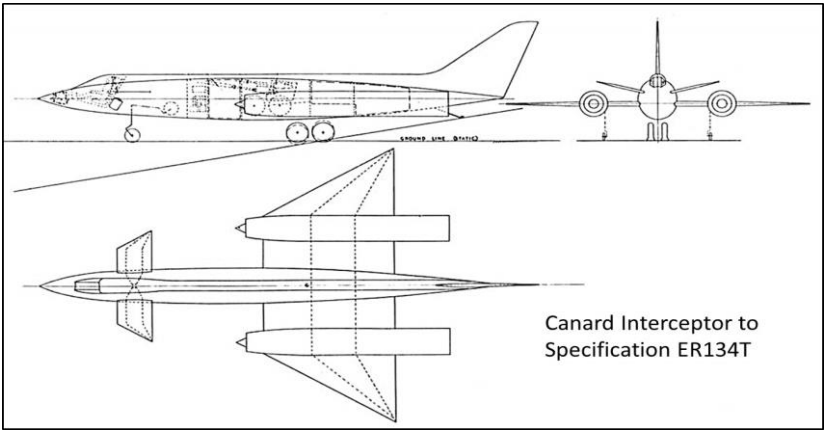


Fig 3. P6D canard proposal, September 1953.

Fig 4. Bristol Type 188 to ER134T.

they presented the radical canard design shown in Figure 3. By this time, however, the RAE had dismissed EECo's assessment of straight wings as being too pessimistic. Also, the goal was now to research speeds up to Mach 2·5 to support the development of the planned supersonic fighter, bomber and reconnaissance types.

Certain that a straight-winged design with wing-mounted engines was the right solution, the RAE favoured the Armstrong Whitworth and Bristol submissions. These were very similar. The Design Conference preferred the AW, but the choice finally went to the Bristol Type 188 because of their lower workload as minuted by CS(A) on 7 October 1953. The original plan was for two aircraft, the first with an alloy wing and the second with an experimental steel wing, for a total cost of £2·5m. First flight was expected to be by 1957. The development proved very complex, delaying progress and raising costs. Extra prototypes were ordered and then cancelled. By December 1955, the cost estimate had risen to £7m and doubts were raised as to whether the aircraft would fly in time to be of any use to other programmes. By May 1958, cost predictions were rising to £10m and the OR329 and OR330 projects that were intended to benefit from it had been cancelled. First flight was achieved on 14 April 1962. The aircraft fell far short of its goals in speed and endurance. Its maximum speed was only Mach 1·88. The two prototypes had cost £14m for the airframe alone. In total the programme cost about £20m. Flying lasted less than two years. Sir George Edwards of Vickers said that nothing was learned from the Type 188 except 'not to build aeroplanes like that'. Before this lesson was learnt, however, the thinking behind the ER134T programme was also driving the OR329 fighter programme.

A conference in December 1951 about replacing the Hunter and Swift had proposed an aircraft with a speed of up to Mach 1·8. A draft OR was prepared in February 1952. This proved controversial and,

after a year of meetings and papers on fighter requirements and concepts, a completely new draft, OR329 for a ‘high altitude supersonic interceptor’, was circulated in February 1953 followed by a second draft in November and three more in early 1954. A sanitized version of the fifth draft was circulated to eleven firms, including EECo, on 19 March 1954. The requirement was finally issued in August 1954. It was sent to the eleven firms in October. In the same month, a draft specification, F155T, was circulated. It was eventually issued on 15 January 1955 and eight firms were invited to tender. A meeting with the tendering firms on 5 April led to amendments to OR329 in July revising the performance goals and in August changing the title to ‘all weather interceptor’. A second issue of F155T on 5 July 1955 relaxed the performance and weapon load requirements.

A key aspect in all this was the framing of the requirement and specification as being for a ‘weapon system’. Thus, the aircraft Operational Requirement included, as addenda, five other ORs covering weapons, radar and equipment. In 1956, concerned that only lip service was being paid to the weapon system concept, DOR(B) drafted a single replacement for these five addenda to emphasise the need for all the elements to be considered together.

During 1954, the broad development of the specification was influenced by the concurrent work of an Air Defence Committee Working Party chaired by Arnold Hall of the RAE. This was exploring the future needs for all elements of the UK Air Defence System. The fighter aspects were studied by RAE and reported in April 1954 as ‘Air Defence against High Altitude Bombers by Mach 2 Fighters’. It was also published later as RAE Report Aero 2513. Drawing on the work for the Mach 2 research aircraft, it proposed a twin engine fighter configuration similar to the RAE’s ideal research aircraft from report Aero 2462 and the Bristol Type 188 selected against ER134T. In contrast, it also presented a layout clearly based on EECo’s P6/1 submission to ER134T as being unsatisfactory. The configurations are shown in Figure 5. The RAE design was assessed to be lighter and with better performance than the Lightning-like design. A subsequent RAE study about a year later revised the design to meet the F155T specification. This doubled the weight and changed from two to four engines.

Of the eight companies invited, seven submitted tenders in October

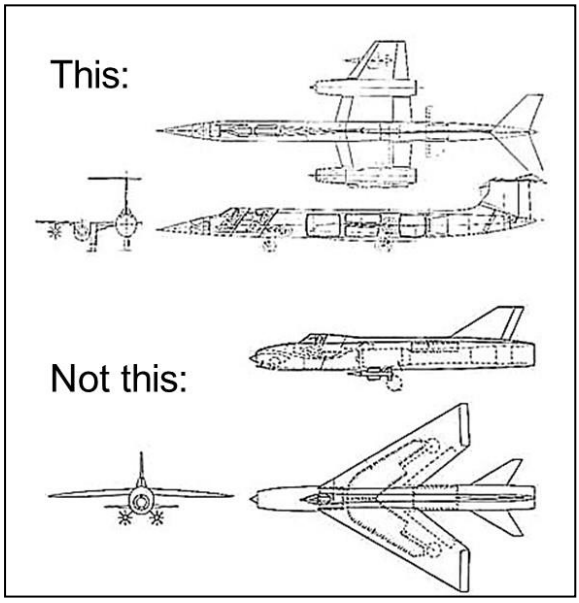


Fig 5. RAE guidance for F155T, 1954.

1955. They varied widely in their response. Some were sceptical of the possibility of meeting even the new, relaxed specification. At the other extreme, Saunders Roe believed it could satisfy the original, more challenging specification. These various responses were received differently by the RAF and the MoS. The Air Staff had asked that the aircraft be kept as small and cheap as possible. They also asked the firms to consider the totality of the weapon system and the nature of the operational task and to propose any innovative solutions that might offer a more economical approach. By contrast, the MoS believed that the only fair and practical way to assess the tenders was by ranking them rigidly according to the extent to which they met all the demands of the revised specification. This include meeting all the performance goals while carrying a crew of two, a large radar and two huge radar-guided Red Hebe air-to-air missiles.

Hawkers and EECo were the leading sceptics. Both believed that meeting the performance goals while carrying Red Hebe would be unaffordable. Hawkers designed what they believed was the smallest fighter capable of meeting the performance goals while carrying the much smaller Blue Vesta missile. Their design was capable of carrying Red Hebe, but with reduced performance. They did little to explore the weapon system aspects as they believed that the procurement system left them little ability to influence the equipment choice and design. EECo, on the other hand, were credited with

having a strong grasp of the weapon system concept and did extensive studies to show that adequate role performance could be achieved with a single-seat aircraft armed with Blue Jay Mark 4 (Blue Vesta) missiles. The proposed aircraft, P8, is shown at Figure 6. It was essentially a derivative of the P1B but with RB126 engines instead of RA24s, a fuselage mounted undercarriage and wing tip missile carriage. Its all-up weight was almost the same as the P1B. This choice of development route was also seen as offering the prospect of meeting the required early service date.

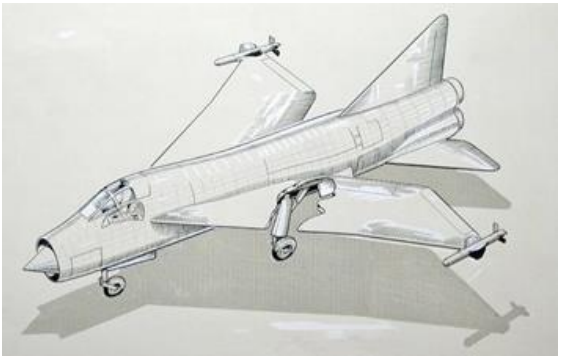


Fig 6. English Electric P8.

The contrast between these proposals and those of the other firms bemused the Air Staff. They noted that the confidence of the various firms as to their ability to meet the specification was inversely proportional to their experience of building this type of aeroplane. The competing designs are shown at Figure 7.

At the tender review conference, some of the Air Staff favoured basing the choices for the way ahead on the general capabilities of the firms rather than the specific designs submitted. They particularly mentioned English Electric as first choice. The Ministry of Supply, however, insisted that the agreed tendering process meant that the choice must be based strictly on whether the designs met the specification in detail.

The initial down-selection ruled out the Saunders Roe proposal as unnecessarily heavy and complex, being aimed at the earlier specification. It was twice the weight of the EECo P8 when empty and three times as heavy when loaded. Conversely, the Hawker and EECo proposals were ruled out as failing to satisfy so many aspects of specification. Furthermore, RAE believed that EECo were being too optimistic about the performance of the Blue Vesta seeker and hence

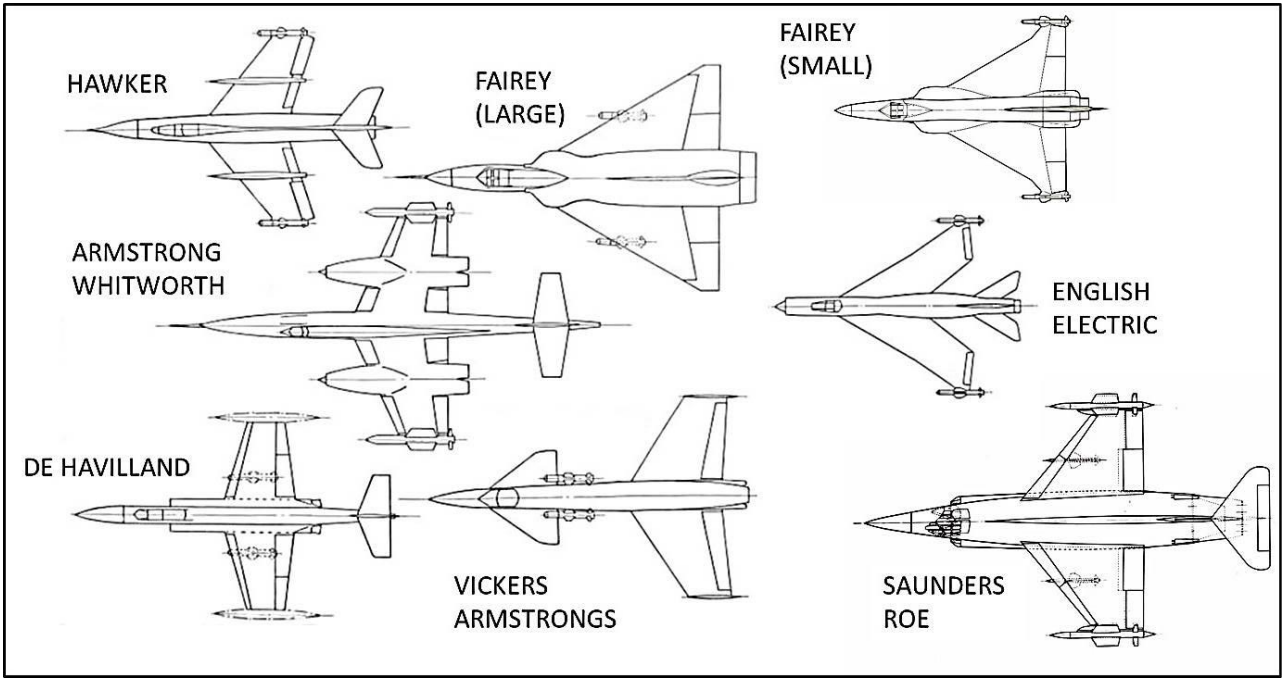


Fig 7. Tender Submissions to F155T, October 1955.

the use of infra-red weapons for front hemisphere attack.

The choice eventually narrowed down to the larger of the two designs submitted by Fairey and the Armstrong Whitworth design. The former drew upon Fairey's experience with the ER103 research aircraft. The latter, with its four jet engines plus rocket motor, was very like RAE's own suggestion to meet F155T. After the next phase of work, the final choice was the large Fairey delta, before the programme was cancelled in 1957.

When the EECo P8 was rejected, the Air Staff requested that funding be found to continue it as a Lightning development. No money could be spared. The Lightning would eventually be developed to perform interceptions with Red Top in the manner proposed for P8, but without the possible benefits of the other design features of P8.

Early Development Proposals.

Even before the 1957 Defence White Paper left the Lightning as the only advanced fighter project for the RAF, industry had already begun to look at possible developments to widen its roles and capabilities. On 30 January 1957, English Electric, de Havilland Propellers, Ferranti and Elliots jointly presented a set of proposals for developments of the P1. At this time, the baseline was P1B fitted with Rolls Royce RA23R engines plus two Napier Scorpion rocket motors (awaiting an ITP). It was designed to perform 'lead-pursuit' interceptions, employing AI 23, or as interim, AI 20, and Blue Jay Mk 1 or Mk 2 or Sidewinder guided missiles, changing to Blue Jay Mk 4 as soon as possible. Unguided weapon options included four Aden guns or two Adens to supplement the guided weapons or two Adens plus 48 unguided rockets.

The development proposals were covered by four EECo project numbers: P11, P15, P18 and P19. The configurations are shown in Figure 8. P11 retained the original P1 wing planform. The other three incorporated the proposed addition of an extended, cambered, outboard leading-edge. This was already under test on the P1A and was eventually adopted for later marks of Lightning.

P11 was a two-seat trainer. It had started as a response to OR318 for an advanced trainer in 1953. A tandem seat design was proposed in 1955. It had now evolved to a side-by-side cockpit, some of the space being found by deleting the upper pair of Aden guns.

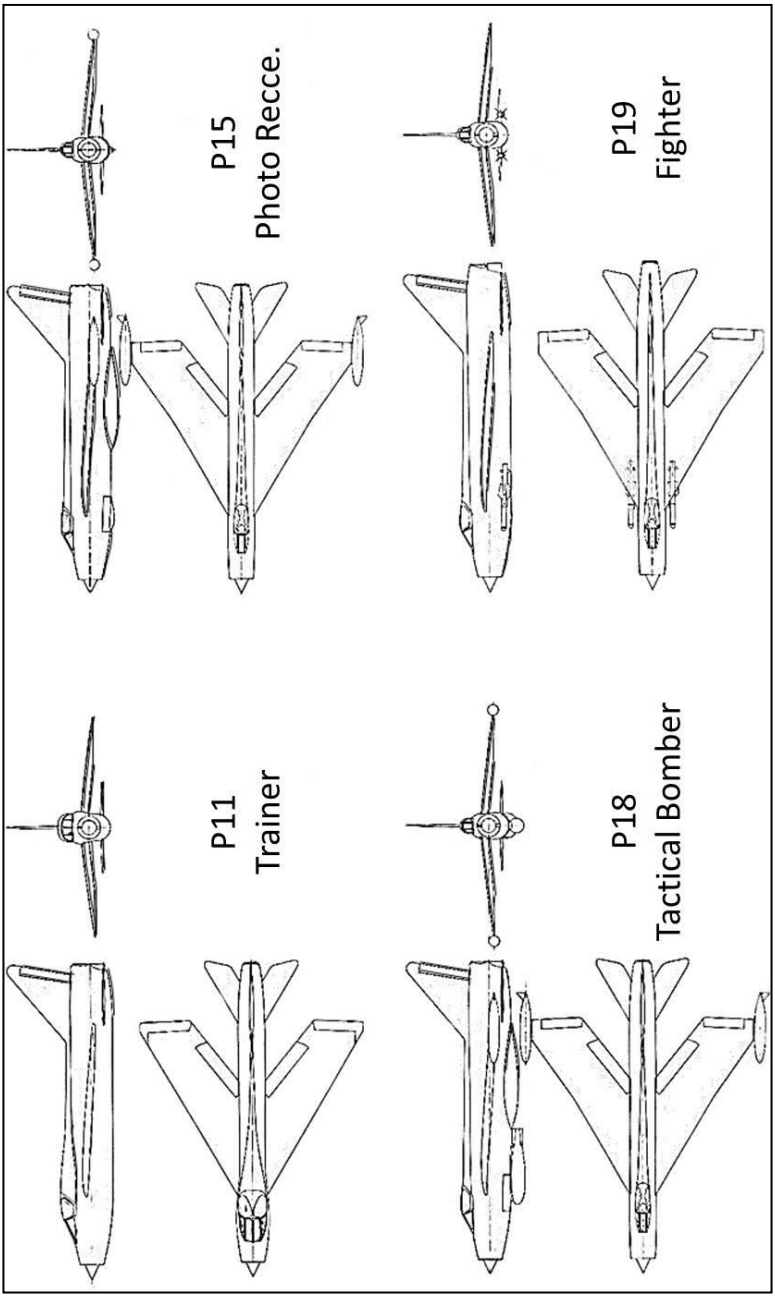


Fig 8. Development Proposals, 30 January 1957.

P15 was a photo-reconnaissance variant. The cameras were to be fitted in a pack to substitute for the weapons pack. Two alternative packs were offered. Each had six F95 cameras to give forward and lateral oblique and near-vertical settings. The two packs differed only in the camera focal lengths, one set being four-inch and the other twelve-inch. It also had wing-tip overload fuel tanks to extend the radius of action.

P18 was described as a tactical bomber. It is shown configured for the strike role with a single 'Target Marker' (Red Beard nuclear weapon) mounted tangentially under the fuselage.

P19 was an improved fighter variant. It proposed new, more powerful Rolls Royce engines such as the RB133 with convergent-divergent nozzles and mass flow control plus weapon system improvements offering a front hemisphere interception capability. This was based on ideas already offered for the P8 to F155T in 1955 and a P1B development proposed in 1956. It included a J-band version of AI 23 and armament of Blue Jay Mk 4 or Sparrow 2.

The contributions from the equipment companies focused on the P19 fighter. De Havilland Propellers detailed the seeker and performance improvements for Blue Jay Mk 4. In particular, they demonstrated the increased sensitivity of a lead telluride seeker to replace the lead sulphide seeker of Blue Jay Mk 1 (Firestreak). Ferranti described the features and benefits of the proposed J-band version of AI 23. Elliotts proposed the changes to the autopilot that were needed to go from a 'lead-pursuit' to a 'lag-collision' intercept mode.

Any official response seems to have been overtaken by events with the publication of the Defence White Paper in April 1957. The main line of Lightning development for the RAF would focus on the interceptor fighter role. Ideas for widening the role capabilities would be directed mainly at potential export customers.

Export Proposals

As Lightning approached entry into service with the RAF, EECo was allowed to start promoting it to selected potential customers. To widen its appeal, further efforts were made to add extra operational features. A development brochure was issued in 1958 and revised in 1959. Continuing the search for longer range, the 1958 brochure

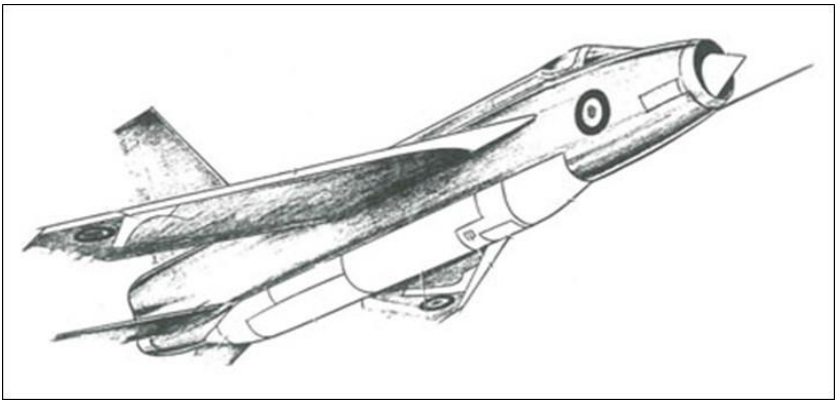


Fig 9. Tactical Fighter for Australia (first version), 1960.

introduced under-wing tanks on forward-swept pylons plus wing-tip tanks. The 1959 version dropped both of these and introduced instead the idea of large over-wing tanks. A ground attack capability was possible by means of rocket pods instead of the under-wing or over-wing tanks. Photo-reconnaissance would be by a camera pack as proposed for the P15.

These developments were taken further in a major 'Tactical Fighter' proposal to Australia in 1960. This introduced a multi-role fit based on the latest F Mk 3 fighter design. As shown in Figure 9, it had a large ventral pack with facilities to allow different role fits to be incorporated as and when desired. These included fuel tanks, sensors, electronic and armament options. This proposal was aimed at satisfying the Australian requirement (OR AIR 34 Iss. 4) for a single-seat aircraft. It was suggested, however, that the full weapon system capability could be exploited better by a crew of two. A two-seat, multi-role variant based on the Lightning T5 was proposed. This was given the project number P33.

Although the Australian proposal was not successful, the general design concept was broadened as a suite of configuration options with the label PL1. These were again based on the Lightning T5. They offered short or long ventral packs, both incorporating additional fuel and a bay for weapons or sensors or yet more fuel for ferrying. An example is shown with weapon options in Figure 10.

In March 1963, a mock-up of the long, multi-role ventral pack was

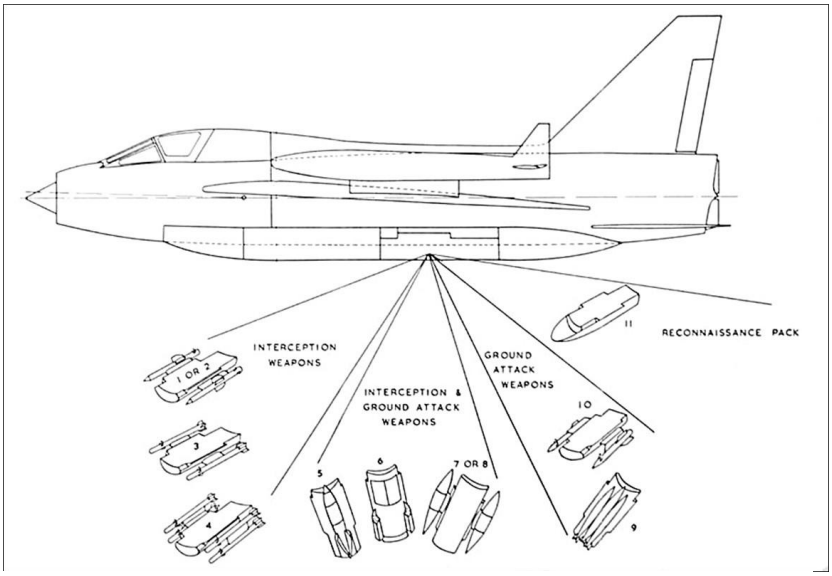


Fig 10. A PL1 Option showing weapon possibilities, 1961.

fitted to Lightning XN725 as shown in Figure 11. This also shows a mock-up Bullpup air-to-surface missile on a stub pylon and some alternative stores. This may relate to the P34 project for a ground attack variant for the RAF.

By the time a proposal was made to Italy's *Aeronautica Militare* in

Fig 11. Ventral Pack and Weapons Mock-up, 23 March 1963.

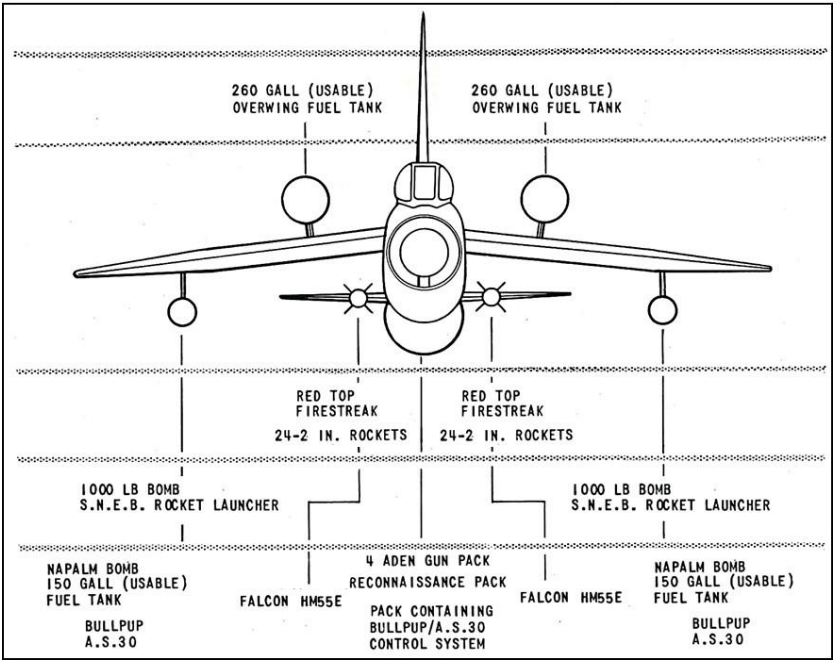


Fig 12. Weapon Options for Italy 1965.

1965, a final design for a larger ventral tank was being introduced for RAF Mks F2A and F6. This was therefore used as the basis for multi-role export proposals. Possible weapon loads, as proposed to Italy, are shown at Figure 12. Firestreak, Red Top, 2-inch rockets pods and the overwing tanks were classed as existing. Design was proceeding for SNEB rockets and 1000lb bombs. All the remaining items were said to have feasibility established. This design would form the basis for the version eventually exported to Middle Eastern customers as the Mark 53.

Fighter Developments

The Defence White Paper of 1957 retained Lightning as the only remaining interceptor project for the RAF and stated that it should be developed to its full capability. Numerous weapon and equipment possibilities were investigated in the period 1957 to 1966. Changing perceptions of air defence requirements and the acceptance of the need for more advanced interceptor types led to the acquisition of the

Phantom and then the Air Defence Variant of Tornado. Investment in these eventually overrode further major investment in the Lightning.

Soon after the first consideration of guided weapon armament for the Lightning in 1952, attention had been drawn to air-to-air missile developments in the USA. The Hughes Falcon and its E9a fire control system was considered for RAF use in 1953. By 1955, EECo had gathered details of the various versions of Falcon, Sparrow and the recently-developed Sidewinder. Meetings with US company representatives at the Paris and Farnborough air shows in 1956 produced more details on Falcon and Sidewinder but nothing about intended developments. The MoS was unsupportive of these contacts; although Sparrow was under consideration for carriage on Sea Vixen and possibly F177.

In May 1958, the MoS held a review of alternatives to Blue Jay Mk 4 (Blue Vesta) as a replacement for Blue Jay Mk 1 (Firestreak) on Lightning. It considered four weapons: Sidewinder, Falcon, Sparrow and Genie. Sidewinder was rejected as offering no improvement on Blue Jay Mk 1. Falcon offered the attraction of both radar and infra-red guided versions. The radar-guided version, however, would require AI radar development to provide target illumination. Furthermore, the infra-red versions offered no coverage improvement over Blue Jay. Finally, the very small warhead made it essentially a 'hittile' and required salvo firing to achieve adequate lethality. American aircraft carried six Falcons for this reason. This would be too difficult for Lightning. Sparrow was attractive for its radar guidance and hence forward hemisphere capability. It was ruled out, however, because the space could not be found to add the necessary CW illumination. (EECo would later re-examine Sparrow in the context of other radar developments.) This left Genie as the focus for further study since, in spite of its high cost, it seemed to offer a useful increase in engagement capability and simpler integration with the Lightning's systems.

Genie was not a guided missile. It was an unguided rocket projectile with a 1·5 kiloton nuclear warhead. Its US designation was MB-1 and, from 1963, AIR-2. In the UK it was also known as RP3. Over 3,000 were produced for US and Canadian deployment in defence of North America. A single live firing test was carried out on 19 July 1957. The warhead was detonated with a yield of about 2

kilotons 4,000yd after launch and 3,000yd clear of the launch aircraft. The detonation at 18,000ft altitude caused so little radiation at ground level that the weapon was declared safe for use over populated areas.

UK industry had already been tasked with studying the employment of Genie. EECo had studied the carriage and operation of Genie by Lightning under the project number P23. The study was reported on 31 December 1957. The carriage proposal and the options considered are shown at Figure 13. The interception profile involved a front hemisphere engagement with the projectile launched on a lofted trajectory. The fighter then broke away in a diving turn to maximise the separation and minimise exposure to blast, heat and radiation. The EECo study was accompanied by a comprehensive weapon study by Ferranti. Work continued into 1959 until the programme was finally cancelled by ACAS(OR) on 4 November 1960.

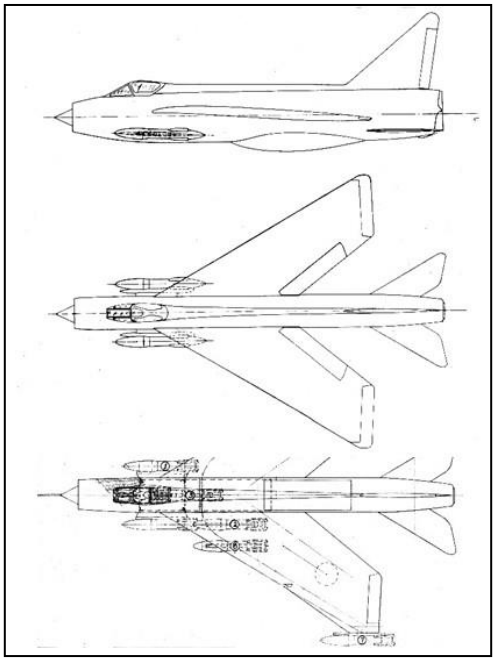


Fig 13. P23 Genie Installation, 1957.

It was now accepted that Red Top offered the only viable way ahead. It now had an even more sensitive indium antimonide sensor instead of the lead telluride of Blue Vesta. Nevertheless, the weather limitations remained. Studies continued to find viable radar-guided options. These included an examination of a radar-guided version of Red Top, using the Matra 530 guidance head, in 1962.

At a meeting of the Lightning Aircraft Systems Integration Committee on 30 November 1963, EEA (English Electric Aviation) requested a meeting for guidance on forward thinking and priorities. In response, on 13 February 1964, DOR(A) wrote a summary of

desirable developments with regard to performance, weapons and equipment. The focus was on meeting the problems of operating world-wide, given the major changes in the international political situation since Lightning was first designed. With regard to armament, there was a need to carry secondary armament of guns or rockets as well as Red Top. At the subsequent meeting on 18 March 1964, all of DOR(A)'s topics were addressed together with some additions from EEA including the benefit of variable geometry to meet some of the performance goals. For secondary armament, EEA offered five options:-

a. Aircraft with forward Red Tops plus underwing pylons with gun pods or missiles.
b. Aircraft with an Aden gun installation in the forward bay, as per the Mk 1A, and Red Tops on underwing pylons.
c. Mk 2A aircraft with upper guns and Red Top missiles on the forward bay.
d. Aircraft with a mixed load of Red Top and a radar-guided Red Top or HM55A Falcon
e. Aden gun installation in a pack exchangeable with the ventral pack engine hatch tank with the displaced fuel carried in tanks on underwing pylons. These tanks would be jettisoned when empty.

All of the options except the first and last were rejected on grounds of cost, complexity or physical impracticability. Further work was required on the underwing pylons, tanks and gun installations. This led eventually to the choice of the gun installation in the ventral tank.

Sparrow was re-examined in 1965, but this was part of an examination of new target acquisition options which had become the main focus for weapon system improvement.

Two main problem areas were addressed: hostile ECM and the fundamental look-down problems of AI 23 as a basic pulse radar. The ECCM study considered two threats: X-band self-screening jamming of AI 23 or S-band jamming of the GCI link. To counter self-screening jamming, AI 23 had a home-on-jamming mode to give the direction towards the jamming source. This permitted closure until AI burn-through or visual acquisition. To achieve range information at longer range under these conditions, it was proposed to fit a supplementary Q-band ranging radar. This was studied in detail during

1961. The main problem was finding an installation with adequate field of view. The options are shown in Figure 14. The final choice was to fit it in the front section of the ventral tank. In the end it was not adopted, possibly because of space priorities for other equipment or because of the improved ECCM features of AI 23B.

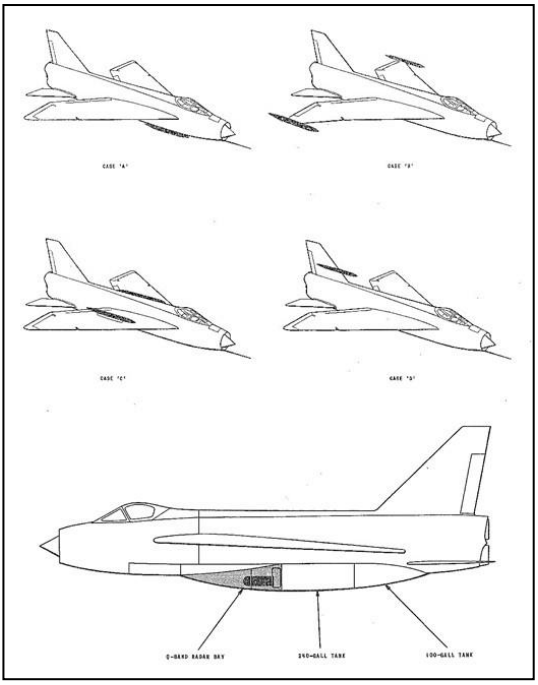


Fig 14. Q-band Radar Options, 1961.

To cope with S-band Jamming, an S-band homer was proposed. This was developed as a feature of AI 23B and was described in the design notes for the Lightning Mk 3 system in May 1960. It went for flight test in 1964 and entered service with the Mk 3.

As a general aid to target acquisition and tracking, especially in severe jamming circumstances, passive infra-red search and tracking was investigated between 1963 and 1966. Interest focused on the Hughes Aircraft Company 71N Infrared Search and Tracking Set (IRSTS) which was going into service on USAF fighters. In early 1963, Hughes had approached the UK government and industry proposing the adoption of the IRSTS. EEA had joined them in a high level presentation. By 22 July, Hughes were pressing EEA for support in presenting a proposal, jointly with Ferranti, for a trial installation on a Lightning Mk 3. The Air Ministry had offered to make a Mk 3 available for three months. The MoA had indicated that it could probably obtain funding. A brief examination suggested that the equipment could be fitted in the upper equipment bay hatch on the fuselage nose. Integration of the IRSTS with AI 23B was considered

feasible in discussions with MoA, RRE and Ferranti. More detailed examination was hindered by the current workload of the Warton Electrical Systems Group. Contacts continued, but in January 1964 it was decided that submission of a brochure would be premature. In February, however, EEA requested the loan of an IRSTS to display at the CFE Convention in April.

A year later, between April and November 1965, RRE trialled an IRSTS installed in a Canberra, but not integrated with a radar. It was tested against Canberra, Lightning and F-101 targets. In anticipation that the results would confirm the manufacturer's data, Hughes and EEA agreed to review the possible application to Lightning. EEA would reappraise installation and operation. Hughes would consider re-design to facilitate integration with AI 23B. All came to an end when an MoA letter on 23 August 1966 declared that after all due consideration no further information was required.

To overcome AI 23's look-down limitations, two routes were explored: a new Pulse Doppler radar or the addition of Airborne Moving Target Indication (AMTI) to AI 23B. These were also tied to the provision of Continuous Wave (CW) illumination to allow the use of the Sparrow III missile.

On 8 April 1964, a memorandum from Dr J V 'Vic' Hughes to Lightning Project Manager, Alec Atkin, reported a discussion with EMI and Hughes Aircraft Company (HAC) about a Pulse Doppler radar that they had proposed for P1154 in June 1963. They detailed its functions and features. Its weight of 800lb would be a problem for Lightning. Reduction to 600lb could be achieved by deleting several functions including range-while-search and track-while-scan. Lowering it to 500~550lb would leave just a basic pulse radar.

This began the search for look-down radar options. In the next week, discussions with RRE confirmed the value of pursuing Pulse Doppler options and a meeting with Westinghouse touched upon radars from the Phantom and radars derived from the Bomarc missile seeker. In July, further information confirmed the Bomarc seeker derivatives being offered for F-104 and F-5A as being most suitable for Lightning but they were dismissed as not offering enough capability.

Attention turned to Ferranti. Initial interest was in an adaptation of the OSIRIS Pulse Doppler radar being planned for the P1154. It would

be re-packaged and have some modes deleted to save weight. This was seen as ‘pushing the state of the art’ and requiring long development.

In September, Elliott Bros wrote to Atkin offering to produce an outline of a radar solution for Lightning within two weeks and a detailed proposal in October. They assumed that a coherent radar would be required in the light of the operational demands on the RAF in Malaysia and Indonesia.

GEC entered the fray in December offering an MTI module to link to AI 23B. This was under development for AI 18 and being tested on a Canberra. EEA agreed to supply installation ideas and GEC would supply flight test results. EEA offered space for fitment in the upper nose area.

Through January to March 1965, studies centred on an evolving set of options to be considered with Ferranti to improve the low altitude engagement capability. These were as follows:-

- Replacement of the Light Fighter Sight (LFS) by the Pilot’s Attack Sight (PAS)
- Re-packaged OSIRIS radar
- Ferranti coherent AMTI addition to AI 23B
- GEC incoherent AMTI linked to AI 23B
- CW injection into AI 23B for Sparrow III guidance
- A separate CW illuminator slaved to AI 23B

On 23 February, Atkin wrote to D(RAF)B and DOR1 outlining ideas for developing Lightning in the interceptor, air superiority fighter, reconnaissance and strike roles. The interceptor options included the spectrum of radars under consideration. The CW provision for Sparrow was linked to the fact that the recent decision to purchase Phantom would bring Sparrow and Sidewinder into the RAF inventory. They could therefore be considered as future primary and secondary armament for Lightning.

By 16 March, the OSIRIS development and the Ferranti coherent AMTI module had been dismissed as too expensive to develop. CW injection into AI 23B was also seen as too complex and expensive. Costing therefore focused on the PAS, a separate CW illuminator and GEC’s incoherent AMTI unit. There were still major reservations

about the AMTI especially the difficulty of adapting it to AI 23B with its significant differences from AI 18.

On 28 April 1965, the requirement for auto-attack was cancelled. This relaxed some of the space restrictions that had hindered the fitting of new equipment.

EMI and HAC returned with a proposal for a coherent AMTI unit to be integrated with AI 23B. This was CORDS, a system that had been tested as an addition to the MA1 radar of the F-106 and was expected to be fitted to the APQ-109 pulse radars of some recent Phantoms. A detailed presentation was given on 10 June. It was attractive but suffered from a number of deficiencies. There was concern about the multiple blind speeds and it would prevent the use of the monopulse tracking facility of AI 23B. It would also suffer from the higher sidelobes and lower prf of AI 23B. Space and environmental limits were also problems.

By September it was felt that there was little hope for it on Lightning. By November, however, more environmentally suitable space had been identified and a programme of phased development trials was suggested. It was still under consideration in December, but space was again proving problematic and the options seemed to be to sacrifice some fuel space in the ventral tank or to delete the S-band homer.

While all these radar studies had been underway, more advanced interceptor projects had been studied against ORs 346, 355 and 356; an interceptor version of TSR2 had been proposed; in January 1964, CFE had produced an outline of requirements for a future fighter assuming that Lightning Mk 3 would go out of service in the mid-1970s; and a major study of future fighter possibilities had been carried out by industry and the research establishments during 1964 for a committee chaired by Professor R V Jones. Meanwhile, the Government was grappling with increasing pressures on the defence budget. Everything came to a head with the change of Government in 1964 and the subsequent cancellation of many projects. By 1966, an initial proposal that the RAF's version of the new AFVG should be an interceptor had been dropped in favour of a strike aircraft and the RAF was set to receive the F-4M Phantom to OR385. The tightening budget and the priority for funding new aircraft led to the cancellation of the IRST and radar improvements for the Lightning.

Variable Geometry Lightning

The benefits of varying an aircraft's wing sweep in flight began to be investigated during the Second World War. The idea was then taken further in the USA and UK. At Vickers, between 1945 and 1959, Barnes Wallis pursued the concept to an extreme with his flying-wing designs, Wild Goose and Swallow. Vickers drew upon these studies for its Type 581 in response to OR346/ER206 between 1959 and 1961. Meanwhile, between 1958 and 1960, NASA had been performing extensive wind tunnel tests on Swallow and other configurations as part of a US/UK joint programme. These revealed that the Swallow's tail-less configuration had intractable stability and control problems. The advantages of a swing-wing could be realised best in conventional tailed design. Vickers adopted this for subsequent VG designs such as the Types 583 and 584. To increase confidence in the use of VG for high speed combat aircraft, a research aircraft was suggested. Adaptation of an existing aircraft was seen to be the cheapest route. Vickers initially suggested a swing-wing version of the Swift. This received a lukewarm response. It was felt that, to be useful for future advanced designs, the experimental aircraft should be supersonic. Lightning was the obvious candidate. Vickers drew up a swing-wing conversion as the Type 588 as shown at Figure 15. By this time, Vickers and English Electric Aviation had been brought together as parts of the British Aircraft Corporation. Vickers therefore turned to BAC Warton for help with wind tunnel assessments of the Type 588.

Warton staff had been alerted to DDOR1's interest in variable geometry at the 1960 SBAC Show. They visited Vickers in April 1961 for a briefing on VG. In July 1961, Vickers turned to BAC Warton for assistance with performance estimates for the Type 588. Warton began to supply data but pointed out that the low speed, 25° sweep configuration required experimental evidence for confidence. They had begun to modify a wind tunnel model accordingly. On 21 July Vickers placed a subcontract on Warton to modify an existing Lightning wind tunnel model for tests on the low speed configuration of the Type 588. This was delivered to Vickers in September and some tests were carried out. Meanwhile, on 11 August CA (Sir George Gardner) had written to Sir George Edwards at Vickers expressing interest in the work and requesting a copy of Vickers' preliminary

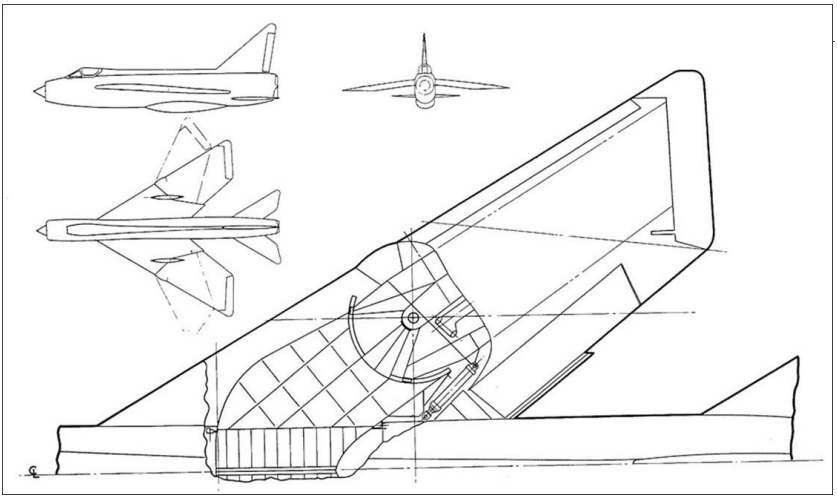


Fig 15. Vickers Type 588, 1961.

estimates of the likely benefits of VG ahead of the confirmatory wind tunnel work. Edwards replied on 24 August with tabulated figures plus a request to spend up to £50,000 from existing project funding on the Lightning and proposing further funding to modify two Lightning development batch aircraft to variable sweep. Gardner's reply on 12 September ruled out the proposed spend and deferred a decision on the way ahead. In November, Warton carried out its own wind tunnel tests and produced a report with both the Vickers and Warton results. No further work seems to have been done for nearly two years.

In June 1963 BAC Warton revived the concept as a possible quick and economical approach to meeting the Royal Navy requirement AW406 for a carrier-based fighter. It drew upon the Vickers work already reported to the Ministry of Aviation and proposed a design based on the Lightning T5 with a new wing as designed by Vickers. Apart from the VG wing, the main changes were an extended ventral pack, arrestor hook, tail skid, fuselage strengthening, inward retracting undercarriage, dorsal fin and fitment of observer's displays in the starboard crew station. The extended ventral pack was divided into three fuel tanks. The centre tank could be removed and replaced by packs for reconnaissance or ground attack or extra air-to-air missiles or the electronics and aerials for the AST1168 missile. Pylons under the fixed part of the wing could also carry air-to-air or air-to-ground weapons.

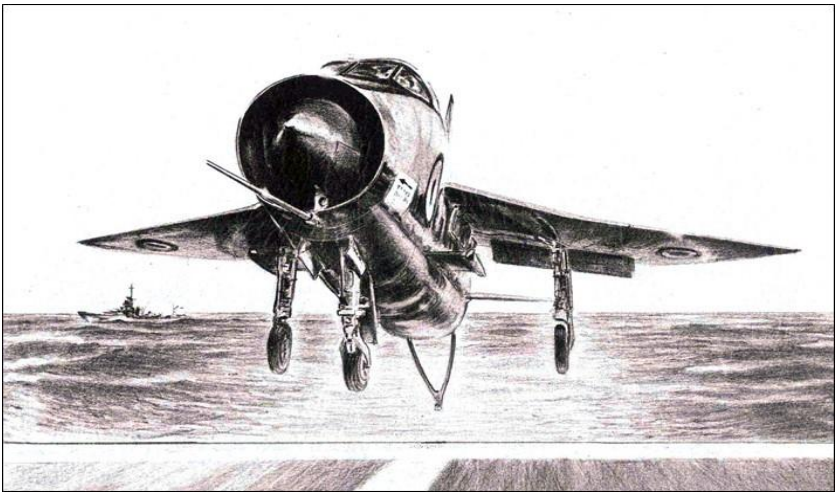


Fig 16. Lightning for the Royal Navy, June 1963.

The brochure offered a wide variety of weapons. The basic design, adapted from the T Mk 5 was shown to meet almost all of the requirements of AW406. It was noted that there would be a small reduction in top speed when carrying four Red Tops instead of the Lightning's usual two. The main deficiencies were due to the limitations of the AI 23B radar. The detection range against a Canberra-type target was 25nm as against the over 60nm required. It could not detect targets flying at low altitude or provide terrain warning in the ground attack role.

A number of further developments were offered to overcome these deficiencies and increase the overall capabilities. Convergent-divergent nozzles would restore the top speed. Weapon carriage could be improved. A change from Avon 301 to RB168 engines would enhance the mission performance but would require a new rear fuselage. The most significant change proposed was the design of an entirely new nose section to accommodate a new radar with a 30-inch dish. This would necessitate a change to side intakes as shown at Figure 17.

This design was presented in more detail in a subsequent brochure titled 'Lightning for the Royal Navy Phase III Developments'. Most of this is devoted to a comparison of performance with alternative new

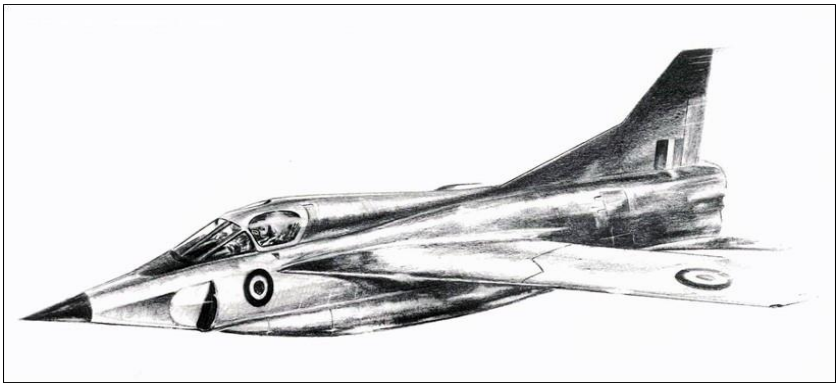


Fig 17. RN VG Lightning Phase III, 1963.

engines, the RB153/61C or the RB168/1R. The former had the advantage of being small enough to fit the existing fuselage. It could also provide performance to meet AW406 to the letter. On the other hand, the RB168, although requiring a larger fuselage, showed significant advantages when considering the performance in more detail and in a wider range of climates.

In the end, nothing came of this. Naval interest was very much focused on the P1154 and then switched to the F-4 Phantom.

RAF interest in a VG Lightning lingered on. DOR(A)'s paper of 13 February 1964, listing areas for development, prompted a quick assessment of the range and duration improvement resulting from fitting a VG wing to the Mk 3. These were briefed at a meeting on 18 February. On 4 April, 'since considerable interest is being shown by the Ministry and RAF', the firm held a meeting to define a programme of work for a feasibility study. The goal was to achieve a ferry range of 2,000nm and operation at maximum all up weight from 2,000yd runways while retaining all the existing high speed fighter performance. The wing design should be compatible with the existing fixed wing so that it could be fitted as a conversion. The goal was to retro-fit forty in-service Mk 3 aircraft four years after ITP with a target maximum cost of £8·5m for the whole programme. As well as being variable geometry, the new wing was to have increased area and fuel volume. A new wind tunnel model would test the design. A preliminary cost estimate arrived at £6·5m-£7·5m for the development programme, including three prototypes adapted from existing aircraft.

Following a visit to Warton, Gp Cpt Ellacombe of the Central Fighter Establishment requested the loan of a slide on the VG Mk 3 to use in a presentation on the Mk 3 at a forthcoming convention. In supplying it, Lightning Project Manager Alec Atkin stressed the need for a feasibility study to give confidence to the performance estimates and requested CFE's support. After the convention, on 24 April, Air Cdre Tacon of CFE wrote to Freddie Page expressing thanks for the firm's support. He had taken the opportunity to promote the VG Lightning to C-in-C Fighter Command, VCAS and DCAS. They were all interested, particularly in light of concerns expressed at the convention about the Lightning's lack of range for overseas deployment. Both they and Professor Jones were, however, sceptical of the cost and timescale. Page replied, summarising the studies to date and pressing again for a feasibility study as being essential for assessing cost and timescale.

A detailed cost estimate on 15 June quoted £4·8m for development, including two prototypes, and £6m for modification of forty aircraft leading to a cost, without profit, of £10·8m.

At about this time the project seems to have been dropped, possibly because of the change of Government or because the application of variable geometry was being focused on new aircraft designs.

For these same reasons, over the next two years, all of the major development studies for the RAF's Lightning were wound up. For the RAF at this time, the main debate centred on procuring the existing design in appropriate numbers. Multi-role capability would evolve only for the export Marks. During the long service life ahead, developments would be limited to items essential to achieve and maintain the full capability of the original weapon system in the Mark 3 and, eventually, the Mark 6.

Sources

BAE Systems Warton Heritage:-

Drawing Archive

EAG Drawing Register

Freddie Page Archive: FWP 6-2_10, FWP 6-2_11, FWP 9-4_P1

Main Document Archive: HA268, HA1076, HA1080, HA2521, HA2523, HA2525, HA2533, HA7047, HA7050, HA7395 and uncatalogued Wind Tunnel records

The National Archives (TNA);-
AIR 2/13059, AIR 2/13267, AIR 2/16522, AIR 2/16533, AIR 19/937, AVIA 6/17937, AVIA 6/19287, AVIA 65/93, AVIA 65/94, AVIA 65/1407, AVIA 65/1769, DEFE 7/2062, DEFE 8/46

All illustrations courtesy of BAE Systems' Heritage Department.

Annex A

‘LIGHTNING’ PROJECTS

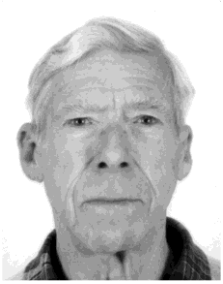
Project Number	Description
P1	Fighter/Transonic Research Aircraft
P1	Day fighter
P1	All weather fighter
P3	P1 development with side intakes
P5	P1 developments with single RA12 engine and 2000K reheat
P6	Aircraft to Spec ER134T
P8	High Altitude Fighter to Spec F155T
P11	P1B Two-seater Trainer Variant to OR318 (Became Lightning T4)
P15	PIB Photo Reconnaissance Version
P18	PIB Low Altitude Bomber Variant
P19	PIB-Interceptor Development with RB133 engines
P23	Installation of Genie on Lightning
P25	Lightning Mk 2 for RAF
P26	Lightning Mk 3 for RAF
P27	Lightning Mk 5 for RAF
P33	Lightning 2 seat strike fighter to Australian OR AIR 34 (Iss. 4)
P34	Lightning Ground Attack Single Seat Aircraft for the RAF

GLOSSARY

ACAS	Assistant Chief of the Air Staff
ADV	Air Defence Variant
AFVG	Anglo-French Variable Geometry
AI	Air Intercept (radar)
AMTI	Airborne Moving Target Indication
AW	Armstrong Whitworth
BAC	British Aircraft Corporation
CA	Controller Aircraft
CAS	Chief of the Air Staff
CFE	Central Fighter Establishment
CORDS	Coherent On Receive Doppler System
CS(A)	Controller of Supplies (Air)
CW	Continuous Wave
DCAS	Deputy Chief of the Air Staff
DDOR	Deputy Director of Operational Requirements
D(RAF)B	Director(Royal Air Force)
DOR	Director(ate) of Operational Requirements
EECo	English Electric Company
EEA	English Electric Aviation
ECM	Electronic Countermeasures
ECCM	Electronic Counter-Countermeasures
GCI	Ground-controlled Intercept
HAC	Hughes Aircraft Company
IRSTS	Infra-red Search and Track Set
ITP	Intention To Proceed
MoA	Ministry of Aviation
MoS	Ministry of Supply
MTI	Moving Target Indication
NASA	National Air & Space Administration
OR	Operational Requirement
PAS	Pilot Attack Sight
prf	Pulse repetition frequency
RAE	Royal Aircraft Establishment
RRE	Royal Radar Establishment
SBAC	Society of British Aircraft Constructors
SNEB	Societe Nouvelle des Etablissements Edgar Brandt
USAF	United States Air Force
VCAS	Vice Chief of the Air Staff
VG	Variable Geometry

LIGHTNING OPERATIONS IN THE KUWAIT AIR FORCE

by Sqn Ldr Clive Brimson



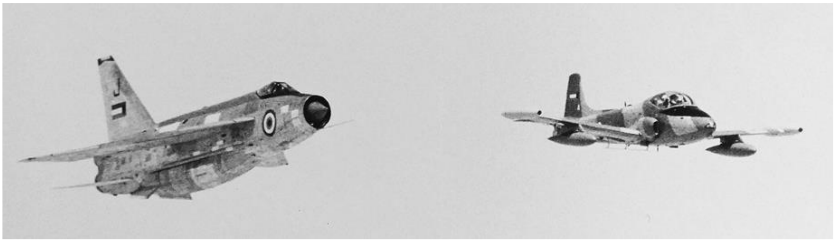
Clive Brimson joined the RAF as a National Serviceman. Commissioned in 1957, he retired as a squadron leader in 1978. In the course of his career he flew 1,200 hours on Lightnings and, as a QFI on type, he was seconded to the Kuwait Air Force to convert its Hunter pilots to Lightnings. After leaving the service, he instructed in Saudi Arabia and at the Oxford Air Training School. In retirement, he is interested in all things horological and is a member of the Antiquarian Horological Society

Background. The Lightning had limited success in export terms with only Saudi Arabia and Kuwait placing orders for an export version in December 1965. The aircraft were modified variants of the F2, the T4, the T5 and the F6 designated as the F52, T54, T55 and F53 respectively.

The year is 1899. Kuwait is known as The Pearl of the Arabian Peninsula and Iraq is sabre-rattling. Kuwait becomes a British Protectorate which prevents any chance of its subjugation.

Fast-forward sixty-two years to June 1961. Kuwait becomes an independent state and Iraq promptly lays claim to the country. Under the terms of a defence treaty, Kuwait requests the strengthening of her defences by the UK and all three services react, the RAF by detaching a squadron of Hunters from Bahrain. (*see Jnl 21*. ***Ed***) Once again, Iraq's intention has been thwarted.

In 1965 the Kuwait Air Force (KAF) expanded with the purchase of eleven more Hunters and an order for twelve BAC167 Strikemasters, the first of the latter being delivered four years later in 1969. In 1966 the KAF had decided to equip with Lightnings and ordered twelve F53s and two T55s. At the Paris Air Show there was a static display of an export Lightning with all of its possible armament options. The contract also included a flight simulator, two RAF Lightning QFIs, a weapons instructor and other support. The first two



A Strikemaster arriving in Kuwait escorted by a KAF F53.

aircraft, an F53 and a T55, were ready for delivery in 1968. They were in-flight refuelled as far as Cyprus and, having received a final top-up, turned south for Jeddah, landing some six and a half hours after take-off. After a night stop, they were flown to Kuwait with a refuelling stop at Riyadh. The KAF's Lightnings were operated from the Kuwait International Airport.

All RAF personnel stationed in Kuwait were administered by an organisation called the Kuwait Liaison Team, although the two QFIs were actually seconded to the KAF with effect from April 1969. Prior to that, two more F53s were ready for delivery and they were flown to Kuwait by the same route. With four aircraft, including a two-seater, now in-theatre and the QFIs in post, the conversion of the Hunter pilots started on 2 May. Unfortunately, by August the rate of unserviceability was greater than the delivery rate of spares. As a result, despite using parts from one of the recent deliveries ('Christmas treeing') it was impossible to sustain a satisfactory degree of training continuity. The conversion programme had to be halted with the pilots returning to the Hunter Squadron. This was the first indication of problems to come.

Conversion flying was not resumed until the following year, but in the meantime the QFIs had been exploring the export version's capabilities in the low-level ground attack role. The ventral gun packs and underwing pylons had been fitted and various weapon options were being exercised on the desert range. The Kuwait Army's Forward Air Controllers were also learning how to cope with the Lightning's performance, and those Hunter pilots that had gone solo were allowed to keep current on type, carrying out medium level practice interceptions. During this period the Lightning was proving to be an exceptional multi-role aircraft.

By the latter part of 1970 the flight simulator and the weapons instructor had arrived. Conversion flights restarted with a dozen or so pilots, but the conversion programme was not going to be easy. The continuing poor serviceability, coupled with an increase in commercial air traffic, made the International Airport less suitable for military operations. By 1973, two new airfields, Ahmad al-Jaber and Ali Al Salem, had been built but their technical infrastructure could not support Lightning operations and were little used by them. It seems incredible that, after five years of Lightning activities, the KAF still preferred to use their Hunters and Strikemasters for the interceptor and strike roles. As a result, they decided to put the Lightnings up for sale and commenced negotiating for a replacement. Only Egypt showed any interest, but that soon faded when it was realised just how costly it would be to get them into operational service. By 1974 contracts had been concluded with Dassault for twenty-seven Mirage F1s and with Douglas for thirty-six A-4 Skyhawks. The Kuwait Air Force continued to operate the Lightning until December 1976 when they were grounded to make way for the Dassault and Douglas aircraft that had begun to arrive.

This brought an end to the activities of Lightnings in Kuwait. At the time there were eleven surviving aircraft. Most were stored externally at the International Airport; some were put on display as gate guardians at Ali Al Salem AFB, at the Technical College and Museum, and three were mounted on stands at Ahmad al-Jaber. Many, however, were subsequently destroyed during the 1990 air raids. Lightning activities in Kuwait had lasted but eight years.

Lightning on a stick - retired KAF F53s at Ahmad al-Jabr.

LIGHTNING OPERATIONS IN THE ROYAL SAUDI AIR FORCE (RSAF)

by Gp Capt Andy Williams

Andy Williams joined the RAF in 1963. His early flying career focused on the Lightning, including a stint in Saudi Arabia, 1972-75, and culminated as OC 5 Sqn 1985-87 and as Station Commander at Coningsby (Tornado F3s) 1992-95. Ground appointments included tours at SHAPE, at Gloucester and at the MOD overseeing the lease of Tornado ADVs to the Italian Air Force. As late as 2000, at the age of 55 (is this a record?), he became a QFI and spent the next nine years as an FTRS flight lieutenant working with prospective fast-jet pilots at No 1 FTS, Linton-on-Ouse.

I think it important to spend a moment looking at what was going on in the region in the 1950s/60s. In 1956 King Saud and President Nasser signed an agreement in which their countries agreed to determine the future of the Yemen. The agreement failed and Egyptian incursions into Saudi airspace continued. In September 1962 there was a coup in the Yemen when the Army seized power and proclaimed the Yemen a republic. King Saud gave aid to the royalist tribes opposing the coup, whilst Egypt supported the newly declared republican regime. The Royal Saudi Air Force's (RSAF) handful of Sabres was unable to counter the threat posed by the more numerous and more capable Egyptian Air Force. The Saudis needed to give their air force some teeth so King Saud and his brother, Crown Prince Faisal, requested the preparation of plans for a thoroughly sophisticated air defence system, including early warning radar, communications equipment, surface-to-air missiles and supersonic interceptors with a strike capability.

In November 1963 the Saudis began to show an interest in the Lightning. In the summer of 1964 a Lightning F2 was flown to Riyadh from Bahrein, where it had been engaged in long-range ferry trials. The Lightning was demonstrated to the Saudis by English Electric's Chief Test Pilot, the late Jimmy Dell. A month after the Riyadh

demonstration a Saudi Arabian mission visited the UK to study the overall defence package that was on offer. The Saudi Chief Test Pilot, Lt Hamdam, a Sabre pilot, went solo in a Lightning F2 following two brief check flights in a T4.

The Magic Carpet

An interim defence package of Lightnings, Hunters and Thunderbird 1 surface-to-air missiles was ordered from the UK. This became known as the Magic Carpet Contract and called for the immediate supply of four single-seat Lightning F52s and a pair of two-seat T54s, all drawn from RAF stocks. Additional aircraft included four Hunter F60s, two T70s, plus a battery of eight launchers and 37 redundant Thunderbird 1s. British pilots and maintenance personnel were hired to operate this equipment and several Saudi pilots were sent to the UK for training at Lightning and Hunter OCUs. Meanwhile Khamis Mushayt airfield, close to the Yemen border, was rebuilt to serve as a forward operating base for the aircraft ordered from the UK.

The Lightnings were refurbished and flown to Riyadh during May and June 1966. One F52 crashed shortly after arrival, but it was replaced by a Lightning from Boscombe Down. The Hunters also reached Riyadh in May and were immediately deployed to Khamis Mushayt to form 6 Squadron. Later, Lightnings joined them. Both the Hunter and the Lightning responded to infrequent incursions into Saudi airspace for the next 12 months. In June 1967 the Six-Day War broke out between Egypt and Israel. No Saudi aircraft were involved in this conflict and, later that year, Saudi and Egyptian forces agreed to disengage themselves from the civil war in the Yemen.

Finally, Saudi Arabia decided to acquire a comprehensive air defence system. It was to be an Anglo-US package comprising the BAC167 Strikemaster, Hawk surface-to-air missiles and an advanced version of the Lightning, coupling intercept with ground attack, with technical training and support being provided by Airwork Services. The companies formed the Saudi Arabian Air Defence Consortium. The fighter component of the package comprised thirty-four Lightning F53s with six two-seat T55s for conversion training. A new Type 40 surveillance and tactical radar, and fighter controllers, provided data for the Lightnings.

F6	F53
Radar AI 23B/C	Radar AI 23S
E/F band homer	—
Max Speed 2.0M/650kts	2.0M/700kts
Height 60,000ft	75,000ft
Arrestor Hook	—
—	Improved air conditioning*
—	Improved engine performance*

* Also applicable to T55

Table 1. The F6 and F53 – compare and contrast.

At this stage I should perhaps make the point that, while the RAF's F6 was a pure interceptor, the broadly similar Saudi F53 had additional ground attack and recce capabilities. The major differences are summarised at Table 1.

The first Saudi Lightning T55, a converted ex-RAF aircraft, was destroyed in a landing accident at Warton in March 1967 and the next four aircraft went to RAF Coltishall, the first arriving in February 1968, to train Saudi pilots. These four T55s were eventually ferried to the Lightning Conversion Unit at Dhahran in August 1969 and the fifth was delivered a year later.

The first Lightning F53s were delivered to Riyadh in December 1967, but had to be placed in storage due to a lack of facilities to operate the aircraft. Only thirty-three F53s were actually delivered as one had crashed in September 1968 and was never replaced. The aircraft were refuelled by Victor tankers and routed from Warton, via Akrotiri, over Turkey, Iran and down the Persian Gulf to Saudi Arabia. The first two aircraft were delivered to the Lightning Conversion Unit (LCU) at Dhahran in December 1969 and their low-level supersonic run over the airfield and the nearby town of Al Khobar caused a stir amongst the locals, who believed the sonic boom was a manifestation from Allah. The flight refuelling probes were removed and returned to Warton as the Saudis had no requirement for in-flight refuelling.

The LCU began operations in May 1969 with two RAF QFIs flying one or two sorties per day. All aircraft were initially allotted to the LCU. As more aircraft arrived, the sortie rate was increased to

Above, an RSAF Lightning, with underwing SNEB pods, loosing off 2" RPs from the integral rocket pack and, below, an RSAF Lightning bomber. (Hedley Molland)

between 6 and 8 sorties per day. However, training came to a halt when a number of high-ranking officers attempted a coup intended to overthrow the King. The coup was thwarted even before it started, but no flying took place for some six weeks while investigations were

carried out. Some RSAF officers disappeared, never to be seen again. Flying was eventually resumed in September, but there were further delays because of Ramadan. Once the curriculum had stabilised, the LCU conversion and basic radar syllabi were near copies of those used at Coltishall. However, while there was no ECM training, ground attack (GA) was included. The GA attack patterns were similar to those taught within the RAF.

Meanwhile, hostilities with the Yemen had resumed in November 1969. Later that month, the order came for the Lightnings and Sabres to be detached to Khamis as threats had been made against the airfield. Lightning ground crews worked long hours preparing for operations, removing the forward part of the ventral tank and replacing this with the 30mm Aden cannon and the air-to-air missile pack with the 2" rocket pack. Reconnaissance packs were fitted on two aircraft. A few familiarisation flights were conducted before the aircraft were flown the 800 miles from Dhahran to Khamis via Riyadh.

The first offensive sorties against Yemeni strongholds and troop concentrations commenced in December 1969 and this led to the formation of the first operational Saudi Lightning unit, No 2 Squadron. Some of the aircraft were flown by British pilots on contract with Airwork, but the bulk of the operational sorties were flown by Saudis. In January 1970 this conflict came to an end and peace was declared between King Faisal and the President of the Yemen. The Sabres returned to Dhahran but the Lightnings remained at Khamis to hold QRA duties. In the spring of 1970, the Saudis lost two Lightnings, an F53 just across the Yemen border when a jet pipe fire forced the pilot to eject and an F52 lost near Khamis. By July 1970 all Lightning F53s had returned to Dhahran. By the end of the year some stability with Lightning operations had been established. No 2 Squadron had been assigned ten F53s whilst the LCU had six T55s and five F53s. Lightning activity continued at a respectable pace flying up to 25 sorties per day.

I arrived at Dhahran in October 1972, towards the end of the Airwork contract. BAC was awarded the new contract in the autumn of 1973 and addressed the high turnover of the workforce by negotiating the building of a company compound with living quarters and recreational facilities. Moreover, the family unit was encouraged to go and live in Saudi. My time came to an end in October 1975 but,

A pair of ex-RSAF F53s, now in British markings, departing Saudi Arabia for the ferry home to the UK. (Hedley Molland)

as fate would have it, I would find myself back in the Kingdom ten years later, albeit only briefly.

By the mid-1980s, the Saudis had started a re-equipment programme, with the Lightning being replaced by the Tornado ADV and IDS. This programme, the Al-Yamamah arms deal, was paid for with Saudi oil. As OC 5 Sqn at the time, I was tasked with leading the recovery of twenty-two Lightnings from Tabuk. In the first of two waves we brought back twelve and a few days later we recovered the final ten. Clearly, we could not overfly Israel, so the recovery route took us southwest from Tabuk, south of Sinai and west towards Egypt to coast-out over the Mediterranean at Alexandria. The 3,000-mile non-stop flight took approximately 8 hours and required eight refuelling brackets from VC10s and Victors. A notable aspect of this exercise was that all twenty-two Lightnings were fully serviceable and carried no ‘acceptable deferred defects’ – the only reported snag on arrival at Warton was a single TACAN failure.

Many years after the Saudi Lightning contract, Sir Frederick (Freddie) Page summed up his final assessment of the Lightning project as follows: ‘The great thing is that the project was so successful in spite of all the obstacles, and BAE is today still earning money from the Tornado Al Yamamah project as a direct fall-out from BAC's presence in Saudi Arabia due to the Lightning and other associated contacts’ and, of course, that continues today with the Typhoon.

LIGHTNINGS IN RAF GERMANY

by Air Cdre Rick Peacock-Edwards

Rick Peacock-Edwards joined the RAF in 1965. He flew the Lightning, the Gnat, the Phantom and, as OC No 229 OCU, the Tornado F3. Air staff appointments were concerned with flying training and air defence. By 1990 he was OC RAF Leeming but spent several months at Dharan in the run-up to Gulf War I. More senior posts included those of Assistant Air Attaché in Washington, Inspector of Flight Safety and, finally, as Director of the Eurofighter Typhoon project at the MOD. Since 1999, his post-RAF career has involved General Dynamics, Vector and In Command Ltd and association with many aviation-related organisations and institutions, not least the RAF Club where he has been Vice-Chairman since 2011.

Background

The Lightning operated from Germany between 1965 and 1976 before being replaced by the Harrier. In 1965 No 19 Sqn moved from RAF Leconfield to RAF Gütersloh and No 92 Sqn moved to Geilenkirchen before a further move to Gütersloh in January 1968. Both squadrons were equipped with the Lightning F2. The F2s were upgraded to F2A in the late 1960s. In February 1968, I was the first pilot, and a first-tourist, to join 92 Squadron after the move to Gütersloh

Gütersloh

Gütersloh was the closest RAF base to the East/West border. It had been built by the *Luftwaffe* in 1935; captured by the Americans in 1945, it was handed over to the RAF later that year. Gütersloh is famous for 'Goering's Room' in the Officers Mess. The story goes that Goering used to hold court in this room and would say, 'If I am lying, then let the beam above me collapse'. A young officer had rigged up a beam to seemingly collapse when a button was pressed. The rest is history, but the room and the collapsing beam still exist.

When I was at Gütersloh it was indeed an impressive place and you needed no reminder of history, nor of how close you were to the other

A 92 Squadron F2, XN769. (92 Sqn Association)

side. The Cold War was very real. It was the home of two Lightning squadrons, two Hunter fighter reconnaissance squadrons (Nos 2 and 4 Sqns), a helicopter squadron (No 18 Sqn) equipped with the Wessex, an RAF Regiment squadron and, for many years, a Bloodhound missile battery.

The weather was usually hot in summer, but the winters were cold and very grey. The weather, perhaps even more so than back in the UK, provided challenges but it also helped sharpen our skills. Gütersloh and Germany were the perfect training environment for a first-tour Lightning pilot.

The Germany Lightnings

Initially, Nos 19 and 92 Sqns were equipped with the Lightning F2 which was very similar to the Lightning F1A but with some minor improvements. Fitted with Avon 210 engines and AI 23 radar, and armed with a pair of Firestreak missiles and two integral guns, avionics included the OR 946 avionic display, a pilot attack sight and offset TACAN. There was also the capability to carry four guns, but at the expense of the missiles. The biggest drawback of the F2 was the lack of fuel, which meant that sorties were short, especially if supersonic. The F2s were replaced by the F2A in the late 1960s but each squadron retained two F2s in addition to the F2As.

The F2A was a significant improvement. Similar to the F6 in appearance, it had the big ventral tank, squared-off fin, kinked leading edge wings and Avon 211 engines. The average subsonic sortie time

improved from 40/50 minutes to an hour and fifteen minutes or more and sorties of over two hours duration were not uncommon. The big effect of the additional fuel was transferred into the operational capability and use. Of note, unlike the F6 where the guns could be carried in the forward section of the ventral tank, the F2A retained the original arrangement with the guns installed integrally in the upper nose, allowing the whole tank to simply carry fuel.

Operations

The main task of the Lightning in Germany was the policing/air defence of the British sector of Germany under the control of Second Allied Tactical Air Force (2ATAF) with its headquarters at Rheindahlen near München Gladbach. At Gütersloh two Lightnings were kept at 5-minutes readiness, 24 hours per day, 365 days each year on 'Battle Flight'. Scrambles were very frequent, and you were certainly kept on your toes. No-notice operational scrambles at any time of the day or night were common. With fighters of the other side based little more than 50 miles away there was a fair amount of testing reaction. We would be scrambled towards the border because Warsaw Pact aircraft had been detected heading our way. We were always airborne very quickly and well within the 5-minute readiness. We might reach the border and, indeed, a kink in the border might have been breached by the other side for a few seconds and we would end up each patrolling the border on our separate sides. However, probably the majority of scrambles were the result of light aircraft either being lost or entering the buffer zone, a sanitised area to protect aircraft from straying over to the other side. The intercepts that followed were invariably interesting because the light aircraft would be flying at around 100 knots and our *minimum* speed was closer to 180 knots. However, when a light aircraft sees a large armed fighter pass close by, they get the message and we used to get their tail number. They knew they were in trouble.

In the context of these scrambles it is worth mentioning the 'brass monkey' call, which was broadcast on the emergency frequency, on which all pilots had to listen out, if/when an allied aeroplane was seen to be at risk of infringing the border. The call was an executive order requiring all aircraft to turn onto a westerly heading and establish their position. We were scrambled for other activities as well, but the above

No 92 Sqn's F2As on the flight line. (92 Sqn Association)

examples were the bread and butter.

Exercises were pretty frequent – NATO exercises, 2ATAF exercises, national exercises and station exercises. Two o'clock in the morning always seemed to be the favoured time. Some events simply required the generation of as many aircraft as possible, against the clock; others were integrated war exercises progressing from a period of tension via a conventional phase to nuclear war – and there was always the prospect of a TACEVAL. For all these reasons, we were always at a high state of alert. There was another special exercise for which we also trained – the policing of the air corridors to Berlin. If the Russians were ever to close them, the plan was to send a military transport to Berlin, accompanied by a fighter escort. Remember that these corridors were the only way to connect with West Berlin by air. More about that later but, suffice to say that this was a UK/US/France joint commitment and we would have an annual exercise, normally held near the border at Fassberg, where we would practice our tripartite procedures. A UK squadron would normally join us for these events – No 5 Sqn as I recall – and it was yet another fine opportunity for international bonding. The Germans were not allowed to police the border.

Turning to day-to-day training, we flew day and night and certainly in my days at Gütersloh we often didn't finish until 3 or 4 in the morning. Compare that to these days! In the early days in Germany, as I recall, most of our training involved interceptions carried out mainly in the middle or upper airspace, subsonic and supersonic, high-fliers and ECM training. However, as the F2A came on-line, by the end of the 1960s more and more training was carried out at lower levels.

Very effective low level search patterns, manned by a number of Lightnings, were introduced and the training became much more exciting. All of the previous training remained a part of the syllabus. Of special note a 'Dial-a-Lightning' system was introduced whereby other aircraft operating in our area could announce their availability for intercept. This was a very popular and useful training medium.

Supersonic training used to take place over land above 36,000 feet and supersonic bangs were commonplace at Gütersloh. Another useful training vehicle was known as Exercise FREELANCE. If ,on a training sortie, you were left as the only aircraft you could declare yourself to the Ground Controlled Intercept (GCI) Station as available for Exercise FREELANCE. Intercepts were various, but airliners were often on the receiving end.

Also, in the late 1960s air-to-air combat training (ACT) and air-to-air refuelling were introduced, another important increase in the overall capability of the Germany-based Lightning squadrons.

Finally, working with other NATO nations, from all sectors, was a very important part of our operational training. This included dissimilar air combat training (DACT), at all heights, with the opposition being provided by a variety of units – it was all very relevant.

Recovery to Gütersloh at the end of a sortie was always a rapid event with the fuel gauge becoming a major part of any instrument scan. If recovering from height this was done through the traditional Lightning dive arc where we would often find others in wait for us. The area around the dive arc became known as MiG Alley.

With regard to weapon training, missiles were fired at Missile Practice Camp detachments to RAF Valley in North Wales or direct from a Battle Flight scramble. In the early days, the guns used to be fired once every so often into the sea off the Dutch coast; the aircraft would shake and you sometimes found yourself with a radio or instrument failure as a result of the vibration. Eventually, Armament Practice Camps were introduced and aircraft were detached for this purpose to Decimomannu.

Finally, although hardened aircraft shelters (HAS) were not available during my time at Gütersloh, they were built in the mid-1970s and the Germany Lightnings were, as far as I am aware, the only RAF Lightnings to have carried out some operations from a HAS

environment.

Memories

I thought that I would conclude my talk with a few more personal reminiscences.

- **Camaraderie.** This, quite frankly, is one of the most important of my memories. The squadron had twelve aircraft and fifteen pilots. We worked together; we socialised together; we were a 'band of brothers'. The bonds that were built at Gütersloh were very special and those of us still living remain in good contact. All I can say is that it was quite a shock, years later, when I went, as an executive, to my first Phantom squadron, No 111 Sqn, where we had 44 aircrew. I know which I preferred.
- **Squadron Exchanges.** This actually goes with my comments on camaraderie, but what a wonderful experience it was to meet so many fine people from other air forces and to operate and socialise together.
- **Battle Flight**. I will never forget the Russian invasion of Czechoslovakia in 1968 when I was on Battle Flight. The Russians closed the Berlin corridors and we were immediately brought to readiness to react. In fact, the two aircraft on Battle Flight rapidly became ten and we were ready to escort transport probes down the corridors to Berlin – exciting stuff for a young 23-year-old. Fortunately, however, with hindsight, the politicians won the day. Who knows what might have happened had that not been the case?
- **Bolthole to the 'Clutch'.** In 1970, Gütersloh's runway was resurfaced and the squadrons deployed to RAF Brüggen and RAF Wildenrath; in the case of No 92 Sqn we went to Brüggen. After a very pleasant four-month detachment we finally returned to Gütersloh – or so we thought. We departed Brüggen in style, as a nine-ship formation, and made ourselves known, both on departure from Brüggen and arrival at Gütersloh. I recall that I was Number 7 in the formation and I burst a tyre on landing. The aircraft behind me were

A 92 Squadron nine-ship. (92 Sqn Association)

immediately diverted to our crash diversion, the *Luftwaffe* base at Hopsten. The Boss was in the process of giving me a king-size bollocking for my burst tyre when the SEngO came up and said that every tyre in the formation was shredded. In short, the landing had felt like a landing on sandpaper and it transpired that the co-efficient of friction for the runway was all wrong. We then spent a week at Gütersloh, mainly in the bar, whilst the engineering contractors worked on the runway. We then flew another nine-ship to test the runway – more burst tyres, so we were redeployed to Wildenrath for another month whilst the runway was finally sorted. It was all very exciting to me, a young, bachelor, fairly wild colonial boy with no family commitments. I am not so sure that was the case for those who were married.

I could go on. I have so many happy memories of my time flying Lightnings in Germany. I recognise that I will not have covered all eventualities, and that my presentation is perhaps more related to my own time, but I hope that my memories will satisfy most. Thank you for listening to what to me is a great memory.

LIGHTNINGS OVER CYPRUS

by Gp Capt Geoff Brindle and Wg Cdr John Ward

Geoff Brindle joined the RAF in 1964. Following tours on the Lightning with Nos 23, 56 and 11 Sqns, interspersed with stints at HQ 11 Gp, HQSTC and Staff College in India, he switched to the Phantom in 1980 and commanded Nos 56 and 23 Sqns. He later *commanded RAF Mount Pleasant and RAF Wildenrath* (1989-92) *while fitting in ground tours at HQSTC (twice), Ramstein and Oman (twice). An experienced display pilot and manager, he has worked with RIAT, Duxford and other locations at home and abroad, including Malta and Australia.*

Having gained his 'wings' in 1964, John Ward became the first first-tourist to fly the Lightning. He flew with Nos 56 and 5 Sqns, and with the Interceptor Weapons School at Coltishall. Following a tour with the UK TACEVAL Team, a USAF exchange and a stint at HQSTC, by 1984 he was OC Ops Wg at Coningsby. After an air staff job at the MOD and a tour with the DS at Bracknell, in 1989 he moved to Saudi Arabia to join the Al Yamamah project. In 1993 he left the RAF for BAe, remaining in the Kingdom until retirement in 2003.

Introduction – Gp Capt Brindle

To understand why such a formidable air defence capability was operating from a small island in the Mediterranean between 1957 and 1975, we must first turn to the political considerations. In the RAFHS Journal No 38 there is a very informative and in-depth review of the RAF's post-war posture in the Eastern Mediterranean; hence I give only a brief résumé here.

After the Suez debacle in 1956, Britain needed a base in the Eastern Mediterranean to secure its many responsibilities in the Middle East and the Arabian (Persian) Gulf. Cyprus, initially Nicosia and later the Sovereign Base Areas (SBA), Akrotiri, Episkopi and Dhekelia were ideal. Indeed, to provide some idea of the political

mindset of these times I can do no better that quote the then Prime Minister, Anthony Eden, on a visit to Norwich in 1956:

> 'No Cyprus, no certain facilities to protect our supply of oil. No oil, unemployment and hunger in Britain. It is as simple as that!'[1]

That statement is certainly a gross oversimplification but, as late as 2012, the Secretary of State for Defence, Philip Hammond, when informing the House of Commons of the findings of a report on the SBA military bases, following a review of their operations by Lord 'Paddy' Ashcroft, stated that:

> 'The Sovereign Base areas are in a region of geo-political importance and high priority for the United Kingdom's long-term national security interests. […] Our military personnel, United Kingdom civilians and locally employed personnel in the sovereign base areas make a major contribution to the national security of the United Kingdom and will continue to do so in the future.'[2]

Not much has changed over that 50-year period or indeed since. But, to return to the mid-1950s and provide some detailed background, RAF Akrotiri was constructed in the mid-1950s to relieve pressure on RAF Nicosia. It was used to base detachments of fighter, photo reconnaissance and ground attack aircraft – Meteor night fighters, Canberras and Venoms, reinforced by further Canberras and Hunters during the Suez Crisis. After Suez it was clear that it was not practical for a command centred in Cyprus to control units in the Arabian Peninsula so Middle East Command was split, with Aden controlling units east of Suez and Cyprus, specifically Akrotiri, becoming the core element of the Near East Air Force. At this time the Soviet Union was building up forces in the eastern Mediterranean and measures, both political and military, were needed to defend NATO's southern flank.

The initial framework was provided by the Baghdad Pact until 1959 when, following Iraq's withdrawal, it was replaced by the Central Treaty Organisation (CENTO). The new base at Akrotiri was critical to supporting these political developments. Nuclear-capable strike forces, first Canberras and later two squadrons of Vulcans, were

'Now thrive the armourers' – preparing a Firestreak.

deployed there and there was an obvious need for an air defence capability. To bolster and exercise the existing static air defences, UK-based fighter squadrons were regularly deployed to Cyprus in the early 1960s starting with Hunters from No 43 Sqn and in 1964 29 Squadron's Javelins became the resident fighter force. With the retirement of the Javelins in 1967 the local air defence capability was much enhanced by their replacement with No 56 Sqn and its Lightning Mk 3s. Wing Commander John Ward, who was on the squadron at that time, takes up the story of the subsequent operational build-up, which became especially critical during the crisis in June 1967 when The Six Day War erupted.

Deployment and Early Operations – Wg Cdr Ward

In fact, the very first Lightnings to reach Akrotiri were from No 56 Sqn – two jets with Valiant tankers in July 1962. Indeed, John Mitchell, who we heard from earlier, was one of the pilots. They stayed just a few days but thereafter there were almost continuous assorted detachments by the UK-based squadrons.

Early in 1964, No 56 Sqn was there with nine aircraft when trouble flared between the Greek and Turkish communities, and for a while they were required to keep two armed-aircraft at two minutes readiness.

These continuous Lightning squadron detachments provided the necessary presence for the next few years, but with most of No 29

Seeing-off a Turkish F-84 over Cyprus.

Sqn's aircraft in Zambia and the rundown of the Javelin force, No 56 Sqn became the resident squadron, moving from Wattisham in May of 1967. No 56 Sqn had started the upgrade to Red Top back at Wattisham but at Akrotiri it quickly became apparent that the infrastructure was not in place to support it, and for the first six months we reverted to Firestreak. A major building programme was begun, to provide new squadron offices, a hangar and workshops and accommodation for the flight simulator.

But the move generated other issues too; in view of the threat, UKADR rules and procedures were not relevant, so with magnificent support from Barry Holmes, the HQ NEAF staff officer, and the radar controllers at Cape Gata,[3] we began to draft more locally appropriate rules, procedures and tactics – air combat minimum came down from 20,000 ft to 7,000, low-levels down to 250 ft, with evasion, and we devised Silent Scrambles – and a training syllabus to match.

But, just a month after arriving, the Arab/Israeli war led NEAF to order increased alert states; for a time, we had four armed jets at 5 minutes readiness. And that summer of '67 generated plenty of scrambles too – for example, Soviet An-12 Cubs taking resupplies to the routed Egyptian military. Flying directly across the island, they each had a Lightning escort.

Later in the year, the tension between Greece and Turkey led to a big increase in the number of scrambles, particularly against their fighter-recce jets – we intercepted many F-84s and RF-84s. Essentially, we scrambled against every unknown track in our patch; we took our job of defending the strike assets very seriously. Such was the tension in November of 1967, that the UK deployed three Shackletons to Akrotiri – each night one of them would patrol off the north coast, all night long, watching for movement from the invasion barges in the Turkish ports. I am convinced that we helped to calm the

A Soviet Tu-16 being escorted by a Lightning.

situation, albeit if only to defer it. That response in 1967 contrasted so vividly with the pathetic reaction of the Wilson government in 1974.

Those first six months at Akrotiri showed a significantly higher than expected engine defect rate so, in January 1968, Dennis Witham, the Rolls-Royce test pilot was sent out to investigate. I flew him in the T5 on a night low-level intercept sortie, when he saw at first-hand the engine handling problem at 600 kts; the result was the introduction of intake swirl vanes.

A classic illustration of the issues that plagued us with the F3 in Cyprus occurred on Bank Holiday Monday of May 1969. I was sitting Battle Flight with Roy Somerville when he was scrambled against an unknown track to the south-west. Roy's target was a high-level Tu-16 Badger, and I sat in the Ops Room listening to a running commentary over the telebrief line from the Gata ConEx.[1] Suddenly, he shouted, 'John, there's another one, Scramble!' I ran to the jet, hit the starters and raced off to the south-west. Very quickly I found the target; another Tu-16, very low, moving fast and as I sat alongside him, I realised that we were pointing directly at Akrotiri – I could see the RAF Hospital on the Cape quite clearly. I thought he was going to fly

[1] 'ConEx' – Control Executive.

right over the base, but he made a small right turn to fly along the cliffs, a couple of miles or so to the south. The Gata controller shouted his next instruction: 'John, you are to order him to land!' The Tu-16 started to turn south as I tried everything – hand signals, wing-waggling, turning directly in front of him – to make him comply, but he just flew on, very low and fast, and lack of fuel eventually forced me to give up. I was full of adrenalin but gutted at being asked to do a job with only half the tools required. I did find some solace a year later in the UK when I took XR726, the very first squadron F6 fitted with a gun pack, on its gun proving air test.

Back now to Geoff to cover the run-down.

Sustained Operations and Run-down – Gp Capt Brindle

As John has explained there was a big adjustment to be made when transferring Lightning operations from the UK Air ORBAT to Cyprus. Not just in the operational mechanisms and intercept procedures but also in our approach to, and planning of, the flying task. Compared to the UK, there was greater freedom of operational movement – uncluttered airspace, better weather and almost full manning – the latter point being possibly the most telling. We were still required to meet NATO standards with respect to flying hours and operational statistics but the very tangible benefits of being at Akrotiri instead of Wattisham or Binbrook – the greatly reduced transit time to the play areas, ample airspace, good weather for combat flying and the more tactical profiles – also brought their problems.

To take a simple example – sortie lengths were much shorter, because we could commence the exercise virtually straight from take-off, which meant higher fuel consumption leading to more landings and turn-rounds. We noted increased wheel, tyre and brake usage, higher fatigue consumption and some unintentional overstresses. These all led to more un-serviceabilities and, inevitably, more fuel leaks leading to problems with aircraft availability because of the ongoing requirement to maintain two fully-armed aircraft at 10-minutes readiness – and we had to protect a spare in case of problems. These factors combined to put a great deal of pressure on the engineers. Not surprisingly the squadron was hard-pressed to reach the flying hours targets and extending the working day did nothing to assist in the post-flying recovery of aircraft. After 2-3 years in theatre

we also suffered a marked turn-over in manpower as the inevitable result of many of the original team becoming ‘tourex’ at much the same time. Additionally, we were at the end of a long logistics trail and the response to urgent demands for spares depended upon how quickly the UK supply system could get the items to the airhead and onto a scheduled trooper. It must have been equally difficult for the Singapore-based No 74 Sqn to manage during this period, although they did have the slight advantage of the greater fuel capacity of the Mk 6 aircraft.

All too often, the immediate solution to a problem was to rob an unserviceable aircraft to get another one airworthy, but when robbing became the norm it simply doubled the manhours bill for every item. AOGs became commonplace and the temptation to fly every aircraft, including those with red ink entries in the F700, had to be resisted for fear of digging a bigger hole . . .

Many in this audience will remember the ‘fire integrity programme.’ I can’t recall whether the modifications were embodied locally – but I do remember that it involved a significant down time on aircraft while the work was being done. However, one notable element of the story was the research done into the internal temperatures in the aircraft. Given that 56 Squadron regularly operated with ASP temperatures in excess of 35ºC, we were tasked with a trial involving aircraft being fitted with recording devices and certain internal areas coated with temperature-sensitive paint, its discolouration providing an indication of the temperatures being reached in the engine bays. The anecdotal answer was ‘very hot’ – in fact, not much different from the temperatures *inside* the engines! – hence the short life of some of the adjacent hydraulic and fuel pipe seals. A combination of seals made from new materials and greater ventilation of the engine bays, with enhanced fuel draining capacity, were the basis of a very effective preventative modification.

The high temperatures did not affect the aircraft handling greatly, although care had to be taken when advancing the throttles at taxing speed or an overswing on the TGT (Turbine Gas Temperature) was very likely. The greatest care was needed with the brakes and tyres. After landing, G Dispersal was a long 2-mile drive back along the parallel taxiway and it was not uncommon for the fusible plugs in the high pressure tyres (340 psi) to blow. However, heat soakage on the

The Vulcan could be a tricky target at high level. .

ground was a problem with some equipment reaching their max operating temperatures even before they were switched on. We tried using the ground cooling trolleys, but they were somewhat unreliable and very unwieldy to handle. We resorted to white-painted spines to keep the Avpin tanks cool and simple cockpit covers to help keep internal temperatures down

General handling in the air was uneventful and there was no great loss of performance at sea level and, given the high tropopause, often 45,000 ft or so at minus 70ºC, chasing down fast or high-flying targets was no problem. It was possible to exceed the aircraft's nominal ceiling of 56,000 ft quite easily. However, against a target fitted with an RWR you had to leave locking-on the radar almost until you pressed the trigger, otherwise the target would use infrared decoys and/or, in the case of the Vulcan, execute a 60º banked turn which, at 50,000 ft, was very hard to follow with an aircraft armed solely with Firestreak. The Red Top had a better seeker head with a greater angle-off limit but, even so, it was impossible to match the Vulcan's rate of turn. Given the volatile political atmosphere that pervaded the area at this time, a high rate of Battle Flight (QRA) intercepts was maintained against Egyptian, Israeli and US aircraft; especially the US Navy. The acquisition of the ex-74 Sqn Mk 6s in September 1971 was most welcome as it enabled us to prosecute interceptions much earlier and much further away.

Given a full complement of aircraft and a resident target facilities

In 1971, No 56 Sqn acquired No 74 Sqn's F6s. The white panel on the spine was an attempt to reflect some of the sun's heat from an equipment bay.

flight, the future seemed assured and just when it seemed that all was settling down, we became aware of the effect of the serious economic problems and crises in the UK during the early 1970s. There followed, in 1974, the inevitable Defence Review and, in accordance with its recommendations, the UK opted for military disengagement from CENTO. (CENTO actually continued until 1979 when it was dissolved after the Iranian revolution.) But any arguments for the RAF remaining in Cyprus were not helped when on the morning of 15 July 1974, the Greek *junta*, through its officers commanding the Greek Cypriot National Guard, launched a *coup d'etat* against the Makarios government. This led to the Turkish intervention and in 1975 all permanent fixed wing assets were withdrawn from Akrotiri.

No 56 Sqn's Lightnings returned to Wattisham and the squadron prepared for the changeover to the Phantom. But the squadron's involvement with Cyprus did not end there. In 1983, as Boss of No 56 Sqn, I led Firebirds Phantoms from Akrotiri flying over Lebanon in support of BRITFORLEB – but that's another story!

Notes:

1 Conservative Party Convention, Norwich, 11 June 1956.

2 *Hansard, Written Ministerial Statements, 15 December 2011, cols 114-115WS.*

3 No 280 Signals Unit was a Convoy Radar Unit that operated, initially under canvas, from Cape Gata from 1956 until 1972 when it relocated to Akrotiri. In 1982 a long-standing detachment on Mount Troodos became the unit's home station; it currently operates as Golf Section, MOD Joint Services Signals Unit, Troodos. (**Ed)**

LIGHTNING OPS IN THE FAR EAST

by Air Cdre Dennis Caldwell

Dennis Caldwell joined the RAF as a National Serviceman in 1951. His early flying experience embraced Vampires, Sabres and Hunters and a USAF exchange on F-100s before getting to grips with the Lightning on No 19 Sqn in Germany and as OC 74 Sqn at Tengah. He was Station Commander at Lossiemouth (Jaguars and Hunters) 1978-80. Senior ground appointments were as the Air Adviser, Ottawa and as Air Commodore Air Defence at High Wycombe. He left the service in 1985 to join General Dynamics.

I should point out that I will not be pointing out the unique capabilities of the Lightning, but concentrating on the differences that were most important to understand in operating from Tengah in 1969-71. First, there was no threat to the area, thus no QRA. In this context our aircraft remained in silver trim, rather than being camouflaged. Second, we were part of a multinational air force, epitomised by the air staff at Changi. The Air Commander was a Brit, Sir Neil Wheeler; his AOC was an Australian air vice-marshal and the Gp Capt Ops was a New Zealander. This was further reflected by RAF squadrons at Tengah and Changi, a New Zealand Canberra squadron at Tengah and an RAAF Mirage wing at Butterworth.

No 74 Sqn had great rapport with the Mirages, with frequent exchanges of 4-6 aircraft going in each direction and air combat sorties generating the usual banter in the debriefs. Wg Cdr Tex Watson was conducting one such debrief and at the end he asked whether there were any questions. One of my young gentlemen, Mike Rigg, asked, ‘Sir, could you tell us the secret of how you keep us bottled up in your six o’clock?!’

The next major difference was the international scope of our deployments. Just after I took over in March 1969, we were told that we would be deploying to RAAF Darwin in northern Australia as part of a major air defence exercise – Exercise TOWN HOUSE. It included Victor tankers – obviously – a Vulcan squadron, and a

XR764 on finals at Tengah.

number of RAAF Mirage and Canberra squadrons. As I climbed out at Darwin after a 4½-hour flight with four Lightnings, I was met by Australian Customs. They confiscated our water and bite-sized sandwiches and then asked when I had last worked in an abattoir? – not, you should understand, that I have *ever* worked in an abattoir! It was a major exercise and lasted ten days.

Back to Darwin in September 1969 and then a display at Bangkok in October 1970. In 1971 it was the 50th Anniversary of the RAAF and on 11 April 1971, I took four aircraft, via Darwin, to Edinburgh Field, just north of Adelaide, to participate in the celebrations. It was a big event and we were there for ten days during which Peter Carter took the four, with tanker support, to the Melbourne area. In September 1971 the Tigers withdrew from the Far East. Two Lightnings per day via Gan in the Maldives and then direct to Cyprus, a flight of some 9 hours, 4,000 miles and seven refuellings. I got agreement to cut-out a stop at Bahrein on the basis that the best way to keep the Lightnings serviceable was to keep them in the air.

Our place at Tengah was taken by 2-4 Mirages while the Republic of Singapore Air Force (RSAF) was building-up and this brings me to my final anecdote. There was a store in Tengah village called ‘Heckle and Jeckle’ after the two Walt Disney crows; the store could make you a shirt in a day; a suit in two. I went back to Tengah in 1974 and – remember those Australian Mirages? – the ‘Heckle and Jeckle’ sign had been replaced by ‘The Fair Dinkum Emporium’. Now that is enterprise!

SECOND DISCUSSION PERIOD

Anthony Stevens. Was any attempt made to intercept supersonic targets and, if so, what sort of success was achieved?

AVM George Black. When the Concorde was doing its trails, we – Wattisham – were allowed to do a couple of head-on intercepts, not least to check the capability of the Red Top missile. The Concorde ran down the North Sea to allow the east coast radars and SAM sites to track it as well. As I recall, it was quite successful but, that said, it did come down the tube at one helluvaspeed so there was only just time for the missile to confirm a lock before the target passed overhead.

Ian Black. Supersonic intercepts were still part of the training syllabus at the end of the 1980s – of course they required careful setting up and, from memory, we didn't do them on the LTF, only the operational squadrons. Normally planned to tie in with a tanker sortie, the co-ordination with GCI was paramount. Leaving the tanker, GCI would set us up probably 100 miles apart and crucially, thinking ahead, on a final intercept heading of roughly South – or more importantly towards Binbrook! With fighter and target both doing Mach 1·6 things happened very quickly on the radar. If you had a pick-up at 25-20 miles and 32 miles-a-minute closure, the attack would be over in seconds. Trying to take out any altitude difference, as well as putting yourself on the correct intercept geometry, was tough. From memory, once locked-on you could squeeze the trigger and the Red Top would only launch once in range – it was then a case of carrying out a breakaway manoeuvre which again required a degree of skill at night or in cloud. In summary it was one of the harder intercept profiles we undertook – with a missile that was built and conceived in the 1960s.

Gp Capt Dave Roome. We used to do quite a lot of interceptions against supersonic targets, indeed, the Annual Training Syllabus required a certain number to be conducted against targets in the speed range approaching 1·6M and again at speeds *in excess of* 1·6M. A proportion of these had to be a stern hemisphere intercept and some were front hemisphere engagements. A stern attack on a target faster than 1·6M was quite demanding as, if you got the entry point into the final turn wrong, you may well finish up with a tail chase and have to

throw the intercept away for lack of fuel. Of course, front hemisphere attacks against a target going at better than 1·6M were much easier because the Red Top attack profile would only require a speed of about 0·95M. I do, however, particularly remember one intercept with me as a Mach 2 target against Dave Carden (on his last trip on 74 Sqn) flying a fighter speed also of 2·0M. I locked on to him and the blip came down the scope very quickly indeed!

Gp Capt Andy Williams. I recall we were talking about attacking supersonic targets head-on using the Red Top missile and I mentioned that I had been involved with Trial Digitation in 1976 to assess Red Top's ability to attack supersonic jamming targets. We had no difficulty locking-on to a jamming spoke on the radar, but we lacked any range information, which was essential if the Red Top was to be released within its launch parameters. For a successful firing the missile required target speed *and* range. The Lightning's radar had software that allowed the pilot to input a 'predicted target speed' which was provided by the fighter controller on the ground. The computer was able to calculate the range by the rate of change of the site-line angle – called radar ranging. As the Lightning got closer to the target the rate of change of the site-line increased. This aspect of the Lightning's radar had never been proven in the air so Trial Digitation was arranged with USAFE F-111s from Upper Heyford as the targets. The intercept set-up involved an F-111 flying down the North Sea at about 45,000 feet and 1·5M – one of the pre-set speeds we could select. A pair of Lightnings, a couple of hundred yards apart, flew towards them at 1·3M, but they were fitted with different magnetrons. That way, one aircraft would get the full effect of the jamming on which to lock, while the other would see a discrete target. The recorded radar films from each Lightning were then projected side-by-side and the results showed that the jammed radar using the predicted target speed and radar ranging software were accurate enough to give the Red Top all the information it required for a successful launch.

Sqn Ldr Peter Symes. I have read somewhere that the Lightning's attrition rate did not compare favourably with that of the *Luftwaffe's* F-104s. Was that the case?

AVM George Black. I think that the figures were probably worse for the F-104, but then, there were a lot more of them, so it's quite difficult to draw a comparison. My personal feeling is that we were sometimes a bit unfortunate with some of our accidents, and if you look at the records, I fancy that you will find that we could go for quite long periods without any incidents and that we would then have two or three in quick succession. Towards the end of the aeroplane's life, of course, things would also have been getting a bit tired, so one might perhaps have expected an increased accident rate.

Air Cdre Rick Peacock-Edwards. So far as RAF Germany was concerned, I think you will find that, in eleven years, 19 and 92 Sqns lost only two aeroplanes, an F2A and a T4.

Tony Wilson. Among the documents that I consulted in preparation for today was a report by the Reliability Department at Warton which compared the loss rate per 1,000 flying hours for the Lightning against various other aeroplanes. I could follow this up in arrears. (*Post meeting note*: The document was raised in 1969 and suggested that, at that time, the loss rate for Lightning was probably better than F-104 in *Luftwaffe* and USAF service but not as good as the F-104 in some other NATO air forces such as the Dutch. More research would be needed to provide a definitive answer.)[1]

Wg Cdr Gareth Cunningham. Just to follow-up on what Rick said, thirty Mk 2s were converted to F2A standard and only two of those were written off. One in a flying accident, from which the pilot ejected successfully, the other was burned out by Aircraft Serving Flight on the reheat pan. I think that the F2A probably had the best safety record of any mark of Lightning.

Air Cdre Bob Lightfoot. Just for the record, in the context of visual identification at night, at one stage there was a plan to fit a light in the nose of a Firestreak. It was to be slaved to the seeker head, so it could

[1] Accident statistics can be contentious, because of the many variables. The Germans had more than 900 F-104s and flew them for 27 years, in the course of which they wrote off about 30% of their inventory. By comparison, the Canadian F-104 fleet was only a quarter the size of Germany's, but they managed to lose almost half of theirs. On the other hand, the Spaniards didn't lose any – but then they had only 18 and operated them for only 7 years. (**Ed**)

scan in azimuth and elevation. I saw this device, on the ground, at Hatfield, but I don't think that it ever came near entering service.

But I would like to raise the issue of the gun. The ADEN was a very well-developed cannon that had been used in a variety of aeroplanes before the Lightning, but it seems to have been forgotten. It did come back into favour eventually, notably in Germany, but why was so little attention paid to guns in the early days?

AVM George Black. I can't answer that definitively, but in my time in Air Plans at the MOD, in the early '70s, the OR staff were strongly opposed to putting guns in the Mk 3 Lightning. I recall having lengthy discussions with them, urging them to reconsider, but they insisted that missiles were now so capable that guns were simply unnecessary. That said, there were, and always will be, occasions when a gun will be useful. I thought they were essential – as did the Saudis. We did win the day, eventually, of course, albeit somewhat unusually by putting them in the ventral tank!

Gp Capt Jock Heron. At the CFE Convention in 1963 AFDS lamented the lack of a gun in the Mk 3, which was shortly to be delivered. We made representation to MOD about that, supported by, then Wg Cdr, John Nichols and I think that must have had some effect because not long after that Warton came up with the idea of installing guns in the ventral.

Air Cdre Rick Peacock-Edwards. In Germany we thought the gun was particularly important, the more so with the increase in low level operations when a gun attack could sometimes be the only option. When I first arrived in Germany, we would occasionally fly out over the North Sea just to fire the guns before recovering to Gutersloh – while coping with whatever instrument or radio failures we had picked up as a result . . . As time went by, however, gunnery was taken more seriously, and we began to do APCs at Decimomannu.

Gp Capt Andy Williams. Another thought on armament. I was the last OC 5 Sqn on Lightnings, in 1985-87, and it was apparent that, at least some of, our Mk 6s had been built to a similar standard to the Saudi F53s which had hardpoints under the wings. So I put up a paper proposing that, as a contingency option, we should consider fitting two LAU-7 launchers under the wings, which would permit us to

carry bombs, SNEB pods, even Sidewinder. My argument was that if there was an inherent capability, it should be exploited. If, for instance, the Phantoms at Leuchars had been taken out, it might still have been possible to move some of their Sidewinders down to Binbrook for us to use. Needless to say, the LAU-7s never materialised . . .

Paul Burton. I'm with the Atomic Weapons Establishment. This one is for Tony. You put up a slide suggesting that RED BEARD might be an option for the Lightning – it was dated 1957. We had only just tested it at that stage, so how much hard information would you actually have had, beyond the shape? I ask because the envelope turned out to be quite tricky and I think that we would have struggled with it on a Lightning.

Tony Wilson. I think we just had the drawing of the basic shape as a store to be carried. I suspect that, when it came to looking at a Lightning ground-attack option, this was chosen as typical of the stores that the RAF were asking to be carried. Interestingly, there is a document in the National Archives reporting a Science (Air) study where they looked at Swift, Hunter and Javelin lofting a nuclear weapon against incoming bombers – this was long before the Genie study – and when I first saw RED BEARD associated with the Lightning I thought it might be something to do with that idea, but it turned out to be ground attack.

AVM Black. Time to wind-up, so may I just thank you all for coming today – our largest ever attendance – and it's good to know that the proceedings will eventually be published in the RAF Historical Society's Journal. The Lightning was a very fine aeroplane, one that many of us had the pleasure of operating. So, our thanks to the presenters and our Vice-President would like to say a few words.

Sir Freddie Sowrey. It's been a good day. An iconic aeroplane. Record numbers. Lots of old fighter pilots have turned up and I hope that they are all as satisfied as I am. But today would not have been possible without the work of the Society's Chairman and his Committee – their choice of topics, and recruiting of speakers, and the professionalism of the presenters have produced a great day and I invite you to offer them a round of applause.

THE INADVERTENT FLIGHT OF LIGHTNING XM135 – SOME BACKGROUND CONSIDERATIONS

by Wg Cdr W V Holden

Wg Cdr 'Taff' Holden died in December 2016; his account is reproduced here by kind permission of his grandson, Dan Rostron.

In attempting to write a more detailed personal account of my unfortunate flight in Lightning XM135 back in July 1966, I think I should add some of the reasoning and reason why I attempted the test in the first place. This might remove some of the erroneous facts, misapprehensions and misconceptions which I have seen in some accounts of the event.

First, I should explain that I was a qualified pilot, even although I was an RAF Engineer Branch officer. I joined the RAF as an apprentice in 1943, from where I gained a cadetship to university. At the university I read mechanical engineering and learnt to fly on Tiger Moths, with the University Air Squadron. On graduation, I was given the option to continue with an engineering career or to follow a General Duties (Flying) career. I chose the former path and the Air Ministry at that time, considered that there was merit in allowing me to qualify to 'wings' standard as a pilot, in the belief that an engineering officer with a pilot qualification, could more easily see the pilot's point of view in aircraft maintenance matters. I too, thought this was a very good idea.

I qualified on Harvards, but my early engineering duties only allowed me to keep in flying practice on Chipmunks. Whilst I was at Kinloss, I managed to get checked out on Oxfords and on occasions assisted a qualified test pilot to air test twin-engine Neptunes. My only jet aircraft experience was as a passenger in the second seat of a Javelin T3 and again on the 'rumble' seat of a Canberra. In my service, one of my postings took me to No 33 MU at Lyneham where, as the CO of a civilian-manned aircraft storage unit, I had Canberras, Meteors and Lightnings which were gradually being prepared for despatch to various flying unit tasks. When the Meteors and Canberras had been cleared, the powers that be, decided that the MU should close after the last Lightnings had been despatched. Up until the last Canberra, I had a qualified and current test pilot on my staff for those

aircraft, but he was not a current Lightning pilot. When a Lightning needed test flying, I had to call for any available pilot with a current test pilot rating. Most times I would find one who could be spared within a 24- or 36-hour period. So much for my personal and RAF unit background.

Lightning Mk 1 XM135

XM135 was being prepared for despatch to a Target Facilities Flight, but over a period of weeks, it had been giving no end of trouble. Each time it was being flight tested, the pilot found that on the initial few yards of a take off run, the inverter supplying power to the primary flight instruments, would cut out and the stand-by inverter would have to cut in – clearly an unsatisfactory state of affairs. Electricians were using every trick of their trade to establish the cause, each time thinking that they had removed, replaced and tightened every likely component. With nothing out of order, they would seek another test flight. It was a Boscombe Down pilot who next attempted to fly the aircraft, found the same problem persisting and refused to fly until a more positive explanation could be determined.

Back to the drawing board; the electricians decided to devise some tests which might isolate the problem and indicate roughly where and which component was at fault. They intended to ask the next test pilot to switch in and out parts of circuits, using trailing wires from the likely circuits to temporary switches in the cockpit and to do these electrical switchings before and after each few yards of a simulated take off run, when the fault was manifest. The temporary wires from internal circuitry required the cockpit canopy to be removed and in this state the aircraft was made ready for another air test. Being a pilot, it was easiest for me, as CO, to request the services of a qualified test pilot, from wherever I could find one, but for the next test on XM135, no pilot was available for at least another week. With my unit closing down, many civilians being made redundant and a timetable of clearance being upset with this ‘rogue’ aircraft, there was much tetchiness and irritation amongst my staff.

The intended Boscombe Down pilot, knowing I was a pilot, suggested I might try the test myself. He suggested using an out-of-use runway (Runway 30) as I would only be using 30 or 40 yards at a time. He suggested using a Land Rover to communicate with Air

The second production Lightning F1, XM135. (Steve Ryle)

Traffic Control and to get their clearance for each movement of the aircraft. However, there was one remaining minor problem. I had only sat in a Lightning cockpit once before and I had no idea how to start its two Rolls-Royce Avon engines! The foreman of engine trades gave me a 5-minute briefing on how to do this and XM135 was towed out to Runway 30 on 22 July 1966 for my electrical tests.

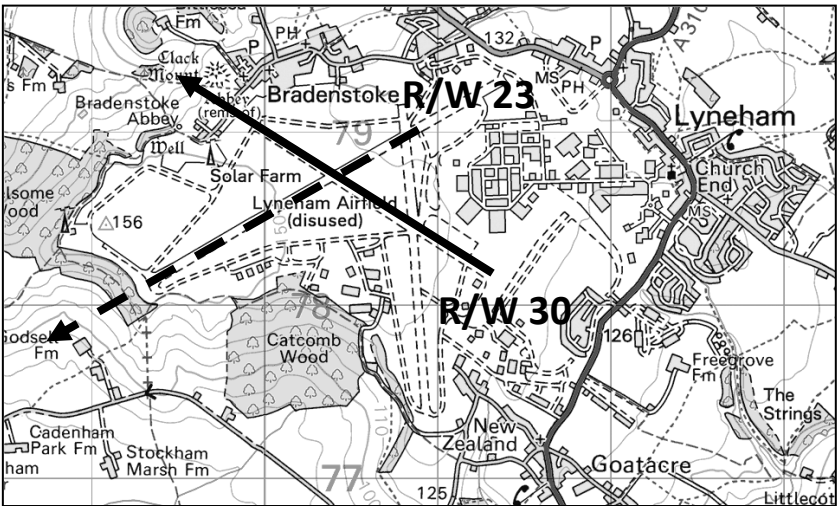
It was by way of extraordinary good fortune that my engine foreman had explained that, although I would not be needing reheat, that reheat needed the throttles to be pushed past a reheat 'gate' and that one had to 'feel for the gate keys', behind the throttle, to unlock. My only other knowledge of the Lightning was what I could remember from Pilot's Notes. At each test flight by the qualified pilot, I would be in ATC with a copy of Pilot's Notes, should he need any aircraft figures to be relayed to him. One or two figures stuck in my mind, namely that the undercarriage had a maximum speed before it should be retracted and I had an even vaguer figure of about 150 knots for a landing speed. Some extra knots would be required for each 1,000 lb of unused fuel, but I did not need to bother with any such figures for the test, which I was to undertake.

The Ground Test

I was correctly strapped into the cockpit (seated on the *in situ* parachute and ejector seat) and after starting the engines and holding the aircraft static, on the brakes, I did the necessary preliminaries for

the electrical checks in the cockpit, checking the notes I had scribbled on a notepad which lay on the coaming in front of me. All seemed ready for the first test and I indicated to the Land Rover to obtain ATC clearance for use of the short 30 or 40 yards of runway. Holding the brakes I gradually opened the throttles to about 90%. My feeling at the time was the unexpected heavy vibration of Avon power held against the brakes. I did a quick check of the temporary electrical switches and circuitry lights, then released the brakes. That initial punch from the thrust was quite remarkable and I moved the expected 30 to 40 yards before I throttled back and applied the brakes. So far so good. I made some notes, altered some more switch positions, noted the on/off lights and prepared for the next test. This was done in a similar fashion and I was leaving the 'fault' diagnosis to my electrical staff who would have to interpret my notes. I needed to do one more test and ATC had noted that I had only used about 100 yards total, so they were quite happy to clear me for a similar short distance. ATC had also been holding up a fuel bowser and trailer with 3,600 gallons of AVTAG for a C-130 awaiting refuelling, so they decided to allow the bowser to cross the runway. On opening the throttles for that final test, I obviously pushed them too far, misinterpreting the thrust, because of the unexpected heavy vibration and they got locked into reheat. Yes, I did use some expletives, but I had no time to think of getting out of reheat, because in front of me, the bowser and trailer had just crossed the runway, from right to left, so my thoughts were to make sure I was missing them by sufficient margin. No, I couldn't steer to clear them; reheat takes you in a straight path like a bullet out of a gun. The time between finding myself in reheat and just missing the bowser was less than half the time I have taken to write this sentence.

Before my thoughts could return to getting myself out of reheat, I was gathering speed and about to cross the main duty runway, where a Comet had just passed on its take off run. I then had no time to look for reheat gate keys, my eyes were on what next lay ahead. Two things, the end of the short runway 30 and just beyond was the small village of Bradenstoke which I just had to miss. There was no chance of stopping, none whatsoever. I had gained flying speed (that is what reheat is for, short sharp take offs) and I had no runway left. I did not need to heave it off the runway, the previous test pilot had trimmed it exactly for take off and only a slight backward touch on the stick and I



was gathering height and speed. Then my thought was to get my speed back in case I should damage the undercarriage. Incidentally, I could not have raised the undercarriage; the ground servicing locks were in place for safety reasons.

With only clear blue sky in front of me, I could then search and feel for those gate keys. Yes – I found them and thanked my lucky stars that my engine foreman had quite incidentally told me of their location and I was soon able to get the speed back to (I am guessing now) about 250 knots. My next thoughts were to keep Lyneham airfield in sight and where had the Comet got to? – the one I had missed a few seconds ago. Then I asked myself, should I eject and where and when? No, I could not; the safety pins were in the ejection seat and safe for servicing, not for flying. My only alternative then was to attempt a landing, but how does one interpolate or extrapolate Tiger Moth, Chipmunk and Harvard flying to a two-engined, 11-ton beast like the Lightning?

After regaining my bearings, a little composure and simply by observation, making sure that the Comet had been warned away, I decided I should attempt a landing on the duty runway and direction. I was trying to combine all my limited flying experience into a few minutes of DIY flight ‘training’ on a Lightning. It wasn’t easy, but I must admit that some of the elementary rudiments of my proper flying training and flight theory were coming in useful. I needed to get the

feel of the aircraft, if I was to get it back on the ground. My first approach was ridiculous, I could tell that my speed, height, rate of descent, even alignment weren't correct and my best plot was to go round again, this time making sure that my throttles would be well below the reheat position. A second approach was no better; I had some aspects better, but as the duty runway 23 (*sic*) is on the lip of an escarpment, with a valley floor beyond, my rate of descent took me below runway height and I found myself adding power to get back to the right level. More power also meant more speed and I was trying to get to something like 150 knots for landing, but my uncoordinated attempt was becoming a mess so I abandoned it, took myself away on a very wide circuit of Lyneham and decided to land in the opposite direction. This, I thought, would give me more time to get the 'feel' right and if I made a mess of the landing, I would overrun the runway and just drop (crash) into the valley beyond. In that direction, with a messed up landing, I would have no fear of crashing into Lyneham village.

The long final leg of this approach gave me the thinking time that I needed and I gradually got the feel so that speed, alignment, rate of descent, height and approach angle were better. I plonked it down at about the right position off the runway threshold, but just forgot that I was in a nosewheel aircraft and emulated my best three wheelers in a Chipmunk or Harvard. The result was that I crunched the rubber block which encases the brake parachute cables. However, I had got it down – but I then had to stop. I obviously knew the Lightning had a brake parachute, but where was the 'chute lever, button or knob? There, I found it, marked Brake Chute, and I pulled it and I could then look ahead and concentrate on keeping straight and somewhere near the centre line. I hung on to the brake lever, I wasn't slowing as much as I would like, so I just kept up my hand pressure on the brakes. I had about 100 yards of runway left when I stopped and even then, I didn't know that the brake parachute had dropped off as soon as it was deployed, because the cable had been severed as a result of my super tailwheel three-pointer!

Events Immediately After The Flight

XM135 was towed back to the hangar and I was taken to see the Medical Officer who gave me some pills to calm my nerves. I felt

Restored to its former 1960s-style 'Flying Tiger' glory, XM135, is on permanent display at the IWM, Duxford. (Damien Burke; Thunder and Lightnings)

reasonably calm because I had almost killed myself on five occasions in that 12-minute flight, yet I had miraculously survived. What is more, I would see my wife and young family again. Two or three times in that same 12 minutes, I had thought that I would never, ever see them again. My only priority was to save my own skin; I was not thinking about the non-insured loss of a Lightning Mk 1A. The minor damage to the aircraft was repaired with a new set of brake shoes and a new rubber 'chute block. As a memento, I have kept that rubber block; one day it might be returned to XM135 at Duxford.

The Fault

Although the tests I did, and the ensuing flight, did not immediately provide a reason for the initial electrical fault, my electrical staff, with additional assistance from English Electric, Samlesbury eventually did. Apparently, in early versions of the Lightning, there was to be a ground test button fitted into the standby inverter circuit. It was never fitted to the Mk 1A but the wires were left in the looms. It was one of these redundant wires which shorted on

to the UHF radio as it moved on its trunnions when the aircraft nudged forward on take off. Who would have thought I should risk my life to find it, in the way I did?

Events Subsequent To The Flight

There was a subsequent Inquiry to find out what had happened and why and to make recommendations for it never to happen again. As I was the Commanding Officer of the unit, I was responsible for my own, as well as the service actions of all my staff. I was not acting against any orders in the Flying Order Book which I religiously kept up to date. But those orders did not cater for engineering officers doing investigative type checks on Lightnings. They were later amended. After the Unit Inquiry I had to go up in front of the Commander-in-Chief. That was when I thought my career would be placed in jeopardy. I even thought that my coveted 'wings' would be taken from me; I had no idea how the incident was being regarded by Command or indeed the Air Ministry. But, as I stood in front of Air Marshal Sir Kenneth Porter, he read the proceedings, asked me if I agreed with his view that, 'With the limited flying experience that I had, the test would have been better left to an experienced and current Lightning test pilot.' I agreed, of course. He then told me to remove my hat, sit down and proceeded to tell me some of his unfortunate flying incidents in Mesopotamia in the Middle East. I was thankful that nothing more was to become of the incident and that I still had a job to do back at 33 Maintenance Unit, Lyneham.

I coped with all the official communications regarding the incident, but what I was unprepared for was the release of the story to the public. I had had very little experience of working with the press, certainly none with radio, TV, national and world press. I had no training in how to deal with their quest for news. My Command Headquarters suggested that I should go away on leave before press releases were made by the Air Ministry. This I did and took my family off camping to Jesola, in Italy. Imagine my complete surprise when, on the first day of camp, on my way to find some ice, someone shouted 'Hello Taffy, I've just been reading about your Lightning flight!' The world seemed a very small place. On returning to the UK, I was overwhelmed to find that the incident was still front line news. People wanted to write articles in newspapers, books, magazines,

interviews on TV and radio and underhand attempts to hear my account of what had happened. Having admitted that I had made an unwise decision to do the ground tests, I decided that the unwanted publicity that I had attracted was in no way going to be for financial gain. I steadfastly refused offers, although for a two-page article in the *Sunday Express*, I requested that the editors should make a contribution to the RAF Benevolent Fund. Despite prompts, no moneys were ever handed over and I became very disillusioned with all publicity media. Some friends thought I had gained reward for an article in *Mayfair*; it was written without my knowledge and authority, but, because it was factually correct, I had no redress from the Press Complaints Board. Nonetheless, I was extremely annoyed.

Some years after the incident, my hidden fears of high-speed flight came to the surface and I had to spend two periods in hospital. I had not come to terms with the emotional side of the event. To return to my wife and family after five close encounters with death, was indeed a miraculous experience, but I had not been honest with myself, to accept it as such, so I needed psychiatric help. I could recall the technicalities of the flight without any hang-ups but was unwilling to talk about that emotional side of the ordeal until I was placed under medical drugs in order to bring those emotions to the surface. That was a rewarding experience and it gave me a much better understanding of people who might need that same kind of help, after similar unfortunate occurrences.

Forty Years On

I am now retired and living with my wife in Cheshire. Apart from being an active DIY plumber, carpenter, electrician handyman, my main pastime is involvement with family history. My inadvertent flight is still very vivid and in writing this personal account, I needed little prompting. Over the intervening years, I have received many letters and reminders from people whom I did not know, all praising my efforts to return myself and aircraft back to the ground safely. Yes, I have basked in some glory, when accounts of what happened, have been retold in social gatherings. I have never sought publicity, but whenever it became impossible to suppress, I have had to live with it. I enjoyed my career in the Royal Air Force, but not because of XM135!

BOOK REVIEWS

Note that the prices given below are those quoted by the publishers. In most cases a better deal can be obtained by buying on-line.

Black Leader by George Black. Firestreak Books; 2018. £29.99.

AVM George Black will be a familiar name to many members of this Society but this book is about George the pilot, not George the air vice-marshal, indeed the tale it tells ends when he is still a mere group captain. His flying career began with Harvards in Canada in 1951. After jet conversion back in the UK, an initial 3½-year tour with No 263 Sqn at Wattisham started on Meteor F8s and ended on Sapphire-engined Hunters. In 1956 George was seconded to the FAA to fly Sea Hawks with No 802 NAS, a tour which included 265 deck landings, 25 combat sorties from HMS *Albion* during the brief Suez campaign and a cruise to the USA aboard HMS *Ark Royal*. Having attended CFS in 1958 he was a QFI on Vampires at Linton-on-Ouse before a major change of pace with a posting to No 74 Sqn as one of the initial cadre of pilots to fly the Lightning. A staff tour at Bentley Priory was rewarded by command of No 111 Sqn, followed by a stint as CFI with No 226 OCU at Coltishall, which provided an opportunity to fly Spitfires with the Historic Flight, and a final Lightning tour 1969-70 as OC 5 Sqn. Having spent ten years with the Lightning there was a remarkable change of pace – from Mach 2 to zero knots – with command of RAF Wildenrath and the three squadrons of the RAFG Harrier Force.

George had a penchant for display flying and he was a member of formation teams on Meteors, Hunters and Sea Hawks and led teams on Vampires and Lightnings. Other career highlights included leading a dozen Lightnings of No 5 Sqn to Singapore and back in 1969 and winning the AFCENT Trophy in 1970. Other exploits with the Lightning involved taking VIPs up in a two-seater to qualify for a Mach 2 Certificate and a ‘Ten Ton Club’ tie; these notables included King Hussein of Jordan, sundry senior air officers and last, but definitely not least – Mrs Black!

Although, he does not overplay the issue, making only passing references to such matters, it is very evident that the upper echelons of the RAF hierarchy regarded George Black as a safe pair of hands and

on more than one occasion he was parachuted in to right a listing ship. Reading between the lines of these episodes provides some illuminating insights into practical leadership. In his Foreword, Sir Richard Johns notes that his 'contribution to the development and operational efficiency of the Lightning Force was second to none' and that he had subsequently been instrumental in laying 'the firm and enduring foundations that transformed the Harrier from a novelty to a formidable weapon of war.' This humble reviewer can hardly improve on that endorsement.

The narrative is relatively concise – the book, which is well presented on coated paper, runs to only 176 pages – but it is a very easy, and entertaining, read. The text is supported by a remarkable 300 illustrations, many of them in colour.

CGJ

Hunters over Arabia by Ray Deacon. Pen & Sword; 2019. £30.00.

Anyone with a bit of Arabian sand in their desert boots will be familiar with the name of the author – Ray Deacon. He is, of course, the author/owner of the excellent 'Radfan Hunters' website. This book could be regarded as the printed version of the website, pulling together all the information and photographs contained therein. It traces the life of the Hunter in Arabia from its introduction to the theatre at the beginning of 1960 to the rather sad, and politically shambolic, ending at the end of 1971. It is a meticulous record of the activities of Nos 8, 43 and 208 Sqns and No 1417 Flt. The three squadrons based at Khormaksar were equipped with Hunter FGA9s and 1417 Flt with Hunter FR10s.

Their role was basically no different from what the RAF had been doing since the 1920s in Aden, namely Air Control. Indeed, it was almost certainly the swansong of Air Control and Proscription. This had worked well when the various tribes were just involved in sundry nefarious activities concentrating on economic gain. However, fuelled by nationalism and effective propaganda, by the 1960s the motivation had changed to one of a political desire for independence from the UK and Air Control was no longer so effective.

There are many excellent photographs (circa 300), about half of them in colour, and the description of events leaves you in no doubt as to how operationally active the squadrons were. However, what it

does not do is reflect what a really nasty little war this was. The description of the incident involving the SAS, resulting in the death of Captain Edwards and Trooper Warburton, fails to mention the fact that they were decapitated and their heads put on display on sticks in the Yemen. To start with, life in Aden, was generally pretty pleasant with cruise ships stopping off at the harbour; it was the biggest oil bunkering port in the world and a free port, enjoying a certain amount of prosperity. However, it deteriorated into escalating unrest, mayhem, murder and violence. Up-country, which was more properly referred to as the South Arabian Federation, was even more difficult to understand as the various tribes and sultanates had for years, centuries even, spent their lives shooting at each other – there was not much else to do to pass the time. However, when the British arrived that focussed their attention and gave them a welcome alternative target. There is an excellent book, written by Jonathan Walker called *Aden Insurgency – the Savage War in Yemen 1962-1967*, which is worth reading if you wanted to know more of the political and military context.

But to return to *Hunters in Arabia*, a 380-page hardback, it is a reference book, and an excellent one. It would, perhaps, have been useful to have a more detailed map of the region to which to refer. There are one or two inaccuracies and omissions that I noticed. It omits the fact that Hunters of No 54 Sqn visited Khormaksar, 1-4 April 1960, just after No 8 Sqn had re-equipped. The four ship was led by OC 54 Sqn, Sqn Ldr Ian Worby, with Wg Cdr Bennet (OC Flying Wg at Stradishall) as his Number 2, the second pair being led by Chris Bruce (OC A Flt) with a Fg Off G C Williams as his Number 2! No 8 Sqn made much of the fact that they took OC 54 and the wing commander up-country on an operational mission to show the upstarts from UK the ‘real world’. Little did I realise that I would return a few years later. Finally, I cannot help but comment on the implementation of centralised servicing. It destroyed squadron spirit and certainly did not lead to improved serviceability. The theory was good, but the practice disastrous.

Hunters over Arabia has obviously been the subject of much research and also has the advantage of the personal knowledge of the author. The many illustrations are very well reproduced and the overall presentation is good. Its claim to fame will be as a first class

historical record of how the Hunter operated in the Middle East and of the people and aircraft involved. For those of us who were there, it will provide many nostalgic memories. For those who were not, it will give an insight in to the activities of the past.

AVM Graham Williams

The Vultee Vengeance in Battle by Peter C Smith. Pen & Sword; 2019. £25.00.

Peter C Smith has written more than 70 books, perhaps half of which are to do with some aspect of dive bombing and/or dive bombers. This 324-page hardback, with a 30-photograph insert, is his latest title. It focuses on the use of the Vengeance in the India/Burma theatre, its employment by the RAAF in New Guinea being summarised in a brief supplementary chapter. The units concerned were Nos 7 and 8 Sqns of the Indian Air Force and Nos 45, 82, 84 and 110 Sqns RAF, each of which has a dedicated chapter. Having some familiarity with the exploits of No 45 Sqn, this reviewer went to that unit's chapter first, only to be somewhat disappointed.

The first problem is the dust jacket which features a painting of a Vengeance of No 45 Sqn but, unfortunately, the artist has misinterpreted (or been ill-advised about) the unit's code letters. 'OB' has been rendered as 'DB' – not a good start. Moving on, the chapter devoted to the squadron is headed, and this is repeated on every right hand page, 'No 45 (R) Squadron RAF'. The '(R)' – for 'Reserve' – suffix was not introduced until the 1970s; it is no longer applied today and is a glaring anachronism in the case of a fully operational unit during WW II.

So what of the narrative? The second sentence states that, 'having been operating in the Mediterranean area […] in March 1942 it left for India without its Blenheims.' Simply not the case; the squadron had redeployed to Burma with twenty-four Blenheims and fought itself to a standstill there before withdrawing to India with its remaining handful of aeroplanes. The author goes on to state that the squadron received Vengeances in August 1942 and used them to fly anti-submarine patrols from Cholavarum (*sic*) 'from July'. The juxtaposed dates aside, this is nonsense. Following the loss of Burma, and without aircraft, No 45 Sqn's personnel spent much of 1942 dispersed all over India attached to a variety of units. With the prospect of re-equipment,

however, they were recalled and the unit began to coalesce at Cholavaram (the conventional spelling at the time), but this was not until November. The first Vengeances were not taken on charge until as late as 11 December – and there were only two of them. All of this misinformation is in the first paragraph. The next one says that the squadron moved to Salbani in May 1943 – it just didn't (No 82 Sqn did, although this move is not recorded in the chapter devoted to that unit).

The presentation of personalities is inconsistent, sometimes just surnames, sometimes with initials and, surprisingly often, with full given names. The problem here is that the names are frequently, far too frequently, simply wrong. Just as examples (there are *many* others): 'Arthur John Laney' was really Paul Clipsham Lahey; 'Gilbert Challans (sometime Charles) Hockley' was actually Cyril Garbutt Hockney; 'Andrew Hastie Furmage' was actually Geoffrey Greer Furmage; 'A H Lebas' was really Alpine Rae 'Al' Lebans RCAF. We are told that there was a pilot called Maurice Gordon Fountain, but he was not a pilot; he was Tech Sigs. Poul (known locally as Paul) Ulrik Keel was not 'an Aussie' – he was a Dane. No 45 Sqn did have a Donald Stuart Edwards – but as a squadron leader pilot on Mosquitos in 1944; the Edwards of the Vengeance era was Fg Off Laurence Sydney – and he was Tech Eng. Then again, 'Allen Henry Halley RAAF' was, in reality, Len Halley RCAF. There is a random scatter of such post-nominals throughout, but they are applied inconsistently, and sometimes inappropriately – as in the wrong air force. Many aircraft serial numbers are incorrect, and the two missions said to have been flown on 11 November 1943, were actually flown on the 10th. The author insists that the squadron's first Mosquito, LR250, arrived at Yelahanka on 1 March – 'not 29 February'; yet the ORB, which the author claims to have used as the basis of his research states, very specifically, that it arrived on 29 February! Oh, and Wg Cdr 'Stephen Claude Alfred Stephen Claude Alfred Leathers', suggests inadequate proof reading, as does Mingalawon, for Mingaladon.

Beyond a casual dip into No 82 Sqn's chapter, which did nothing to inspire confidence, I did not investigate the accounts of the other squadrons. But the many problems associated with No 45 Sqn are clearly sufficient to attract a serious health warning. Needless to say,

there is some worthwhile information in this book, but the reader will already need to be *very* familiar with the Vengeance and its brief career to be able to sort the wheat from the chaff. Sadly, since this book cannot be relied on, it cannot be recommended.
CGJ

Archaeology of the Teufelsberg – Exploring Western Intelligence Gathering in Cold War Berlin by Wayne D Cocroft and John Schofield. Routledge; 2019. £45.00.

There are many aspects of Cold War history that will progressively disappear as those who were there are no longer with us to bear witness, or are indeed still constrained by the Official Secrets Act. Wayne Cocroft is manager of Historic England's Historic Places Investigation Team and is co-author of *Cold War – Building for Nuclear Confrontation 1945-1989*, the 'bible' for those interested in the hardware of Britain's Cold War Heritage.[1] He is therefore well suited to taking a clinical look at the remains of one particular aspect of the confrontation between East and West. *Archaeology of the Teufelsberg* traces the history of the key monitoring installations on Berlin's man-made Teufelsberg hill and its associated intelligence gathering sites in the area, including RAF Gatow.

Still shrouded in a veil of secrecy – FOI requests were rejected – the authors have applied novel yet rigorous archaeological processes to the extant remains to analyse the nature of what went on during the site's operational days. Though representing one of the most secretive aspects of government activity and yet, by its very nature, offering a strikingly overt presence, the Teufelsberg was, and remains even in dilapidation, an iconic Cold War structure. This book throws some light on what took place there when occupied by the RAF, Army and United States intelligence gathering resources, although the two British services evidently endured a frosty relationship. But, as is pointed out, it cannot reveal the secrets of the software or what was intercepted.

The authors completed a building-by-building survey of the somewhat derelict remains on the hill to reveal the nature and purpose of these structures when they were operational, thereby shedding

[1] Published by The Royal Commission on Historical Monuments; 2005.

much light on the West's intelligence gathering infrastructure. Whilst the majority of the buildings have bland exteriors the 'Arctic Towers' best represent the shadowy nature of the past, albeit that at least one has evidence of a second life as squatters' accommodation. Inside there still remain many indications of purpose along with the inevitable artistic 'zaps' left by the occupants of the time. It is a reminder of what happens when derelict sites become the focus of public interest that care had to be taken to identify items brought onto the site since its closure and to exclude these items from the evidence. One example of the thoroughness of the investigation is the taking of residue samples from the incinerators to identify the type of material that had been destroyed.

This book will obviously appeal to those both in the Royal Air Force (26 Signals Unit) and the Army who operated from the Teufelsberg, but equally provides an interesting and informative read for a wider audience interested in the more obscure aspects of the Cold War and its intelligence gathering operations. The text is supported by photographs and site plans as well as being thoroughly referenced throughout, providing much source information for anyone seeking a deeper knowledge. It is perhaps a stark reminder of how things have changed that in 1999 the Teufelsberg hosted a conference at which former CIA and KGB operatives (the British were noticeably absent) were able to openly exchange views of what went on on either side of the Cold War divide. As with many academic books, however, and with only 162 pages, the price may well prevent this interesting book reaching a wider deserving audience.

John Boyes

Nimrod Boys by Tony Blackman and Joe Kennedy. Grub Street; 2019. £25.00

The 'Boys' series of books is now well established. The editor assembles veterans, aircrew or ground crew, concerned with one particular type of aircraft, who recall first-hand tales from their experiences. The initial books had covered most post-war RAF jets, but latterly we have had a Shackleton book, with a second on the way. A Beaufighter volume is in the offing as a stock of suitable interviews is available.

Nonagenarian author Tony Blackman has produced several books

from his experiences, including *Vulcan Test Pilot* with some hair-raising adventures, and the Valiant, Victor and Vulcan in the 'Boys' series. These books are not definitive technical histories of the types, though much is to be gleaned from them about their operation. Where the Nimrod is concerned, Tony also wrote *Nimrod Rise and Fall*, as definitive history as you are likely to find.

Tony has legitimacy to do all this having been chief test pilot for A V Roe and, tested most Nimrods (and Vulcans) as they left the factory. In this case, he is partnered by Joe Kennedy, a retired Nimrod AEOp who trained a few years after me on the 'Vomit Comet'. There are few Nimrod backenders who will not identify with Joe's description of his early Nimrod sorties, with the unique smell of 'conditioned air, sweat, burnt food, hydraulics, electrics, and the acoustics station heat sensitive recording paper' and I would add airsickness! Thanks too to Joe for reminding me of the joys of enduring a 'MAD comp'.

At this point we have encountered the first obstacle to the understanding of the life of the Mighty Hunter. More so than any other genre, Maritime had an exclusive language, generally incomprehensible to the rest of the RAF. Attempts to explain things were constricted by 'the need to know' and by high security classifications, often Secret or Top Secret and caveated UK/US Eyes A, because any inadvertent disclosure might incense our American partners who might pull the plug on vital intelligence.

Thankfully, Tony and Joe explain things well for the uninitiated, including things we are assured are now declassified. I found myself in the same position as the old lady who had worked on ULTRA at Bletchley Park and was told that she could now talk freely for a TV documentary, as permission had been given by PM Tony Blair. 'What would he know?!' she said and remained silent on the subject. It still comes as a shock to see some of the codewords and operations described in unclassified print. There are two more operations that I flew that are not covered, rightly so in my opinion, but that goes to explain further why Mr Cameron and presumably his cabinet and advisors were apparently woefully ignorant of how important an asset they willingly discarded.

It is hard to escape such politics when talking of the 'toxic' Nimrod. An excellent introduction by AVM Andrew Roberts sets the

ball rolling. Eminent test pilot Sir Charles Masefield gives insight to the trials and tribulations of the MR2 and the AEW3 and suggests an alternative view on the cause of the loss of XV230, as well as querying the permanent grounding of the fleet for want of a few simple modifications at a time when the capability was much needed. He also queries the wisdom of 'those with no background or experience in aviation (*being given*) the overall responsibility for such an inquiry.' He comments also on the cancellation of the MRA4 on which £4 billion had been spent.

To round off the politics we have a letter from pilot Andy Trotman to David Cameron advising him of the 'utter folly' of his decision. Whether or not it made an impression on the PM we know not.

The book, with about 160 well-reproduced illustrations, many of them in colour, contains accounts covering most Nimrod exploits, from tracking Soviet submarines and surface ships, to the Falklands and the introduction of AAR and Harpoon. There is the Gulf War and, of course, SAR for which for many years a Nimrod was on permanent standby. We also peer behind the curtain into the murky world of the R1 and hear from Billy Speight how they flew the Golden Jubilee Flypast on three engines with no one knowing – including the operating pilot!

Mark Faulds also contributes an article about his Nimrod days, but is enthusiastic about the future on Poseidon. The Eyeore in me says, all well and good but we need more of them – and AAR!

Two stories stand out for me. The first is the miraculous recovery of XV257 with a flare fire. That the late Gordon Smith was not awarded an AFC for such splendid airmanship amazed me at the time. Included here is the transcript of the intercom recording. The crew should have died, but the fact they did not was, in my opinion, due to Gordon's pre take off brief that, in the event of an emergency after take-off, owing to the light wind, he would dumbbell back and land in the reverse direction, and his subsequent adherence to that brief.

Also of note is 'Nimrod Girl', Shelley Faulkner's take on our lifestyle, albeit in the later years. After my Britannia days, I only flew with all male crews, though there were lady navs on Nimrods before I left. I considered the AEOp role a tough male bastion to

breach, but Shelley achieved it. Having left the service and moved to New Zealand, Shelley has applied to sign up again and may be one of those who bring the Poseidon into service.

The 254-page *Nimrod Boys* is not full of stories of people worried about their safety, but of people who enjoyed their time and loved the aircraft and are proud of its achievements. I thoroughly enjoyed this book, but as Mandy Rice-Davies might have said, 'I would, wouldn't I?'

Ian Coleman

Beaufighter Boys by Graham Pitchfork. Grub Street; 2019. £2000.

Having effectively established an exclusive claim to the 'Boys' concept, and having dealt with most of the RAF's post-war combat aircraft (Vampire/Venom anyone?), Grub Street has broadened the scope of its franchise to embrace WW II. First up is the Beaufighter, which runs to 221 pages with about 120 photographs. It has been printed on a rather coarser grade of paper than most earlier books in the series, with adverse effects on the reproduction of the pictures.

As ever, the content consists of a series of accounts, brought together and ably edited by Graham Pitchfork, providing the recollections of individuals who flew the aeroplane in all of its roles and in all of the theatres in which it was deployed. Thus, we have: night fighting over the UK, North Africa, Sicily, Italy and India; maritime strike in home waters and the Mediterranean, Aegean and Adriatic and overland strike in Burma plus RAAF strike operations over New Guinea and Timor. Having begun in 1940, the story ends in Malaya in 1950 with a contribution by the late AVM Mike Robinson describing his time as a junior pilot with No 45 Sqn in the opening rounds of Operation FIREDOG. There are twenty-eight chapters in all, several of which have multiple authors.

Problems? A few typos/anomalies, eg break for brake (twice); an RO was a radio (not radar) operator; Heinkel He III vice He 111 (repeatedly); ·50 mm anti-aircraft fire, (which should surely have been ·5-inch); the Hercules was a radial (not rotary) engine and the Beaufighter was flown by No 16 (not 12) Sqn SAAF. None of these are fundamental flaws, of course, but there is one real oddity; a description, on page 120, of a crash landing at Cassibile (Sicily) in September 1942 is cross-referred to an amplified account on page 103,

but they are not the same incident – the latter was at Taher (Algeria) in June.

Such niggles aside, the tales told are full of interest and incident. I was particularly impressed by two issues. First, the loss rate involved in maritime strike operations. It was always a risky business, as exemplified by No 47 Sqn which lost eleven of its sixteen crews in less than three weeks operating over the Aegean in 1943. Secondly, as an erstwhile nav myself, it was pleasing to note that several of the accounts were provided by back-seaters. That said, as contributor Dennis Spencer of No 211 Sqn observes, 'the provision of accommodation for the second crew member […] seemed to me to have been something of an afterthought.' For relatively short-range night fighting, an AI radar sufficed but for strike operations, the RAF might at least have provided the nav with a drift sight – but it didn't, at least not in 211 Squadron's aeroplanes. This was in marked contrast to the RAAF whose Beaufighter back seaters had a drift recorder and an astrocompass – and one accounts even tells of shooting the stars. There is another interesting Anglo-Aussie contrast in that one of the RAAF accounts specifically mentions the effect of cannon fire on the aircraft's compass, causing it to deviate by as much as 12°, necessitating frequent compass swings; curiously, there is no mention of this problem in any of the RAF accounts.

But I digress. What comes across is the respect that its crews had for their aeroplane. It was hardly a match for a single-seat fighter, of course, but its firepower was devastating and it could withstand a fair amount of damage and keep flying or, if not, the crew had a much better than even chance of surviving a ditching or belly landing – as many of the tales in this book testify. I was surprised to find no reference to the aircraft's alleged tendency to swing on take-off, so perhaps this was not as significant as has often been claimed in Beaufighter folklore.

Beaufighter Boys fully maintains the standard set by its predecessors in this long-running series.

CGJ

ROYAL AIR FORCE HISTORICAL SOCIETY

The Royal Air Force has been in existence for one hundred years; the study of its history is deepening, and continues to be the subject of published works of consequence. Fresh attention is being given to the strategic assumptions under which military air power was first created and which largely determined policy and operations in both World Wars, the interwar period, and in the era of Cold War tension. Material dealing with post-war history is now becoming available under the 20-year rule, although in significantly reduced quantities since the 1970s. These studies are important to academic historians and to the present and future members of the RAF.

The RAF Historical Society was formed in 1986 to provide a focus for interest in the history of the RAF. It does so by providing a setting for lectures and seminars in which those interested in the history of the Service have the opportunity to meet those who participated in the evolution and implementation of policy. The Society believes that these events make an important contribution to the permanent record.

The Society normally holds three lectures or seminars a year in London, with occasional events in other parts of the country. Transcripts of lectures and seminars are published in the Journal of the RAF Historical Society, which is distributed free of charge to members. Individual membership is open to all with an interest in RAF history, whether or not they were in the Service. Although the Society has the approval of the Air Force Board, it is entirely self-financing.

Membership of the Society costs £18 per annum and further details may be obtained from the Membership Secretary, Wg Cdr Colin Cummings, October House, Yelvertoft, NN6 6LF. Tel: 01788 822124.

THE TWO AIR FORCES AWARD

In 1996 the Royal Air Force Historical Society established, in collaboration with its American sister organisation, the Air Force Historical Foundation, the *Two Air Forces Award*, which was to be presented annually on each side of the Atlantic in recognition of outstanding academic work by a serving RAF officer or airman, a member of one of the other Services or an MOD civil servant. The British winners have been:

1996	Sqn Ldr P C Emmett PhD MSc BSc CEng MIEE
1997	Wg Cdr M P Brzezicki MPhil MIL
1998	Wg Cdr P J Daybell MBE MA BA
1999	Sqn Ldr S P Harpum MSc BSc MILT
2000	Sqn Ldr A W Riches MA
2001	Sqn Ldr C H Goss MA
2002	Sqn Ldr S I Richards BSc
2003	Wg Cdr T M Webster MB BS MRCGP MRAeS
2004	Sqn Ldr S Gardner MA MPhil
2005	Wg Cdr S D Ellard MSc BSc CEng MRAeS MBCS
2007	Wg Cdr H Smyth DFC
2008	Wg Cdr B J Hunt MSc MBIFM MinstAM
2009	Gp Capt A J Byford MA MA
2010	Lt Col A M Roe YORKS
2011	Wg Cdr S J Chappell BSc
2012	Wg Cdr N A Tucker-Lowe DSO MA MCMI
2013	Sqn Ldr J S Doyle MA BA
2014	Gp Capt M R Johnson BSc MA MBA
2015	Wg Cdr P M Rait
2016	Rev (Sqn Ldr) D Richardson BTh MA PhD
2017	Wg Cdr D Smathers

THE AIR LEAGUE GOLD MEDAL

On 11 February 1998 the Air League presented the Royal Air Force Historical Society with a Gold Medal in recognition of the Society's achievements in recording aspects of the evolution of British air power and thus realising one of the aims of the League. The Executive Committee decided that the medal should be awarded periodically to a nominal holder (it actually resides at the Royal Air Force Club, where it is on display) who was to be an individual who had made a particularly significant contribution to the conduct of the Society's affairs. Holders to date have been:

Air Marshal Sir Frederick Sowrey KCB CBE AFC
Air Commodore H A Probert MBE MA
Wing Commander C G Jefford MBE BA

SECRETARY
Gp Capt K J Dearman
1 Park Close
Middleton Stoney
Oxon
OX25 4AS
Tel: 01869 343327

MEMBERSHIP SECRETARY
(who also deals with sales of publications)
Wg Cdr Colin Cummings
October House
Yelvertoft
Northants
NN6 6LF
Tel: 01788 822124

TREASURER
John Boyes TD CA
70 Copse Avenue
West Wickham
Kent
BR4 9NR
Tel: 0208 776 1751

EDITOR and PUBLICATIONS MANAGER
Wg Cdr C G Jefford MBE BA
Walnuts
Lower Road
Postcombe
Thame
OX9 7DU
Tel: 01844 281449